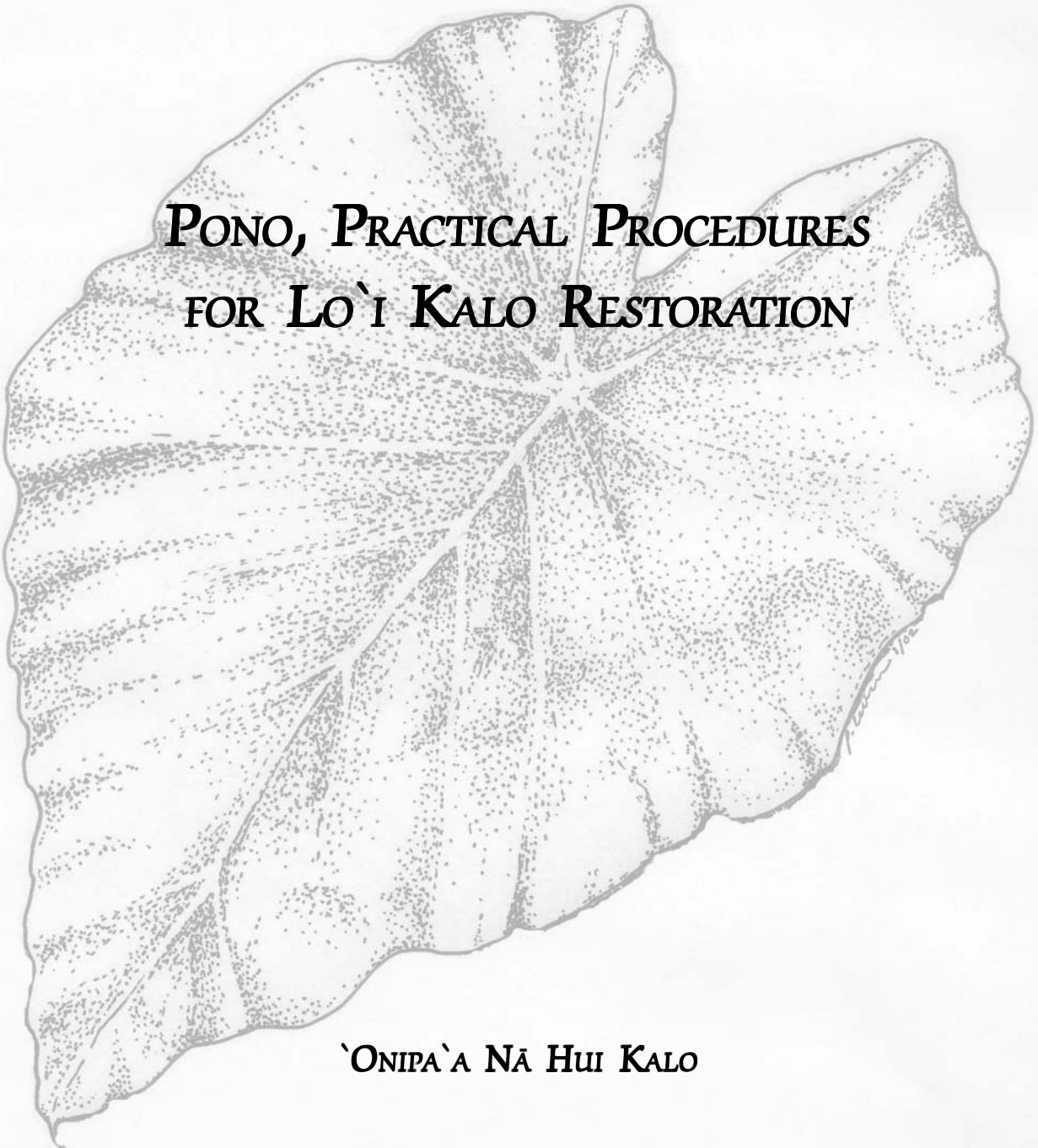


# GUIDELINES FOR GRASSROOTS LO'I KALO REHABILITATION



PONO, PRACTICAL PROCEDURES  
FOR LO'I KALO RESTORATION

'ONIPA`A NĀ HUI KALO

## DISCLAIMER 2025

The *Guidelines for Lo‘i Kalo Rehabilitation: Pono, Practical Procedures for Lo‘i Kalo Restoration* (© 2003 and 2004 ‘Onipa‘a Nā Hui Kalo) is being made available in pdf form to support the growing number of young kalo farmers and rehabilitation efforts around Hawai‘i.

The *Guidelines* are an introduction to sound practices in the rehabilitation of lo‘i kalo that remain on the land; the best learning is still in the lo‘i and under the mentorship of a skilled kalo farmer.

The original *Guidelines* was in the form of a workbook that could be copied and placed in a binder for personal use. We recognize that certain forms of information exchange and learning have shifted from hardcopy to digital format and phone accessible. The copyright for the *Guidelines* remains the same. *No portion of the Guidelines may be reproduced in any form for profit.*

This copy of the *Guidelines* has not been updated and mistakes in spelling, grammar and other typos remain uncorrected. Much has changed regarding water rights as it relates to lo‘i kalo in the last 22 years and the legal section of the book is largely out of date. We recommend interested growers go to *Ola i ka Wai: A Legal Primer for Water Use and Management in Hawai‘i* (2010 D. Kapua Sproat) and the 2023 Addendum for current water law and case law.

<https://manoa.hawaii.edu/kahuliao/scholarship-and-legal-resources/legal-primers/>

‘Onipa‘a Nā Hui Kalo 25 December 2025.

© 2003 and 2004. All rights reserved.

No portion of this book may be reproduced in any form for profit. Requests to use or reproduce any portion of this book by agencies, organizations or individuals should be made to `ONIPA`A NĀ HUI KALO through the Queen Lili`uokalani Children's Center nearest you.

Unless otherwise noted, all `ōlelo no`eau and their translations come from *‘Ōlelo No`eau: Hawaiian Proverbs & Poetical Sayings*.  
Mary Kawena Pukui. Bishop Museum Press. Honolulu. 1983.

## DISCLAIMER

No implied or other license is created regarding the content of this publication. `ONIPA`A NĀ HUI KALO does not represent or warrant that the information herein is accurate, complete or current. Any reliance on the information contained in this publication is solely at the user's own risk.

# HE PULE

## Mele ho‘oūlu ‘ai

E o‘u kūpuna wahine  
I ke kualono, i ke kuahiwi  
I ke kuamauna  
I ka hei  
I ka manomanowai  
I ka waokele  
I ka waoakua  
I ka ‘ōhi‘a lōloa  
I ka uluhe  
I ke ‘āma‘uma‘u  
I ka lā‘au kala‘ihi o‘o i ka nahele  
Hihi a ka ‘ie‘ie la e  
E iho e kanu i ka māla a kākou  
Iā Kahihi-‘ie-i-ka-nahele  
I ka māla ‘ai a ke ali‘i  
A Pāhoehoe-nui-a-Lonohea  
A me ke ali‘iwahine  
Me Honokua-lau-a-lipo  
I ulu ke kalo  
A pua ke kalo  
A o‘o ke kalo  
A i‘o mākole  
A pili wale mai  
Ka ‘ohā o ke kalo a kākou  
Mai kēlā kaikā a kēia kaikā  
Mai kēlā kuaīwi a kēia kuaīwi  
‘Oia ho‘i e, ‘oia ho‘i la  
A lele ka huli a kākou la

## Chant to increase the growth of food crops

O my ancestress  
Upon on the mountain ridges, mountain peak  
And mountain tops  
All knowledgeable  
[Ancestress] Of the multitudinous waters  
In the wet forests  
In the region of the gods  
The long ‘ōhi‘a  
The uluhe fern  
The ‘āma‘uma‘u fern  
The rigid woods of the forest  
The tangled ‘ie‘ie growth  
Descend and plant our garden  
O deity, Tangled-growth-of-‘ie‘ie  
[Plant] the garden which the chief eats  
Garden of Great-Pāhoehoe-of-Lonohea  
And the chiefess  
Honokua-lau-a-lipo  
Cause the kalo to grow  
Let the taro bloom  
Let the taro mature  
Till the flesh reddens  
Till the offspring (growth)  
Clings to our taro  
From that patch and this patch  
From that row to this row  
Let it be, it is so  
Let our planting stalks leap to their place.

Source: J.W.H. Isaac Kihe et al., from “Kaao Hooniua Puuwai no Ka-Miki” in *Ka Hoku o Hawaii*, October 29, 1914-February 5, 1915; Kepā Maly, translator in *Notes on Hawaiian Traditions and Practices of Agriculture*, Feb. 13, 2003. In this prayer-chant, Ka-Miki calls to his ancestress, the goddess Ka-uluhe-nui-hihi-kolo-i-uka, asking her to clear the land and prepare for more kalo planting.

# ACKNOWLEDGEMENTS

‘ONIPA`A NĀ HUI KALO is a partnership of kalo planters, Queen Lili‘uokalani Children’s Center, and the University of Hawai‘i College of Tropical Agriculture and Human Resources that grew out of numerous lo‘i kalo restoration efforts throughout the state of Hawai‘i. We would like to thank the OFFICE OF HAWAIIAN AFFAIRS for its generous contribution which brought these guidelines to final publication. We are grateful for the unwavering support of the QUEEN LILI`UOKALANI CHILDREN’S CENTER, without whom ‘ONIPA`A NĀ HUI KALO and these *GUIDELINES FOR GRASSROOTS LO`I KALO REHABILITATION* would never have been possible. We owe our thanks to the Queen for funding to gather at ancient lo‘i around the islands, for meeting places, for the chance to share experiences and learn from each other, and for the opportunity to include nā keiki of QLCC in lo‘i kalo rehabilitation work over the last four years. The children are our hope for continuation of this effort. We also hope that they have benefited, along with the communities the Hui has worked in, as much as Hui members have. We now have over two hundred members on all the islands.

To all the members of ‘ONIPA`A NĀ HUI KALO - for your contributions, experiences big and small, the many questions, for your willingness to engage in kalo planting and all the things that go along with that – mahalo nui loa. The *GUIDELINES* committee wishes to acknowledge the fun we have had in putting this work, which we affectionately called ‘the poi scout handbook,’ together with so many of you. We also acknowledge that the rehabilitation of ancient lo‘i kalo and the growing of kalo is a constant learning process; an education that all of us continue to be involved in daily.

Without the many years of experience of Hui members, and the humble presence of our kūpuna, many of us would still be way back on the learning curve, still wondering how to begin this work. They remind us that anyone who puts kalo in the ground is a planter – whether it is one stalk or hundreds.

Mahalo to the families of the *GUIDELINES* committee who allowed us to take up so much of their time.

We also wish to thank students at the UH LAW SCHOOL - NATIVE HAWAIIAN RIGHTS CLINIC for an important resource supplement to the *GUIDELINES*. They were able to map out the complex legal permitting system for the Hui.

Finally, to the many maka‘āinana who, through their work, revive the mana that lies dormant within the land; they inspire us with their example.

E kuahui like i ka hana.  
*Let everybody pitch in and work together.*

# TABLE OF CONTENTS

<b>HE PULE</b> .....	<i>iii</i>
<b>ACKNOWLEDGMENTS</b> .....	<i>iv</i>
<b>TABLE OF CONTENTS</b> .....	<i>v</i>
<b>PREFACE</b> .....	<i>vii</i>
<b>HOW TO USE THIS BOOK</b> .....	<i>ix</i>
<b>CHAPTER ONE: PRINCIPLES</b> .....	<i>2</i>
<b>CHAPTER TWO: `IMI A`O `ĀINA</b>	
WHY BEGIN THIS JOURNEY .....	<i>7</i>
<b>SECTION I: `IMI I KA `ĀINA</b>	
1. PLACE NAMES AND MO`OLELO .....	<i>12</i>
2. THE PHYSICAL ELEMENTS .....	<i>16</i>
A. CLIMATE .....	<i>17</i>
B. TOPOGRAPHY .....	<i>18</i>
C. SOIL .....	<i>20</i>
D. FLORA - PLANTS .....	<i>23</i>
E. FAUNA - ANIMALS .....	<i>31</i>
3. ARCHAEOLOGY .....	<i>34</i>
4. LAND USE .....	<i>39</i>
5. PEOPLE .....	<i>44</i>
6. GOVERNMENT LAND USE DESIGNATIONS .....	<i>46</i>
<b>SECTION II: KA WAI O KA `ĀINA</b>	
1. PLACE NAMES AND MO`OLELO .....	<i>50</i>
2. PHYSICAL ELEMENTS .....	<i>53</i>
ORIGINS .....	<i>53</i>
WATER PATHS .....	<i>55</i>
ENDING AND EXITS .....	<i>57</i>
A. SEASONAL BEHAVIORS .....	<i>58</i>
B. TOPOGRAPHY .....	<i>61</i>
C. FLORA - PLANTS .....	<i>62</i>
D. FAUNA - ANIMALS .....	<i>64</i>
E. WATER QUALITY .....	<i>66</i>
F. WATER QUANTITY .....	<i>70</i>
3. ARCHAEOLOGY .....	<i>76</i>
4. WATER USE .....	<i>77</i>
5. PEOPLE .....	<i>80</i>
6. GOVERNMENT WATER USE DESIGNATIONS .....	<i>82</i>

# TABLE OF CONTENTS CONTINUED

<b>KEY RESOURCES AND MAPS</b> .....	83
-------------------------------------	----

## **CHAPTER THREE: THE PHYSICAL REHABILITATION PROCESS**

1. A SAFETY PLAN .....	112
2. LABOR FORCE AND DOCUMENTATION OF YOUR WORK .....	114
3. SITE INVENTORY	
A. FLORA AND FAUNA .....	116
B. ARCHAEOLOGY .....	117
4. SITE CLEARING	
A. BRUSH REMOVAL .....	121
B. TREE REMOVAL .....	123
5. EROSION CONTROL .....	125
6. THE `AUWAI .....	126
7. THE MĀNO	
A. LOCATION .....	128
B. INTAKE REHABILITATION/CONSTRUCTION .....	129
8. LO`I PREPARATION	
A. EARTH BANKS AND STONE WALLS .....	131
B. BRINGING THE WATER IN .....	133
9. FROM KEIKI TO HARVEST .....	135

## **APPENDIX A: LAWS PERTAINING TO WATER**

HAWAI`I STATE WATER LAW: PROTECTING NATIVE HAWAIIAN INTERESTS .....	A-1
ANCIENT HAWAIIAN WATER RIGHTS AND SOME OF THE CUSTOMS PERTAINING TO THEM .....	A-7

## **APPENDIX B: OUTLINE OF THE PERMITTING PROCESS**

THE REGULATORY PROCESS .....	B-1
NATIVE HAWAIIAN RIGHTS CLINIC - LAND CLASSIFICATION AND REQUIRED PERMITS .....	B-5

## **APPENDIX C: MULCHING PRACTICES AND COMPANION PLANTS FOR THE LO`I**

TRADITIONAL MULCHING PRACTICES IN OLD HAWAI`I .....	C-1
COMPANION PLANTS FOR THE LO`I .....	C-7

## **APPENDIX D: GLOSSARY**

# PREFACE

ʻONIPAʻA NĀ HUI KALO is a statewide association of practitioners and enthusiasts who grow kalo in backyard gardens, on reclaimed kuleana lands, and even large scale farming operations. Our members come from all the islands and include kalo farmers, community builders, Hawaiian families, and UH-CTAHR agents. We originally met to exchange information, ideas and experiences about kalo and found the discussions growing to include water and economic issues, regulations and responsibility, family, children and community. We shared huli and shared work to reactivate loʻi kalo. Laulima and aloha restored our sense of cultural continuity and ʻohana.

Members began to discuss the idea of putting together these guidelines for loʻi kalo rehabilitation in response to an idea that “pono, practical procedures” based on traditional principles and practices could benefit many people interested in restoring loʻi kalo. The agricultural systems of mānowai, ʻauwai and loʻi, are part of the cultural archive left us by the ancient people of Hawaiʻi nei. Many systems lie virtually intact beneath a thick growth of hau, grass or introduced trees. Reclaiming them to productive use requires much thought and consideration of their value as cultural and historic properties, beyond their potential economic worth. The cultivation of kalo is key to understanding the Hawaiian people, their psyche and their culture. Our hope is that these GUIDELINES can help rehabilitation work to be done in a way that both honors the works of the ancient ones, and preserves the integrity of the environment in which these unique systems repose.

The State of Hawaiʻi has in place a regulatory system meant to discourage harmful practices, but which has not yet developed the appropriate language or protocol to handle activities best defined as “renewed traditional use.” ʻONIPAʻA NĀ HUI KALO recognizes that while some may consider government regulation to be unauthorized intrusion, others may find those same regulatory systems a requirement of social order. Some members may feel compelled to comply, while others are compelled to require reform. These guidelines do not provide a streamlined State regulatory process for loʻi kalo restoration. That will require internal, systemic work with the State Department of Land and Natural Resources that is beyond our capability as grassroots change-agents. Our immediate intention is to present practical guidance for consideration by those interested in restoring loʻi kalo to use. We encourage responsible behavior on the land, and building good relations within communities, so that passion and effort can find productive statement, while doing no harm to life present or life to come.

ʻONIPAʻA NĀ HUI KALO recognizes that we have a common responsibility to conserve the life of Hawaiʻi’s lands and waters, preserve the archaeological record and cultural features left us by our kūpuna, and honor and build community relationships as rehabilitation work moves forward.

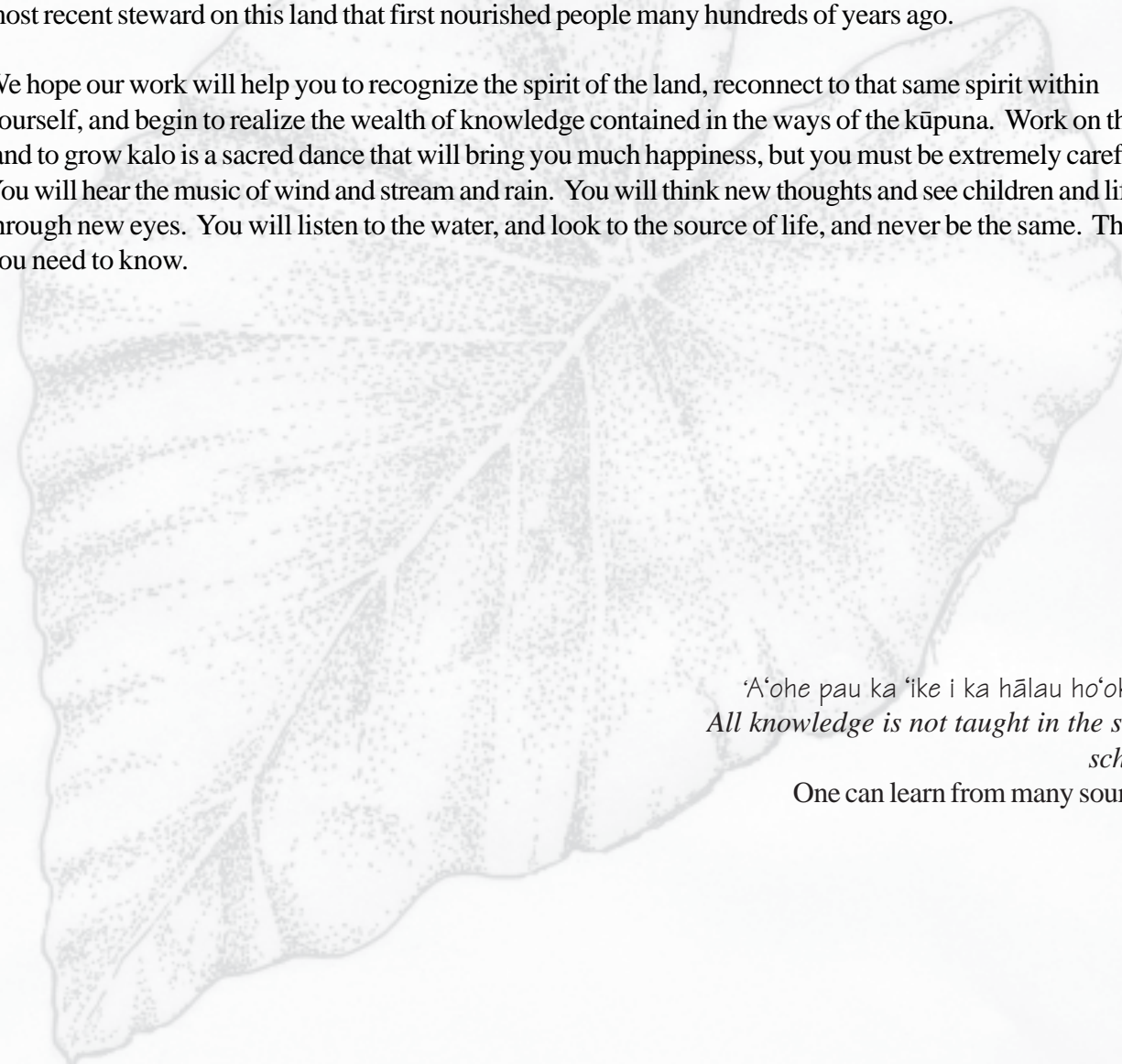
We see the terracing and layout pattern of loʻi kalo as an engineering blueprint left on the land by ancient Hawaiian hydrologists and agronomists. They are the physical record of wisdom gained over centuries of observation, each loʻi kalo system skillfully matched to the unique conditions of place and population. We encourage that their integrity be preserved, and systems restored faithfully to their original design.

Stay true to traditional practices. That will allow you to reference the Environmental Assessment done generations ago by Hawaiian environmental engineers whose only goal was efficient use of resources in a manner consistent with life, and thus pleasing to the gods, who sent the rains to fall on the earth to make the

crops flourish. We consider working in this way still the best guidance for work that will be socially, environmentally and economically responsible.

We encourage every practitioner to seek out resource people and materials, whether from private or government sources, with the goal of developing the highest level of knowledge possible. This is a lifelong practice that every kalo planter will engage in... thoughtful curiosity, keen observation, investigation, information gathering, planning, careful work and reflection about planting and place and cycles and movements. Work in the environment requires one to become a part of the unique place you clear and plant... you will smell like the earth and your toes will take on the color of mud and you will think thoughts that the kūpuna had when they walked this earth. This is not work to be taken lightly. You are only the most recent steward on this land that first nourished people many hundreds of years ago.

We hope our work will help you to recognize the spirit of the land, reconnect to that same spirit within yourself, and begin to realize the wealth of knowledge contained in the ways of the kūpuna. Work on the land to grow kalo is a sacred dance that will bring you much happiness, but you must be extremely careful... You will hear the music of wind and stream and rain. You will think new thoughts and see children and life through new eyes. You will listen to the water, and look to the source of life, and never be the same. This you need to know.



*‘A’ohe pau ka ‘ike i ka hālau ho’okāhi.  
All knowledge is not taught in the same  
school.  
One can learn from many sources.*

# HOW TO USE THIS BOOK

There are three parts to this book. CHAPTER ONE: PRINCIPLES talks about the principles behind the work of the `ONIPA`A NĀ HUI KALO and what the rehabilitation of ancient lo`i represents to us. That doesn't mean you have to abide by these same principles to do lo`i kalo work, but, you may find some common ground. Each of you joins in the work of planting kalo through his or her own experience. You will have your own thoughts about what is at the heart of being a mahi`ai kalo. We encourage you to articulate what is meaningful to you, and why, as your work proceeds.

CHAPTER TWO: `IMI A`O`ĀINA (*seek counsel of the land*) will help you tune into the place you will be working. There are two major SECTIONS to this chapter; `IMI I KA`ĀINA (*look into the land*) and KA WAI O KA`ĀINA (*the water of the land*). Each SECTION asks you to research the past (historical) and present aspects of your `ahupua`a; the lo`i you wish to restore and the lands adjacent to your parcel, including the physical attributes and conditions of each. Understanding your land and its water source will be critical to the success of your project.

The format for CHAPTER TWO includes discussion, checklists, and a whole lot of questions – about place names and mo`olelo (stories), physical elements, archaeology, land use, people, and government designations on your land. At the end of the chapter are KEY RESOURCES AND MAPS where you can discover answers to questions in the text, or additional information if you wish to look deeper into the subjects of the chapter. The KEY RESOURCES lists are by no means exhaustive, but they include a bounty of books, archives, videos, websites, map types, and other references divided by topics which match as closely as possible the topics in each chapter.

The SIDEBARS throughout the GUIDELINES are filled with definitions and descriptions, tidbits, enticements, clues and clarifications related to the text you are reading, and, that is one way to read this book. Stories from practitioners illustrate the principles as they have been applied in real life to lo`i rehabilitation. APPENDIX C is an extra big “sidebar” about traditional mulching practices and companion lo`i plants.

The GUIDELINES references government agencies and programs that are sources of information or assistance. Be aware that contacting some of them about your *specific* place may trigger scrutiny. APPENDIX A and B will give you a feel for the legal issues surrounding what you are undertaking. Talk with other planters about their experiences with these organizations to help you decide what is the best way to get assistance for your project.

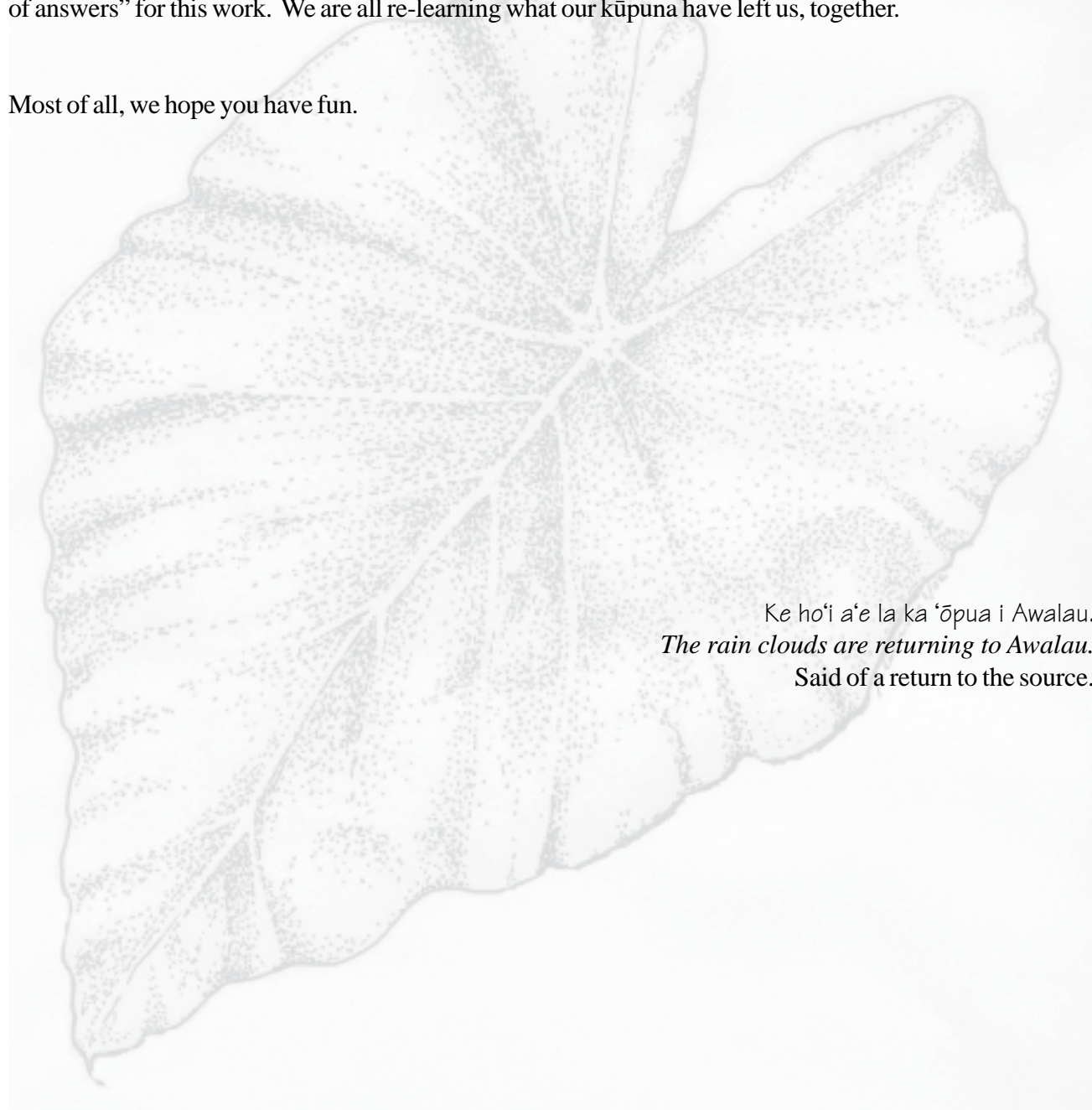
CHAPTER THREE: THE PHYSICAL REHABILITATION PROCESS, provides a general step-by-step checklist for actual rehabilitation work based on the practical experience of present-day kalo planters. We hope this will make it easy to carry out tasks in a safe manner for you and the ancient system you are working with. You will find some overlap between the second and third chapter mainly to remind you that the activities of each are not mutually exclusive and that you will often work on the “research” side at the same time as you will do physical labor on the land.

The GUIDELINES are designed to be used directly as a workbook where you can write down information as you go. There are many opportunities to involve every family member in this experience. Collect data in a meaningful and useful manner.

We recommend that you read through each section in its entirety, before you go out and do, so that you see the bigger picture of where you are headed. You may even see a reminder or two to revisit the information you've gathered.

Remember, that each locale is unique and the ancient system at your site was designed for the specific conditions of that place. As you answer the questions in this book, you will teach yourself...the land will teach you. Your answers will also prepare you to plan strategically for lo'i recovery. There is no real "book of answers" for this work. We are all re-learning what our kūpuna have left us, together.

Most of all, we hope you have fun.



Ke ho'i a'e la ka 'ōpua i Awalau.  
*The rain clouds are returning to Awalau.*  
Said of a return to the source.



# CHAPTER ONE: PRINCIPLES



D. P. Rochlen

Genealogies connect us, one to the other. The story of Hāloa reminds us of our relationship to the earth and the gods. Wakea (the male – god of light and the heavens) and Papa (the female – goddess of the earth) emerge in the middle era of the Kumulipo genealogy. They are referred to as the ancestors of the Hawaiian people.

It is from Wakea and his daughter by Papa, Ho‘ohōkū-ka-lani, that the kalo (taro) plant comes. Their first child was stillborn. From the spot where the mis-formed body was buried grows a kalo plant. A second child was born and lives. Wakea names him after the firstborn, calling him Hāloa (from the stalk-hā, and the length - loa).

It is from Hāloa that the Hawaiian people descend. The older brother, in the form of the kalo, feeds the younger brother. Kalo became the staple food for many generations of Hawaiians. This sacred connection is renewed each time kalo, lū‘au, or poi is eaten.



Hilaka, P. Levin (1996)

## PRINCIPLES



For many, planting kalo is an active, spiritual practice. Hāloa perpetuates life.

The principles below have been successfully followed for generations. They are shared by many peoples and cultures; here they are placed in a Hawaiian context. `ONIPA`A NĀ HUI KALO accepts these principles as the foundation for good work on the land.

**MĀLAMA `ĀINA.** *Tending a place returns life to the `āina, which then returns us to a place of abundance.* Both lo‘i (wetland) and māla ‘ai or ‘āina malo‘o (upland or dry) kalo systems were designed to allow the natural flows of the ecosystem to continue uninterrupted, to make efficient use of those resources, and to be sustainable over time.

**NĀNĀ I KE KUMU.** *Look to the source; look to the past to guide you into the future.* Have respect (ho‘oihi) for what you don’t yet understand. The “libraries” the kūpuna left us are in the ancient systems, the mo‘olelo (stories), the names that remain. Those few who can bridge the past to the present for us are gifts to be treasured.

**PILIANA NĀ MEA ĀPAU.** *Everything entirely connected.* Understand the bigger picture from the top of the watershed to the reefs below you. There is a reason that not all lo‘i systems are the same. Each site has a unique ecology and natural resources differed from place to place. In the same way, you belong to a community; an interconnected system.

**MAKA`ALA.** *Be an observer, a recorder. Analyze.* Ask yourself why (no ke aha mai). Why was this place named that? This wind name – what does it mean? Why did kūpuna design the ‘auwai this way? Makawalu; see with more than your eyes and from all directions. Ho‘olohe mai (listen) to the ‘āina and wai. Recognize intuition and practicality in the ancient system and in the present. There is no one way to farm kalo.

**LIMA HANA.** *Work by hand as much as possible and wherever you can.* Kalo farming is by nature a communal act. ‘A‘ohe hana nui ke alu‘ia. No task is too big when done together by all.

**HO’OMANAWANUI.** *Do the work when the time is right.* It’s not only okay to go slow; it’s smart – for your health and safety and the health of your site. ‘A‘ohe hua o ka mai‘a i ka lā ho‘okahi. Bananas don’t fruit in one day. Some of your work will be determined by the seasons.

Patience is your biggest insurance policy. Slow work is safe work. Speed and efficiency come with knowledge and practice.

**PONO.** *Balance.* The practice of lo‘i rehabilitation and the search for balance is an ongoing process with the land, your family, your neighbors, and your community.

*A final thought...*

Water and land are resources which require a personal relationship of you. Growing kalo is a part of an ecological cycle far greater in value to these islands than conventional economics can describe. The way in which we talk about restoring kalo to the land is a guideline in itself. It is a different kind of economics that speaks of feeding our families and our spirits; of rebuilding the land so that we can rebuild ourselves and our communities. These principles from our past bring us to a future of abundance for the generations to come.



D. Cooke



D. Cooke

#### OBSERVING THE LAND

**I ka nānā no ka 'ike.**  
*In observing, comes understanding.*

The importance of observation cannot be stressed enough. Everything we know as human beings begins there. In traditional cultures, this was not limited to the eyes, but included all of the senses, as well as the na'au (the inner senses). Na'au-ao, literally *daylight mind*, is to be learned, enlightened, intelligent or wise (Pukui and Elbert 1986).

In the Hawaiian tradition, there are many ways of knowing. Observation is the first step to understanding your lo'i system and how your piece of land interacts with, and is impacted by, surrounding lands and waters. The environment is a living thing. You need to know it as a living, constantly growing and changing being.

**Ma ka hana ka 'ike.**  
*In working one learns.*

**Nānā.**  
To look at, observe, see, notice, inspect; to care for, pay attention to.

**'Imi.**  
To look, hunt, search, seek. As you read through this guidebook you will find many questions that only careful nānā and 'imi will answer.

**‘ike.**

To know; to see, feel, greet, recognize, perceive, experience, be aware, understand; to receive revelations from the gods; sense, as of hearing or sight; sensory, perceptive, vision.

**Maopopo.**

to understand, recognize, realize, clear; understanding.

**‘ike mahu’i.**

To glimpse; inkling.

**‘ike or Maopopo pono.**

To understand completely, properly, rightly, well, carefully, much. To know definitely.

**Nānā ka maka; ho’oiohe ka pepeiao; pa’a ka waha.**

Observe with the eyes; listen with the ears; close the mouth. Thus one learns.

**‘ike kūhohonu.**

Deep knowledge; insight.

**‘ike pāpālua.**

To see double; to have the gift of second sight and commune with the spirits. To understand deeply; profound understanding.

**Lawe i ka ma’alea a kū’ono’ono.**

Take wisdom and make it deep

**THE MOST IMPORTANT QUESTION IN THIS BOOK:**

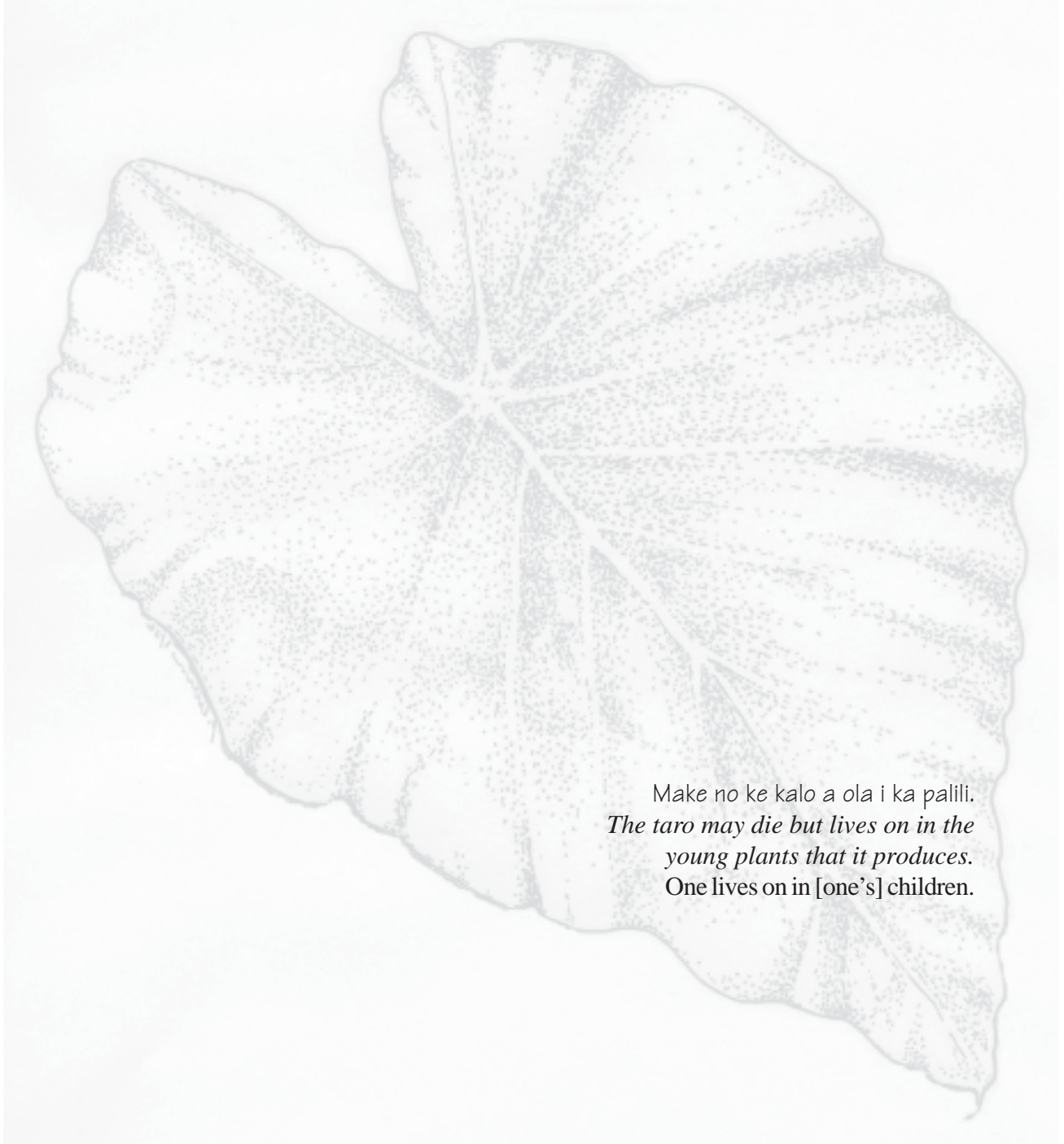
**Q:** Why do you want to rehabilitate this lo‘i system and what is (are) your priority(s)?

- As a primary source of income.
- As a secondary source of income.
- To provide food for my ‘ohana (self-sufficiency).
- To have extra food to share and trade with others (abundance).
- For the future of my mo‘opuna (grandchildren).
- Cultural learning and practice.
- Environmental education.
- To open land and make it beautiful (aesthetic values).
- To restore an ancient site.
- To create a place where my family and friends can do something together.
- To build laulima in my community.
- A safe place for youth to refocus their energy and stay out of risk.
- A place for my own well-being.
- To restore my family’s kuleana.
- Other

Your answer to this question should become your VISION STATEMENT. It defines where you are headed as a person, as a family, as a community. It will affect the choices you make about how the work will be done and who will do it, throughout the project. You will revisit this question and your answers many times – and you may notice your response will change over time.



Mai kāpae i ke a'ō a ka makua, aia he ola malaila.  
*Do not set aside the teachings of one's parents for  
there is life there.*



Make no ke kalo a ola i ka palili.  
*The taro may die but lives on in the  
young plants that it produces.  
One lives on in [one's] children.*

# CHAPTER TWO: 'IMI A'O 'ĀINA



M. Laws

# WHY TO BEGIN THIS JOURNEY

`Imi a`o `āina - seek, learn from, take counsel with the land. This key idea will influence the character and experience of the road you are on and the speed by which you travel. The root of the word `āina is `ai; that which provides nourishment. `Ai often refers specifically to poi. In the very act of walking down this path of discovery you will become maka`āinana; one who attends the land.

Every journey requires a “road map.” For some journeys, the “map” is already made; it may have been pictured, written, chanted, spoken, photographed, recorded or videotaped. For others, you may need to make the map as you go. Some journeys will be harder to record than others. If you know where to look there are many guideposts along the way. Those who follow in your footsteps to restore ancient lo`i will benefit from the careful notes you make.

## A DIVERSITY OF SOURCES

There are at least three paths you will take in the endeavor of recovering the history of your lo`i system. One will be through maps and written records; one will be through asking and listening to kūpuna, families and community members; and the third will be through your senses. Your eyes, ears, nose, hands, feet and your na`au will tell you much as you walk your parcel.

You will probably follow each of these roads simultaneously. Perhaps one family member enjoys researching at the archives; another may have keen eyes. It is important, however, to try and understand at least some of the history of the site before you begin any clearing or rehabilitation work.

## AN ABUNDANCE OF INFORMATION

There are many sources of information to help you recover the history of your lo`i system and the ahupua`a it resides in. For example, a chant to Moikeha by his son Kila reveals the natural resources of Kaua`i:

My father enjoys the billowing clouds over Pohaku-pili  
 The sticky and delicious poi,  
 With the fish brought from Puna,  
 The broad-backed shrimp of Kapalua,  
 The dark-backed shrimp of Pohaku-hapai,  
 The potent `awa root of Mai`aki`i,  
 The breadfruit laid in the embers at Makialo,  
 The large heavy taros of Keahapana...

Source: Handy and Handy 1972:424



You will find the reference books noted here and throughout the text in the KEY RESOURCES lists at the end of this chapter.

Look too, for your own resources, such as hand drawn maps and stories from kūpuna. Visit kalo growing places for inspiration.



**THE STORY BEHIND  
KE KALO PA`A O WAIĀHOLE:**

“The solid taro of Waiahole, according to the opinion of the public, was a very hard taro. It was not so, it became famous because of the strange deeds of a man, Kuapunohu, a warrior. He went about Koolaupoko to find some one to challenge. His sister was living there with her husband Imaole. She went fishing while he remained at home. The stranger said to the native son, “Have you two any food?” The native son answered, “We have food but standing in the patch.” The stranger thought that he was going to suffer with hunger so he asked the native, “Where is your patch?” The native gave him specific directions and he went ‘til he came to the border of the taro patch. Here he broke off the tip of his spear and used it as a prod. He reached out for two taros, cut them into small pieces and laid them on the fire. He continued doing this ‘til he made a big work, clearing up the whole patch of four acres and burning it up like the blowing away of the sea of Ukuoa. “Serves him right.” said Kuapunohu as he went off.”

Kaehuaea  
Na mea Kaulana o Waiāhole  
Kuokoa, Sept 16, 1865 in  
Sites of Oahu, 1978:189



A description of a place helps map out where and how springs and lo‘i were connected, as in the following;

“Farther up the main valley [of Ka‘alaea on O‘ahu] on the north side is a spring named for the god Kanaloa...and near this spring is another named Ka-houpo-o-Kāne (The-Diaphragm-of-Kane). These springs were the sources of water that used to irrigate lo‘i north of the main stream below the ridge toward Waiāhole. Below this, also north of the stream, was another lo‘i section irrigated from a spring name Keahue.

There were extensive irrigated flats along the main stream, Ka‘alaea, from the low hills to the seashore, a distance roughly of a mile and a half.”

Source: Handy and Handy 1972:452

Or gives clues to kalo varieties specific to an ahupua‘a or ‘ili.

“There were three varieties of wild taro found in the many abandoned terraces of the upland lo‘i [of Hamoa on Hawai‘i].”

Source: Handy and Handy 1972:452

The variety names aren’t listed in this reference from Handy and Handy, however, some research in the State Archives, Bishop Museum, or talking to the families of that area might reveal the details behind this entry in *Native Planters In Old Hawaii: Their Life, Lore and Environment*.

**THE IMPORTANCE OF PLACE**

The kūpuna thought enough of places to name them. Any place with “wai” in the name was a water place. A name often described the character of the water, the role it played in the natural ecosystem, or it may have had a mo‘olelo attached to it, as in these examples:

- |                               |                                  |
|-------------------------------|----------------------------------|
| Waipi‘o (curved water)        | Wai‘āpuka (water coming out)     |
| Waiāhole (mature āhole water) | Wailau (many waters)             |
| Waikīkī (spouting water)      | Waimānalo (potable water)        |
| Wainiha (unfriendly water)    | Waikamoi (water of the moi taro) |

Hawaiians did not give names idly and names often had multiple meanings. Not all of those meanings have been preserved. As with the name of a person, perhaps only the giver will truly understand its full significance. However, place names often describe the natural resources or forest types that used to be there; a kalo species known to that place (as in Pōlolu on the Big Island); the behavior of the winds (Waikapū i ka makani kokololio. *Waikapu of the gusty wind*.); ecological dangers (such as the “destructive waters” of Wailuku); or an event that occurred in that spot, as in the following ‘ōlelo no‘eau:

Ke kalo pa‘a o Waiāhole.  
*The hard taro of Waiāhole.*

Try to see the world as the kūpuna understood it.



**SECTION I. 'IMI I KA 'ĀINA**



P. Levin

**Piliana nā mea āpau.** Everything is connected in the natural world and it is also that way in the traditional Hawaiian lo`i system. Where you sit at the lo`i is a tiny ecosystem reflective of the larger ones which surround you - your ahupua`a, your island, the Hawaiian Islands as a whole, the ocean and beyond. It just keeps growing outwards AND coming right back to where you sit every day. That is why it is important to start closest to home.

Your task is to learn as much as you can about your lo`i system. From here on out in the GUIDELINES, the questions, discussions and research you will be asked to engage in will challenge you to investigate this from a number of perspectives: the past and the present; within your immediate site; in relation to the lands adjacent to you; and through your ahupua`a.

We have tried to provide enough space below each question or in the sidebars so that your answers can be written down right there. But, we also encourage you not to limit your observations by the size of the space. Add extra pages, make a journal, keep a notebook close by. Hawaiian knowledge and practice was passed on through an oral tradition. You were expected to remember from observation over many years rather than writing things down. And so, it may be enough that the questions in this chapter help you think things through. We recommend that you write things down for two important reasons: primarily, so that you can share what you are learning with others, especially your family; but also to have a record of your actions in the event that you are ever challenged in your efforts to rehabilitate these ancient works of life.

#### RESOURCES YOU WILL CREATE AND COMPILE

You will find many types of reference materials at the end of the chapter, however, you will need to develop a few of your own.

**A WORKING MAP.** You should try to find several maps, including the USGS quad map for your area; an ahupua`a map; and a map specifically for your site. You will be asked to add information to and gain information from these maps throughout CHAPTER TWO.

An important question that the maps will help you answer is one of relationship; “How do you fit into the landscape that surrounds you?”

- Get a good map with a large enough scale that you can draw some details on it. See MAPS in KEY RESOURCES on page 90 for a list of possible sources. If you can't find one; make one.
- Find out which ahupua`a you will be working in.

He ali`i ka `āina; he kauwā ke  
kanaka.

*The land is a chief; man is  
its servant.*

Land has no need for man,  
but man needs the land and  
works it for a livelihood.



US Geological Services  
map showing topography,  
elevation and streams.



Many of these activities, such as making a map, collecting stories and place names, keeping a journal, photo album or plant collection make good school projects for students of all ages; especially when it comes to mapping and plants! There are plenty of science and geography lessons hidden in discovering all about a plant, its names, uses, where it came from and how it got here.



- Mark the physical boundaries of the traditional land divisions of your moku (island or district) and ahupua`a on a map – ma i uka a i kai – from the the mountains to the sea.

**A JOURNAL.** To record the day-to-day observations that will help you understand your site, but also to record such things as new questions that arise, the cost of equipment you purchase, or who comes to help (a good measure of the support and interest your project is generating). If you have a non-profit project, volunteer numbers and time are important to record because they count as in-kind contributions with a dollar value!

**A PHOTO ALBUM.** For all those before, during and after pictures you will take as you work.

**A PLANT COLLECTION.** As simple as pressing plants between newspaper and a few heavy books, a collection will help you to identify what is growing (native or non-native) at your site. This will be valuable when you need to make decisions regarding plant use and/or removal.

### **I. PLACE NAMES AND MO`OLELO**

- Find out and write down any information you can about the natural named elements and wahi pana (storied land features) of your ahupua`a (e.g., the mountain peaks, rocks, trails, reefs, streams, forested areas, winds, or rains) and mo`olelo (stories or legends), mele (songs) or oli (chants) associated with these names.

What is the name of your ahupua`a?

What is the `ili (a subsection of an ahupua`a) you are located in?

Name one rain of your valley/place? If there are more, record those too.

Ka ua Kuahine o Mānoa.  
*The Kuahine rain of Mānoa.*

Name one wind from your ahupua`a? There may be several.

Ka ua kea o Hāna.  
*The white rain of Hāna.*  
Refers to the misty rain of Hāna, Maui, that comes in from the sea.

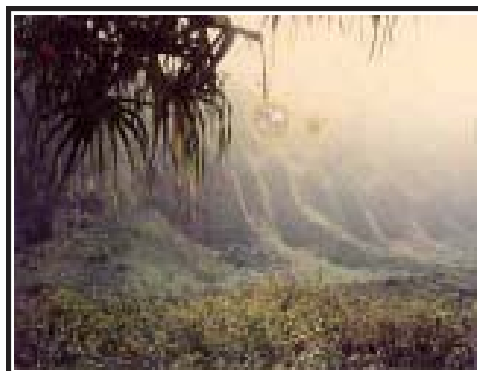
Perhaps, the name tells of a prevailing wind from one side of your valley. Or a rare, strong, storm wind that seeks you out in the winter months. Keep this in mind when you walk around at your site. Will you need to keep some trees for wind protection for your kalo?

Ka makani `Āpa`apa`a o Kohala.  
*The `Āpa`apa`a wind of Kohala [Hawai`i].*

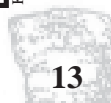
Can you find the names of the mountain peaks that surround you?

Is there a name for your specific site?

Ka `ai niho `ole a ka makani i ka `ai.  
*Even without teeth the wind consumes the food crops.*  
Said of a destructive wind.



K. M. Davis



**HE MO`OLELO O KE`ANAE**

*“The story of the founding of the Ke‘anae lo‘i area is highly interesting. Anciently, according to Henry Ikoa, the peninsula was barren lava. But a chief, whose name is not remembered, was constantly at war with the people of neighboring Wailua and was determined that he must have more good land under cultivation, more food, and more people. So he set all his people to work (they were then living within the valley and going down to the peninsula only for fishing), carrying soil in baskets from the valley down to the lava point. The soil and the banks enclosing the patches were thus, in the course of many years, all transported and packed into place. Thus did the watered flats of Ke‘anae originate. A small lo‘i near the western side of the land formerly belonged to the chief of Ke‘anae and has the name Ke‘anae (the Big Mullet); it is said that the entire locality took its name from this small sacred lo‘i.”*

Handy and Handy, 1993:500

Record a mo‘olelo, ‘ōlelo no‘eau, mele or oli associated with your place or ahupua‘a?



- Begin to think about the meanings of the names you have found. What might the stories and sayings be telling you about the place you wish to restore?

As accurately as possible, locate your work site on your ahupua`a map.

If you can, locate the place names you have found on your map.

Do you see any associations beginning to form?

Yes       No       I`m not sure

Describe them if you can:

If you can`t see anything yet, that`s okay. The picture will become more clear as you answer the questions that follow about the historical and physical characteristics of the land and water system you are building a relationship with.



**WHAT IS A BASELINE?**

A known measure or position used to calculate or locate something; a set of critical observations or data used for comparison or as a control against which to measure change or difference.

*Webster's Dictionary*

Hawaiians recognized the wao akua (distant mountain regions) or wao lani, and even the wao kele (upland forests; the rain belt) as places belonging to the gods and inhabited by spirits. Very few had permission to enter into and gather resources from these places. In practical terms, this protected the top of the watershed. The less reserved nahele (forest, grove or shrublands) provided resources for weaving, firewood, building, sailing, medicine, food, clothing, ornaments and other items and was a carefully managed resource. However, while the uplands were more protected, as ancient populations grew, lo'i and 'uala lands did take the place of forests in some locations. Historically, demands for natural resources such as sandalwood and hardwoods further contributed to forest decline. Today, wild pigs, goats, sheep, deer, invasive plants and insects, along with poorly designed and managed human practices in agriculture, ranching and development, continue to negatively impact native forest survival.



**2. THE PHYSICAL ELEMENTS**

A few basic landscape questions here ask you to investigate change over time in your ahupua'a. What you discover will help you visualize the not-so-distant past and understand how dramatic (or not) change has been in your valley. THE PHYSICAL ELEMENTS include CLIMATE, TOPOGRAPHY, SOILS, FLORA and FAUNA.

The questions that follow will provide you with the first aspect of a historic BASELINE by which to measure the changes that have occurred over the lifetime of human habitation at your site. See the topic NATURAL HISTORY in the KEY RESOURCES section as you seek information.

Was the mauka portion of your ahupua'a forested in ancient times?

- Yes       No       I don't know

In the last 30 years?  Yes  No  I don't know

Discover, if you can, what type(s) of forest or ecosystem used to inhabit the lands of your ahupua'a. Visit NATURAL HISTORY in the KEY RESOURCES for help.

Record the reference where you found this information (e.g., atlas, neighbor family, etc.)

Were any significant ancient Hawaiian communities, lo'i complexes or other sites recorded for your ahupua'a? Visit HISTORY, ARCHAEOLOGY or PLACES TO DO RESEARCH topics in the KEY RESOURCES for help.

- Yes       No       I don't know

Locate them on your map if you can (even if its a rough estimate).

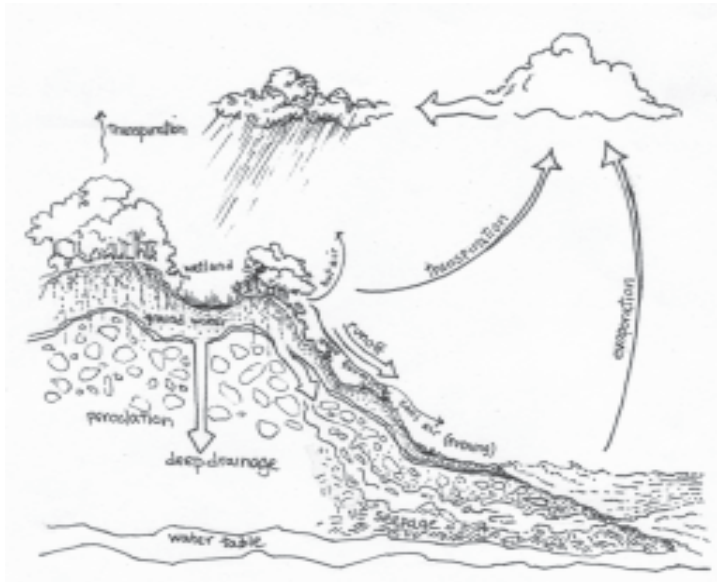
Look mauka. Hike into the upper portions of your ahupua'a if you can and look makai. This may not always be possible given development, fences and loss of access, but try to get a view from mauka to makai. This will help you see how things 'fit together' ecologically.

## A. Climate

Climate is a set of prevailing conditions over a period of time; an expression of temperature, humidity (air moisture), wind velocity (speed) and direction, and precipitation (rain fall).

Hawaiians were keen observers of their environment. They adjusted their work and their planting strategies in relation to the behavior of land and water and to the patterns of winds and rains. This awareness helped them to survive seasonal wind storms, droughts or excessive rainy years. This kind of knowledge will be just as important to you when you begin the physical rehabilitation work and the practice of growing kalo.

Questions you will need to explore regarding rainfall patterns will be asked in SECTION II: KA WAI I KA `ĀINA under SEASONAL BEHAVIORS. However, as you look through books such as the *Atlas of Hawai`i*, record here anything that might tell you about prevailing weather conditions in your area.



THE NATURAL WATER CYCLE  
Source: P. Levin (after ATIK1, 1992) in *Restoring the Invisible Water System on Kaho`olawe* (technical report, KIRC 1997).

- ☐ Each time you visit your site, observe and record from which directions and how strong the wind blows; when it rains, when it is humid or dry and how often; temperature (relatively speaking); how many hours of daylight you receive (and during what hours); and any other relevant information.



P. Levin

Ka`ohu wānana ua o Hā`upu.  
*The mist of Hā`upu that foretells rains.*  
When the clouds circle the peak of Hā`upu, Kaua`i, it is sure to rain.

Na maka o ka makani  
*Eyes of the wind.*  
Clouds that show the direction of the wind.

Ka makani kā `Aha`aha la`i o Niua.  
*The peaceful `Aha`aha breeze of Niua that drives the `aha`aha fish.*

The `Aha`aha breeze begins as the Kili`o`opu in Waihe`e, Maui, before reaching Niua Point in Waiehu. It is a gentle breeze and the sea is calm when it blows. Fishermen launch their canoes and go forth to fish, for that is the time when the `aha`aha fish arrive in schools.



**WHAT'S A RIPARIAN FOREST?**

*A riparian forest or buffer zone is a vegetated area adjacent to a stream or body of water.*

Riparian forests improve local biodiversity (the number and variety of life forms present in a place) by creating quality habitat for plants and animals. They keep stream areas shaded and waters cool (important for survival of native aquatic species such as ʻoʻopu, ʻōpae, and hihīwai). These forested corridors also provide protected passageways for birds to move mauka and makai. At Hakalau, on Hawaiʻi, planted tree corridors of koa and other native species have assisted the movement of native bird populations.

Riparian areas help prevent erosion by stabilizing soils and stream banks. They filter sediment, pollutants and other debris; provide flood control; and improve soils, absorbing or replenishing water as stream flows change. Coastal fisheries are directly impacted by the health of these upstream areas.

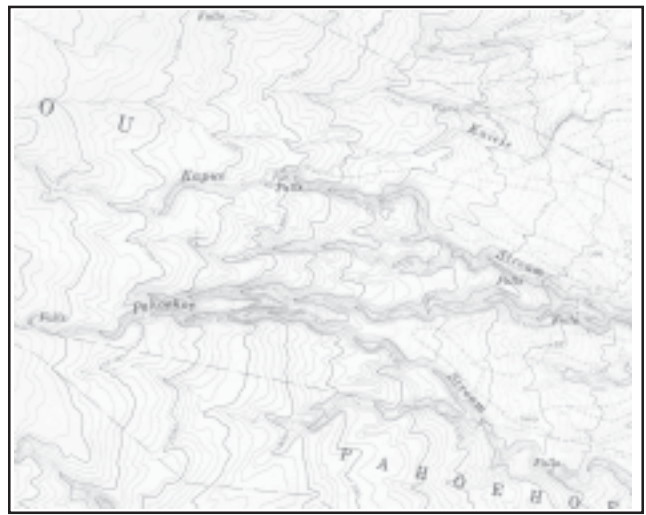
Downstream domestic water users and agricultural practitioners benefit from healthy riparian forest zones for all of these reasons. Additionally, these areas can be a source for lāʻau lapaʻau, pepeiao, and other useful plants. And, they are a place of enjoyment visually and recreationally.



**B. Topography**

Topography, to put it simply, is the lay of the land. A cartographer (a map maker) would be interested in the physical surface of the earth (its features, elevations and slopes). Here we ask you to focus on and map out the elements or features on that surface; especially within mauka watersheds that will affect the health of your water source (there are usually multiple watersheds within a single ahupuaʻa).

- Observe and map the drainages that appear to form the watersheds that feed your water source.
- Note the elevation at the top of your ahupuaʻa and at your work site from the USGS map and record it on your site map or in your journal. Elevation and air temperature are related.



US Geological Services Map

Are there *currently* large areas of forested lands in the mauka sections of your district?  Yes  No

In the mid-elevations?  Yes  No

In the lowlands?  Yes  No

Do you see any riparian forests or vegetated buffers along stream areas or gulches towards the top of your ahupuaʻa?  Yes  No

In the mid-elevations?  Yes  No

In the lowlands?  Yes  No

- Map the location of riparian areas and forested sections on your baseline ahupuaʻa map.

The presence of forested and riparian buffers along streams is one of the Clean Water Standards for the State of Hawai'i. Establishing and maintaining these areas improves stream and soil health and is a critical approach to stabilizing soils.

- Describe the topography of your land parcel.
- |  |  |
|--|--|
| <input type="checkbox"/> Flat                                      | <input type="checkbox"/> Flood plain/zone      |
| <input type="checkbox"/> Gently sloping                            | <input type="checkbox"/> Lowland               |
| <input type="checkbox"/> Steep slope                               | <input type="checkbox"/> Wetland or swamp      |
| <input type="checkbox"/> Gully(s)                                  | <input type="checkbox"/> Estuary               |
| <input type="checkbox"/> Bisected by a stream                      | <input type="checkbox"/> Natural rock outcrops |
| <input type="checkbox"/> Undulating (up and down like small waves) |  |
| <input type="checkbox"/> Other (describe)                          |  |

Are any of the characteristics of adjacent lands significantly different from your lo'i site?  Yes  No

If yes, how are they different?



C. Wichman



*Vegetation* is the primary source for organic matter, even if it's banana peels and coffee grounds from breakfast.

*Organic matter* provides both mulch (for use on top of the ground) and compost (broken down organic matter) key resources for any planter.

If you are rehabilitating old lo'i, the organic matter built up over the years will provide you with fertile soil for your first crop. After that, productivity goes down quickly. It is imperative that organic matter be regularly turned into the soil to keep productivity up.

#### A NOTE ABOUT SOIL COLOR

Red, yellow, tan or gray soils may be naturally limited in minerals and nutrients *or* may have become degraded through poor land management practices.

## C. Soil

Good soil is the foundation of a healthy ecosystem and a healthy lo'i kalo. Two components determine what you have to work with at your site. The first is *soil type* (what the land is “born” with).

Most of the soils in Hawai'i have been mapped out over the years. That means that soil scientists and geologists have studied and described the composition of these soils. The information is coded onto maps to help determine what types of land use might be appropriate to a given area.

- Look at a soils or land use classification map to find out the predominant soil type code(s) for your site. Look up the soil description in the associated key for the map or ask someone to help. For example, the code C126 (1972 Land Use Classification map) will tell you that your soil is machinery tillable, non-stony, deep (>30inches), with an average slope of 0-10 percent, of moderately fine texture, non-expanding (that's good clay), well-drained, dark reddish-brown to dark-brown in color and part of the Waikāne soil series.
- Record your findings from the soils or land use classification map.

Knowing your soil classification is NOT necessary to your work, but, it might provide you with information you can use later on. Some soils may be naturally poor in nutrients or have a tendency to “lock up” nutrients because of their chemical composition; knowing this can save you time experimenting with soil improvements.

The presence of *organic matter*, *decomposers* (from microbacteria to bugs), *mycorrhiza* (fungus-like organisms which support plant health), and levels of *nitrogen* (N), *phosphorous* (P), *potassium* (K) and *micronutrients* are the second set of elements in soil composition (what you can add). These are the “amendments” to original soils.

If you are interested in a detailed soil analysis, you can send samples to the Cooperative Extension Service at the University of Hawai'i, College of Tropical Agriculture and Human Resources for testing at very little cost. Ask your Extension Agent.

However, you can gain a rough understanding of what kind of soil you have by making a few simple observations.

- Take a handful of dirt, look at it closely, then squeeze it to see how it sticks together.

What are the primary characteristics of the soil in your hand?

- |   |   |
|---|---|
| <input type="checkbox"/> Clay (smooth and sticky) | <input type="checkbox"/> Sandy                  |
| <input type="checkbox"/> Loamy                    | <input type="checkbox"/> Rocky                  |
| <input type="checkbox"/> Course-grained           | <input type="checkbox"/> Fine-grained (silty)   |
| <input type="checkbox"/> Red and crumbly          | <input type="checkbox"/> Dark and clumps easily |

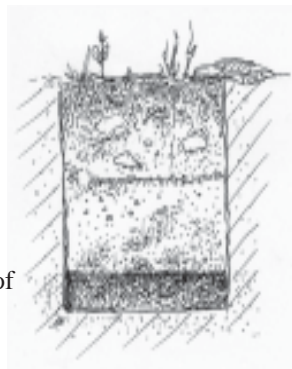
Red and crumbly soil may indicate (but not always) that original topsoils are gone along with the nutrients they held. Fine, silty soil that doesn't stick together may mean it lacks nutrients and organic matter, possibly a result of flooding or constant buffeting from winds (floods can wash nutrients away or deposit them in soils). Soils that stick together "like clay" are going to be good lo'i soils but hard to work. Soils that are dark and clump together well but are still "porous" indicate the presence of well-broken down organic matter and are the best soils for dryland planting.

Is there a lot of leaf litter and organic matter built up on the soil surface at your site?  Yes  No

Is the original soil still intact?  Yes  No  I'm not sure  
(Visit the LAND USE questions in this section to help you answer this.)

As you begin the clearing and re-opening process in the lo'i, you should find evidence of the sticky soil types best suited to lo'i kalo, including the sealed layer at the bottom of the old patches. A sample trench can give a nice record of previous land uses or 'events' (e.g., fire or flood). Ask a soil scientist, your agriculture extension agent, a geologist or archaeologist to help you 'read' the story of your lo'i soil.

**SOIL PROFILE.**  
In your lo'i you may see a dark organic layer at the top and a dark clay layer that indicates the sealed bottom of the patch.



### WHAT'S LOAM?

A soil consisting of a friable (easily crumbled) mixture of variable proportions of clay, silt, and sand. A good balance of these three components creates the best of growing conditions for many agricultural crops. For kalo, of course, lo'i soils should have a higher proportion of clay in the mix.

For a good, easy to understand overview of soil structure and health, visit Mollison's *Permaculture: A Designers' Manual - Chapter 8*.

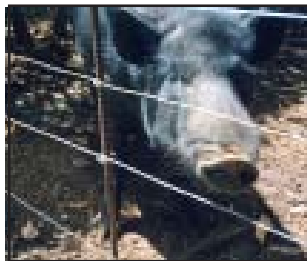
### THE IDEAL SOIL

Any soil can be amended to become rich, loamy and black. Whatever you start with; you are not stuck with. Traditional Hawaiians were big on mulch. It was an important practice in the *creation* and successful care of food producing lands. Mulch pits on the lava fields of Kona, Hawai'i and the kalo fields of Ke'anae, Maui stand as testimony to this.

**APPENDIX C** contains information on traditional Hawaiian mulching materials and practices.

*Sometimes place names give a clue to soil types. Pālolo on O'ahu gets its name from the dense, sticky mud unique to the Valley.*





D. Cooke

Setting up a single strand electric fence (on a solar panel even) is easy, cheap and effective way to keep pigs out of both small and large planted areas.

*An overpopulation of any animal on a given amount of land, including humans, will have a negative impact on the ability of the land to care for itself.*



**SOIL EROSION** is one of the most prevalent land conditions effecting our Islands today. The loss of soil in an ahupua`a impacts the ability of land to absorb and hold onto moisture and ground water, not to mention its impact on the reefs.

Do you notice any bare areas of eroding soil within your ahupua`a?

Yes       No

On your own site?  Yes       No

Do you see a significant amount of the forest floor or stream banks mauka of your site dug up a lot of the time?

Yes       No

Ungulates (hooved animals) are major contributors to erosion conditions on all of the Hawaiian Islands. Overgrazing or digging (in the case of pigs) damages plant roots and kills vegetation cover. In drought years, one of the effects of overgrazing, where grasslands have replaced large areas of forest, can be more frequent and longer droughts. For kalo planters dependent on natural water sources, the conditions of your ahupua`a will have a direct impact on stream and lo`i water levels and water quality. Feral (wild) animals may also take a liking to your kalo patch!

Are there pigs, goats, deer, cattle, or other feral animals present in the uplands of your ahupua`a?       Yes       No

Near to or on your site?       Yes       No

Feral:

Pigs       Sheep  
 Goats       Deer  
 Cattle       Chickens  
 Horses

Farmed:

Pigs       Sheep  
 Goats       Chickens  
 Cattle       Ducks  
 Horses

If the answer is yes, are they fenced out of the stream and riparian areas of the watershed?

Yes       No

If they are fenced, do pastures or pens areas appear overgrazed or eroded?       Yes       No

You may not be able to do anything about current conditions such as these now. Being aware is the first step. There may be opportunities in the future to open a dialogue with mauka land managers and owners.

## D. Flora

It is important to know the flora (plants) and fauna (animal life) at your site. In ancient times, the inhabitants of your ahupua`a would have been familiar not just with kalo varieties but with many of the other plants around them. They would have kept an ‘inventory’ in their heads of the useful plants and other natural resources accessible to them along with their locations in case it was ever needed. They would have also known which plants had a tendency to “take over” and would have managed them accordingly.

- Walk the project area with a knowledgeable plant person and learn the flora (plant life) at your site.
- Make a names list of all the plants you find.

Use the blank PLANT ID LOG sheets at the end of this set of questions. For each question in this section on FLORA there is a space to fill in the information in the LOG. If you need additional sheets, make copies, or start a plant journal.

Are there Hawaiian names for some of the plants you have found?

- Yes       No       I don't know

- If you can't identify a plant, collect a sample of a branch with several leaves, flowers and fruit (if it has any) and press them between newspaper and cardboard with something heavy on top to keep it flat until it dries. There are several good plant books to explore and great picture sites on the Web (see KEY RESOURCES). Or, take the sample to your local forestry or agriculture extension office, college or university botany department, or any other community expert you might know.

Ask the science teacher at your school or local environmental organization to help. Identifying plants in the ahupua`a makes a great science project (try to see how much the plant community has changed) or a fun family project!

You can create a “file” or album of plant species sheets that you can refer back to each time you need to identify a plant or check a name.



C. Wichman

Students conducting botanical survey at Limahuli prior to opening lo'i.

### WHAT'S IN A NAME?

Just because a plant has an Hawaiian name doesn't mean its from here. Lots of plants with Hawaiian names are recent arrivals to the islands. They were given a name because they had a use or relationship to someone here.

Hawaiian names, common names and scientific names all provide information about a plant if you understand the language. If you know Latin (not many of us do) the names reveal characteristics about a plant, just like Hawaiian names do. For example, Kukui, or Candlenut in English, reveals that the tree is a source of light, and *Aleurites moluccana* in Latin, describes the tree as appearing to be ‘dusted with flour.’

### HINT:

Here in the tropics, it's hard to keep bugs out of plants. After you have thoroughly dried your plants, put them in a freezer for a week to kill the bugs. That will help your collection last longer.



**WHAT'S ENDEMIC?**

A plant that is found here in Hawai'i and nowhere else in the world is *endemic*; the lā'au maoli of these islands.

Many endemic plants and animals are also "threatened and endangered" (T&E). This *status* means a plant is in need of protection because there are very few left. Such a plant may be listed as a legally protected species by the Endangered Species Act (ESA) under one of four designations: Threatened, Endangered, Candidate, or Proposed species.

*Indigenous*

An indigenous plant is one found in Hawai'i and other places but got to these islands on its own (on the wind, on a bird, or by water)

Endemic and indigenous plants are often lumped together as "native" species.

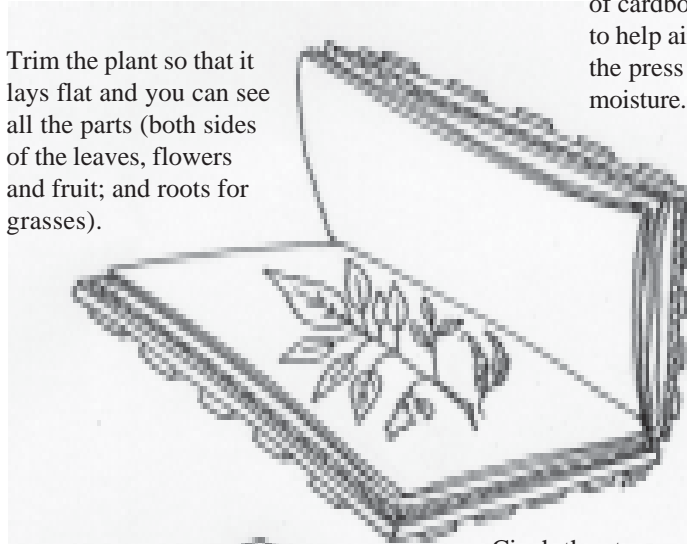
*Polynesian Introduced* are plants brought here in canoes by Hawaiians. These are a very small number of species; including kalo.

*Alien or Non-native* species are plants that were brought here after contact (after the arrival of Captain Cook). There have been thousands of plants and animals introduced to Hawai'i in the last century.

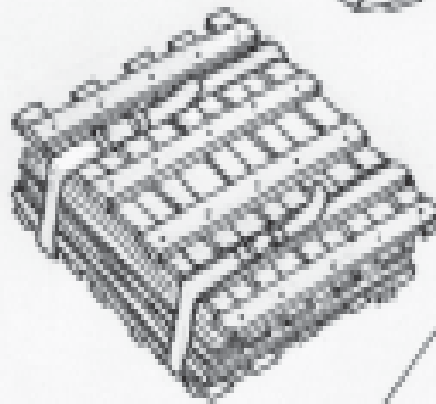
Some "aliens" have been here so long and are so thoroughly distributed about the Islands that scientists call them *naturalized*.

**HOW TO PRESS A PLANT**

Trim the plant so that it lays flat and you can see all the parts (both sides of the leaves, flowers and fruit; and roots for grasses).

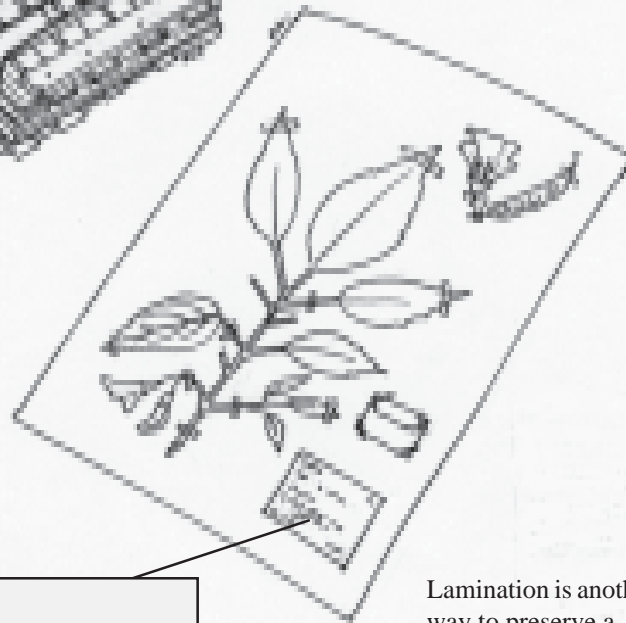


Lay the plant flat between newspaper. Alternate layers of cardboard with newspaper to help air circulate through the press and remove moisture.



Cinch the straps on the press as tight as possible. As the plants dry, continue to tighten the press to keep plants flat. A press is easy to make, but, if you don't have one, you can use heavy books or other flat objects.

Tape the plant to a clean sheet of heavy paper. You can use a small envelope to keep loose seeds from getting lost. Attach a label to identify the plant.



Lamination is another way to preserve a plant but it is expensive.

Plant Name:	
Location:	
Elevation:	
Habitat:	
Remarks:	
Date:	No:
Collected by:	

**WHAT TYPE OF PLANT IS IT?**

Plants come in many forms. While scientists classify plants into many types, the basics, in layman’s terms, are:

Algae (limu)	Sedge	Vine	Shrub
Fern	Grass	Herb	Tree

Which plants at your site are ENDEMIC?

Which plants are INDIGENOUS?

Which plants are POLYNESIAN INTRODUCTIONS?

Which plants are NON-NATIVE OR ALIEN introductions?

How many of the plants at your site are you familiar with?

- A lot       Some       A few
- None, this is the first time I’ve really looked at plants!

- Plants left over from the original native ecosystem will be either endemic or indigenous. Make a check in the appropriate box as you discover more about each plant at your site.

Are there any rare, Threatened or Endangered (T&E) plants at your site?

- Yes       No

Which species?

Are any of the plants you listed in the above question, also on the list for Critical Habitat?       Yes       No

Which species?

Is your lo‘i in designated Critical Habitat?       Yes       No

This might happen if your lo‘i is in an area that a T&E plant or animal currently or historically inhabited. The US Fish & Wildlife Service (USFWS) will have maps which delineate Critical Habitat on each island. The USFWS and the Department of Land and Natural Resources - Division of Forestry and Wildlife (DLNR - DOFAW) are the federal and state agencies responsible for species protection.

Revisit the information you gathered about forests in the ancient watershed in the first part of this chapter.



P. Levin

Lama, an endemic tree, growing in an ancient ‘auwai wall.

**WHAT IS CRITICAL HABITAT?**

This is a federal level designation which identifies areas believed to be essential to the survival and recovery of a species and that require special management.

As of this writing, the USFWS is still in the process of finalizing designations for 225 plants currently listed. Maps will become available as each proposal is made. The Endangered Species Act requires the designation of Critical Habitat with any future listings.

USFWS and Earthjustice provide information on Critical Habitat at:

[www.protectparadise.com](http://www.protectparadise.com)

[www.earthjustice.org/regional/honolulu](http://www.earthjustice.org/regional/honolulu)



**MICONIA: HOW FAST DOES IT SPREAD?**

First introduced to Tahiti in 1937, in 60 years, miconia (*Miconia calvescens*) has invaded more than 65 percent of an island whose size is just smaller than Kaua`i. Miconia has drastically changed the landscape, with stands so dense that almost nothing else can grow. The tree produces thousands of seeds that are dispersed by birds and animals; including humans, by sticking in the mud on the soles of shoes.

**MICONIA IN HAWAI`I**

A single miconia plant was introduced on O`ahu about 1961. By the end of the 1960`s it had reached Maui and Hawai`i islands. It made it to Kaua`i a decade later and now poses a threat to any place in the islands with 75-80 inches or more rain per year.

In 2003, state agencies indicated they could no longer eradicate (completely eliminate) miconia on the Big Island, and have shifted to containment; preventing it from entering new areas.

The Invasive Species Committee (ISC) on each island asks that you report any miconia findings so they can track its spread and work to control it.

For articles, pictures, ISC contacts and how to kill it ([MiconiaTreatItYourselfPoster.pdf](#)), we encourage you to visit the following website:

[www.hear.org/MiconiaInHawaii/](http://www.hear.org/MiconiaInHawaii/)



If you answered yes to any of the above questions about plant status:

- Prepare a mitigation plan for any T&E species (how are you going to save/protect them?).

Are any of the plants you have identified invasive (spread rapidly, hard to control)?

- Yes
- No
- I don`t know

If yes, which ones?



P. Levin

Bamboo covering slopes on Maui.

Below are some of the trees you may find at your site that, while useful, are prolific seeders and growers and are considered invasive. If you have any of these species nearby consider their impact on your work site:

- |   |   |
|---|---|
| <input type="checkbox"/> Albizia              | <input type="checkbox"/> Koa haole                |
| <input type="checkbox"/> Ironwood             | <input type="checkbox"/> Guava                    |
| <input type="checkbox"/> Black wattle         | <input type="checkbox"/> Waiwī (strawberry guava) |
| <input type="checkbox"/> Christmasberry       | <input type="checkbox"/> Surinam cherry           |
| <input type="checkbox"/> Java plum            | <input type="checkbox"/> Mango                    |
| <input type="checkbox"/> Octopus (Schefflera) | <input type="checkbox"/> Monkey pod               |
| <input type="checkbox"/> African tulip        | <input type="checkbox"/> Miconia                  |
| <input type="checkbox"/> Silky oak            | <input type="checkbox"/> Bamboo (a grass)         |

The **KEY RESOURCES** will link you to websites with a number of more complete lists for species that need careful control to keep them from rapidly reclaiming your ancient system as you open it. If you have miconia at your site - eradicate it completely as soon as possible. Pull seedlings when they are small; don`t wait until they begin to flower and seed!

- Begin to think about which trees you might need to remove and/or replace with more appropriate species, and why.

Tree “species” is only one thing of many that you should consider in deciding to remove a tree. It may be better NOT to remove trees that are protecting stream banks even if they are in the above list unless you are prepared to replace them with something else, because of their location in the riparian zone. Careful consideration of tree removal should also be made if the ancient walls of your system are right on the stream edge. Or perhaps, you may need to modify your use of the loʻi closest to the riparian area. In CHAPTER THREE you will find a more indepth list of questions to help you further decide about tree removal.

Problem grasses or other plants that can creep into your loʻi system or your stream include:

- |  |  |
|--|--|
| <input type="checkbox"/> Any of the Cane grasses           | <input type="checkbox"/> California grass          |
| <input type="checkbox"/> Job’s tears                       | <input type="checkbox"/> Molasses grass            |
| <input type="checkbox"/> Honohono                          | <input type="checkbox"/> Pluchea or India fleabane |
| <input type="checkbox"/> Kamole (not the same as pūkamole) |  |

Be careful, too, of hilahila and lantana in the open spaces around your loʻi, especially if you or your kids like to go barefoot. Besides their rapid spread, these species have thorns. Even ong choi, a food plant in the morning glory family, can take over quickly if not well-managed.

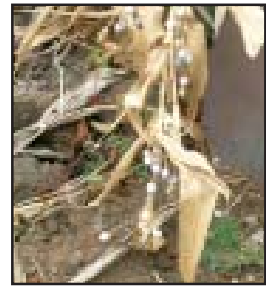
Are any of the plants you found at your site harmful or poisonous to you or someone else you know (this includes allergic reactions)?

- Yes       No       I don’t know

If yes, which ones?

Keep a note in your mind about these plants. Consider how you will dispose of poisonous or invasive species. Burning poisonous plants is probably not a good idea because the smoke may be irritating. Composting invasive species may not be feasible because invasive plants often have the ability to propagate from a single node or rootlet if they remain wet.

**CANE GRASSES AND JOB’S TEARS** are notorious for colonizing degraded waterways where there is little shade and waterflows are depleted. They are thick-stemmed grasses that can reach heights of over 10 feet. The roots go deep and are dense and fibrous. In channelized sites, it often requires the use of a bobcat to remove. Once established these grasses are difficult to eradicate.



P. Levin



P. Levin

So many plants introduced to Hawaiʻi with good intention have become costly to control - *after they have been abandoned*. How long you will work this loʻi is unknown. Before you bring in new plants to the area around your loʻi, investigate their growth and seeding habits; think about what their impact might be after you are gone if you leave them.

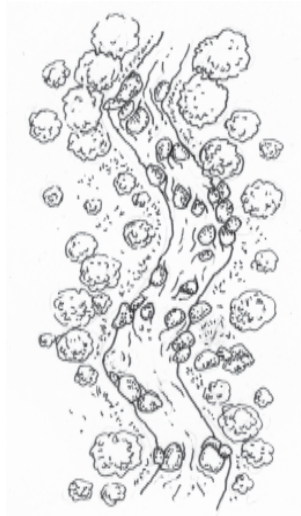


Revisit “What’s a riparian forest?”

**HOW WIDE IS GOOD ENOUGH FOR A RIPARIAN ZONE?**

The Division of Forestry and Wildlife has recommendations for bare minimum buffer distances, in a booklet called *Best Management Practices for Maintaining Water Quality*, however, these recommendations may not be appropriate where water flows rise and drop quickly, at the outside or inside curve of a stream, or where steep drop-offs and cut-aways occur along your water source.

Remember that stream channels change often; especially along the outside curves where water forces are greatest. Leave room for the natural shifting and cycling of the streambed to occur without hindrance.



**PLANTS IN THE RIPARIAN ZONE**

Is there a healthy riparian area as a buffer between your lo‘i site and the stream (if you are along a stream)?  Yes  No

- Consider if you have enough space between your patches and the riparian zone so that you keep your lo‘i clean and healthy and keep the banks of the stream stable.

Some ancient lo‘i sites were built right to the edge of streams and may not have had a riparian area. However, due to the significant changes in stream conditions and watershed cover today, allowing for a riparian area will benefit the larger stream system.

- If there is a riparian zone, make a list of the trees and other plant species in the buffer area.

Are there any plants or trees in the riparian area and/or at your site that may cause a problem to your planting kalo on this property?

- Yes       No       I'm not sure

Which ones, and why?

Along with the issue of invasiveness, a tree may drop too much litter and seed, or create too much shade over your loʻi which can slow the growth of your kalo. Root systems can intrude into your loʻi and the walls. Some species have acidic (e.g., java plum) or tannic properties (e.g., leaf litter of ironwoods) which can suppress the growth of other plants or change soil nutrient availability.



P. Levin

Hau tree in flower.

#### MAKING USE OF WHAT YOU HAVE

Are any of the plants on your land useful?

- Yes       No       I don't know

- If you can, find at least one use for every species of plant you listed in your PLANT ID LOG. You might want to revisit your list every once in awhile as you learn more.
- Before removing, burning, composting, chipping, etc., think about what plants from your site would be useful to the people in your community.

Is someone else presently using your site to gather things?

- Yes       No       I don't know

#### WHAT IS A RESOURCE?

A resource is anything useful. It all depends on how you see the world. You know the old saying; “*One man’s junk is another man’s treasure.*” In the same way, a “weed” is only a plant you don’t know how to use. Usefulness changes over time as our worldview changes.

A lot of the plants we consider weeds in our backyards today were traditionally used for medicine, food, cordage or other resources by our kūpuna.

Can a plant be a resource *and* something you need to control or get rid of at the same time? You bet! Especially when it is growing outside its native habitat or falls out of use. Hau is a prime example of an important resource in ancient Hawaiʻi (especially for cordage and mulch) that has overgrown many loʻi sites because it goes unused and unmanaged today.

Honohono grass is another plant you will see around the loʻi. It can be used to feed pigs but it is very hard to control and get rid of. It’s not great for mulch because it sprouts and spreads by tiny bits of stem but it can be stomped into your loʻi where it will decompose under the mud.

That monkeypod tree you might need to take down has many poi boards inside it.





C. Wichman

Under this hau bush lays ancient lo`i walls.

**WOODS USED FOR POI BOARDS**

- Monkey pod
- Mango
- Tamarind
- ‘Ulu

Some kinds of wood, such as koa, aren’t good for poi boards. It’s not about being rare or expensive; the oils in koa and some other woods will taint the poi! Kukui is too light weight and decomposes quickly.

The bark of many trees yield dyes and fiber for rope or kapa; even guava makes good lomi sticks or ‘ö’ö.

When you begin to look for a pōhaku for your poi pounding stone be mindful of whether it is a part of the structures you are trying to rebuild or not. Take a trip to the makai side of your ahupua‘a where there may be plentiful stones at the beach more suited to this purpose.



There may be people who can put those plants to good use as you begin to clear the ancient lo`i system. Keep this in mind as you talk to people. Are there lā‘au lapa‘au practitioners that need resources you might have? Wood workers, weavers, food gatherers? Does someone need imu wood or poles for growing peas?

All of the plants species mentioned above can be a resource even after removal by allowing them to compost, as chip for trails or keeping weeds down, or some other purpose. See APPENDIX C: MULCHING PRACTICES IN ANCIENT HAWAI`I for a list of traditional mulch plants. Even if you burn, the ash is a soil amendment. Nothing is wasted. Most plants won’t need to be “thrown away.”

- ☐ As you plan for growing kalo, also plan for your papa ku‘i ‘ai (poi pounding board) and your pōhaku ku‘i ‘ai (poi pounder). If you choose to practice traditional culture, you will need both to complete the cycle of growing kalo – to make the poi and enjoy the fruits of your labor. Or, you may prefer to stockpile stones and wood for an imu. If not, do you need to start saving money now for that juicer you will need to process your poi when the kalo is ready for harvest?



Source: F.E. Compton and Co. 1931.



C. Wichman

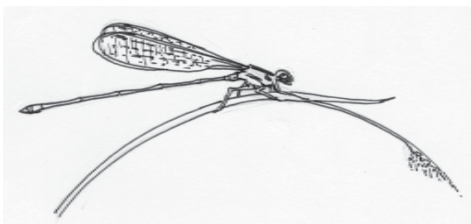
## E. Fauna

Fauna is all animal life. That includes insects, fish, amphibians, reptiles, mammals, birds, snails, down to the smallest organisms and up to the biggest (that's whales). Hawai'i has some pretty unique bird and bug life. And again, just like with plants, there are plenty of alien species around - like the ungulates discussed on page 22 - competing with what belongs here. You will find most of the fauna questions focused on freshwater aquatic animals in SECTION II: KA WAI I KA `ĀINA.

There are a few terrestrial (land based) animals to be aware of as you inventory your site. Most endemic forest birds have moved mauka as native forests have moved that way. You will probably see few, if any, in and around your lo'i, with the exception of waterbirds or birds of prey. The same will be true of things like the 'ōpe'a pe'a (Hawaiian hoary bat) or the beautiful pūpū kuahiwi (native land snails). If you do see these species make note of it in your journal. Be aware, also, that some, like the 'io (Hawaiian hawk) and the 'ōpe'a pe'a, are T&E species and need to be protected and left undisturbed.

One group of insects you should be aware of are native pinao or pinao'ula (dragonflies and damselflies). They are a component of Hawaiian wetlands, streams and forests, and were once well-known in ancient lo'i ecosystems. They depend on freshwater for their larval stages of life.

- Make a list of any terrestrial fauna you see as you move around your site, in the same way you did with plants. You will probably see things like insects, butterflies, spiders, geckos, slugs, snails, skinks, toads, anole lizards, mice or mongoose...but, you might see more!



Are there Hawaiian damselflies at your site?  Yes  No  
See KEY RESOURCES to find an excellent identification guidebook.

### KALO PESTS

Insects can cause damage to your kalo at the larval and the adult stage. You might not notice them at your site until after you have cleared it and you begin to plant. Are any of these bugs causing damage in your neighbors lot (e.g., on fruit trees or hibiscus)?

- Rose beetles
- Aphids
- Grasshoppers
- Thrips
- Whitefly
- Taro leafhopper
- Scale or mealybugs
- Mites

Insect infestations are often seasonal but if you are growing for leaf some of these bugs can take a real toll on your production. Sucking insects such as aphids can wilt leaves and stems, stunt plants, and spread viral diseases. Ants, nematodes and root aphids can be a problem for wet and dryland kalo.

Mole crickets may be found in your lo'i once it is flooded. They like to burrow into the walls and may cause minor leaking.

Dryland planters may need to keep an eye on slugs. They will eat young shoots down into the corm. Ask your friends and neighbors and you will hear many amusing anecdotes (that work!) of how to get rid of slugs.





Plant ID Log

Common Name	Hawaiian Name	Scientific Name	Plant Type	Endemic	Endangered (T&E listed)	Proposed or Candidate T&E species	Critical Habitat Listed	Indigenous	Polynesian Introduced	Alien (not from here)	Known Invasive	Poisonous	Use

**YOU SHOULD KNOW...**

some conservation practices to use in your lo'i kalo management program to help native waterbirds survive.

*'Alae'ula* or *'Alae ke'o* build floating nests hidden among the kalo from March through September. Leave a 6 foot buffer zone for them and harvest around the undisturbed nest. Some taro farmers have experienced problems with *'alae* populations that developed an appetite for young taro leaves.

*Koloa* nest on the ground in vegetation near the water from December through May. Mow prior to this time to prevent nesting or disturbing existing nests.

*Ae'o* make their nests on clear mud, dirt or in fallow fields from March through August. Check for nests or young birds before tilling. Leave your lo'i wet for a month after you harvest. *Ae'o* will feed on aquatic life that are left behind.

*Nēnē* may appear at your lo'i site because they enjoy grazing on new shoots and seeds of grasses. Your well maintained, mowed banks between lo'i may look very appealing!

Dogs are especially bothersome to native birds. Do everything possible to discourage them. Rats, mongoose, and cats pose a danger to eggs and baby birds. Remove these animals; avoid using poisons where possible.

The *'auku'u* is known to eat young chicks of other native waterbirds as well.



**NATIVE BIRDS IN OR AROUND THE LO`I**

Lo'i kalo are wetland environments that provide refuge and habitat for Hawaii's native freshwater birds.

Have you observed any of the following bird species at your site or within a short distance from your property?

- 'Alae'ula (Common moorhen or Gallinule)
- 'Alae ke'o ke'o (American coot)
- Koloa (Hawaiian duck)
- Ae'o (Hawaiian Stilt)
- Nēnē (Hawaiian goose)
- Kōlea (Pacific golden plover)
- 'Auku'u (Black-crowned night heron)
- 'Io (Hawaiian hawk)
- Pueo (Hawaiian short-eared owl)

Hawaii's native freshwater birds evolved with the ancient lo'i and fishpond systems of our kūpuna and were once an integral part of these managed wetland systems. Today, their numbers are limited and the *'alae'ula*, *'alae ke'oke'o*, *koloa*, *ae'o* and *nēnē* are endangered and federally protected under the Environmental Protection Act. The U.S. Fish and Wildlife Service administers this Act.

The plover is a winter visitor. The last three are native predators. Some consider the *'auku'u* an indigenous rather than endemic bird. It is predatory on a number of aquatic fuana, as well as the young chicks of other birds.



D. Cooke

The *pu'eo* is a ground nester. If you see this bird landing in the same place regularly, it may have a nest or young on the ground. Give them room and leave the area undisturbed. *'Io* nest in trees, so look up before you cut a tree. If you see any of these species take a picture if you can!

You may also see cattle egrets (non-native). They eat insects, small fish and crayfish, and even mice in freshly tilled fields. They also harass native freshwater birds and go after young chicks. Large flocks at a site can prevent native birds from nesting in an area.

**ALIENS YOU SHOULD BE CONCERNED ABOUT.**

Do you have coqui frogs at your site?  Yes  No

You might miss seeing them but you won't miss their loud calls. They are spreading rapidly on Hawai'i and Maui and are present on O'ahu and Kaua'i. These frogs are bad news economically for anyone with a plant nursery and also eat native insects. The Coordinating Group on Alien Pest Species (CGAPS), with state agencies and the Invasive Species Committees (ISCs) on each island are in the process of setting up a state-wide website (as of this printing). There is already a hotline for you to call if you hear the coqui or see any other nasty invasive.

If you see or hear these frogs, call the Hawai'i Department of Agriculture (HDOA) at:

**Pest Hotline at 586-PEST.**

The following website has pictures and a sound track of their call:

<http://www.hear.org/AlienSpeciesInHawaii/species/frogs/index.html>

The DLNR-DOFAW, USGS and the HDOA are the agencies testing for control of these frogs. You can contact them or the Invasive Species Committee on your island for help in eradication.

Several varieties of apple snails are present in Hawai'i. The worst species, *Pomacea canaliculata*, lives in water but lay eggs on plant stems above the waterline. Its egg clusters are bright pink and can't be missed. They can travel across grassy areas under very wet conditions. If there are any in your area, you will need to take extra precautions to keep them out of your own patches. See more about apple snails under FAUNA in SECTION II.

**WILD CHICKENS IN KAUA'I**

Sometimes pest species are the ones you might least expect.

After Hurricane Iniki hit Kaua'i, many chickens escaped to the wild. The population has exploded and become so dense in some areas of the island that they have overrun lo'i in their search for food. The chickens appear to have a sixth sense about when a crop is ready to harvest. Like the apple snails, farmers have reported chickens descending on a lo'i and destroying it, eating everything in a single night, including the smallest remnants of huli.



**WHAT'S A MIDDEN?**

A mound of garbage; a refuse heap. Depending on how well preserved a midden is, it may reveal seeds, scraps of wood, bone, fiber, charcoal, shell, or broken tools - clues to how people lived in ancient times, what they depended on for food, and how long ago they may have resided in that place.

Charcoal and midden deposits left from previous users are important to reconstructing the story of a place. Charcoal analysis might tell you what trees grew in an area. What may look like blackened dirt or rubbish to one person may represent an encyclopedia of data to a trained archaeologist.



P. Levin

Midden layer



P. Levin

A firepit is visible just under the root layer in this cutaway along a sand bank.

### 3. Archaeology

*Nānā i ke kumu.* What, if any, evidence of the kūpuna remains on your site? At this point in your work, you will begin the careful process of uncovering the wealth of knowledge hidden within the unique structural system of the lo'i you wish to rehabilitate. You will find additional details for this in CHAPTER THREE: THE PHYSICAL REHABILITATION PROCESS, but start here with some basic questions and tasks.

- Enlarge the map you are working on so that you can draw in the details of your site. You may want to blow up the map you started with or make a new one. There are two blank sheets on the following pages on which to draw the details of the stone work you find.
- Look for signs of the ancient lo'i system.
- Record what you see.

Become familiar with some of the basic features you may see that belong to an ancient lo'i system, including:

- 'Auwai (ditch or channel)
- Pā pōhaku or kuāuna (stone or earthen bank)
- Pā pōhaku (wall; called paepae in Ha'ena, Kaua'i)
- Kipapa or lo'i (terraces)
- Māno (dam or diversion)

If you are rehabilitating ancient dryland mauka or makai kalo systems, look for:

- Kuaiwi (long rows of rock mounds or walls)
- Well-like structures used as mulch pits
- Pu'e pu'e (mounds).

Lo'i structures did not stand alone and were often part of a larger cultural complex. There may be other features within your parcel that served a variety of purposes; such as house sites, shelters, walls, platforms, heiau, midden or other formations. It's not likely that you will find any artifacts, but, in the off chance that you do, make a note of where you found it (e.g., in a lo'i wall) and take a picture in the place where you found it. Again, CHAPTER THREE provides more information about the importance of preserving the archaeological record that may be buried at your site.

Are there structures or other things on your property that you are not sure of what they are?  Yes  No

Having the added insights of someone with experience in Hawaiian archaeology will increase what you learn from your site.

- Is there an archaeologist available to help you pro bono? An archaeologist can provide valuable insight to the land area in addition to what the land owner knows. If an archaeologist is willing to help, have them map the system .

If you work with an outside specialist, make sure there is an understanding that you will receive a copy of all reports, maps, photos and other documents for your own records.

- Sketch a picture of the ancient system on the following two pages. You will add the details of the system as you begin to clear the area (see CHAPTER THREE for the actual clearing and loʻi rehabilitation process) but for now a rough guess is fine. A good map of “how it was” will prove to be invaluable after your land has been modified and rehabilitated.
- Make sure you get “before” pictures prior to any work on the site. Add these to your photo album.

Are there archaeological features you share in common with adjacent lands? For example, trails, ʻauwai or walls or even individual loʻi.

- Yes  No

What is the condition of this shared resource?



C. Wichman

Old rock wall hiding under tree roots.

It is important to remember that stonework may be unique to a place or a time period. The style of construction can tell you when a people worked on the land, and how long they were there.

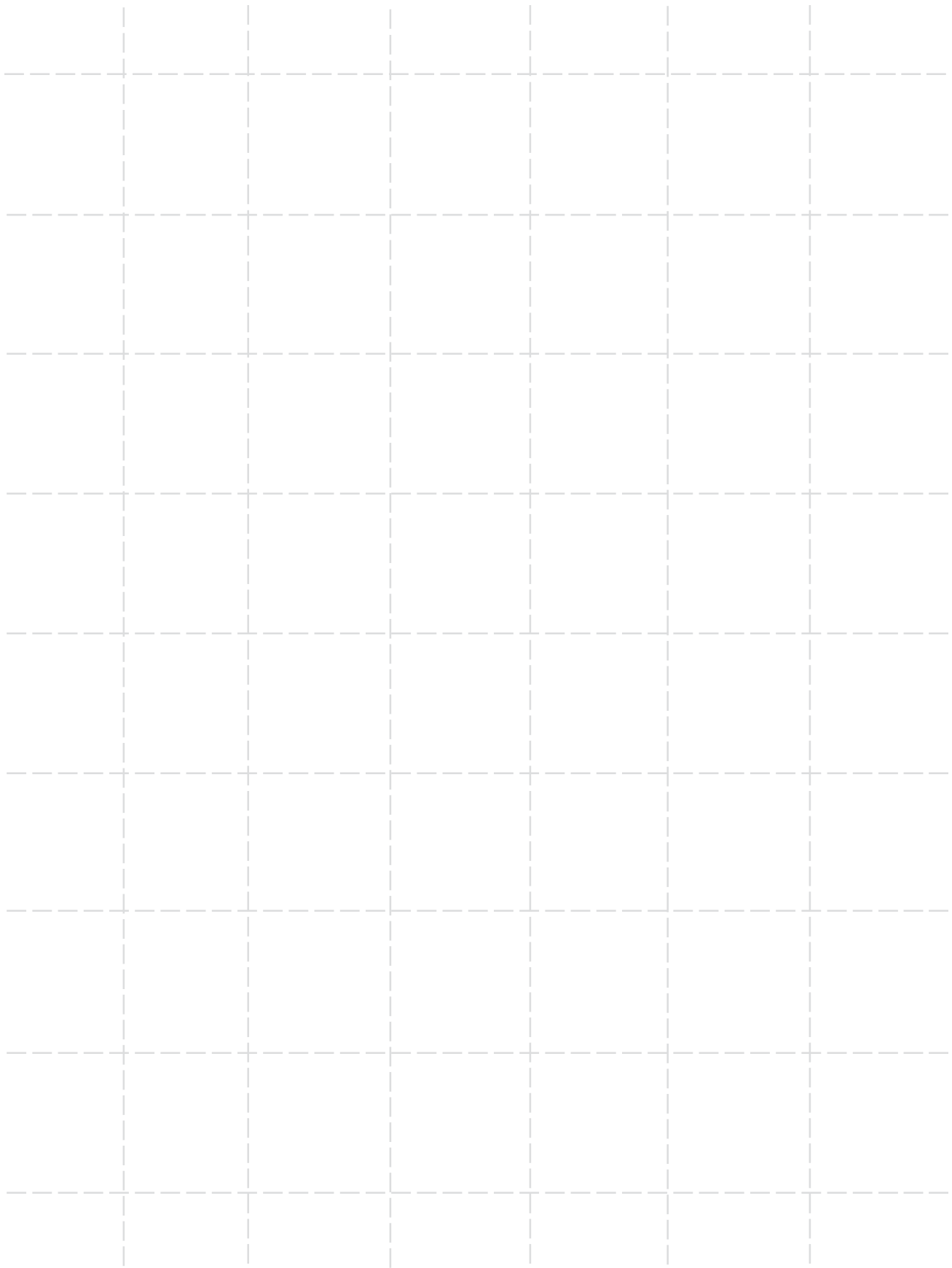
Stonework infrastructure for agriculture systems were built to hold up under the pressures of water and wear. These systems have not been as fully studied as heiau or habitation sites.

What you learn as you restore your loʻi may prove important to restoration work for others. The specific design at your site was ideal for your agricultural system at the time it was built and it probably still is; as engineers, Hawaiians excelled.

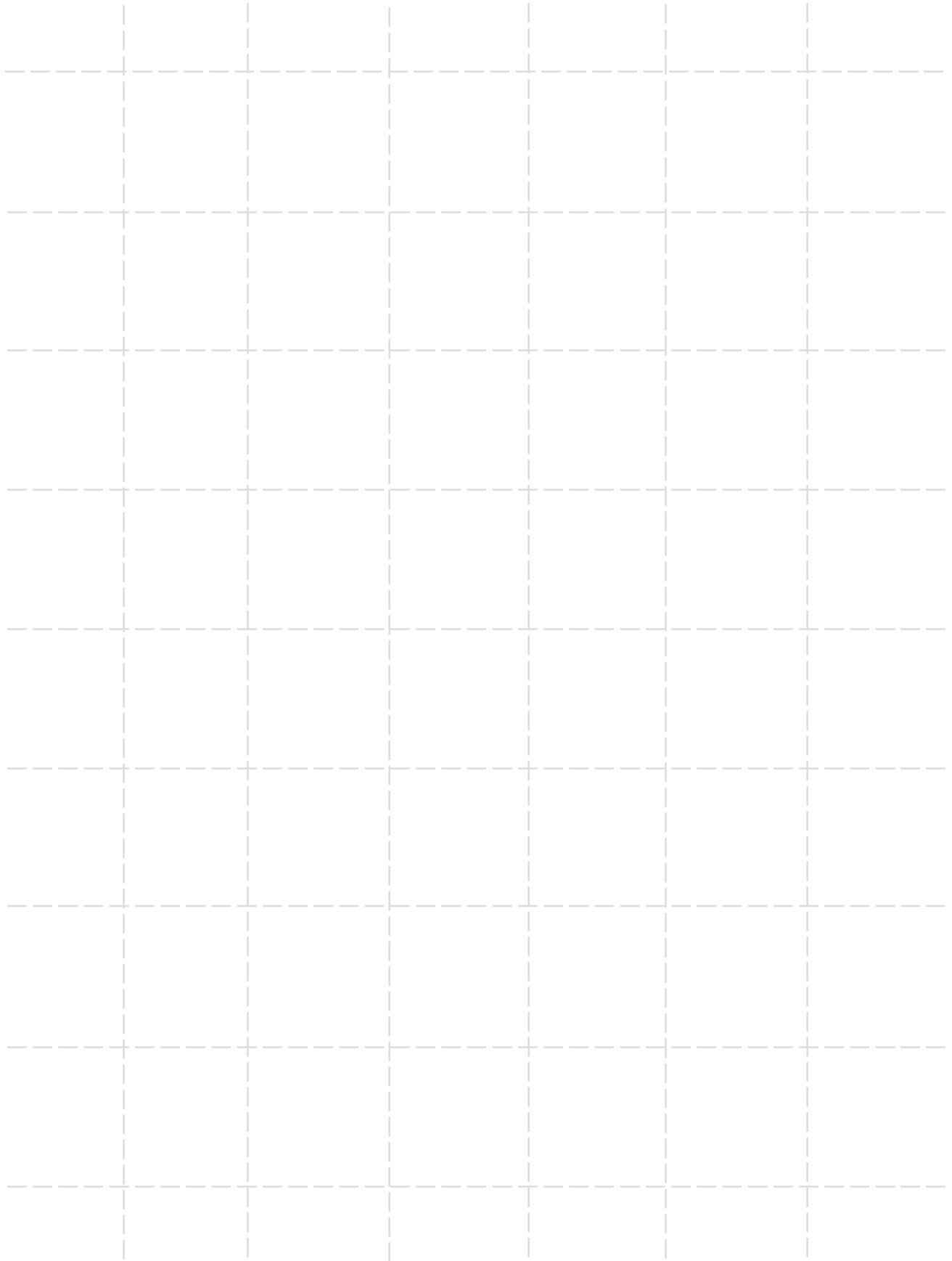
Following in the footsteps of the ancestors is the best way to gain full advantage of their knowledge, their environmental wisdom, and their insights. In a very real sense, they are still present on the land.



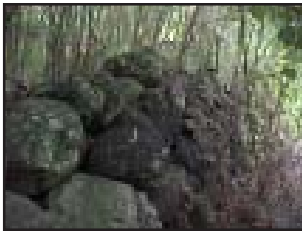
**ARCHAEOLOGICAL FEATURES SITE MAP**



**ARCHAEOLOGICAL FEATURES SITE MAP**



Ancient trails and old government roads are, by legal definition, recognized as historic sites and often traditional cultural places (TCPs), and should be preserved.



P. Levin

Modern property lines may dissect a place without regard for existing archaeological structure or natural resource boundaries. Traditionally, care for the walls, `auwai, trails and roads, fishponds or heiau were the common responsibility of everyone in a community or family. Consider this - an alahele (trail) was a “way for people”; an `auwai or alawai was a “way for water.” Both were maintained by all because both provided access to food - one as a path that connected resources and places; the other as the medium from which food grew.

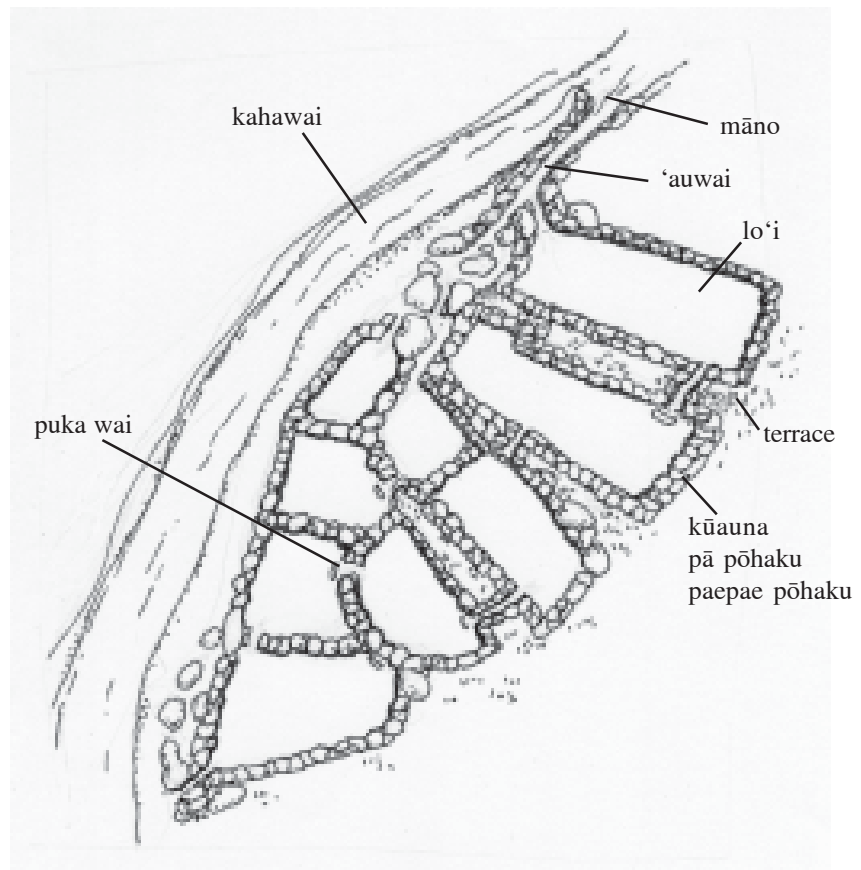
Are there any ancient mauka-makai trails within your ahupua`a?

- Yes       No

If yes, where are they in relation to your land?

Are there any ancient access routes or historic trails nearby or passing through your parcel?     Yes       No

- Put them on your ahupua`a map if you can. Remember your site was probably part of a larger community within a district.



## 4. Land Use

In these GUIDELINES we are assuming that the lands you will work were kalo lands historically.

Was this kalo land in  wetland or  dryland cultivation?

- If possible, make an estimate of the earliest date the site was under kalo cultivation.
- Identify the source of that estimate (written document, dated picture, remembrance by a local family, etc.). Keep a copy of any document or photo for your records.

What year was the last kalo crop pulled from these lo`i?

- Discover, if you can, what varieties were grown there. This will provide you with clues about what varieties did well at your site historically, or perhaps, were known as a specialty of the area.

Were there any kalo cultivating techniques unique to this district?

- Yes  No  I don't know
- If yes, make a note of them here.

Consider some of the techniques detailed by Handy and Handy in *Native Planters*. This book also describes some of the places various planting methods were used.

**KALO NAMES AND PLACES**  
Occasionally, a kalo variety was named for the place it was primarily grown in, or for a characteristic that the kalo and the place shared. Other varieties were recorded by historians in association with a specific island or ahupua`a but without a shared name. Here are a few examples:

*Pololū*  
known to Pololū Valley, Kohala, Hawai`i (*lit. long spear*).

*Mana keokeo*  
grown in the district of Kona, Hawai`i.

*Papakolea*  
from the district of the same name.

*Kumu eleele*  
known to Olowalu, Maui.

*Kalalau*  
named after a place on Kaua`i.

Several hundred kalo names have been recorded by historians; in 1939 only 69 native varieties were known to have survived.



C. Wichman

Lo`i pu`u at Limahuli.

**OF INTEREST:**

Many lo`i were modified to produce rice by early Chinese and Japanese immigrants. In doing so, wall thickness was often significantly reduced or in some cases removed altogether to create larger ponds.



Source: F. E. Compton. 1931.

Taro lands converted to rice paddy circa 1930's.



The history of land use at your site should

provide you with an idea of what has happened to the soil. For example; was it former cane land? Then it probably lost a lot of topsoil and is depleted of many nutrients.



There are a number of chemicals associated with growing conventional agricultural crops in Hawai`i that impact soil and water quality. Atrazine is a common contaminant on sugarcane lands and in nearby wells. Ginger crops have problems with nematodes after a few rotations. Your local Agriculture Extension Agent should be able to provide you with more specific information regarding what chemicals were used on various crops in your area. If your kalo land became pineapple fields expect layers of black plastic embedded in the soil as well.



More often than not, kalo lands were destroyed or used for other purposes at some point in their history. Many patches went from kalo to rice cultivation and back to kalo again.

Determine and document (written records, oral history, photographs, etc) other *historical* uses of your project area.

- |  |   |
|--|---|
| <input type="checkbox"/> Rice paddy              | <input type="checkbox"/> Truck gardens            |
| <input type="checkbox"/> Sugar cane              | <input type="checkbox"/> Pineapple                |
| <input type="checkbox"/> Ornamental horticulture | <input type="checkbox"/> Ginger                   |
| <input type="checkbox"/> Coffee                  | <input type="checkbox"/> Cattle                   |
| <input type="checkbox"/> Sheep or goats          | <input type="checkbox"/> Pigs                     |
| <input type="checkbox"/> Chickens or ducks       | <input type="checkbox"/> House site (development) |

Dump site

What kind:

(e.g., chemicals, paint, oil, old cars, bottles, cans...)

Other uses

Changes in land use may have altered the topography of your site. Was the landscape modified in recent history?

- Yes       No       I don't know

If yes, how did it change and when?

- Ripped or plowed  
 Graded (leveled)  
 Stones removed or pushed to the side  
 Filled in  
 Other

Was heavy equipment used to modify the land?

Yes       No       I don't know

Look for scars on large rocks, earth piles, flattened areas, etc for evidence. If the land was put into sugarcane or pineapple, or cleared for a house site in recent times, this is sure to be the case.

Or, was the modification done by hand?

Yes       No       I don't know


If it has remained in ancient lo'i kalo since the beginning, then the work was done by the many hands of nā po'e kahiko (the ancestors).

Can you talk with the person or family that modified your site and find out what the original place was like?     Yes       No

What are the *current* uses of any adjacent lands?

Are any adjacent neighbors growing kalo?     Yes       No

Put this land use information on your map.



One of the best illustrations of how much information can be gathered from old photographs is the book *Kāne'ohē: A History of Change*. This collection of pictures and other documents records the disappearance of forests, lo'i systems, and fishponds and their subsequent replacement with residential and industrial facilities and infrastructure throughout the lands that make up Kāne'ohē Bay from the late 1800's to the 1950's.

**SOME ADJACENT LAND USES THAT MIGHT AFFECT YOUR ABILITY TO GROW KALO AT YOUR SITE:**

*The landscape is maintained using heavy chemical controls.*

*There is a hedge of koa haole or java plum that frequently seeds and drops 'ōpala onto your property.*

*There is a junk yard next door with numerous dead vehicles and car batteries right up hill from your best lo'i spot.*

*Your neighbor is growing apple snails for restaurants and there are escapees.*



Are any activities or land-use practices occurring that you think might affect your project?

- Yes       No       I don't know

If yes, describe what and how.



D. Cooke

More than a few old sites have become dumping grounds for all kinds of trash.

Will current adjacent land uses make it difficult to grow *healthy* kalo?

- Yes       No       I'm not sure

Can you mitigate these impacts?

- Yes       No       I'm not sure

If yes, how will you mitigate these impacts?

Will restoring your lo'i system create any problems for your neighbors' land use? (see SECTION II: WATER USE for more about this.)

- Yes       No       I don't know

If yes, how might it impact them?

How will you mitigate these impacts?

Will restoring your lo'i benefit adjacent lands and families?

- Yes       No       I'm not sure

What do you think those benefits might be?

This is a good time to get to know your neighbors and to talk with other kalo planters who might have worked under similar conditions.

*Will your project impact on your neighbors' privacy?*



**HINT:**

Get to know the kama`āina families of your ahupua`a, and your neighbors. They may be important resources for you regarding the history of your site, traditional kalo farming techniques or old varieties of taro that grew there. They might even assist you in your work.

Don't overlook the skills and experiences of neighbors.



C. Wichman

Do your best to make neighbors supportive *before* you start. Often problems arise because people don't know and make assumptions about what is happening, or they get offended because they haven't been talked to. Including people during the planning stage will let people know that you respect them.



## 5. People

*O ku'u wahi ōpū weuweu la, nou ia.*  
Let my little clump of grass house be yours.

*Hilina'i Puna, kālele ia Ka'ū.*  
Puna leans and reclines on Ka'ū.

What is the “genealogy” of ownership of your lo'i?

- Find out whose name was on the original kuleana or Land Court Award and how the land was handed down.

Who was the last person or family to work the lo'i that you want to re-open?

Who were the families who cultivated kalo in the lands *around* your site historically?

Who are your neighbors on all sides now?

Are/will neighbors be supportive of your project or will they make humbug and report you to the “authorities”?

- Yes       No       I'm not sure

Are any neighbors a resource to your work?

- Yes       No       I don't know

Are any of your neighbors interested in growing kalo?

- Yes       No

Who are the community and/or school groups in your project area?

Who is the *legal* owner of the loʻi you wish to restore?

Who has legal or other interests in the adjoining parcels?

- Check the TMK maps.  
 Make a copy of the most recent TMK map that contains your parcel and the lands immediately around it. Compare this map to older TMK records to trace change of ownership. This will be of use to you later.



An example of a section of a TMK.

Are there any future developments being planned for your project area or adjacent properties that might affect loʻi rehabilitation or your ability to grow kalo?  Yes       No

If yes, what, if anything, in those plans might affect you?

If you are planning for the long term these last four questions are important when there are shared resources between parcels. Or, if the legal owner's intent is for future development.

Community groups can provide support and assistance. If there are youth groups or schools (including home school groups and after school programs) in your area, inviting them into the loʻi can be a great learning experience and resource for everyone.

**FUTURE DEVELOPMENT PLANS**  
 Look for regional development plans, or individual community development plans to see what might happen down the road. Check your county tax office or ask your Neighborhood Board what might be in the works.



**THE LAW:**

The following are the constitutional and statutory provisions (the laws and rulings) which form the basis for traditional and customary rights and kuleana land rights. You may want to become familiar with them. See APPENDIX B for an outline of the various permits that may apply to your parcel.

*Regarding traditional and customary use rights:*

- Hawai‘i State Constitution, Article XII Section 7
- Hawai‘i Revised Statutes 1-1
- Hawai‘i Revised Statutes 174 C-63; 174C-101



## 6. Government Land Use Designations

Federal, state or county land use designations may affect your ability to work at a site, or the way in which you work. It is important to be aware of these possibilities (see APPENDIX B for additional information). However, don’t let these designations scare you or stop you from engaging in your lo‘i kalo rehabilitation efforts. There are rights associated with water use on lands adjacent to streams as well as rights which support cultural practices related to growing kalo and restoring kalo to traditional places.

What is the zoning for your land? What activity is allowed in that zone?

- Conservation      What type:
- Agriculture      What type:
- Rural or Country
- Urban
- SMA (Special Management Area)
- Other

It is possible for a single parcel of land to have multiple zoning designations (county, state and federal).

What other designations or authorities might be attached to these lands?

- National Park (Federal)
- State Park (Department of Land and Natural Resources)
- County Park (Department of Parks and Recreation)
- Forest Reserve or Natural Area Reserve (DLNR-DOFAW)
- Hawaiian Homes (Department of Hawaiian Home Lands)
- Ceded lands (Office of Hawaiian Affairs)
- Hawai‘i Housing Authority (HCDCH)
- Critical Watershed (DLNR/DOH - Clean Water Branch)
- Critical Habitat (USFWS)
- Flood plain (County Office of Planning/Public Works)
- Tsunami evacuation zone (County - Civil Defense)
- Nā Ala Hele (trails) (DLNR-DOFAW)
- Historic Register (National, State, County)
- Other

What zoning or other designation(s) are attached to the lands immediately surrounding you?

Did you see any Land Grant, Land Court Award or kuleana claims for your site on the Tax Map Key when you investigated Land Use?

Yes       No

What are the names and numbers for those Grants, Awards or other claims?



# SECTION II. KA WAI O KA `AINA



Source: Bishop Museum

In the year 2000, the Hawai‘i State Water Commission was required by law to establish minimum standards for stream recovery and watershed health and to assess all major streams in the state to determine existing conditions relative to historic flows.

Within the next 3-5 years the state will also test all of its streams to assess water quality. If you work with children in the lo‘i, especially in urban areas, these studies will be important to you. At the date of this publication (2004), there is only one currently assessed stream in Hawai‘i which meets all the health and water quality standards for the state: Pelekunu, Moloka‘i.



**Nānā i ke kumu.** Look to the source...of your water. This is an era where water use and availability has become an imperative issue for the State of Hawai‘i; where drought cycles are becoming more and more visible; where sugar is gone and the potential for stream restoration is greater than ever before. Understanding the history and current conditions of your water source, as well as the demands on it, will be critical in helping you plan lo‘i rehabilitation and future water use wisely.

As with SECTION I of this chapter, you will need to consider the topics below on three levels - your lo‘i, adjacent lands, and the ahupua‘a that your lo‘i are in. You will also need to compare changes over time for the conditions of your site, ahupua‘a and water source.

**RESOURCES YOU WILL CREATE AND COMPILE**

You will continue to add to the resources you developed in SECTION I. In addition, you may want to expand your map to add more detail on the path and shape of your stream and ‘auwai system. Continue to take pictures as you work, especially of stream fauna if any natives show up!

You may want to keep a separate journal for water observations for quicker access to data. Some of the things you will record include daily rainfall, seasonal patterns, and cyclical stream behaviors.

A WATER WEIR OR OTHER FLOW MEASURING DEVICE. This will help you determine how much water is available to you. The “how to” are found under WATER QUANTITY in this Section.

You may also want a THERMOMETER, a RAIN GAUGE, and a couple of CLEAN GLASS JARS for specimen collection.

**I. PLACE NAMES AND MO’OLELO**

What is the name of your stream or water source ?

What are the names, if any, of the tributaries that feed your stream?

Is there a name(s) for the coastal and reef area(s) where your stream exits to the ocean at the makai side of your ahupua`a?

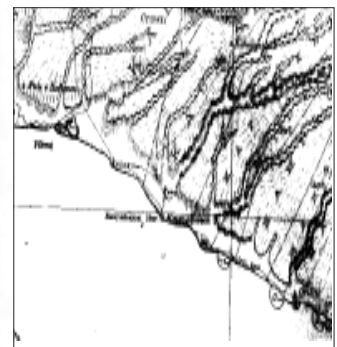
If there are any, name the fishpond(s) at the bottom of your ahupua`a.

Record any `ōlelo no`eau or mo`olelo about your stream.



P.Levin

Don't be discouraged if you can't find the ancient names for these places. There may not be any historical anecdotes for your place or stream. The ones that were recorded were those available or accessible at the time. The number of individuals gathering information was small indeed compared to the wealth of information out there at the time and how quickly it was disappearing. Many names have left us along with the kūpuna who knew them. They may also have been changed, moved, or even removed from maps in more recent history.



Monsarrat map 1880.





What do these names, saying or stories suggest about the habits of your stream?

- Add each new name and feature to your ahupua‘a map as you discover them.



C. Wichman

## 2. THE PHYSICAL ELEMENTS

Before you assess the physical elements of your water source, take a little time to consider the ORIGINS, PATHS, and EXIT of your stream as it travels through the lands of your ahupuaʻa from mauka to makai.

THE PHYSICAL ELEMENTS in this Section include SEASONAL BEHAVIORS, TOPOGRAPHY, FLORA, FAUNA, WATER QUALITY and WATER QUANTITY.

### ORIGINS

The historical source of your water directly affected the design of your loʻi system and the present day condition of that source will influence your rehabilitation decisions. So, *makaʻala*. Observe carefully.

- Walk the stream and your watershed up and down as far as you can. Get to know its character. Make notes on your map or in your journal as you go.

Streams may begin from a series of watershed planes without visible perennial drainages; from a steady seep of water along a cliff or a small spring.

- On your map, color in the most important watershed area(s) in relation to your stream.

What was the *original* source of water for the ancient system you are rehabilitating?

- |   |  |
|---|--|
| <input type="checkbox"/> Seep             | <input type="checkbox"/> Marsh         |
| <input type="checkbox"/> Stream           | <input type="checkbox"/> Delta/estuary |
| <input type="checkbox"/> Punawai (spring) | <input type="checkbox"/> Rainfed       |
| <input type="checkbox"/> Other            |  |

A more recent historical source for your water may have been a well.

What is the *current* source of water for your loʻi system?



C. Wichman

Hāʻupu covered in the mist.



Revisit the information you gathered about watersheds in SECTION I under TOPOGRAPHY.





P. Levin

An old agricultural flume.

Your lo‘i may receive water from a pipe, ‘auwai (ancient or recent), cement ditch, or flume (ha wai). These are part of the water *delivery* system, not the source. Be careful to establish the true *source* of water that flows through those conduits. It may be that your present day water is coming from outside your ahupua‘a!

If your water source is different from the original source, how did it change and why?

- Draw in the streams, springs and ‘auwai of your ahupua‘a if they are not already on your map, especially the ones that will converge to feed your lo‘i.



P. Levin

An ancient ‘auwai.

**WATER PATHS**

Water paths include both ways of moving water such as ditches, pipes and 'auwai, and the 'lines' that water traverses (across whose lands). Knowing how water is used and changes across various parcels will help you in water use decisions. You will find related questions about access to your 'auwai and māno under PEOPLE in this Section.

- Map the water system (tributaries, stream, 'auwai, māno, etc.) as it crosses through the various lands of your ahupua'a and immediately adjacent to your site. You may want to do this on your TMK map as well as your ahupua'a map

Were there any diversions (small or big) along your water source in the past?  Yes  No  I don't know

If yes, where were these located?

- If you know where these sites are, mark them on your map.

From observation, are any of these *historic* diversions still in effect up or down stream from your site?

- Yes  No  I don't know

If yes, which ones?

**`AUWAI AND MĀNO**

As defined in the Hawaiian Dictionary, an 'auwai is a ditch or canal.

A māno has broader meaning and can be a dam; stream or water source; headwaters; a place where water is directed for distribution into channels; or, a channel.

The use of these two words can be confusing. To keep things simple, in these GUIDELINES, we use 'auwai to indicate a ditch, canal or channel that brings water from a stream into your lo'i or draws water away from the lo'i back into the stream. Māno, diversion, or intake, refers to the rock dam or other feature (and its location) that brings water into the 'auwai from the stream.

Māno take many forms. It may be a naturally formation of rocks that creates a pool and raises water levels or a man-made rock dam that runs the width of a stream. Or, it may simply be a large rock, 'sand bar', or pile of rocks that juts out from the bank into the stream just enough to split water away from its main course.



P. Levin

A traditional māno.





With all the changes that have happened on the land since ancient times, the structures that brought water from the stream to your lo‘i may have been destroyed. Fences or buildings may have gone up between you and the stream. Access issues can be found under PEOPLE in this section, but the most important question is, can you still bring water to your lo‘i *and* return it to the stream?

- Yes       No       Not sure

Do you still have an ‘auwai and māno for your lo‘i system?

- Yes       No

- If you can, locate the specific diversion for your lo‘i system and the adjoining ‘auwai (or where it might have been, if it no longer exists).

Are there any *new* diversions up or down stream?

- Yes       No       I don’t know

- Locate these in-use diversions and channels on your map.

Is the stream channelized anywhere along its length?

- Yes       No

Upstream or downstream from your immediate site?

- Upstream       Downstream

- Mark the channelized section of your stream on the map.

If the stream is channelized mauka of your site, it will impact on the overall health and condition of your water, including raising water temperatures (see WATER QUALITY in this section). Channelization also inhibits the presence and survival of native species.

Along with major physical changes in the land, the stream itself may have changed course, dropped within its channel or been severely or completely reduced in flow. If the stream bed is dry and you can’t get the water restored, you may still be able to grow kalo but you will need to change to dryland methods.



D. Cooke

Channelized and diverted, this stream presents a number of water quality and habitat challenges.

Kalo growing on the banks above a channelized section of a stream.



P. Levin

**EXITS AND ENDINGS**

How the water leaves your loʻi is just as important as how it comes in. There are other users that will want the water to remain as healthy as you do; especially the freshwater fauna that live in the stream. It is significant to understand that in the ancient system, water was always returned to the same stream that it was borrowed from; there were no “exit-only” users where water was taken from the stream and not returned. The lawaiʻa (those who fished) depended on this agreement to ensure healthy estuaries and fisheries at the makai end of the system.

Where and how does the water you used return to the stream?

Does your water source (stream) enter the ocean directly or join with another stream first?

- Enters the ocean     Enters another stream

How far from the ocean are you?

Do the remains of a fishpond still exist at the makai end of your stream system?     Yes     No

- If a pond does remain, locate it on your map.

If an ancient pond is still intact or visible, the potential for restoration still lives. Freshwater intrusion into fishponds is a vital component of healthy pond ecology. Keep the water as clean as you can for the benefit of ponds, reefs, the deep ocean and all the organisms who make those places their home. See CHAPTER THREE: THE PHYSICAL REHABILITATION PROCESS, for discussion about how to reduce siltation in the outflow from your loʻi. Piliāna nā mea ʻapau, it is all connected!



P. Levin



P. Levin



Can ecological changes on other continents affect us? You bet. All over the world historic rainfall patterns are changing due to large scale deforestation, air pollution and water diversion. Hawai`i is no exception. Locally, vegetation changes or volcanic activity on one island can impact rainfall patterns on the other islands.



### A. Seasonal Behaviors

Recording daily, weekly, and monthly rainfall is important to understanding any fluctuations in water levels that you may have to deal with in managing your lo`i system. Over time you will become more familiar with the cycles and be better able to protect your infrastructure from flood damage.

- Ask kama`aina families in the area what the historical rain patterns have been.
- Find out what the average rainfall pattern at your site is currently.

Which are the wet months and dry months at your site?

Wet Months

Dry Months

Has this pattern changed over the last few generations?

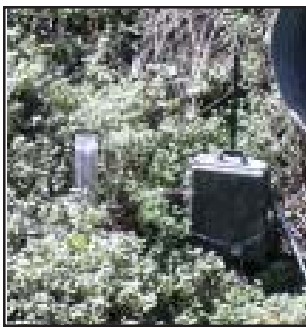
- Yes
- No
- I don`t know

Is it changing now?  Yes  No  Not sure

What are the daily, monthly, and annual flow cycles of your stream?

This is a question you may not find an answer to until you have watched your stream and lo`i system for several years.

- Make a rain gauge at your site and record the amount of precipitation each time it rains. If it`s been raining really hard and your gauge says you got 3 inches of water but the stream never rose...what`s up with that? You may need to do a site inspection of your watershed.
- Begin to observe and document your water cycles. One way to do that is to place a marked stick in the stream or find a spot against a stream bank where you can easily monitor and record average depth over time.



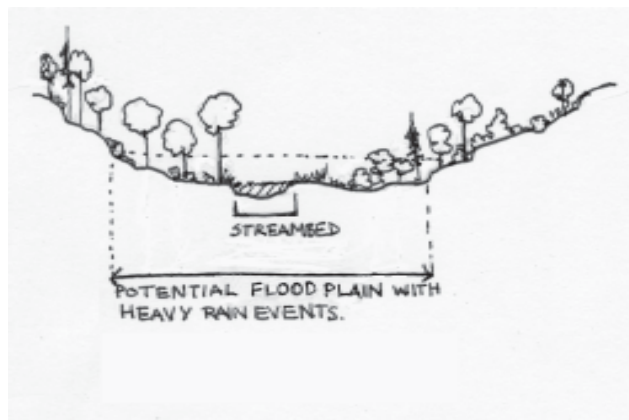
P. Levin

Rain gauge with a battery powered recording box.

Is there a daily cycle (eg., your water comes from a plantation ditch, like in Punaluʻu where they open the flume every day at 2 pm. and water levels go way up)?  Yes  No

Describe the daily cycle:

Loʻi kalo are often located in a flood plain or flood fringe area. Later, as you rediscover the ancient system at your site, think about how it was designed to deal with flooding. You may need to develop your own “flood plan.”



- Determine where the boundaries of the flood plain of your stream are. Color in this area on your map.
- Each time it rains hard, observe and record the location of over-the-banks surface water flows (if there are any). Mark them on your site map for future reference. This will be important in controlling soil erosion later.

#### WHAT'S A FLOOD PLAIN?

A flood plain is the area or level (elevation) to which water in a stream bed will rise or spread during heavy rain events. Typically planners and engineers are concerned with 10-year to 100-year flood events. The Planning Department or the Army Corps of Engineers will have this information and can provide you with FEMA maps which outline flood plain elevations.

#### THE DYNAMICS OF THINGS.

Animals sense floods and other earth changes long before we do. During one Molokaʻi flood of 2001, residents observed prawns crawling out of the streams and into the bamboo about 2 hours before big water hit Wailau Valley.

Annual deposits of silt, leaf litter and other organic debris in flood plain areas from heavy rain events are part of the natural process of nutrient renewal that occurs along waterways.



**KĀNĀWAI**

Some believe the word kĀnāwai, today commonly understood to mean “law,” originally referred specifically to “rules relating to water.”

“The most famous kĀnāwai is the kĀnāwai kai`okia promulgated by the god Kāne after the flood of Kahinali`i, promising that ever afterwards the sea would be separated (‘okia) from the land (i.e., not encroach on the land). Persons swore oaths by this and other kĀnāwai.”

Pukui and Elbert. 1986: 127  
Hawaiian Dictionary



K. Faris

**WARNING!** Our islands are built of steep, rapid slopes. Flood waters flow fast and naturally carry lots of debris. Move out of the way or it will move you!

He wai makamaka `ole.  
Water that recognizes no friend.  
Said of flooded streams that are dangerous.



What are the stream’s highest flood levels?

There may be records of this. Check with the Office of Planning or the state GIS office. Ask for FEMA maps (50 and 100 year flood event insurance maps). Ask families who grew up in your neighborhood what they remember about the flooding patterns.

How long after a heavy rain at the top of your ahupua`a before you see stream levels rise at your site?

How long does it take for this water to get to the shore? Hint: look for the start of colored runoff in the ocean.

What evidence is there of flooding?

- Debris on top or inside the lo`i, along stream banks, or higher up in the trees
- Movement of sand/stones
- Fresh soil cuts or undercut banks
- Built-up mudflats
- Ripped up root mats
- Matted down vegetation
- Bare soil or bedrock areas along the banks
- Other

- Look around the riparian areas adjacent to your land. If there is a lot of debris and abandoned things within the flood zone it may plug up the stream in a big storm. It could end up in your lo`i.

Does the water in your stream become stagnant in the dry season?

- Yes
- No
- Only in drought years

- Consider how fluctuations in stream depth and flow might affect your lo`i system and your planting cycles.

- Look at the ancient system that is revealing itself to you – how does its design reflect this knowledge of water cycles?

Before



D. Cooke

After



D. Cooke

Notice the undercutting along the tree line of the streambed and what is left of the kukui sapling in the foreground.

## B. Topography

The character of your stream bed has a lot to do with how water in a stream behaves.

- Take a moment to revisit the stream along the stretch you will be borrowing your water from. Get to know its character, especially the mauka reaches of the stream.

- Describe the stream near your site.

Trajectory:

- Straight
- On a bend
- Gently sloping
- Steep drop(s)
- Other

Shape:

- Pool
- Narrow
- Wide



C. Wichman

If the stream channel adjacent to your loʻi seems relatively flat and broad, but the upper sections have sharp drops and narrow banks, be prepared for floods!

The stream bed has:

- Large boulders
- Small cobbles
- Flat rock
- Fine gravel or pebbles, silt or mud
- Other

The banks are:

- Undercut
- Steeply sloping
- Gradually sloping

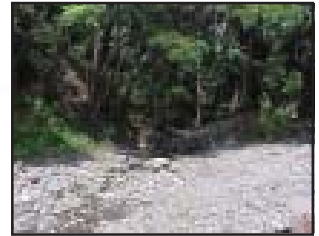
Deposits of silt or fine pebbles will tell you where water may be slow allowing smaller particles and debris to drop out of moving water. These places are often swept clean during high floods. Large boulders may trap debris during floods which can cause water to pool up behind them.

As you work daily with your loʻi system, pay attention to how the water in your stream behaves based on its physical character.



P. Levin

A wide streambed (relative to other streams in Hawaiʻi) with large boulders and cobbles on a slope.



P. Levin

Flat grade with small cobbles, pebbles, fine gravel and silt.



P. Levin

Straight trajectory and flat grade with primarily silt and mud bottom with some gravel.



### C. Flora

The first section of this chapter covered a lot of territory regarding plants. In the water, however, the primary focus will be on the presence or absence of limu, freshwater ferns, grasses and a few herbaceous species. Not all streams will have obvious aquatic flora; for many, it is the micro-organisms that keep the system thriving. A stream restored to healthy flows will be cool and swift moving, and have little, if any, limu. Concentrate on the stretch of stream around your site.

Is there limu present in the water and/or on the pōkahu in the stream?

- Yes       No

- If yes, describe what it looks like here, including color, shape, size, texture. Pictures are always helpful in identifying flora and fauna.

- Collect a sample of each kind you find. Lay it out carefully on a sheet of plastic or wax paper and press it as you did the other plants in your collection. Or, preserve it in a jar (easy to bring to an expert for identification).

How much limu is present?

- Frequent       Occasional       Rare

Where is it?

- Above the water line (e.g., in the high water zone)  
 On rocks  
 Everywhere on surfaces under water  
 In deeper water  
 In shallowest water  
 In slow or standing water  
 In fast moving water

It can be hard to determine what kinds of limu are growing in your stream or ‘auwai, but you may recognize some of them as escapees from fishtanks. Kūpuna in your community may recognize native limu if they were used as food or medicine.

Often when alien species of limu do well, it may mean too much nitrogen in the water or that water flows are too slow, too low, or too warm. This could be natural or it might be from agricultural runoff. Introduced limu species consume high levels of oxygen making it difficult for native fauna to thrive.

An excellent indicator for high water quality is the presence of the native black limu huluhulu ʻāina (not to be confused with huluhulu waena, a marine species). This one likes cold, well-aerated water.

Is azolla present in the still areas of your stream or in your loʻi?

- Yes       No

Azolla is a tiny, floating fern that is often present in today’s loʻi. This little plant is a nitrogen fixer, keeps weeds down and waters cool without inhibiting kalo growth. When it dies back it provides organic matter to restore loʻi mud. If you have a lot of it, you can pull it out and use it as mulch around other plants you may have growing on the banks.

Alien water plants that can invade your loʻi system or your stream include:

- Arrowhead (swamp potato)       Salvinia  
 Water hyacinth       John –Thomas grass

Some of the worst invasive water plants in Hawaiʻi have come from decorative ponds or the careless disposal of fishtanks into our streams. If you have any of these species, remove them as quickly as possible.

Non-native freshwater plants can survive on wet mounds of weeds or soil outside the loʻi for a long time. Water hyacinth, which has clogged major waterways across Southeast Asia since its introduction there, and plants like Salvinia and John-Thomas grass take a long time to kill. Be careful not to accidentally introduce any of these plants to your loʻi or to new areas. What may seem like an easy-to-control plant or animal can rapidly turn into a costly species for your farm, your ahupuaʻa, and the state. Salvinia cost millions of dollars to clean up on Oʻahu and Hawaiʻi (see the next page for the alien aquatic fauna to watch out for). While Arrowhead is less aggressive, it does compete for nutrients in the loʻi and can crowd out young huli.



P. Levin

Arrowhead can look deceptively like young taro leaves.

Azolla in its red phase.



P. Levin

**JOHN-THOMAS GRASS**, known on the mainland as parrotfeather milfoil (*Myriophyllum aquaticum*), is not a grass, but a water plant originally used in fishtanks and ornamental ponds. A small piece of this plant will quickly grow another one. It has heavily invaded loʻi kalo in Waipiʻo, Hawaiʻi.



Dept. of Aquatic Resources

**GIANT SALVINIA** (*Salvinia molesta*) is also a fishtank plant that got thrown away in our freshwater systems. It smothered Lake Wilson and invaded wetlands on Oʻahu. It was also found in ponds on the island of Hawaiʻi.



Dept. of Aquatic Resources



Did you know...Hawai`i has an indigenous freshwater sponge?

Check out *Hawaii's Native and Exotic Freshwater Animals* by M. Yamamoto and A. Tagawa for some great pictures.



Hihīwai with egg sacs on its shell.

*The Statewide Strategic Control Plan for Apple Snail (Pomoacea canaliculata) in Hawai`i* (2006) will be available on several websites soon, including [www.hear.org](http://www.hear.org)

The plan, developed by taro farmers across the state, brings together all kinds of information about the snail including its life cycle, behavior, how far it has spread throughout the islands and recommendations for improved control efforts.



## D. Fauna

Freshwater fauna in Hawai`i have been diminished by many factors over the last 150 years. Water quality and quantity will have everything to do with their presence in your stream. Most prefer cold, fast running, well aerated water. If you have any native fauna in your stream, that is a good indication that your water source is healthier than not.

What, if any, native fauna are in your stream?

- |  |  |
|--|--|
| <input type="checkbox"/> `O`opu nākea  | <input type="checkbox"/> `O`opu akupa (`o`opu `ōkuhe)      |
| <input type="checkbox"/> `O`opu nōpili | <input type="checkbox"/> `O`opu hi`u kole (`o`opu alamo`o) |
| <input type="checkbox"/> `O`opu naniha | <input type="checkbox"/> `Ōpae kala`ole (`ōpae kuahiwi)    |
| <input type="checkbox"/> `Ōpae `oeha`a | <input type="checkbox"/> `Ōpae `ula                        |
| <input type="checkbox"/> Hihīwai (wī)  | <input type="checkbox"/> Pīpīwai                           |
| <input type="checkbox"/> Other         | <input type="checkbox"/> Hapawai (hapakai)                 |

The snails often called pūpū lo`i are not native to Hawai`i. They were introduced more than a century ago and are actually part of the family that includes apple snails.

The Hawaiian Dictionary lists more than 20 names for variety of `o`opu, distinguishing between male and female and the various life stages of the fish. Each species of native `o`opu is specific to different parts of the stream system from estuary, lower, mid-level, to the high, mountain reaches.

In addition to `o`opu, other native fish species important as traditional food sources, are present seasonally in lower or mid-level stream areas or move between fresh and brackish water in the lower reaches of a stream. Hawaiians often raised these fish in ponds.

- |  |   |
|--|---|
| <input type="checkbox"/> `Ama`ama (mullet)                                       | <input type="checkbox"/> Awa (milkfish) |
| <input type="checkbox"/> Āholehole (young stage of the āhole; Hawaiian flagtail) |   |

What alien/exotic fauna are in your stream?

- |  |   |
|--|---|
| <input type="checkbox"/> Crayfish            | <input type="checkbox"/> Turtles                  |
| <input type="checkbox"/> Malyasian prawns    | <input type="checkbox"/> Tahitian prawns          |
| <input type="checkbox"/> Suckermouth catfish | <input type="checkbox"/> Tilapia                  |
| <input type="checkbox"/> Swordtails          | <input type="checkbox"/> Guppies or mosquito fish |
| <input type="checkbox"/> Apple snails        | <input type="checkbox"/> Cichlids                 |
| <input type="checkbox"/> Asiatic clams       | <input type="checkbox"/> Other fish species       |
| <input type="checkbox"/> Other snails        |   |

Almost all of these alien fauna were introduced to Hawai`i through the aquarium or aquaculture industry.

**WHAT DOES IT MEAN TO HAVE EXOTICS IN YOUR STREAM OR LOʻI?**

Most exotic species thrive in areas where water flows have been severely reduced and water temperatures are higher than normal. They displace or eat native populations of fish, shellfish and mollusks.

Exotic species of fish and snails can pass parasites to native fish and to you. Your stream temperatures might tell you that the waters are too warm to support native species. Crayfish burrow into kuāuna (banks) and cause leaking. Suckermouth (also known as armored) catfish dig into the sides of stream and loʻi banks as well.

**APPLE SNAILS IN HAWAII**

Are there signs of apple snails (empty shells, live snails, live pink eggs, white hatched egg casings) in any wetland or loʻi areas at or anywhere near your site, including your neighbors or the stream?

Yes       No

Next to pocket rot (a disease), apple snails (also known as ‘golden snails’) are *the* most significant and costly problem for kalo growers.

The most prolific species, *Pomacea canaliculata*, has bright pink eggs easily visible on kalo stems or grass around the edges of a loʻi. The snails are voracious eaters and multiply rapidly. If left to themselves, they will reach densities that can clean out a patch of huli or mature, ready-to-harvest taro in a single day. The snails conceal themselves in the mud, and travel easily by closing up their shells and tumbling through moving water. Newly hatched snails are almost invisible and can hide in the folds of huli or the mud on your boots, tools and vehicle wheels. The adults can survive up to a year in the mud in a dry loʻi and a snail can remain fertilized for months, meaning it may only take a single snail to contaminate an area.

If you have apple snails, be responsible. Don't share your huli with uncontaminated farms. Clean your huli carefully to reduce them in your own patches. Clean your tools, boots and tires if you have been using them in infested areas so you don't transport them to the next ahupua'a.

Controlling apple snails takes a combination of strategies. Ducks seem to be the best at reducing the snails and your labor, but its hard to protect them from dogs. Clean your most mauka loʻi of snails first and work makai. Use traps at your 'auwai and pipes and clean them regularly. Fallow your fields if and when you can. When you re-open them, and before you plant, let a little water in to draw snails out of the mud, bring ducks in to eat them as they rise to the surface, then dry the loʻi again. Repeat this cycle two or three times before you plant to give your huli a fighting chance.

Apple snail eggs, adult snails, and kalo being attacked by snails.



C. Wichman



P. Levin



P. Levin

**SPECIES OF APPLE SNAILS IN HAWAII.**

*Pomacea canaliculata* has the bright pink eggs most often seen in loʻi. *P. bridgesi* and *P. paludosa* are less common. *Pila conica* eggs are white. *Cipangopaludina chinensis* bears live young and is the slowest spreading of the group. Shell shape is a distinguishing factor, but not color. The name pūpū loʻi has been applied to both *Pila conica* and *Cipangopaludina chinensis*.



P. Levin

Onion bag trap





## E. Water Quality

As an integral part of a moving, living and breathing ecosystem, you should be concerned about the quality of water from its source to the sea. As someone who will be using some of that water, you will need to consider the health of that source both entering and exiting your lo`i system.

*Your* best tool for assessing water quality will be your observation skills. For more technical water monitoring there are a number of agencies, organizations and schools doing work around the state. We encourage you to link up with any one of them.

In any water quality assessment, consider the following things to observe:

- Water temperature
- Clarity or turbidity (clear or muddy)
- Nitrogen levels and chemical contaminants (i.e., presence of heavy non-native limu growth, smell, color, feel)
- Presence or absence of native freshwater flora and faunal species
- Presence of a healthy riparian area

Using your best judgement, what do you think is the quality of your water at the source?

If you have any concerns or want to be sure about the quality of your water source, you can get it tested for free by the Department of Health; Clean Water Branch.

Check for leptospirosis, nitrogen, fecal coliform (*E. coli*), especially if there are lots of children involved in your project. All of these bacteria, like leptospirosis, may or may not be regularly present in the water.

A sample must be collected and delivered to the lab within a couple of hours for it to be analysed properly. The Branch staff are helpful and can provide you with assistance.

What is the color of your stream water at your site?

Some streams were known for their colors and this was reflected in their names, for example, Wai ʻōma ʻo (green water), Wailena (yellow water), or Waimā (discolored water). Water running over hāpu ʻu roots is known to be dark in color. Whitish colored water may indicate the presence of insecticides or other chemicals; including traces of arsenic from termite treatment. If it is excessively green, the algae population may be booming from nitrogen runoff. If its black and smells bad it is likely that somewhere along the line, septic systems, farm runoff, or industrial pollutants are getting into your water source.

On clear weather days (preferably not immediately after a heavy rain) do you notice muddy water in your stream?  Yes  No

Describe the pattern you observe (intensity, how often, time of day).

Put some water from your source in a jar.

What is the clarity of the water in the jar?

- Clear (transparent)
- Slightly murky (suspended particles)
- Really murky (suspended particles)
- Completely muddy (heavy soil runoff)

Hawai ʻi streams typically drop rapidly over short distances. Water full of sediment may be natural to your stream. The nutrients carried under these circumstances are part of the food web for freshwater and marine fauna and for the kalo in your lo ʻi. But, it could also be something you should investigate. When sediment loads become too heavy or unnatural in composition they negatively impact water quality. Muddy waters may indicate degraded forest or riparian lands and/or the presence of too many feral pigs mauka of your site; someone grading land upstream may

*One of the mauka tributaries to Pālolo stream is a smaller stream called Pūkele, whose literal name is “muddy.” In heavy rains, it is characteristically full of sediment. A section of a second stream in the valley was known for its brownish-red color associated with the demise of the supernatural rooster, Ka ʻau-hele-moa, whose blood tainted the water. It was said that if you took a jar of this water home, by the time you got there the color would be gone.*

*An unhealthy water checklist includes:*

- Warm, sluggish flow
- Dead fish or rodents
- Trash
- Bad odor or color
- Presence of alien flora or fauna
- Presence of certain types of bacteria which are invisible to the naked eye and the human nose.



**LEPTOSPIROSIS ALERT**

ALL streams in Hawai`i are vectors for leptospirosis. Its source is animal urine (dogs, pigs, goats, rats, etc.) in mud or water. You can get leptospirosis from ANY body of fresh water, even a puddle or pig wallow. The bacteria does not need moving water to flourish. In fact, there is more danger in contracting the bacteria from a stream when there is less of a flow than when it is at its best conditions.

Leptospirosis is also not constant in a water source and can show up at any time. If you, or someone who has been in your stream or lo`i, exhibits flu like symptoms that get rapidly worse, see a doctor right away. Symptoms can show up 2-20 days after infection. Make sure you tell the doctor you were in a stream or lo`i so they can monitor for leptospirosis.

**TAKE PRECAUTIONS:**

Don't go into the stream if you have open cuts or abrasions.

Don't drink the water. The bacteria can also enter your system through the soft tissue of your mouth or nose.

For more information call the Hawai`i State Department of Health at (808) 586-4400 or visit their website at:

[www.state.hi.us/doh/resource/comm\\_dis/cddlepto.htm](http://www.state.hi.us/doh/resource/comm_dis/cddlepto.htm)



cause turbidity to occur. Cattle in the stream can have a similar affect. Does water clarity change daily or remain fairly constant? Record any patterns you begin to see in your journal.

How does your stream look at the makai end of the system? Do you notice any muddy water at the mouth of the stream where it enters the ocean?  Yes  No

If yes, can you describe the pattern of siltation – location, how often, time of day, source?

Is there silt built up along the coastal areas and reefs makai?  Yes  No

Be aware that what goes in at the top will show up at the bottom without proper mitigation.

Does your water feel:  
Soapy?  Yes  No  
Oily?  Yes  No

Does it take the natural oils out of your skin quickly?  Yes  No

What does the water smell like?

- Healthy
- Like sulphur
- Like a septic tank or animal urine
- Other

Do your kids get kākī ʻo (itchy, skin disease) everytime they swim or go in the stream?  Yes  No

These things can indicate if your water is acidic (dry) or base (slippery) - pH levels which may be natural or not - or whether additional pollutants may be present.

Another useful water quality measurement is water temperature. Cold mountain stream or spring water in Hawaiʻi is usually about 67 degrees at its coldest. When the water is warm to begin with, a lot more is needed to run through the loʻi to keep it healthy. Measuring temperature with a thermometer is easy. Soon you will be able to guess at water temperature just by feel.

- Record water temperature in-stream and at the loʻi outflow several times a day for several days (from early in the morning through the late part of the day). Take an average. This is one indication of whether you have too little water flowing through your loʻi or not. Water temperature will have an impact on the health of your kalo in terms of growth rate, vigor and disease.

When is the water warmest and for how long?

- Continue to monitor the temperature and quality of your water throughout the seasons. Soon you will see larger patterns related to weather, water levels, mauka activities, and other phenomenon.

Are there any existing studies of your stream that could provide you with more information about stream quality?  Yes  No

Check with the Department of Health Clean Water Branch Environmental Protection Office (EPO) or with the State Water Commission.

Are there any studies of streams similar to your own that you can use for comparison?  Yes  No



Mōhala i ka wai ka maka o ka  
pua.  
*Unfolded by the water are  
the faces of the flowers.*  
Flowers thrive where there  
is water, as thriving people  
are found where living  
conditions are good.



P. Levin

## F. Water Quantity

Just how much water flows in your stream will change, perhaps, daily, seasonally, with rain events, or due to additional diversions. For any kalo planter, this is critical to monitor. Water quantity will be the deciding factor in *how* you choose to grow your kalo.

Consider the following things when evaluating water quantity:

- Water volume (flow)
- The stream’s flood levels
- Annual rainfall at the top of your ahupua‘a/watershed
- Seasonal patterns of rainfall

### MEASURING WATER AND WATER NEEDS

Knowing how much water is available can give you an idea of how big an area to plant and at what time intervals. The bottom line is that more water and colder water equals higher productivity and better quality, healthier taro. Each site is different (see GOVERNMENT WATER USE DESIGNATIONS in this section and APPENDIX A for more information on minimum water needs).

Measuring water quantity is a little more difficult than measuring water temperature. But, again, with some experience behind you, it will become possible to make an educated guess. Remember, “Enough water” is that quantity (and quality) of water that flows into and out of the lo‘i without being too warm. Cold water is vital for productive, healthy kalo and even more so for native stream life.

- Estimate how much water is in your stream and how fast is it moving.

One simple way to measure water quantity is by catching the flow in a five gallon bucket. The longer it takes to fill the bucket, the less water there is coming from your source.

How does this work?

Here is the math:

1. There are 86,400 seconds in one day.
2. Divide this by the number of seconds it takes to fill a five gallon bucket.
3. Multiply this number by five gallons.

In practice this works out to:

Seconds to fill a 5 gallon bucket	Gallons of water per day
1	432,000
2	216,000
3	144,000
4	108,000
5	86,000
6	72,000
7	62,000
8	54,000
9	48,000
10	43,000
11	39,000
12	36,000
13	33,000
14	31,000
15	29,000
16	27,000
17	25,412
18	24,000
19	22,737
20	21,600
21	20,571
22	19,636
23	18,783
24	18,000
25	17,280

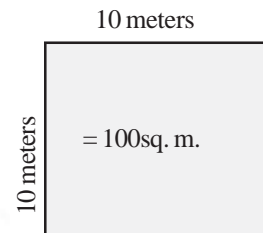
The second measurement you need to make for this method is the size of the area you want to plant, not counting banks and unflooded areas. Measure your planting area in square feet with a tape measure, or by pacing it off (the average pace is about 1 meter or a little more than 3 feet). One acre is 43,560 square feet or about the size of a football field.

How do you use these two numbers?

Here is an example:

If you want water to flow into your loʻi at the rate of 200,000 gallons per acre per day, and you are going to flood one acre, then your five gallon bucket needs to fill in 2 seconds (86,400 seconds in one day/2 seconds x 5 gallons = 215,000 gallons). If you only have ¼ of an acre, then you need to fill your bucket in 8 seconds.

Conversely, if you have 2 acres and you need water to flow into your loʻi at the rate of 200,000 gallons per acre per day, but a 5 gallon bucket takes 12 seconds to fill, you may not have enough water to farm the whole area with the same methods you would use under better waterflow conditions.



$$\frac{86,400}{2} \times 5 = 215,000 \text{ gallons}$$



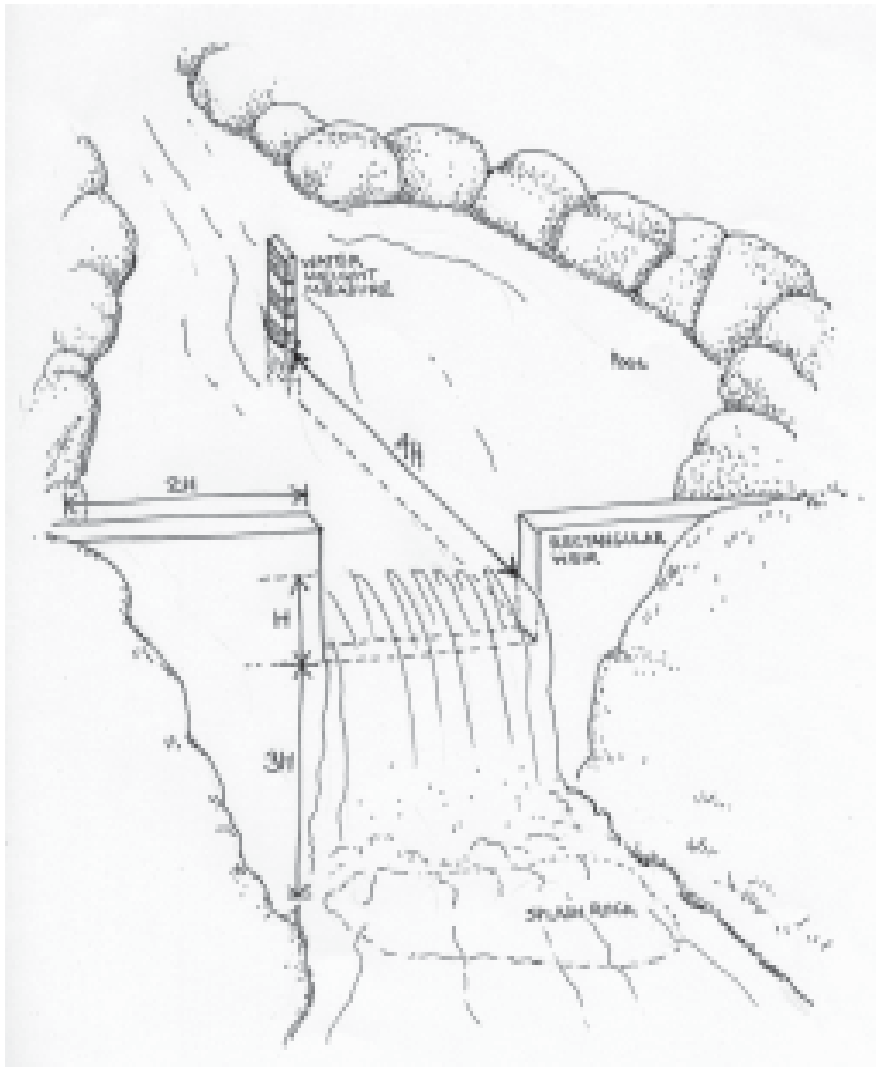
**WEIR METHOD FOR MEASURING WATER FLOW**

To measure larger quantities of water a second simple method is to construct a weir in the ‘auwai. This requires that you are able to dam the flow in the ‘auwai with a board that has a notch cut into the top edge so that the water flows through the notch and makes a small waterfall. Follow these steps:

1. Make the notch in the board 1 foot wide and 6 inches deep. Set it level in the ‘auwai so that water flows through the notch. Measure the depth of the water in the notch. The waterfall from the notch needs to be 3 times the depth of water flowing over the notch. If you have 1 inch of water flowing over the notch, then your waterfall needs to be at least 3 inches high. If the water fills the notch to 6 inches, then the waterfall needs to be at least 18 inches high. Be sure to put something under the waterfall to keep it from scouring the ‘auwai. Rocks or pebbles work well.
2. Make sure the pond behind the dam is wider than the notch. The edges of the board should be at least 2 inches from the side of the notch for one inch of water in the notch, up to 1 foot from the sides of the notch for 6 inches of water (see the illustration on the following page).
3. Upstream from the board, pound a vertical stake in the ‘auwai. Use something narrow so that it won’t obstruct the water flow. For water 6 inches deep in the notch, the stake must be at least 2 feet upstream and not too close to the edge of the pond. Use a carpenter’s level and make a mark on the stick level with the base of the notch. Make marks above the level every 1 inch up to 6 inches. This will be where you check your water height. Compare it to the table below:

<b>Water height</b>	<b>Gallons per day</b>
1 inch	68,000
2 inches	140,000
3 inches	260,000
4 inches	390,000
5 inches	560,000
6 inches	720,000

This is just one of many ways to make a weir. Weirs can be made to measure smaller or larger quantities of water and can be used even in situations where the flow can’t be made to fall.



Weirs should be constructed and used with caution. They can obstruct movement of the streams natural inhabitants, preventing species like hihīwai and ʻoʻopu from returning upstream.

**Makaʻala.** Closely monitor your weir to make sure you're not preventing anyone from returning home.

What is the rate of water flow in your stream/source (how many mg/d)?



**MEASURING FLOW**

From the EPA Volunteer Stream Monitoring methods manual (1997) comes this simple method for measuring stream flow (volume and speed).

You will need:

- |  |   |
|--|---|
| Ball of string   | 4 stakes and a hammer to place them       |
| 6 twist ties   | Tape measure (at least 20 feet in length) |
| A round, floatable object (e.g., a green kukui nut, an orange) | A watch with a second hand                |

The formula in the sidebar to the left will be used to calculate flow. The following steps and diagram will guide you through the process of finding the numbers to plug into the formula. You may need a calculator.

1. Select a straight 20 foot stretch of stream with water at least 6 inches deep and with no areas of slow water such as a pool (riffles are okay).
  - a. Mark out the top and bottom of the 20 foot distance (**Length L**) on both sides of the stream using the 4 stakes; label the mauka (upstream) stakes Point A and the makai (downstream) stakes as Point B.
  - b. Make two transects across **the width of the stream**. Tie the string tightly across the stream and near the surface of the water from one stake to the other at the mauka end of your 20 foot stretch. Repeat at the makai stakes. Measure the distance of each. These strings are your **interval transects**.
  - d. Divide each transect into 4 equal parts. At each point place a twist tie so that it doesn't move from its position. Measure the **water depth**, from the bottom of the stream bed to the twist tie on the string for each tie (there should be three on each transect).

2. Calculate **Average Depth** along the interval transects for each transect. Total your three depth measures and divide by 4 (to account for the 0 depth at the shoreline).

$$\text{Average Depth} = \frac{\text{Interval 1} + 2 + 3}{4}$$

3. Calculate the **Average Cross-section per transect**. Multiply the width of each interval transect (the width of the stream) by the average depth for that transect.

$$\text{Average Cross-section} = \text{Transect Width} \times \text{Average Depth}$$

4. Determine the **Average Cross-section (A)** of your stream. This is done by adding together the **Average Cross-section for each transect** and dividing by two.

$$\text{Average Cross-section (A)} = \frac{\text{Average 1} + \text{Average 2}}{2}$$

5. Measure **Travel Time (T)** of a floating object from Point A to Point B. Drop the

You can find the complete US Environmental Protection Agency *Volunteer Stream Monitoring: A Methods Manual* on the web at:  
  
<http://www.epa.gov/volunteer/stream/>

**Here is the formula:**

**Flow = ALC/T**

**A** = Average cross-section area of the stream (stream width x average water depth).

**L** = Length of the stream reach measured (20 feet).

**C** = A correction factor (0.8 for rocky bottom; 0.9 for muddy-bottom)

**T** = Time, in seconds, for the float to travel the length L (Point A to Point B).

*\* Make sure to use feet and not inches in your calculations.*



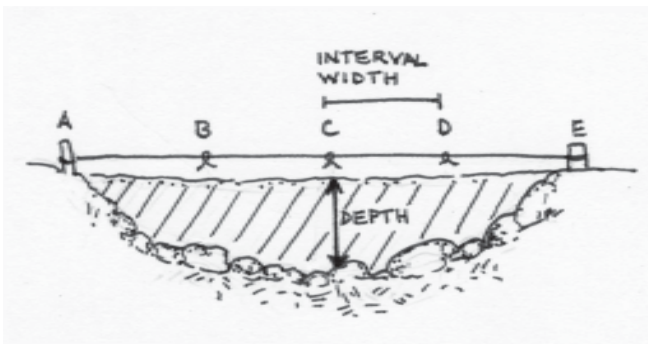
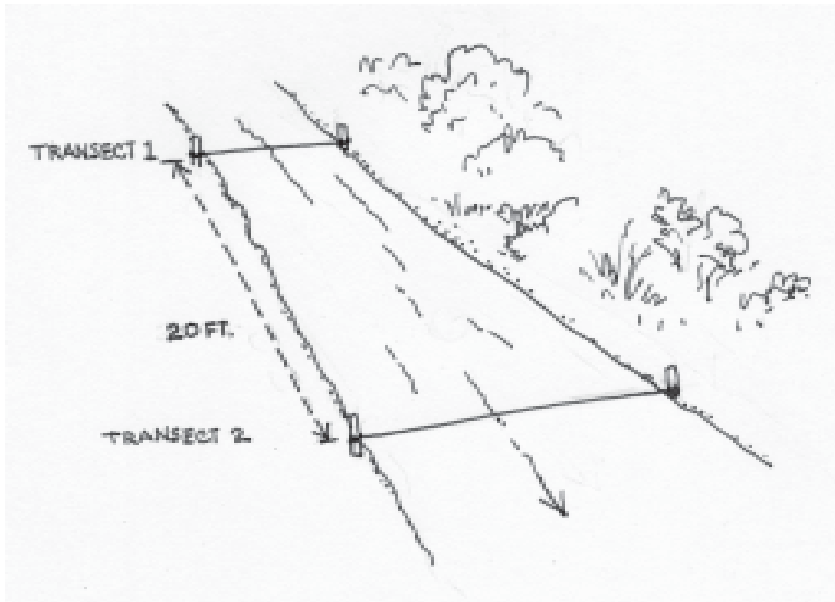
floating object you have selected into the water at Point A. Position the object to float in the fastest current. Stop the clock when it passes under the string at Point B and remove the object from the water. Repeat this at least three times and take an average of the numbers. If the object gets stuck or goes into a back eddy, that measure won't count. Record the time in seconds.

$$\text{Average Travel Time (T)} = \frac{\text{Time 1} + \text{Time 2} + \text{Time 3}}{3}$$

6. Calculate **Flow**. The C value is a constant number; with .8 for rocky bottomed streams or .9 for mud bottomed streams.

$$\text{Flow} = \frac{C \times A \times L}{T}$$

You now have a measure of your stream flow, or discharge, expressed as cubic feet per second (ft<sup>3</sup>/sec). Flow will be directly affected by the amount of water in your stream at the time. If you measure during the winter months, expect higher flows.



Did you know that any structure 50 years or older qualifies as a historical property?

“Historic property” is a legal definition and includes any building, structure, object, district, area, or site, including heiau and underwater sites, of 50 or more years. The term “archaeological site” is more of a field reference for features, complexes (groups of features), and places where human occupation and presence on the land is evident and dates to prehistoric (ancient) times.



P. Levin

This flume is an historic property.



P. Levin

This ancient 'auwai would be considered both an historic property and an archaeological site.

### 3. Archaeology

These few questions pertain to the water delivery sections of your ancient system. Briefly, for right now, you need to know if the water carrying sections of your system are still present and functional. You will consider the repair work in CHAPTER THREE under ARCHAEOLOGY: `AUWAI AND MĀNO.

Was there an ancient 'auwai system connected to your lo'i?

- Yes       No

Can you still locate it? Does it still exist?

- Yes       No

Make sure it is on the ARCHAEOLOGICAL SITE MAP you drew in the last section.

Is this 'auwai intact all the way to the māno?

- Yes       No

Does it need to be repaired?

- Good shape     Needs minor repair     Needs major repair

Before you change or rebuild *anything*, locate, map, document and photograph the lo'i walls, gates, 'auwai or any other parts of the system you can see. They might not be obvious at first until you have walked the area several times.

Is any part or all of your lo'i system on the National Historic Register for historic properties at the county, state or federal level?

- Yes       No

If yes, what is the level of listing and the ID number?

- Federal  
 State  
 County

## 4. Water Use

The discussion on LAND USE in the previous section should already give you an idea as to who is using water along the stream that feeds your lo'i.

Does the stream pass through an industrial area (or industrial agriculture area) mauka of, or adjacent to, your site?  Yes  No

Industrial area Describe:

Residential

Cane

Pineapple

Vegetable farms

Ornamental horticulture

Ginger

Other

What are the present day uses of your water sources adjacent to, mauka and makai of your site?

Mark key use points on your map.

Do these users return water to the stream?  Yes  No

What condition is the water in when it is returned to the stream?

Check the Water Commission's *Declaration of Water Use* to see who else has registered use for your stream.



Watered frequently, and with well-drained soil, kalo can be grown like any dryland crop. Kalo does not do well in stagnant, standing water. Dryland taro tastes different from and is not as sticky as wetland taro but has the advantage of being able to grow almost anywhere.

With wetland taro, the soil is kept saturated and cool. Ideally, water flows through the lo'i and carries away heat. It also keeps the soil surface submerged limiting weed germination.

Under conditions of shortage, water can be rotated between lo'i. This is better than trying to flood too many lo'i with too little water which causes an increase in water temperature and promotes rot.

The quality and quantity of water available to you will influence your ability to rehabilitate your lo'i and the practical techniques you may need to use in growing kalo.

*If you can't get a steady flow of water into your lo'i can you do some form of intermittent flooding or dryland method?*



Revisit the information you gathered about the average water flow of your source (mg/d).



**WATER SHARING**

Traditionally, fresh water was considered sacred and could not be owned. Ancient water management systems within an ahupua'a were balanced by the amount of available water and rainfall and the amount of land under cultivation. A planter was allocated water in accordance to the area he kept under cultivation, no matter how much acreage he might hold. Today's streams are significantly depleted from those times and greater care must be taken in borrowing water from your source.

You will not be the only user of the stream. You will be sharing water with others up and down the course of the water source, as well as with the native flora and fauna that depend on the stream for survival.

How much water will you divert? How much will remain in the stream?

Before you answer that, consider the following questions on water sharing.

Is there enough water to even consider diverting some of the stream flow?  Yes  No

*A key principle to follow is always return the water back to the source and return it as clean as possible.*

If you can borrow water from an 'auwai or stream, is there a way to get it back to the stream (e.g., does it have to go past 10 houses to get back to the stream; is the pipe underground)?

Yes  No

Will your water use impact the native stream life?

Yes  No

See CHAPTER THREE under MĀNO for more information on diversions and to understand why hatchling 'o'opu need properly designed diversions. Make your pipe "'o'opu friendly" by placing the lip below the stream surface.

Will your water use impact on your neighbors or downstream water users?  Yes  No  Not sure

If the answer to the last question was yes, how might it impact them?

How will you mitigate these impacts?

Will restoring loʻi water flows benefit adjacent lands, flora or fauna?

Yes       No

What do you think those benefits might be?



NOT JUST A RURAL THING!

Honolulu, as well as many of Hawaii’s smaller towns were built on top of rich taro lands, and even fishponds, oftentimes filling them in. Some ancient lo‘i kalo have actually survived urban development. A growing number of these sites are being rehabilitated.

Within city limits, where ancient remnants exist and streams, springs and seeps still hold forth life-giving waters, people are restoring kalo to the land. In the ahupua‘a of Nu‘uanu, Kalihi, Mānoa, and Pālolo, on O‘ahu; the lands of Hilo on Hawai‘i; in Waihe‘e, Wailuku, Waikapū and Lāhainā, Maui and many other places, the past is being recovered through the help of community organizations, schools, individual inspiration and passion.

Urban lo‘i restoration efforts have unique issues in working with the communities they reside in, including access and protection of rehabilitation work and the kalo as it grows. They may also need to pay greater attention to mitigating water pollution because of their location within the urban core.



## 5 People

Who are the present day water users in your ahupua‘a ?

What parts of the stream do the most local community (especially kids) use most often?

Mark those places on your map.

Take a second look at whether your water use may impact the other water users on your stream.

Can you change your overall water use or the way you use the water to avoid significant impacts?

Not everyone will have access to large sites, especially those within urban communities. You may need to consider the “path” of water as it affects the ground around the lo‘i; in other words, natural seepage.

Is your lo‘i close to your house (eg. in your immediate backyard)?

Yes       No

What will be the impact of flooding your lo‘i on your yard , the foundations of your house, or your neighbors’ houses or yards?

Are your lo'i walls or berms right on the edge of the stream bank but now there are houses along the banks as well?

Yes       No

What will be the impact of flooding your lo'i in this case?

Is the ancient system intact enough to mitigate natural flooding from rain as originally intended and protect adjacent homes?

Yes       No

Get the support of the other water users in you ahupua'a and immediate neighborhood (if possible) for your project.

**ACCESS ISSUES**

You will need to make sure that you can access your water source, diversion and 'auwai to maintain your system. Keep them clean and do repairs as damage occurs.

Do you have access to your water source?  Yes       No

Is the stream diversion on your property?  Yes       No

Is it upstream and on someone else's property?

Yes       No

If yes, do you have direct access to your diversion?  Yes       No

If you need to make a new diversion, will it be on your property?

Yes       No

Will you have direct access to that diversion?  Yes       No

Is the exit drainage and the point where it rejoins the stream on your property?  Yes       No

Does the water return to the stream through someone else's land?

Yes       No

Do you have access to this exit path for maintenance purposes?

Yes       No

**WATER USE EXAMPLES THAT MIGHT IMPACT ON YOUR ABILITY TO GROW KALO AT YOUR SITE:**

*Most of the water in the stream is being diverted for a koi pond.*

*There is a chicken, pig, horse or dairy farm whose effluent drains into the stream.*

Be aware that changing water flows and opening up lo'i may have impacts on adjacent lands as well:

*Would raising water levels in an 'auwai flood adjacent lands or reduce flows for neighboring kalo farmers?*

*Will water from your lo'i make your own parcel or adjacent lands muddy, weaken building foundations, stream banks, or damage access roads or fences?*



**THE LAW:**

The following are the constitutional and statutory provisions (the laws and rulings) which form the basis for water use in Hawai‘i. In addition, the article in *Thrum’s Hawaiian Annual* of 1893 (pg79-84) entitled “Ancient Hawaiian Water Rights” is worth reading (see APPENDIX A).

*Regarding water:*

- Hawai‘i State Constitution, Article XI, Section 7
- Hawai‘i Revised Statutes 174 C (the State Water Code)
- Hawai‘i Administrative Rules 13-167 to 13-171
- Supreme Court ruling 65 Haw. 531, 554, 656 P.2d 57, 72 (1982) *Reppun vs. Board of Water Supply*
- Supreme Court ruling 54 Haw. 174, 188, 504 P.2s 1330, 1339 (1973) *McBryde Sugar Company vs. Robinson*

At Ali‘ilani Hale Judiciary Building in downtown Honolulu, where the Supreme Court sits, is a small museum that displays the history of law from the kapu system to the present. In the small theatre you can choose to watch short clips about a variety of topics. It is a good place for you and your family to educate yourselves about water law.



## 6. Government Water Use Designations

The current zoning of your land by the State and County may have some impact on water use. In addition, there may be other designations for your water which you will need to be familiar with.

What water designations may have been determined for your stream?

- Critical Watershed Management Zone
- Heritage Stream (blue ribbon stream)
- DOH Stream Quality Limited segment list (Clean Water Act)

There may be health risks associated with these streams.

Is your stream listed in the 1990 Hawaii Stream Assessment/Land Management Plan?     Yes     No

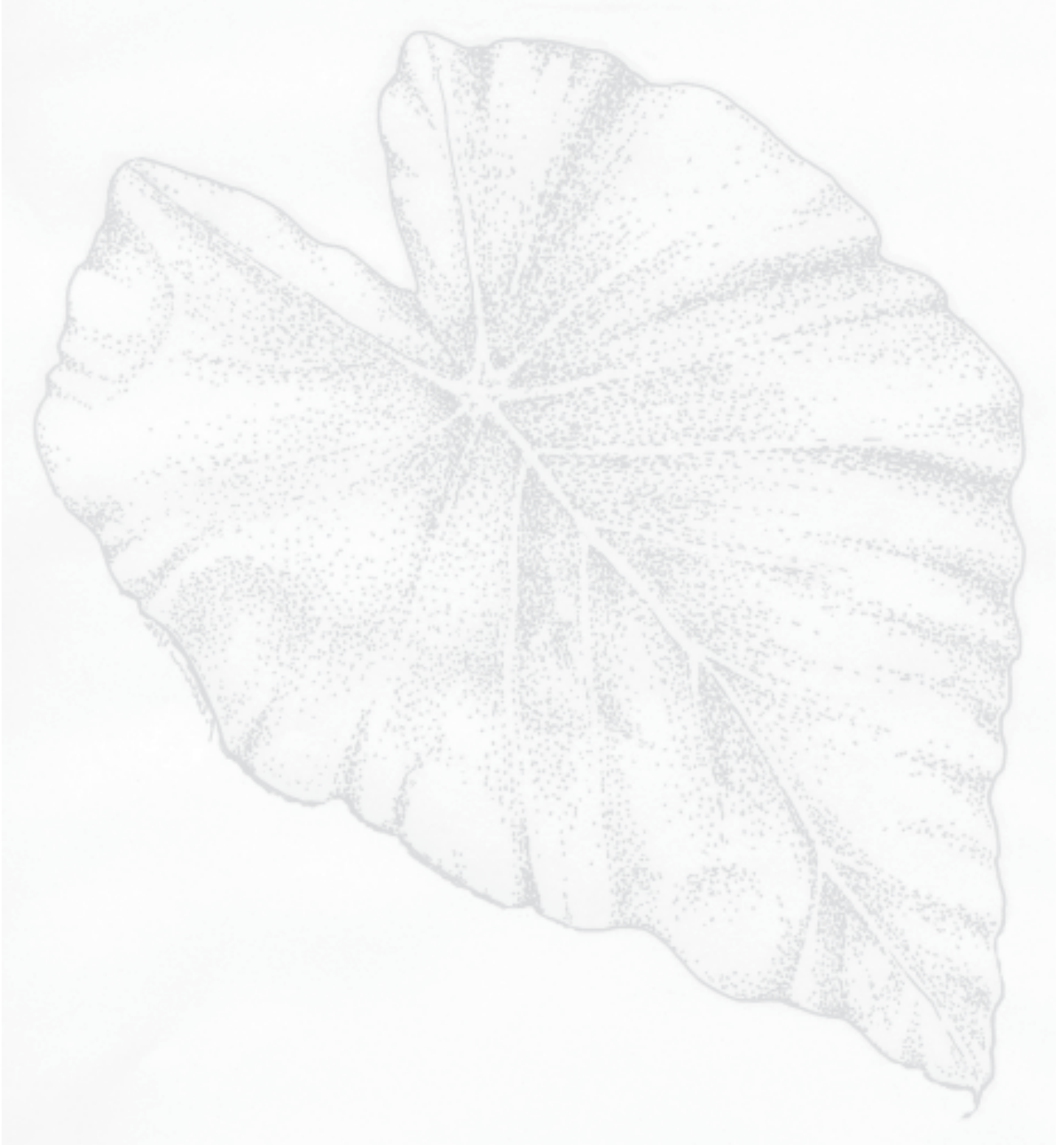
If you answered “yes” to the question of listing on the National Historic Register in the ARCHAEOLOGY portion of this Section, or any of the government designations for land or water that doesn’t mean you can’t do your project, but you will be subject to more scrutiny.

The best approach is to use the highest standards in assessing and managing your stream. Use good stewardship principles and practices.

If the condition of your stream is already degraded, what can you do to help it improve?

Is your lo‘i on kuleana land?     Yes     No

There are rights associated with kuleana lands that have to do with water, kalo and access to land for subsistence purposes that are described under the Hawaiian Tenants Rights law (Hawai‘i Revised Statute Chapter 7-1). You may want to find the native testimony on this law. It is an important piece of land and water use history.



# KEY RESOURCES AND MAPS



T. Takamiya

ʻIke no i ka lā o ka ʻike; mana no i ka lā o ka mana.  
*Know in the day of knowing; mana in the day of mana.*  
 Knowledge and mana - each has its day. Another day may bring greater  
 knowledge and greater mana than today.

This section of the GUIDELINES was probably the most difficult to put together. Our criteria for inclusion on the list looked at usefulness, readability, and quality of the information. We recognize that not everyone will have access to or is comfortable with the web yet, so, in addition, we tried to choose websites that were visually easy to read and understand and had good pictures, especially when it came to flora and fauna. Some of the oldest books were the best sources for photographs, historical practice, archaeological, and biological information. Many are out of print and we hope there are those who might consider republishing them in the future.

If you could only have one book from among the entire list of KEY RESOURCES, *Native Planters in Old Hawaiʻi* should be it. This book has been a constant reference and guide for all of us.

There are many good scientific papers on numerous topics relevant to the activities of kalo planters; but if you needed a ‘translator’ to understand them, they didn’t make it into the KEY RESOURCES. In the end, many of us went to our own bookshelves and compared notes on what we had that we thought was enlightening and useful. And, surely we have missed some that should have been included.

For every reference listed here, there will be additional resources that you think should be included, and we’ve left a blank page at the end just for that purpose. We encourage you to share those with each other.

In order to make it easier to find your way around the KEY RESOURCES, it is broken down by the topics listed on the next page. You may find some repetition in the lists. Where this occurs, it is because a book was a good reference for more than one topic. Be aware that websites may change “address” over time. Most will have a link to the new site but not always. We tried to select the ones that we thought we be around for a while.

What you won’t find in this section is where to go for the small details that belong to your place. For that you will need to go to moʻolelo, mele and oli; to old photographs and the remembrances of the kūpuna in your community; and, to the ʻāina. This is just a place to start.





**RESOURCE INDEX**

**1. Places to do research** ..... 88

    LIBRARIES ..... 88

    ARCHIVES AND MUSEUMS ..... 88

    BOTANICAL GARDENS ..... 89

    BOOKSTORES ..... 89

**2. Maps** ..... 90

    MAP RESOURCES ..... 90

    MAPS ON THE WEB ..... 90

**3. Dictionaries** ..... 93

**4. Historical information** ..... 93

    HAWAIIAN NEWSPAPERS ..... 94

    BOOKS ..... 94

**5. Archaeology** ..... 95

    HISTORIC REGISTER WEBSITES ..... 95

    BOOKS ..... 96

    ARCHAEOLOGICAL SURVEY WORK ..... 97

**6. Natural history** ..... 97

    GENERAL INFORMATION ..... 98

    FLORA ..... 98

        Books ..... 98

        Plants on the Web ..... 98

        Invasive species on the Web ..... 99

        Find out about plant and animal status ..... 99

    FAUNA ..... 100

        Books ..... 100

        Terrestrial (land) animals on the Web ..... 100

    SOILS, GEOLOGY AND EROSION ..... 100

        Soils and geology ..... 100

        Erosion control ..... 101

    CLIMATE ..... 102

        Wind and rain names ..... 102

        Weather on the Web ..... 102

    TOPOGRAPHY ..... 102

**7. Land use** ..... 102

**8. Water** ..... 103

    FLORA ..... 103

        Books ..... 103

    FAUNA ..... 103

        Books ..... 103

        Aquatic fauna on the web ..... 103

    STREAM ASSESSMENTS ..... 103

    WATER QUALITY ..... 104

        Books and websites ..... 104

9. Water use ..... 105  
 BOOKS AND REPORTS ..... 105

10. Government designations ..... 106

11. Legal ..... 107  
 BOOKS ..... 107  
 SUPEREME COURT DECISIONS AND LAWS ..... 107

12. Kalo ..... 108  
 VARIETIES ..... 108  
 CULTIVATION ..... 108  
     Books ..... 108  
     Dryland methods ..... 108  
 DISEASES ..... 109  
 TARO PESTS ..... 109  
 KALO RECIPES ..... 109

13. Resources for children and teachers ..... 110  
 VIDEOS ..... 110



**LIBRARIES AND ARCHIVES  
ON THE WEB**

The Hawai`i State Public Library System has a new site at:

[www.librarieshawaii.org](http://www.librarieshawaii.org)

Hawai`i and Pacific Section of the State Library can still be found at:

[www.hawaii.gov/hidocs/](http://www.hawaii.gov/hidocs/)

University of Hawai`i Library System is at:

[www.hawaii.edu/library](http://www.hawaii.edu/library)

Hawai`i State Archives:

<http://kumu.icsd.hawaii.gov/dags/archives>

Bishop Museum Archives:

[www.bishopmuseum.org/research/cultstud/libarch](http://www.bishopmuseum.org/research/cultstud/libarch)

**1. PLACES TO DO RESEARCH**

**LIBRARIES**

*The public library system.* Each library in the system will have varying levels of resources depending on the size of the community and how long that particular library has been established. The State Library in downtown Honolulu probably has the largest general reference materials collection in the system, including Hawaiian materials, maps and aerial photographs, as well as books on a wide variety of subjects.

*The University of Hawai`i library system.* In addition to the extensive collection of books, journals and videos on a myriad of subjects, the UH Mānoa has two interesting sources for research related to Hawaiian culture and tradition; the *Hamilton Library Hawaiian and Pacific Collection* and the *Oral History Project*, located in the Ethnic Studies Department. Both these resources, and the *Bishop Museum Archives* (see more below) also have tape recordings of mele, oli, interviews, as well as videos, that represent rare recordings of the voices of our kūpuna. The *Hamilton Library map room* in the basement is a great source of maps. You will also find government documents in an adjacent room. The UH Hilo campus library is equally well-resourced.

All public libraries, including UH, will have copies of the regional development and community plans affecting the area they service, and often Environmental Impact Statements for proposed projects.

**ARCHIVES AND MUSEUMS**

The *State of Hawai`i Archives* and *Bureau of Conveyances* (located in the Kalanimoku building) are repositories for land records, including Boundary Commission records, and native testimonies associated with the Mahele of 1848. By definition, commoners could only claim lands that they were actually living on and cultivating, so the Mahele claims often contain descriptions of lo`i kalo, boundaries, `auwai and adjacent land occupants and uses. The sketches and narratives in these original kuleana claims can often help you expand your search for information to families that may no longer reside in the area, but perhaps still have historical accounts, photos or memories of the place.

The *Bishop Museum Archives* contain a rich collection of unpublished materials, including hand written or typed historical accounts, videos, tapes and photographs. The *HEN* (Hawaiian Ethnographic Notes) collection, has many fascinating first-hand accounts. An Hawaiian newspaper collection is maintained there along with an indexing project for this valuable resource. Some *site reports* have been produced by Museum staff and are contained in the Archive. In addition, the Museum's Department of Anthropology produced for many years the *Pacific Anthropological Records*, along with numerous other reports.



Be aware, however, that the cost of accessing the collections and getting photocopies made has increased heavily over the last few years.

Several small museums act as repositories for historical documents and artifacts, including the *Mission House*, Honolulu, Oʻahu, the *Bailey Museum*, Wailuku, Maui, the *Lyman Museum*, Hilo, Hawaiʻi, and the *Kauaʻi Museum*, Lihue, Kauaʻi.

### BOTANICAL GARDENS

Botanical gardens are “libraries of flora” and are dazzling places to do research if you are looking to identify, find, or understand more about plants (native or non-native). The National Tropical Botanical Garden, Lyon and Waimea Arboretums also house extensive reference libraries on the plant kingdom and propagation facilities. Some of these gardens also retain and/or maintain ancient Hawaiian agricultural systems and structures within their grounds that are worth studying.

*National Tropical Botanical Garden* (NTBG) has several locations. *Limahuli Gardens* (kalo and native Hawaiian plants in an actively worked, and beautifully restored ancient loʻi site) and *Lawai* (plants from all over the Pacific and the world) on Kauaʻi; and *Kahanu Botanical Garden* (a collection of over 200 ʻulu varieties adjacent to Piilani Hale heiau) in Hana, Maui.

*Lyon Arboretum*, Honolulu, Oʻahu. A collection of non-native and native species, the Polynesian-introductions collection is in the process of being restored. This arboretum serves as a training site for many UH Mānoa students and also has a tissue culture lab.

*Waimea Arboretum*, Haleiwa, Oʻahu. Now under the care of the National Audubon Society, this garden hosts rare and endangered plants from all over the Pacific and the world. They maintain good collections of traditional Hawaiian food plants including kalo and kō. One of the most complete collections of the hibiscus family, including many endemic T&E Hawaiian species, resides here. The Arboretum also houses a plant quarantine facility.

*Amy Greenwell Botanical Garden*, Kailua-Kona, Hawaiʻi. This small garden is one of the only public examples of a restored ancient dryland kuaiwi (rock mulch) system, complete with a variety of traditional plants including ʻawa, maia, kalo and kō.

### BOOKSTORES

As the public’s involvement in environmental restoration efforts increases, so does their thirst for knowledge and their demand for better information. RETAIL BOOKSTORES are good for seeing what new publications are



### MORE GARDENS

*Hawaiʻi:*  
Manuka State Park features both native and introduced species.

*Kauaʻi:*  
Along with Limahuli, the NTBG system includes the Allerton and McBryde Gardens on Kauaʻi.

learn more about NTBG at:  
<http://www.ntbg.org>

*Maui:*  
Maui Nui Botanical Garden in Wailuku, Maui focuses on native dryland species and useful Hawaiian plants.  
<http://www.mnbg.org>

Keanae Arboretum, located along the Hana Highway above Keanae peninsula is a mix of tropical introductions and Polynesian introductions.

*Oahu:*  
The County’s Honolulu Botanical Gardens system includes:

- Foster Botanical Garden (downtown)
- Hoʻomaluhia (tropicals)
- Koko Crater (dryland species)
- Liliʻuokalani (Waikiki)
- Wahiawa

## MAPS ON THE WEB

The official online GIS map system for the Office of Planning has a couple of “doors” to access the site. The first address is:

<http://kumu.icsd.hawaii.gov/dbedt/gis/>

This “main menu” site has lots of maps, from 3D to demographics. The “geofeatures” tool allows you to overlay customized features on each map. You can also download a simplified version of ESRI (a data management program).

A second address is:

[www.ehawaii.gov.org/dbedt/op/html](http://www.ehawaii.gov.org/dbedt/op/html)

This site is a subset of the above site. On it you can find the following kinds of maps:

- Land Use Boundaries
- Major Land Owners
- Land Study Bureau
- ALISH
- Watershed Boundaries
- Reserve Boundaries

or try the main page at:

[www.state.hi.us/dbedt/gis/indexx/html](http://www.state.hi.us/dbedt/gis/indexx/html)

Two other useful web sites for taro farmers are the UH Hawai‘i Stream Research Center at:

[www2.hawaii.edu/hsrc/home/islemaps.htm](http://www2.hawaii.edu/hsrc/home/islemaps.htm)

This contains GIS generated maps of perennial streams on each island and information on stream monitoring projects going on in Hawai‘i, including Limahuli.

available. SECOND HAND BOOKSTORES are a great resource if you want to find your own copy of something at an affordable price.

## 2. MAPS

Maps will be the foundation documents for recording information from your site. Look at all kinds of maps, including US Geological Survey (USGS), Tax Map Key (TMK) and especially old Territorial maps, for the names of the valleys, streams, ridges and sub-divisions of your valley. The “handbook,” *From the Ground Up*, has an extensive list of where to locate all kinds of maps and a whole section on mapping at the end of Chapter 4. That list has been adapted and reprinted here to help you get started.

Blaich, Beryl and Penny Levin, eds. 1999. *From the Ground Up: A Handbook for Community-Based Land Use Planning*. Honolulu: American Planning Association, Hawai‘i Chapter.

### MAP RESOURCES

[adapted and reprinted by permission *From the Ground Up*. 1999:69-73, 81. Information has been updated where possible.]

1. *USGS maps* (United States Geological Survey). Topography, land and water forms, streets, buildings and vegetation cover. This is probably the best baseline map for your work. Hawai‘i is depicted in 151 sections (quads). Larger libraries may have these (UH does at Mānoa and in Hilo and so does the Wailuku library on Maui), which makes it possible to xerox sections of them. Otherwise, you may have to purchase these maps from a private company. Prices vary from about \$5 to \$10 per quadrangle. It is possible to order diazo-prints of old maps direct from USGS for \$10-25 per sheet (prices are estimates only).

The following website describes the different types of maps produced by USGS.

<http://mac.usgs.gov/isb/pubs/booklets/usgsmaps/usgsmaps.html> old

You can now download USGS maps and aerial photos from Terraserver for recreational, scientific, educational, and GIS use. This site explains how:

<http://rmmcweb.cr.usgs.gov/public/outreach/terraserver.html>

The DLNR-Division of Forestry and Wildlife and the DLNR-Land Survey Division often have older topographic and Forest Reserve maps with greater topographic detail.



2. *Soil classification maps* provide information on soil type, quality and production capability. Check with libraries, County or State Offices of Planning, or your local Natural Resource Conservation Service (NRCS) office. There are several types of soil maps:

LSB (Land Study Bureau)

SCS (Soil Conservation Service; now the Natural Resource Conservation Service)

ALISH (Agricultural Lands of Importance to Hawaiʻi)

LESA (Land Evaluation and Assessment)

Please note that Hawaiʻi soils are in the process of being reassessed and redescribed. Ask if updated maps are available.

3. *Climate, rainfall and temperature maps*. Source: US Weather Service; National Oceanic and Atmospheric Administration (NOAA). The *Atlas of Hawaiʻi* published by the University of Hawaiʻi Press has a good set of maps. There are two editions: 1983 and 1998. The new one has the greater detail and more up-to-date information.
4. *Ecological zones and endangered species maps* can be found on the Hawaiʻi Environmental Heritage Database. Originally with The Nature Conservancy, the database is now housed at University of Hawaiʻi. Wetland maps are also kept by the US Fish and Wildlife Service (USFWS) and the US Army Corps of Engineers.
5. *Aerial Photos* are not technically maps but are used for mapping purposes. Many of the older land classification maps are overlaid on aerial photos. Libraries sometimes have aerial photo maps, and the UH Department of Geography, Cartography Program may be able help. There are two types:

From a plane: The UH Land Study Bureau published a bound set of land classification maps in 1972 overlaid on photos from the City and County of Honolulu Planning Department.

LANDSAT maps are images from satellites. The source for these is the US Army Corps of Engineers.

6. There are two useful types of *building, structures, public institutions, and road maps* located at County Offices of Planning. These provide block-by-block details.

Sanborn Insurance Maps

ELUMS (Existing Land Use Maps)

7. *Infrastructure maps* depict water, sewer, streets, solid waste, drainage, electrical, telephone and other lines, pipes or facilities. They

The second site belongs to the US Fish and Wildlife Service (USFWS) at:

<http://wetlands.fws.gov>

To get directly to our islands go to:

<http://pacificislands.fws.gov/wnwr/nwrindex.htm>

Ahupuaʻa maps for some islands can be found at this Ahupuaʻa Action Alliance site.

[www.ahupuaa.net](http://www.ahupuaa.net)

The State Historic Preservation Office website is:

[www.state.hi/dlnr/hpd/hpinvntory.htm](http://www.state.hi/dlnr/hpd/hpinvntory.htm)

SHPO is in the process of developing a GIS map site for its inventory of historic sites. It is still in progress at this writing.



Some counties now have TMK parcel maps on the web through their county *egov* sites (O‘ahu and Maui) but be aware that as of this printing, the parcel numbers on line do not match up with the original TMK numbers and ownership and other parcel information may not be up to date.

**FEMA ON THE WEB:**  
[www.fema.gov/nfip/fmapinfo.html](http://www.fema.gov/nfip/fmapinfo.html)

**WHERE TO FIND A SOIL MAP?**  
 NRCS field offices will have soil series maps for your island. Other sources include the UH library, UH CTAHR Department of Tropical Plants and Soil Sciences, Agriculture Extension Agents or try an Agronomy and Soil Science teacher at your local college. The language of soil science is not always easy to understand. Ask them to explain what the soil type or names mean.

On the web by island and quad at:

<http://www.ctahr.hawaii.edu/soilsurvey/soils.htm>

These maps were produced in the 1970’s and are in the process of being updated. There is a load of information attached to them about soil character, behavior and capability.



often show both existing and planned capital improvements on the same map. On O‘ahu these are kept by the Department of Land Utilization or County Departments of Public Works. Utility and water companies are another source. Some are available on the web.

8. *Tax Map Keys* (TMKs) show individual parcels, ownership and give some history of ownership (e.g., Land Grants, Land Court Awards, and subdivisions). Every parcel has a number identifying the zone, section and parcel. The maps show present owners or leasees, lot square footage, easements, etc. Most main libraries will have a set for their county, however, they are likely to be out of date. It is the oldest ones, however, that may provide you with more information about kuleana locations and old family names. The TRW-REDI Realty Atlas is used heavily by planners.
9. *FIRM* (Flood Insurance Rate Maps) indicate flood hazard areas including base flood elevations and conditions for any development in each district. They are maintained by HUD (Housing and Urban Development) and FEMA (Federal Emergency Management Act maps) but are regulated by the State and Counties. Try the County Office of Planning on your island or the Department of Land and Natural Resources (DLNR).
10. *Archaeological Resource maps* identify and number historic sites. They can be found at the State Historic Preservation Office (DLNR) and some County Planning Departments.
11. *Historical maps*, information about ahupua‘a boundaries, Land Grants, Land Commission Awards, old area and street names, buildings and activities can be found at the State Archives, University of Hawai‘i Hamilton Library, Bishop Museum Archives, Hawaiian Homelands and Kamehameha Schools Bishop Estate collections.
12. *Census maps* (demographic distributions) are kept by the Department of Business, Economic Development and Tourism (DBEDT). Many are on the Office of Planning website.
13. *State and County Land Use Classification maps* (zoning) divide the state into Conservation, Agriculture, Rural and Urban designations. They are tied to zoning ordinances, specify allowed uses, densities and setbacks. These maps can be found at State and County Planning Offices (including *Shoreline Management Area* and *Special District* maps) and on the web. An interactive CD Rom for City and County of Honolulu GIS maps is available. It uses a Window operating system and allows you to create customized maps. The University of Hawai‘i Map Room at Hamilton Library has a copy or ask the Planning Office. HonBlu sells the CD but it runs over \$500.

14. *County plans* (general, regional and development) contain maps that guide overall development county-wide or within a sub-region of a county. Maps contained in these plans will provide you with an overview of what is being planned for the area you might be working in (think water resources reallocations, property values etc.). Hawai‘i and Maui Counties have placed their most recently proposed rezoning maps on the web.

#### ▲ NOTE ABOUT MAP SCALES:

All maps have a scale of reduction from actual size. Large scale includes USGS maps (1:240,000). A medium scale example is a County zoning map (1:400). TMK maps are small scale at 1:40. The smaller the scale the greater the accuracy.

### 3. DICTIONARIES

The *Hawaiian Dictionary*, first published in 1957, has always been a wealth of information about places, legends, flora and fauna, the winds and the rains, and the many words associated with kalo farming, making poi and eating it. In addition, Lorrin Andrews dictionary, originally published in 1865 and the basis for Pukui and Elbert’s volume, was re-issued in 2003.

Andrews, Lorrin. 2003. *A Dictionary of the Hawaiian Language*. Waipahu: Island Heritage Publishing.

Kent, Harold W. 1986. *Treasury of Hawaiian Words in One Hundred and One Categories*. Honolulu: Masonic Public Library of Hawaii.

Pukui, Mary Kawena and Samuel H. Elbert. 1986. *Hawaiian Dictionary*. Revised and enlarged. Honolulu: University of Hawaii Press.

Pukui, Mary Kawena, Samuel H. Elbert and Esther T. Mookini. 1974. *Place Names of Hawaii*. Revised and expanded. Honolulu: University of Hawaii Press.

### 4. HISTORICAL INFORMATION

Historical information includes legends, stories, records of ancient and historical events and places, and other information that will help you discover the many layers of use at your site.



The Hawaiian Dictionary is now on the web at:

<http://www.olelo.hawaii.edu/>

Designed by UH Hilo’s Kuamo’o office, you can access the dictionary, Hawaiian newspapers and other Hawaiian language resources by clicking on the Ulukau Hawaiian Electronic Library icon on the Kualono home page, or go directly to the English language version at:

<http://ulukau.org/english.php>

**HAWAIIAN NEWSPAPERS** are a huge resource for historical information from the mid-1800's to the 1930's that has yet to be fully tapped. If you can't read Hawaiian, look for translations. Two of the more recent translation and indexing projects are:

*The Indexing Project*, under the direction of Edith McKinzie, at the Bishop Museum. Rather than full translations, the index provides short abstracts in English of what each edition of a newspaper contains. "A view of history as it was being made." The project also continues the work started by Rubellite K. Johnson and her Hawaiian language students at the University of Hawai'i indexing *Ka Nūpepa Kū'oko'a*.

*Ka Ho'olina: Puke Pai 'Ōlelo Hawai'i (The Legacy: Journal of Hawaiian Language Sources)* is another indexing project (2002). Kalena Silva is the editor of this bi-annual journal which provides both the Hawaiian and English translations. Kamehameha Schools Press and the University of Hawaii Press are collaborating on this effort.

#### **BOOKS**

Beckwith, Martha Warren. 1970. *Hawaiian Mythology*. Honolulu: University of Hawaii Press.

Devaney, Dennis M., et al. revised and updated 1982. *Kāne'ohē: A History of Change*. Honolulu: The Bess Press

Emory, Kenneth. 1924. *Island of Lanai*. Bulletin no. 12. Honolulu: Bernice P. Bishop Museum.

Fornander, Abraham. 1917-1919. *The Fornander Collection of Hawaiian Antiquities and Folk-lore*. Vols 4,5, and 6. Honolulu: Bernice P. Bishop Museum.

Kamakau, Samuel M. 1991. *Tales and Traditions of the People of Old (Nā Mo'olelo a ka Po'e Kahiko)*. Honolulu: Bishop Museum Press.

1976. *The Works of the People of Old; Na Hana a ka Po'e Kahiko*. Special Publication no. 61. Honolulu: Bishop Museum Press.

1964. *Ka Po'e Kahiko; The People of Old*. Honolulu: Bishop Museum Press.

- Malo, David. trans. by Dr. Nathaniel B. Emerson. 1898 (reprinted 1951). *Hawaiian Antiquities (Moolelo Hawaii)*. Special publication 2, second edition. Honolulu: Bernice P. Bishop Museum.
- Maunupau, Thomas K. as published in Ka Nupepa KuoKoa June 1, 1922 - March 15, 1923. N. Losch ed, trans. by M. Pukui and M. Chun. 1998. *Huakai Makaikai a Kaupo, Maui: A Visit to Kaupō, Maui*. Honolulu: Bishop Museum Press.
- Pukui, Mary Kawena. 1983. *ʻŌlelo Noʻeau: Hawaiian Proverbs and Poetical Sayings*. Special Publication no. 71. Honolulu: Bernice P. Bishop Museum .
- Pukui, Mary Kawena; Samuel H. Elbert and Ester T. Mookini. 1974. *Places Names of Hawaiʻi*. Revised and enlarged. Honolulu: University of Hawaii Press.
- Sterling, Elspeth P. 1998. *Sites of Maui*. Honolulu: Bishop Museum.
- Sterling, Elspeth P. and Catherine C. Summers. 1978. *Sites of Oahu*. Honolulu: Bishop Museum Press.
- Summers, Catherine C. 1971. *Molokai: A Site Survey*. Pacific Anthropological Records, no. 14. Honolulu: Bernice Pauahi Bishop Museum.
- Thrum, T.G. beginning about 1896 through the 1920s. *The Hawaiian Almanac and Annual* (later called *The Hawaiian Annual*). Honolulu: Thos. G Thrum

## 5. ARCHAEOLOGY

There are too many publications on this topic to list, including the many site reports that are produced by the Bishop Museum, UH Archaeology Department, DLNR Historic Preservation Office, and archaeological consultants, who are typically contracted for county, state or federally required EA/EIS survey and assessment work by private landowners and public agencies. What is listed here are some basic references which should lead you to more detailed documents specific to your site. A quick look at the bibliography of any book can lead you to the primary sources of information for any text. Check the State Library system for any EA/EIS documents from your area that may have archaeological or cultural survey requirements. A copy of those reports may be available at the library or upon request.

### THE OFFICE OF ENVIRONMENTAL QUALITY CONTROL

OEQC has copies of every EA and EIS ever completed in Hawaiʻi since the HRS 343 and HAR 11-200 environmental review laws were enacted in 1974. As of this writing OEQC has begun to scan and digitize all these records to improve access. More recently, really large EIS documents are often available on CD because of the sheer volume of the documents; a result of increasingly stricter requirements by the State, a more informed public, and better and more accurate information on flora, fauna and archaeological sites in Hawaiʻi.

While older EAs and EISs can be fairly slim on information, documents from about 1987 on will have better descriptions of flora, fauna and hydrology, although historical sites and maps information were still limited until the late 90's.

### HISTORIC REGISTER

#### WEBSITES:

The national site:  
[www.cr.nps.gov/nr/](http://www.cr.nps.gov/nr/)

In Hawaiʻi:  
[www.state.hi.us/dlnr/hpd/hpinventory.html](http://www.state.hi.us/dlnr/hpd/hpinventory.html)

[www.historichawaii.org/hawaiiregister.html](http://www.historichawaii.org/hawaiiregister.html)

[www.nationalregisterofhistoricplaces.com/HI/Hawaii/state.html](http://www.nationalregisterofhistoricplaces.com/HI/Hawaii/state.html)



**BOOKS**

An example of the wealth of information that can be learned through literature searches and archaeological survey work about a people and their agricultural practices over time in an ahupua`a is the work at Anahulu, Kaua`i described by Patrick V. Kirch and M. Sahlins.

Kirch, Patrick V. and M. Sahlins. 1992. *Anahulu: The Anthropology of History in the Kingdom of Hawaii. Vol. I: Historical Ethnography. Vol. II: The Archaeology of History.* Chicago: University of Chicago Press.

Apple, Russell A. and William K. Kikuchi. 1975. *Ancient Hawaiian Shore Zone Fishponds: An Evaluation of Survivors for Historic Preservation.* Honolulu: US Department of the Interior.

Bennett, Wendell C. 1931. *Archaeology of Kauai.* Bulletin 80. Honolulu: Bernice Pauahi Bishop Museum

DHM Planners, Inc. and Bernice Pauahi Bishop Museum. 1989 and 1990. *Hawai`i Fishpond Study: Islands of O`ahu, Maui, Lana`i and Kaua`i.* Honolulu.

Farber, Joseph M. 1997. *Ancient Hawaiian Fishponds: Can Restoration Succeed on Moloka`i?* Encinitas and Honolulu: Neptune House Publications in association with the East-West Center Pacific Islands Development Program.

Kelly, Marion. 1983. *Na Mala o Kona: Gardens of Kona.* Department of Anthropology Report no. 83-2. Honolulu: Bernice P. Bishop Museum.

Kirch, Patrick V. 1996. *Legacy of the Landscape: An Illustrated Guide to Hawaiian Archaeological Sites.* Honolulu: University of Hawai`i Press.

1994. *The Wet and the Dry: Irrigation and Agricultural Intensification in Polynesia.* Chicago: University of Chicago Press

1985. *Feathered Gods and Fishhooks: An Introduction to Hawaiian Archaeology and Prehistory.* Honolulu: University of Hawai`i Press.

Landgraf, Anne Kapulani. 1994. *Nā Wahi Pana O Ko`olau Poko: Legendary Places of Ko`olau Poko.* Honolulu: University of Hawai`i Press.

**PROJECT KĀHEA LOKO:**

A new curriculum (2003) from the Pacific American Foundation, called "The Call of the Pond" describes the types of ponds built by native Hawaiians and some pond locations, as well as their links to the uplands. This detailed teachers guide for 4th-12th grades, was produced in cooperation with Waikalua Loko Fishpond Preservation Society, the Hawai`i Department of Education and the UH Sea Grant College Program.

Sterling and Summers' *Sites of...* series contains many brief archaeological site summaries by ahupuaʻa.

#### ARCHAEOLOGICAL SURVEY WORK

Resource people exist in the community and in State agencies that can provide guidance on how best to maintain the integrity of cultural sites while restoring them to use. Archaeologists, cultural historians, practitioners and local residents are all potential resources for how to restore Hawaiian sites and features in their original style. Visit restoration projects such as the rehabilitation efforts at Limahuli Gardens on Kauaʻi. Contract archaeology is expensive, but can provide valuable information about our ancestors and their work on the land.

The UH cartography department (under the UH Geography Department) have often been able to assist in mapping large land areas. There may be an opportunity for an archaeology class or graduate student to do research or field work at your project site. Archaeological societies might also suggest resource people or information sources to help you build your store of knowledge.

*The State Historic Preservation Office (SHPO)* is the agency responsible for surveying, recording and documenting ancient and historic sites in the State. SHPO and *Nā Ala Hele* (both under DLNR) records may provide you with information about the location of archaeological structures and coastal and mauka-makai trails within your ahupuaʻa. Trail reports provide fascinating detail about the landscape, lifestyles, and livelihoods of those who utilized the ancient trails. Be forewarned that both these offices are severely under-staffed and getting access to records, if they can be found, is a slow process. They do have a document library at the main Kapolei office you can search.

The State Historic Preservation Office also houses the *State Burial Sites Program*. Each island has its own Burial Council. To find these agencies, look under Department of Land and Natural Resources in the State Government telephone listings.

## 6. NATURAL HISTORY

Natural history is the study of what has happened biologically to the land from earliest geological times to the present. It includes topics such as geology and soils, climate, native flora and fauna; the “features” that make the ecosystems of Hawaiʻi unique.

What about those ʻōlelo no ʻeau and mo ʻolelo we talked about in the introduction to CHAPTER TWO? Old pictures, descriptions of the





ahupua`a from books, Boundary Commission reports, the State Archives, Bishop Museum and other collections.

**GENERAL INFORMATION**

Carlquist, Shervin. 1980. *Hawaii: A Natural History - Geology, Climate, Native Flora and Fauna Above the Shoreline*. Lawai, Kaua`i: Pacific Tropical Botanical Garden.

Jamieson, Dean and Jim Deny. 2001. *Hawai`i's Butterflies and Moths*. Honolulu: Mutual Publishing.

Juvik, Sonia P. and James O. Juvik. 1998. *Atlas of Hawai`i*. Honolulu: University of Hawai`i Press. This book has a very general historic map of where different types of native forests used to be, along with information on geology, climate, and demographics.

Wagner, Warren L, Derral R. Herbst, and S.H. Sohmer. 1990. *Manual of the Flowering Plants of Hawai`i; Vol I.* (chapters on geology, climate and vegetation). Special Publication no.83. Honolulu: Bishop Museum Press and University of Hawai`i Press.

Ziegler, Alan C. 2002. *Hawaiian Natural History, Ecology, and Evolution*. Honolulu: University of Hawai`i Press.

**FLORA**

**BOOKS**

Abbott, Isabella Aiona. 1992. *Lā`auHawai`i: Traditional Hawaiian Uses of Plants*. Honolulu: Bishop Museum Press.

Carlquist, Sherwin. 1980. *Hawaii: A Natural History - Geology, Climate, Native Flora and Fauna Above the Shoreline*. Lawai, Kaua`i: Pacific Tropical Botanical Garden.

Haselwood, E.L. and G.G. Motter. 1966. *Handbook of Hawaiian Weeds*. Honolulu: Experiment Station, Hawaii Sugar Planters' Association.

Hemmes, Don E. and Dennis E. Desjardin. 2002. *Mushrooms of Hawai`i: An Identification Guide*. Berkeley: Ten Speed Press.

Krauss, Beatrice H. 1993. *Plants in Hawaiian Culture*. Honolulu: University of Hawai`i Press.

**PLANTS ON THE WEB:**

Type in the name of a plant. You may find all kinds of information and pictures, including the beautiful pictures on the UH Botany website by Gerald Carr.

[www.botany.hawaii.edu/faculty/carr/natives.htm](http://www.botany.hawaii.edu/faculty/carr/natives.htm)

**CANOE PLANTS**

To see the list of plants that came to these Islands with Hawaiians check out:

[www.hawaii-nation.org/canoe/contents.html](http://www.hawaii-nation.org/canoe/contents.html)

[www.pvs.hawaii.org/migrationsplants.html](http://www.pvs.hawaii.org/migrationsplants.html)

Krohn, Val Frieling. 1978. *Hawaii Dye Plants*. Honolulu: University of Hawai'i Press.

Lamoureux, Charles H. revised edition 1996. *Trailside Plants of Hawai'i's National Parks*. Hawai'i Natural History Association and National Park Service, US Department of the Interior.

Little, Elbert L. and Roger G. Skolmen. 1989. *Common Forest Trees of Hawaii (Native and Introduced)*. Handbook no. 679. Washington DC: USDA Forest Service. A good resource to find out if the trees you have are hardwood or softwood.

McDonald, Marie A. and Paul R. Weissich. 2003. *Nā Lei Makamae: The Treasured Lei*. Honolulu: University of Hawai'i Press.

Motooka, Philip et al. 2003. *Weeds of Hawaii's Pastures and Natural Areas: An Identification and Management Guide*. Honolulu: College of Tropical Agriculture and Human Resources, University of Hawai'i at Mānoa.

Neal, Marie C. 1948. *In Gardens of Hawaii*. Special Publication no. 40. Honolulu: Bernice P. Bishop Museum.

Palmer, Daniel. 2003. *Hawai'i's Ferns and Fern Allies*. Honolulu: University of Hawai'i Press.

Rock, Joseph. 1913. reprinted in 1974. *The Indigenous Trees of the Hawaiian Islands*. Honolulu: Pacific Tropical Botanical Garden and Charles E. Tuttle Co. This book contains pictures from the early 1900's that show what our native forests used to look like.

Summers, Catherine C. 1990. *Hawaiian Cordage*. Pacific Anthropological Records. Vol. 39. Honolulu: Bishop Museum Press.

Te Rangi Roa (Peter Buck). 1957. *The Arts and Crafts of Hawaii-Section I: Food*. Special publication no. 45. Honolulu: Bishop Museum. See also:  
*Section III. Plaiting*  
*Section IV. Twined Baskets*  
*Section VI. Canoes*  
*Section V. Clothing*  
*Section IX. Musical Instruments*

#### INVASIVE SPECIES ON THE WEB:

One of the most comprehensive web sites for protection of native species, information about alien species, and who is doing what about them is the Hawaiian Ecosystems At Risk project (HEAR) at:

[www.hear.org](http://www.hear.org)

To find an Invasive Species Committee, use the HEAR prefix and add:

O'ahu: [/oisc/index.html](http://oisc/index.html)  
 Kaua'i: [/kisc/index.html](http://kisc/index.html)  
 Hawai'i: [/bimac/index.html](http://bimac/index.html)  
 Maui and Moloka'i: [/misc/index.html](http://misc/index.html)

The HEAR "organizations" link sends you direct to many other plant monitoring groups in the state, including the Coordinating Group on Alien Pest Species (CGAPS).

The UH Botany Department list of invasive species:

[www.botany.hawaii.edu/faculty/cw\\_smith/aliens.htm](http://www.botany.hawaii.edu/faculty/cw_smith/aliens.htm)

#### HOW DO I FIND OUT ABOUT PLANT OR ANIMAL STATUS?

The Threatened and Endangered (T&E) species list for Hawai'i is part of a larger federal ESA list. These lists are updated regularly through the federal register and are available through DOFAW, USFWS and on the web at:

[www.fws.org](http://www.fws.org)

<http://hbs.bishopmuseum.org/endangered/endangered.html>



**TERRESTRIAL (LAND)  
ANIMALS ON THE WEB**

The Bishop Museum has a fairly comprehensive site that covers all kinds of wild life. The main natural science link is:

[www.bishopmuseum.org/research/natsci](http://www.bishopmuseum.org/research/natsci)

for insects add:  
[/ento/ento3.html](http://ento/ento3.html)

damselflies:  
[/ento/Megalagrion/htmlPages/Mega01.shtml](http://ento/Megalagrion/htmlPages/Mega01.shtml)

birds:  
[/vert/bird-images-1.html](http://vert/bird-images-1.html)

land snails:  
<http://aliens.bishopmuseum.org/d-changing/x18-disappearingSnails.html>

more about snails:  
[www.hawaii-forest.com/essays/9908.html](http://www.hawaii-forest.com/essays/9908.html)

For good bird pictures try:  
Sierra Club  
[www.travelwithchallenge.com/Hawaiian\\_Bird\\_Pictures.htm](http://www.travelwithchallenge.com/Hawaiian_Bird_Pictures.htm)

A short informative paper on insects of Hawai'i can be found at the USGS web page:

<http://biology.usgs.gov/s+t/noframe/t068.htm>

Check bats out at:  
<http://pacificislands.fws.gov/wesa/hrybatindex.html>

Valier, Kathy. 1995. *Ferns of Hawai'i*. Honolulu: University of Hawai'i Press.

Wagner, Warren L, Derral R. Herbst, and S.H. Sohmer. 1990. *Manual of the Flowering Plants of Hawai'i; Vol I and II*. Special Publication no.83. Honolulu: Bishop Museum Press and University of Hawai'i Press.

Whitney, L.D., F.A.I. Bowers and M. Takahashi. 1939. *Taro Varieties in Hawaii*. Hawaii Agricultural Experiment Station Bulletin no. 84. Honolulu: University of Hawai'i.

**FAUNA  
BOOKS**

Berger, Andrew J. 1972. *Hawaiian Birdlife*. Honolulu: University Press of Hawai'i.

Hawaii Audubon Society. 1993. *Hawaii's Birds*. Honolulu: Hawaii Audubon Society.

Howarth, Francis G. and William P. Mull. 1992. *Hawaiian Insects and Their Kin*. Honolulu: University of Hawai'i Press.

McKeown, Sean. 1996. *A Field Guide to Reptiles and Amphibians in the Hawaiian Islands*. Los Osos: Diamond Head Publishing Co.

Pratt, H. Douglas, Phillip L. Bruner and Delwyn G. Berrett. 1987. *A Field Guide to the Birds of Hawaii and the Tropical Pacific*. Princeton University Press.

Polhemus, Dan. 1996. *Damselflies: A Field Identification Guide*. Special Publicaiton no. 90. Honolulu: Bishop Museum.

**SOILS, GEOLOGY, AND EROSION  
SOILS AND GEOLOGY**

Carlquist, Sherwin. 1980. *Hawaii: A Natural History - Geology, Climate, Native Flora and Fauna Above the Shoreline*. Lawai, Kaua'i: Pacific Tropical Botanical Garden.

Gordon MacDonald in the 1960's, Harold Stearns in the 1930's and 40's and Harold Palmer in the 1920's and 30's produced a number of works on the geology and water resources of all of the main Hawaiian Islands and even Molokini, Lehua and Kaula



Islands. You can find the complete reference for their most important works in Carlquist.

Habte, M. and N.W. Osorio. 2001. *Arbuscular Mycorrhizas: Producing and Applying Arbuscular Mycorrhizal Inoculum*. Honolulu: College of Tropical Agriculture and Human Resources, University of Hawai‘i.

Land Study Bureau. 1972. *Detailed Land Classification - Island of Oahu*. LSB Bulletin no.11. Honolulu: University of Hawai‘i.

Complete soil classification maps and information are available on the web through UH CTAHR and the NRCS. <http://www.hi.nrcs.usda.gov/soils.html>

Macdonald, George A. and Agatin T. Abbott. 1970. with Frank L. Peterson, reprinted 1995. *Volcanoes in the Sea: Geology of Hawaii*. Honolulu: University of Hawaii Press.

Vitousek, P. M. et al. 2004. “Soils, Agriculture, and Society in Precontact Hawai‘i” in *Science*. Vol. 304:1665-1669.

Ziegler, Alan C. 2002. *Hawaiian Natural History, Ecology, and Evolution*. Honolulu: University of Hawai‘i Press.

#### EROSION CONTROL

The *USDA Natural Resource Conservation Service* (NRCS) is a good resource for assistance with soil and erosion control issues. They provide information, advice and assistance to help landowners improve riparian zones, design and install erosion controls. You can find a field office on each of the main islands.

Their web site outlines the many different types of information available through the Service, including a number of cost-share programs to benefit farmers and help off-set the costs of land stewardship practices.

[www.hi.nrcs.usda.gov](http://www.hi.nrcs.usda.gov)

Bradley, Joan. 1988. Reprinted 2002. *Bringing Back the Bush: The Bradley Method of Bush Regeneration*. Australia: Reed New Holland. This small field book outlines simple techniques for removing alien species with minimal soil disturbance.

Mollison, Bill. 1988. *Permaculture: A Designers' Manual*. Tyalgum, NSW Australia: Tagari Publications. This manual has an easy to understand section on soils and erosion control that is worth reading.

#### BEST MANAGEMENT PRACTICES

The State has guidelines for erosion control in stream and riparian areas that you should be aware of.

State of Hawai‘i. 1996. *Best Management Practices for Maintaining Water Quality in Hawaii*. Honolulu: Department of Land and Natural Resources, Division of Forestry and Wildlife.



**WEATHER SITES ON THE WEB:**

National Weather Service  
Forecast Office Honolulu:

[www.prh.noaa.gov/hnl/  
index.shtml](http://www.prh.noaa.gov/hnl/index.shtml)

NOAA:  
[www.noaa.gov](http://www.noaa.gov)



**CLIMATE**

**WIND AND RAIN NAMES**

Many wind and rain names can be found in the *Hawaiian Dictionary*. Kati Loke Rose compiled *Ka Ua* and *Ka Makani* (a collection of wind and rain names) from the 1971 edition of the dictionary and copies can be found at the UH and State public libraries. Brief notes by kupuna Rubelitte K. Johnson's on wind and rain names for the various islands can be found at the State Archives. The long chant famous for naming the major winds of each island is *The Wind Gourd of La'amaomao*.

Nakuina, Moses K. translated by Esther T. Mookini and Sarah Nākoa. 1992. *The Wind Gourd of La'amaomao*. Honolulu: Kalamakū Press.

NOAA and the National Weather Service, along with the newspaper, will provide you with some daily rainfall, temperature and wind information. However, if the measuring station is on the coast and you live mauka, or it's in a dry area and you live on the windward side, expect higher rainfall at your site.

**TOPOGRAPHY**

While there are no specific references for topography in Hawai'i, a good place to begin is with a USGS map which will have elevation lines that will describe the topography of the landscape. References on geology and volcanic activity might explain why the topography is shaped like it is in your area.

**7. LAND USE**

Check old maps for Land Court Award (LCA) numbers, kuleana and 'āpana family names for your parcel and adjacent lands. LCA testimonies, church records, old tax or census records may provide a clue as to prior land use. If you are lucky, some of the kama'āina families may still be in residence to talk to.

The *Bureau of Conveyances* and the *State Archives, Boundary Commission Records* are two good places to look for these.

A new website has recorded all Mahele and Boundary Commission documents in one place to assist people in land document searches. The database can be queried by island, ahupua'a, 'ili and even by key words such as "lo'i kalo." There is a \$20 download fee per record but the site has done the hard work of hunting down the documents and native testimony and translating them. [www.waihona.com](http://www.waihona.com)

## 8. WATER

### FLORA

#### BOOKS

Shluker, Andrea. 2003. *State of Hawai'i Aquatic Invasive Species (AIS) Management Plan*. Honolulu: Department of Land and Natural Resources, Division of Aquatic Resources with The Nature Conservancy of Hawai'i.

Staples, G. W. and R.H. Cowie, eds. 2001. *Hawaii's Invasive Species: A Guide to Invasive Plants and Animals in the Hawaiian Islands*. Honolulu: Mutual Publishing and Bishop Museum Press.

Reed, P. B. 1988. *National List of Plant Species That Occur in Wetlands: Hawaii (Region H)*. Biological Report no. 88. Washington, DC: US Fish and Wildlife Service.

### FAUNA

#### BOOKS AND PAPERS

Cowie, R. H. 2002. "Apple Snails (Ampullariidae) as Agricultural Pests: Their Biology, Impacts and Management." in G. M. Barker. *Molluscs as Crop Pests*. Wallingford: CABI Publishing. p.145-192.

1993. "Identity, Distribution and Impacts of Introduced Ampullariidae and Viviparidae in the Hawaiian Islands." in *Journal of Medical and Applied Malacology*. Vol. 5: 61-67

Glover, Nancy and Lisa Ferentinos, eds. 1994. *Pacific Island Farm Manual*. Honolulu: Agricultural Development in the American Pacific. This has an ID sheet for the different species of apples snails in Hawai'i.

Levin, Penny with `Onipa`a Nā Hui Kalo. 2006. *Statewide Strategic Control Plan for Apple Snails (Pomacea canaliculata) in Hawai'i*. Honolulu: funded by DLNR-Division of Aquatic Resources.

Yamamoto, Mike N. and Annette W. Tagawa. 2000. *Hawai'i's Native and Exotic Freshwater Animals*. Honolulu: Mutual Publishing.

#### STREAM ASSESSMENTS

The *Hawai'i Stream Assessment* was a preliminary appraisal of Hawaii's stream resources prepared for the State Water Commission by the Hawai'i Cooperative Park Service Unit in December 1990. This assessment was completed, in part, to fulfill the Commission's

New:

Erickson, Terrell and Christopher Puttock. 2006. *Hawai'i Wetland Field Guide*. Honolulu: Bess Press. Funded by the EPA this book is an excellent identification guide to wetland plants found in Hawai'i.

#### AQUATIC FAUNA ON THE WEB

Department of Aquatic Resources has a great site:

[www.hawaii.gov/dlnr/dar/stream\\_natives.htm](http://www.hawaii.gov/dlnr/dar/stream_natives.htm)

[aliens/stream\\_alien.htm](http://aliens/stream_alien.htm)

[geology/stream\\_geology](http://geology/stream_geology)

Jokiel's Illustrated Scientific Guide to Kaneohe Bay is on the web at:

[http://cramp.wcc.hawaii.edu/Study\\_Sites/Oahu/Kaneohe\\_Sector/](http://cramp.wcc.hawaii.edu/Study_Sites/Oahu/Kaneohe_Sector/)

A fun site for kids is this one about the 'o'opu nākea.

<http://kalaheocomplex.K12.hi.us/hamakua/Fish/oopunakea.htm>

A comprehensive website on apple snails can be found at:

<http://www.applesnail.net/>





requirement to identify rivers or streams which were to be protected as wild and scenic rivers or rivers with natural and cultural resources of exceptionally high quality.

*Hawai`i Stream Assessment*. December 1990. prepared for the Commission on Water Resource Management by the Hawai`i Cooperative Park Service Unit, Western Region Natural Resources and Research Division. Honolulu.

The UH Hawai`i Stream Research Center is an important resource for people looking at freshwater streams in Hawai`i. The Center and several graduate students are looking into such topics as freshwater fauna and limu, and water quality.

**WATER QUANTITY**

This older bulletin from the Wyoming Agriculture Extension Service is a simple methods book for measuring water flow.

Brosz, Donald J. and Richard L. Cornia. February 1973. *Irrigation Water Measurement*. Bulletin 583. Laramie: University of Wyoming.

Check with your Agriculture Extension Service to see if they have anything similar.

**WATER QUALITY**

**BOOKS AND WEBSITES**

US Environmental Protection Agency. 1997. *Volunteer Stream Monitoring: A Methods Manual*. Washington, DC: Office of Water. You can download this document from the web at: [www.epa.gov/volunteer/stream/stream.pdf](http://www.epa.gov/volunteer/stream/stream.pdf)

If you think your stream is polluted call the State Department of Health or the Environmental Planning Office. Since 1989, the Department of Health has published groundwater contamination maps for the state. Included with the maps is a list of the contaminants by well for each island, detected levels of concentration and the dates sampled. They also publish a list of Hawaii's threatened and polluted waters, available at:

[www.hawaii.gov/health/eh/epo/303dpcfinal.pdf](http://www.hawaii.gov/health/eh/epo/303dpcfinal.pdf)

A copy of the Hawai`i 2002 *303(d) List of Impaired Waters* can be found at: [http://oaspub.epa.gov/waters/state\\_rept.control?p\\_state=H](http://oaspub.epa.gov/waters/state_rept.control?p_state=H)

The EPA or the State *Standards for Water Quality* can be found on the web at: [www.epa.gov/waterscience/standards/](http://www.epa.gov/waterscience/standards/)

Or call and ask for a hardcopy at: US EPA Region 9 Office. Toll free: (866) EPA-WEST or the Pacific Islands Contact Office (PICO) at (808) 541-2710.

State:

[www.hawaii.gov/health/eh/epo](http://www.hawaii.gov/health/eh/epo)  
[www.state.hi.us/doh/rules/index.html](http://www.state.hi.us/doh/rules/index.html)

## 9. WATER USE

### BOOKS AND REPORTS

The *Water Commission's Declarations* of water use are available in two volumes. Random copies are out there (i.e. Earth Justice office has a set). Or, people can view them at the Water Commission, on the second floor of the Kalanimoku building in downtown Honolulu.

*Declaration of Water Use*. February 28, 1990. Honolulu: State of Hawai'i Commission on Water Resource Management; and September 1992. Volume II: *Locations Data Sorted by Tax Map Key*.

*Thrum's Hawaiian Annual* spans an era from later part of the 1890's to the early decades of the 20th century (1900's). You will find this series in at the State Archives. Among the varied topics of the *Annual* are descriptions of water use and cultural practice scattered throughout.

Fujimura, Faith and Williamson B. C. Chang, eds. 1981. *Groundwater in Hawai'i: A Century of Progress*. Proceedings of the Artesian Water Centennial Symposium. Presented by Cambell Estate and the Water Resources Research Center at UH Manoa, Honolulu.

Scheuer, Jonathan. 2002. *Water and Power in Hawai'i* (dissertation). Honolulu: University of Hawai'i.

State of Hawai'i. January 14, 1985. *Report of the Advisory Study Commission on Water Resources to the Thirteenth Legislature*. Honolulu: State of Hawai'i.

February 1990. *Hawai'i Water Plan: An Introduction*. Honolulu: State of Hawai'i Commission on Water Resource Management, Department of Land and Natural Resources.

June 1990. *Hawai'i Water Plan: Water Resources Protection Plan*. Honolulu: State of Hawai'i Commission on Water Resource Management, Department of Land and Natural Resources.

February 1992. *Hawai'i Water Plan, Water Quality Plan*. Honolulu: State of Hawai'i Commission on Water Resource Management, Department of Land and Natural Resources.

March 1992. *Hawai'i Water Plan: Water Resources Protection Plan Volumes 1 and 2*. Honolulu: State of Hawai'i Commission on Water Resource Management, Department of Land and Natural Resources.





June 1990. *Hawai`i i Water Plan: State Water Projects Plan*. Honolulu: State of Hawai`i Commission on Water Resource Management, Department of Land and Natural Resources.

December 28, 1994. *Review Commission on the State Water Code, State of Hawai`i*. Final Report to the Hawai`i State Legislature. Honolulu: State of Hawai`i.

January 1996. *Management Audit of the Commission on Water Resource Management: A report to the governor and the legislature of the State of Hawai`i*. Report No. 96-3. Honolulu: State of Hawai`i.

November 1996. *Will Stream Restoration Benefit Freshwater, Estuarine, and Marine Fisheries?* Technical Report 96-01. Proceedings of the October 1994 *Hawai`i Stream Restoration Symposium*. Honolulu: Department of Land and Natural Resources, Division of Aquatic Resources.

Environment Hawai`i. September 1994. *Waiahole Water: Where Will It Go When Sugar is Gone?* Vol 5 No. 3. Honolulu.

October 1994. *Waiahole Tunnel: A Drain On Windward Resources*. Volume 5, Number 4. Honolulu.

Environment Hawai`i has many articles on water issues. They can also be found on the web at:

<http://www.environment-hawaii.org>

## 10. GOVERNMENT DESIGNATIONS

The State or County Office of Planning and the Hawai`i GIS database on the web should be able to tell you if any designations are attached to your land.

The Department of Land and Natural Resources Land Use Management Division will have information on Conservation zoned lands

To view the Hawaii State Rules affecting conservation lands go to:

[www.state.hi.us/dlnr/lmd/rules/Ch13\\_5.pdf](http://www.state.hi.us/dlnr/lmd/rules/Ch13_5.pdf)

## II. LEGAL

### BOOKS

Lucas, Paul F. Nahoā. *A Dictionary of Hawaiian Legal Land-Terms*. Honolulu: Native Hawaiian Legal Corporation and University of Hawaiʻi Committee for the Preservation and Study of Hawaiian Language, Art and Culture.

MacKenzie, Melody Kapilialoha, ed. 1991. *Native Hawaiian Rights Handbook*. Honolulu: Native Hawaiian Legal Corporation and Office of Hawaiian Affairs.

McCarty, Joyce E. and Elizabeth Pa Martin. nd. *Hawaiʻi State Water Law Protecting Native Hawaiian Interests: A Primer*. Honolulu: Native Hawaiian Legal Corp.

Miike, Lawrence H. 2004. *Water and the Law in Hawaiʻi*. Honolulu: University of Hawaiʻi Press.

Turner, Tom. 2002. *Justice on Earth: Earthjustice and the People It Has Served*. White River Junction: Chelsea Green Pub. Co. A good overview of community legal battles for protection of lands and waters across the county.

### COURT DECISIONS AND LAWS

In re Water Use Permit Applications (Waiahole Ditch Decision) 94 Hawaiʻi 97.

The Hawsaiʻi Supreme Court's 2000 *Waiahole Decision* and related information, including more recent Water Commission decisions, can be viewed at: [http://www.state.hi.us/dlnr/cwrm/special/waiahole\\_cch.htm](http://www.state.hi.us/dlnr/cwrm/special/waiahole_cch.htm)

The Supreme Court decision is also available on the judiciary's website:

[www.courts.state.hi.us/page\\_server/LegalReferences/73DFB8859867A628EAE7AB3DC5.html](http://www.courts.state.hi.us/page_server/LegalReferences/73DFB8859867A628EAE7AB3DC5.html)

This link is just for the opinion. Amended versions, dissenting opinion, etc. all have separate links, at this judiciary web site.

A. Dan Tarlock, *Law of Water Rights and Resources* § 4:5 (2000).

Douglas MacDougal, *Private Hopes and Public Values in the "Reasonable Beneficial Use" of Hawaiʻi's Water: Is Balance Possible?* 18 U. Haw. L. Rev. (1996).

Hawaiʻi State Water Code, Hawaiʻi Revised Statutes Chapter 174C

Formerly known as Sierra Legal Defense Fund, *Earth Justice* has been the primary legal advocate for water rights taking on State and corporate water users and policy makers for return of waters to their original sources, as well as hold agencies to actively support water quality standards in Hawaiʻi.

on the web:  
[www.earthjustice.org/](http://www.earthjustice.org/)

Native Hawaiian Legal Corp. has also taken on water rights issues, primarily in relation to native Hawaiians and kuleana lands.

Look for new case law to be written for the island of Maui regarding water use and management of aquifers and streams. The depleted conditions of Iao aquifer are raising questions over authority and proper management.



## 12. KALO

### VARIETIES

Whitney, L.D., F.A.I. Bowers, and M. Takahashi. 1939 (reprint 1997). *Taro Varieties in Hawaii*. Hawaii Agricultural Experiment Station Bulletin no. 84. Honolulu: College of Tropical Agriculture and Human Resources, University of Hawaii

### CULTIVATION

#### BOOKS

There is no better resource for descriptions of traditional farming practices and taro cultivation in the Hawaiian Islands than the compilations of Craighill and Elizabeth Handy.

Handy, E.S. Craighill. 1940. *The Hawaiian Planter, Vol. I: His Plants, Methods and Areas of Cultivation*. Bulletin no. 161. Honolulu: Bernice P. Bishop Museum.

Handy, E.S. Craighill and Elizabeth Green Handy, with Mary Kawena Pukui. 1972. Revised 1991. *Native Planters in Old Hawaii: Their Life, Lore and Environment*. Bulletin 233. Honolulu: Bernice P. Bishop Museum.

King, N. 1936. *Dryland Taro and Its Culture*. Hawai'i Agricultural Experiment Station Agricultural Notes no. 129. Honolulu: Agricultural Extension Services.

Lambert, M. 1982. *Taro Cultivation in the South Pacific*. Handbook no. 22. Noumea, New Caledonia: South Pacific Commission

Pollack, N. J. 1993. *These Roots Remain*. Honolulu: Institute for Polynesian Studies.

#### DRYLAND METHODS

*Native Planters* and *Feather Gods and Fishhooks* are two good sources to investigate. Kirch's book *The Wet and the Dry*, along with Marion Kelly's review of the Kona planting system (all listed in the Archaeology section of the KEY RESOURCES) provide some descriptions of methods and practices as well.

The *Amy Greenwell Ethnobotanical Garden* in Kona district of Hawai'i is an excellent example of a recovered dryland cultivation system. Visit dryland kalo planters; several `ONIPA`A NĀ HUI KALO members have rehabilitated ancient dryland sites.

For those who read Hawaiian, look for these articles in the newspaper *Ka Hōkū O Hawai'i*, naming the many kalo varieties known at the turn of the century:

April 18, 1918. *Papa Inoa O Na Kalo Hawaii* by H. L. Holstein (Linekoa), Kohala (submitted April 5, 1918).

August 8, 1918. *Papa Inoa O Na Kalo Like Ole A Me Ko Lakou Ano* by Z. P. Kalokuokamaile, Napoopoo (submitted July 18, 1918)



**DISEASES**

Glover, Nancy and Lisa Ferentinos, eds. 1994. *The Pacific Island Farm Manual*. Honolulu: Agricultural Development in the American Pacific (ADAP) Project, College of Tropical Agriculture and Human Resources, University of Hawaiʻi.

Ooka, J. 1994. *Taro Diseases: A Guide for Field Identification*. Research Extension Series no. 148. Honolulu: College of Tropical Agriculture and Human Resources, University of Hawaiʻi.

also found in Wang, Jaw-Kai ed. 1983. *Taro: A Review of Colocasia esculenta and its Potentials*. Honolulu: University of Hawaii Press.

Sato, D. and A. Hara. 1997. *Taro Root Aphid*. Honolulu: College of Tropical Agriculture and Human Resources, University of Hawaiʻi.

Sedgwick, M.T. 1902. *The Root Rot of Taro*. Hawaii Agricultural Experiment Station Bulletin no. 2. Honolulu: HAES.

Pocket rot disease research has recently determined the source of this disease. For more information go to:

[http://www.ctahr.hawaii.edu/CTAHR2001/CTAHRInAction/Apr\\_02/TaroPocketRot.asp](http://www.ctahr.hawaii.edu/CTAHR2001/CTAHRInAction/Apr_02/TaroPocketRot.asp)

**TARO PESTS**

Mitchell, Wallace G. and Peter A. Maddison 1983:181-235. “Pests of Taro” in Wang, Jaw-Kai, ed. 1983. *Taro: A Review of Colocasia esculenta and Its Potentials*. Honolulu: University of Hawaii Press.

**KALO RECIPES**


Beckham, S et al, eds. 1993. *The Waiʻanae Diet Cookbook*. Waiʻanae: Waiʻanae Coast Comprehensive Health Center.

Na Lima Kokua. 1982. *Taro (Kalo) Uses and Recipes*. Limahuli, Kauaʻi: Pacific Tropical Botanical Garden.

Levin, Penny with ʻOnipa`a Nā Hui Kalo. 2006. *Statewide Strategic Control Plan for Apple Snails (Pomacea canaliculata) in Hawaiʻi*. Honolulu: funded by DLNR-Division of Aquatic Resources.

Pukui, Mary Kawena. 1967. *Poi Making*. Polynesian Cultural History. Honolulu: Bishop Museum Press.





Shintani, T. and C. Hughes. 1993. *The Wai`anae Book of Hawaiian Health*. Wai`anae: Wai`anae Coast Comprehensive Health Center.

### 13. RESOURCES FOR CHILDREN AND TEACHERS

Enos, Eric and Kersten Johnson. 1995. *A Handbook of Kalo Basics*. Wai`anae: Taro Top Publication, Ka`ala Farm Inc.

‘Ōpelu Project ‘Ohana, and Paunani Burgess, ed. nd. *From Then to Now: A Manual for Doing Things Hawaiian Style*. Wai`anae: The ‘Ōpelu Project Inc.

Hanohano, John; E.V. Smith and D. Penna. 1978. *A Trip to the Taro Patch*. Region 9 Department of Health, Education and Welfare. Courtesy of the Department of Planning and Economic Development: State of Hawai‘i.

Akana-Gooch, C., P. Niau, B. Hirai and S. Kawasaki. 1980. *Planting Taro - Ke kanu ana o ke kalo*. Hawaiian Bilingual/Bicultural Education Project. Honolulu: Department of Education.

Hollyer, James et al, eds. 1997. *Taro Mauka to Makai: A Taro Production and Business Guide for Hawai‘i Growers*. Honolulu: College of Tropical Agriculture and Human Resources, University of Hawai‘i. This book is currently being updated. The revised edition should be available in 2007.

#### VIDEOS

‘Onipa‘a Nā Hui Kalo. 2002. He Mana‘o Productions. Courtesy of Queen Lili‘uokalani Childrens Center.

*Back to the Roots*. 1994. Honolulu: Victoria Keith Productions (D.N. Hall and V. Keith producers).

*Kalo Pa‘a O Waiāhole: Hard Taro of Waiahole*. 1995. Honolulu: Na Maka o ka Aina. (This is a longer version of the video *Stolen Waters*)

**ADDITIONAL RESOURCES:**

Add your own here.



# CHAPTER THREE: THE PHYSICAL REHABILITATION PROCESS



P. LEVIN



D. P. ROCHLEN

Ua ahū ka imu, e lāwalu ka iʻa.  
*The oven is ready, let the fish wrapped in ti leaves be cooked.*  
 All preparations have been made; now let us proceed with the work.

CHAPTERS ONE and TWO were the “getting ready” part – the information gathering and planning stage of your work. This is the “getting to work” portion of the guidelines. You will see some overlap in this chapter and what you’ve covered already. For example, a task may be listed here; the details of how to complete that task, or things to consider in accomplishing that action, may be in earlier chapters. There is no beginning or end in the sequence that is described here. Rather, it is a constant, thoughtful process of review, learning, adapting and adjusting.

## 1. A SAFETY PLAN

ALWAYS THINK SAFETY FIRST.

Do you have a safety plan and first aid kit?

Yes       No. Get one.

Have a plan in case an emergency arises to get an injured person from the loʻi to help as quickly and safely as possible.

Where is the nearest help, phone, etc.?

What is the safest route from your loʻi to a place accessible to an emergency medical team and vehicle?

Does anyone in your group have First Responder, Emergency Medical or First Aid/CPR training?

Identify the work capacity at your site.

Identify work activities you will be doing, then ask:

How many people can safely work on this project/property?  
 Felling trees while others are clearing land is a dangerous combination.

Are 20 people with machetes too much (will they be working too close together to work safely)?



P. Levin

### SOME BASIC ITEMS YOU SHOULD HAVE IN A FIRST AID KIT:

- Band-aids
- Gauze pads
- Antibacterial ointment
- Eyewash
- Bee sting kit or antihistamine for allergic reactions
- Sunscreen
- Rubber gloves
- Scissors
- Tweezers
- Sewing needle (for splinters)
- Ace bandage
- Clean water
- Flash light with good batteries
- Cell phone for serious emergencies



D. Cooke

Too close for machetes but no problem for pulling weeds!

Revisit the PRINCIPLES



Adults and children have different abilities and it is important to know who can handle what types of equipment prior to the work day.

What kinds of tools and equipment are appropriate for different groups?

Are there people with the skills and experience to use these tools and equipment properly and safely?

Use the simplest version of tools that will allow you the most opportunity to reconnect. If children are working, think about machete use and other blades. Don't give them to young people unless they are accomplished and safe users. Only skilled adults should be working with chainsaws.



C. Wichman

Do you have a safe place to store tools and are they clean and in good working order?

Does your site have metal, glass, or barbed wire, nails, cans, corrugated iron?

Will you need gloves?

Should you wear shoes?

Does everyone have an updated tetanus shot?

**Ho'omanawanui.** Don't rush tasks; it is perfectly alright to go slow. The old adage, "do it right, or do it twice" rings true. Prepare yourself, do your homework, think things through, and plan activities strategically.

USE COMMON SENSE AT ALL TIMES.

## 2. LABOR FORCE AND DOCUMENTATING YOUR WORK

Handy and Handy (1972) noted that “the making of terraces, ditches, and their maintenance and the regulation of water, entailed much cooperative work and communal labor.” Those who had access to only limited resources (human labor) had small lo‘i.

Who will help you?

What about your own family?

When contemplating who will help with the large task of restoring and rehabilitating your lo‘i system, consider that in the old days building lo‘i was a “community” project that brought together many people within an ahupua‘a. Today there are machines like backhoes and chainsaws that can do the job of many people, yet, there is great value in the opportunity to build relationships while rebuilding the works of our kūpuna. While it will certainly take longer to do the work by hand, the quiet provided by low-tech manual labor allows people to “talk story” and to re-connect with each other. It is amazing what can be accomplished with community laulima and kōkua. While a chainsaw or power mower, or even a backhoe will allow a few people to get a lot of work accomplished, the noise created will isolate the workers from one another. Also, because these machines make quick work of large tasks, they have a tendency to encourage opening up more land than you can handle. Lo‘i preparation, planting, weeding and harvesting phases are primarily human work and not conducive to large tools and machines.

Think of this work as a “journey” - a journey where the scenery along the way is as important as the destination. Enjoy the journey in the company of your family, friends and neighbors. It’s a great feeling.

- Focus your thoughts before you begin work. Traditionally, pule came before starting any work or project of importance.

Have you done a preliminary layout sketch of your land before starting hand clearing?

Who will document your work?



P. Levin



P. Levin



Revisit CHAPTER TWO:  
SECTIONS I and II





- Designate a photo documentary person and a journal keeper.

Name: \_\_\_\_\_

Name: \_\_\_\_\_

- Photo document every step of your “rehabilitation” project. The “before” pictures will help you measure the progress of your work. Digital pictures allow you to share your work instantly with others, from camera to computer, to printer or over the internet.

Got film? Batteries? Photo album?

- Map what you have to start with and update your maps, every step of the way.

The pictures and a good map are invaluable records and tools should you need to justify your actions later. Be pono and practical.



P. Levin

### 3. SITE INVENTORY

#### A. FLORA AND FAUNA

Before you begin the process of clearing brush and archaeological survey, you will need to inventory the natural terrestrial and aquatic resources at your site (see CHAPTER TWO for details).

- Walk your site and inventory the flora and fauna. Record the possible uses of plants on the PLANT ID sheets provided in CHAPTER TWO: SECTION I.

Do you have a plan to recycle plants back into the land or into the community around you?

Do you have plants that need a protection plan?

- Walk your water source and inventory freshwater flora and fauna.

Do you have any native species?

Do you need a protection plan?

- Compare existing land and natural resources conditions to what the original site conditions were.

- Think through and outline the actions that will take place next. Take into account what you have found in your flora and fauna inventory and your research of the site.

In many ahupua‘a, land and soil conditions, water flows and other natural resources have changed dramatically since the original systems were developed. Your rehabilitation process and planting techniques should be determined by what is appropriate for the site and its present-day conditions.



C. Wichman

Just because you don't find native species in the stream now, doesn't mean there won't be any in the future. There is strong evidence that as stream flows are returned to their original courses and strength, that native fish and shellfish come back. *Plan for the future.*

### 3. SITE INVENTORY

#### B. ARCHAEOLOGY

There are many reasons to proceed slowly and do initial clearing by hand when you are re-establishing use of an existing lo‘i kalo system. One reason is to preserve as much of the information contained in the physical sites, features, and subsurface layers of soil as possible. The layout and structure of stone walls, paepae pōhaku, māno, ‘auwai and terraces are the physical record of Hawaiian wisdom and engineering brilliance.

- Consider an archaeological survey for your land.

If you are using these guidelines, you have probably already done many of the tasks that would go into a complete archaeological survey report.

Is there a trained archaeologist who would be willing to come to your site and increase your knowledge of the area? There are methods of subsurface testing that can be done quickly at selected locations (trenching) to recover valuable information about uses, events, even weather patterns over long periods of time.

Is there a university archaeology class or graduate student looking to do research or field work?

- Observe the landscape before you start to clear. Is there any stone or earthwork visible?

- Record, map and photograph these features before you begin to clear anything.

- Take down small plant growth (grasses, shrubs and small trees) to ground level using hand-tools. Carefully clear around stones and structures, and don't uproot anything at this stage. See 4A: BRUSH REMOVAL for more detailed steps.

By applying some thought to the sequence of your restoration tasks, you can help preserve the archaeological record until some future time when interpretive work can be done.

- As features are revealed, observe the layout pattern of the entire agriculture system...lo‘i terraces, banks and boundaries, irrigation inlets and outlets, the main ‘auwai, and most importantly their spatial relationship to each other and to the main water source.

*An archaeological survey should include, at minimum:*

1. An introduction:  
The purpose and scope of the report.
2. A description of the project area:  
Location  
Topography  
Environmental features
3. A map.
4. Historical background of the area: usually through a literature search for references to the area. This section might also include oral history that relates to the site.
5. Previous archaeological work done in the area.
6. Archaeological survey:  
Methods used in discovery  
The resulting inventory of sites and features, cultural deposits  
An analysis of any subsurface examinations.
7. Recommendations.

**A STORY FROM WAILAU**

*There's a stone wall edging the area of old terraces we were clearing to plant kalo. It is four feet wide, level with the terraces we were working but nine feet high on the side facing the terraced area below. We called it a sidewalk while walking its 500-foot length, and wondered at its massive nature, admired its construction, and wondered why all that energy was spent to build it. Also, there were large pohaku, standing like sentinels - one in the middle of a terrace, others at seemingly random locations - and stone work that gave the odd impression of short walls abruptly left unfinished. Hand-clearing was done carefully around all the stonework... no stones were moved except to replace pohaku to the vacant spot in the paepae pōhaku above, from where it had obviously tumbled.*

*Years later, a terrific storm settled over the valley and the rain poured for hours. The swollen streams above and below the land groaned...boulders the size of small cars shuddered by in the dark waters...waterfalls poured down the valley walls and a shadow of cold mist hung on the air for days. Torrents of mud broke through to the ocean from areas pigs had torn through - small diggings became raging gashes bleeding red into the sea. More water poured into the valley in several hours than had been gauged during a week of steady rain. It was wonderful. It was frightful.*

*In the morning light the purpose of the stonework was seen - the sentinel stones, and the stonewalls that seemed undone, and especially the massive wall along the lower edge of the property. All had been engineered to break the force of water, guide water, gently move water through the system of cleared terraces with such perfection that it was not even discolored. Not a speck of soil was washed out, not a single plant uprooted, and not a single stone dislodged from its place. In the midst of torrential washouts, a sheet of water no more than 4 inches deep moving slowly across each terrace in turn.*

*Nā po'e kahiko had surely seen storms worse than this, and over time had adjusted and realigned and maybe redesigned stonework to hold the land.*



S. E. Sykes

Flood waters at Wailau.

- Create a journal and map specifically to record the archaeological evidence of previous occupation that you find.

You may find small objects that indicate occupation of your site by others. Stone, bone, wood and shell artifacts are sought by many people for their value as rare pieces of antiquity. Their true value as cultural resources is in the information they yield about the history and pattern of use unique to the place where they were found. Glass, ceramic or metal artifacts are indications of more recent historic period use.



P. Levin

An 'ulu maika discovered in the process of rehabilitating an 'auwai.

- Indicate the location of any found object on your map. Once moved out of context, single objects lose their meaning. Artifacts can tell us nothing about their relationship to the whole unless the place they are found is carefully recorded.

For each object, record physical information in your journal. Was it a surface find, uncovered while working the soil (how deep)? Was it found in association with anything else (other objects, charcoal, or midden deposits, adjacent to a wall, etc)?

Record the date and location where you found the piece for your own story telling. Remember, you are only the most recent chapter in a long mo'olelo about people on the land.

- Sketch or photograph the object. Even broken pieces could provide important clues. Take measurements or place a ruler with clear markings, or an object of known size (e.g., a quarter), next to the object as a reference before taking a picture.
- Plan to leave wide buffer spaces, in the form of grassed banks to walk on, between your lo'i and the stone walls or earth berms. This will help to preserve in place a fair amount of information for future discovery. Traditional lo'i were surrounded by wide banks where one could sit to rest or work with plant materials, and where herbs and secondary crops may have grown.

It is not likely to happen, but if you discover human bones or burials, **STOP WORK IMMEDIATELY**. Cover the discovery to protect it from harm and contact the police. They will contact your island Burial Council once a determination of age has been made. Sometimes, agricultural sites were adjacent to small areas that were used for ceremonial or other purposes, or agriculture fields were expanded into habitation sites as populations grew. Be aware that history is a progression of people and activities and be prepared to deal with human remains should an inadvertent discovery be made.

- Proceed with restoration work in a way that is consistent with preservation. Destruction of historic sites is unnecessary and illegal if not properly documented. If your goal is to renew traditional use of an ancient lo'i, it should not require any changes to the existing system, only repair work.
- Follow the "blueprint" that is laid out on the land. The original pattern and design of lo'i structures is in place as a result of the engineering and environmental assessments done by Hawaiians long ago.

- ❑ Repair work should be done in a style consistent with stonework in the area. If you don't know what that style may be; find someone who does.
- ❑ Remove large roots and large trees growing out of stonework very carefully to do as little damage to cultural features as possible. The least intrusive method, whether cutting, burning or pulling, should be followed as soon as possible with reconstruction work on the stone structures they came out of (see 4B: TREE REMOVAL). Topping the trees in the wall and letting them rot in their own time is a good way to minimize damage.



#### THE IMU PIT AT LIMAHULI.

*If the land has been disturbed or covered with silt and/or sediment it can be difficult or impossible to understand what occurred at the site in ancient times. In situations like this, having an archaeologist dig some test pits can be very helpful. In the Limahuli Garden lo'i restoration project the lo'i had been damaged by the construction of Kuhio Highway over 50 years ago and also been subject to over 100 years of wild cattle, alien plants, and erosion. In spite of this, the lo'i were still very distinct and after clearing the site of small trees and brush it appeared that all of the terraces in the system were indeed old lo'i kalo.*

*Thanks to a generous grant from the Hewlett Foundation, the Garden was able to hire an archaeologist to come and map the site and do some sub-surface testing and radiocarbon dating. The mapping provided an excellent "blueprint" to follow in rebuilding the broken walls, and the subsurface testing showed that the walls had been built, and rebuilt at least twice in several locations. Yet what was most surprising of all was the discovery of an ancient imu in the middle of one of the terraces. When it was tested, the charcoal in the imu was dated at 1,000 years old! Combined with the soil profile exposed by the excavation, the discovery of the imu proved conclusively that not all of the terraces in that system were once flooded lo'i, and that some of them were used for dryland crops and possibly shelter and habitation. Without the knowledge provided by the archaeologist, the Garden could have incorrectly created flooded lo'i on these "dry-land" terraces and thus destroyed this important evidence of how the site was originally used. This would not have been pono, and probably not practical either. Our kupuna built the lo'i system the way they did for a very good reason. While we may not know what that reason is today, we should honor their mana'o and mālama their works as best we can.*

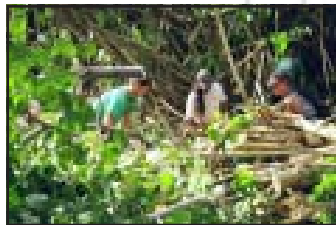


The distance from the wall to the planted area is a little over 3 feet. Note the dead tree stumps in the wall.



C. Wichman

Lo'i walls visible underneath the vegetation.



C. Wichman

Clearing and stacking hau branches.



P. Levin

**TRADITIONAL MULCH SOURCES:**

- Mai'a (banana)
- 'ama'uma'u fern
- Hapu'u fern
- 'akolea fern
- Aeki fern
- 'ie'ie
- Kukui
- 'ulu (breadfruit)
- Hau
- Hala (pandanus)
- Nui (coconut)
- Ki
- Ginger
- Kukaepua'a grass
- Pili grass
- 'uala vines (sweet potato vines - after harvest)
- Pōhaku (stones - dryland cultivation)

*See more on traditional mulching practices in APPENDIX C.*

## 4. SITE CLEARING

### A. BRUSH REMOVAL

**Lima hana.** At this stage, hand clear the project area of under brush, vines, grass and small trees. Handheld tools such as chain saws and weed eaters, machetes, sickles, pruners, rakes and hoes are best for this work.

- Determine how to clean your site in a safe and careful manner while protecting the ancient system you are rehabilitating.
- Determine if there is a use for any plants prior to clearing. Factor this into how you clear the undergrowth and what you do with it afterwards.
- Before you begin to clear, determine a place out of the way or in the middle of a lo'i to place cut materials in order to minimize work later (no need to move brush twice).

You may have a lot of understory brush.

Is burning appropriate?

Note that there is no burning allowed in a Conservation District zone. Burning should never be considered during drought times, under windy conditions or in areas that were previously used for dump sites or military training excercises where unexploded ordnance or chemical hazards may be present. Always prepare a wide buffer zone around a burn pile.

There are several alternatives to burning. Consider these options before you light a match:

- Reuse. Woodwork, imu or fire wood, building materials or ash. Can you use the ash from your imu as a soil amendment later?
- Compost. Herbaceous plants (plants without woody stems) can be put right back into lo'i soils. Hau and kukui leaves, grasses, ferns and other plants were part of the traditional soil management regime. Even non-native limu in your stream or from the ocean can be dried out and put back into the ground.

- Chip.** Chips are good for mushy soil areas, to harden paths, and keep down weeds.

How will you bring in a chipper so that it minimizes impacts to the stone and earthwork?

Will rehabilitation require the use of other types of large equipment?

If you think so, revisit the intent of your project.

Using large equipment might seem easier and faster but consider the consequences. Rehabilitation of an ancient site goes hand in hand with protecting the integrity in the system as much as you can. A backhoe can damage the walls, ‘auwai etc. It can also damage the caprock in a streambed.

- If you decide to bring in large equipment, how will you get it onto the site and use it without damage to any part of the ancient system?
- Time the use of noisy equipment such as chainsaws and weed eaters with consideration for your neighbors. Using small tools encourages you to observe the ‘āina more intimately and allows conversations to take place.
- Leave the big trees, initially, for shade. This will help prevent a quick invasion of underbrush.
- After you have cleared as much as you possibly can by hand; observe the layout of the pā pōhaku (not all lo‘i had stone walls; you may see only earth berms). Based on what you see, refine your map of the project area showing the lo‘i system as it exists. Fill in as many details as possible.
- Take time to reflect on how far you’ve come, what you’ve learned. Celebrate your accomplishments.
- Plan – get strategic about planning the next sequence of rehabilitation activities. What’s the order of the next tasks? How can you make the process easier? Spending time thinking about these things now, will save you time and effort later.
- Consider “land banking” some of the lo‘i complex for the future. Start with one or two lo‘i; expand slowly as your capabilities grow.



C. Wichman

#### **ABOUT CHIPS:**

Some plants and tree species are allelopathic (they contain chemicals that prevent other plants from competing with them while they are alive). Even as chips they may retain such properties until they are well broken down. This can be useful if you are trying to suppress weeds on a path but not in the lo‘i. A number of tree species exhibit similar properties because their leaves are highly tannic or so dense on the ground that they suppress other growth. Eucalyptus, ironwood and kiawe chip have these qualities.

**HOW TO KILL A TREE:**

- Copper nails
- Cut and paint
- Flood the root system
- Burn the core
- A good draft horse
- A water buffalo
- Some good heavy chains, a come-along, rope...and a whole bunch of people.



P. Levin



P. Levin

**CAUTION:**

Be extremely careful in cutting Silky Oak (*Grevillea robusta*). It can be toxic to some people. Wear a long-sleeved shirt, long pants, eye protection, and a mask when cutting this tree. Don't chip it. The sawdust is an irritant to skin and in the lungs.

*Expect to find a lot of seeds sprouting from whatever trees species are around once you begin to clear and bring in the sunlight! Clearing large areas when you are only prepared to work a small portion of your site will provide you with an endless supply of invasive species in the interim. Clear only where you are ready to work.*

## 4. SITE CLEARING

### B. TREE REMOVAL

- SAFETY FIRST- a falling tree can be fatal. Don't be afraid to get professional advice or have a professional remove the trees for you.
- Know the consequences of taking down a large tree(s) before you begin.
- All the following questions need to be addressed:  
Does this tree really NEED to come out?

Which large trees should you remove and which ones can you leave?

Is the tree important to the integrity of stream bank stability?

Is the tree part of the buffer zone in the riparian area?

Do you need more sunlight? If the roots of this tree are important for bank stabilization but you need more sunlight, consider topping the tree without killing it.

Can the tree be dropped safely?

What are the constraints of removing it?

Are the trees leaning on each other or connected by heavy vines? There may be a logical sequence of removal for such cases.

Are there electrical lines, houses, lo'i walls and banks, and streambeds to avoid?

Is the surrounding area cleared of all plant growth so that you can see where the tree will fall?

How will you get the felled tree to your compost/chipping area?

What will grow naturally in place of the tree (before you plant kalo) and what kind of work will you have to do to deal with that (e.g., California grass, cane grass, other invasive weeds, and tree seedlings)?



P. Levin

- ❑ Clear the lo‘i area you are going to work of all tree roots to a reasonable depth so that you won’t injure your feet later when you are in the mud. Some roots may come from trees outside the lo‘i.
- ❑ Do not remove stumps or root systems growing on or in the lo‘i banks. Try to leave a 3 foot buffer area along the walls to preserve the archaeological record. Top the tree, keep re-growth trimmed, and allow the stump to die slowly.
- ❑ If a stump anywhere in your patch is too big to remove now, plant around it. The flooding will eventually kill it and make it easier to remove later.
- ❑ Leave trees on the project area if you are not ready to plant at this point. Your maintenance efforts will be much greater once an area begins to get full sun.
- ❑ What tree will provide your poi board, imu wood, or other useful items?



P. Levin



C. Wichman



C. Wichman

**GIFTS FROM TREES:**

*Sometimes we cut and pile the wood from trees we need to remove from an area, and a friend brings his chipper to the site when we get a pile big enough to make it a full day’s work. All the nice woodchips go into the compost pile for use later after they decompose a bit. But, sometimes we’re clearing an area where the chipper can’t go.*

*When the trees are java plum or kukui or other soft wood, we cut them up, and pile them somewhere they won’t be in the way, remembering not to compact the pile too tightly and to keep it moist. To help the decomposition process along, we plant some melon or squash or gourd vines to climb up over the pile. It will take about two years for the pile to break down into rich, black humus (compost) to add to your soil.*



K. M. Davis

## 5. EROSION CONTROL

Once you have cleared the land of things growing on it, erosion (soil moving from one place to another) becomes a primary concern. Planning the sequence of activities and limiting the size of soil disturbance (open only small areas at a time) are key to managing the movement of water and soils.

- Look for areas sensitive or vulnerable to erosion. Bare dirt erodes quickly. Weedeat, mow, or tether a grass-eating animal, rather than completely remove cover wherever you can. Smaller tools minimize erosion.
- Follow best management practices to prevent erosion and sedimentation of your stream.
- Maintain a healthy riparian zone.
- Where water channels “fall” from one section of the system to the next, reduce erosion by placing pōhaku under the “fall.” Use upturned pipes so that water flows can “bubble up” rather than pour downward.
- Close water intakes and outflows when tilling, stomping, planting, weeding, applying fertilizer, or harvesting. Wait for the mud to settle before opening the gates again.
- Keep water flows steady. Try to limit “flash flood” flows when bringing water into and out of the lo‘i to avoid washing soil out of the patch.



P. Levin



P. Levin

## 6. THE 'AUWAI

- ❑ Locate and assess the condition of the specific māno for your lo'i system and the adjoining 'auwai.
- ❑ If you have your original 'auwai, and it is in good shape, clean, repair, and level it as needed to allow water flow to each lo'i and between lo'i.

Keep in mind that traditional 'auwai structures were both stone-lined and earthen. If the structure was stone lined, be careful not to take pōhaku from one part of the system to repair another without considering the impact on the integrity of the whole. Again, think before you remove a lot of rock from the stream - especially if there are hihīwai present!

If your 'auwai is damaged or has sections missing, don't be afraid to use sections of pipe or flume to get the water to your lo'i; the 'integrity' of the system will still be there. This often makes the rehabilitation easier and can give you excellent control over the amount of water in your lo'i. You can always upgrade the system later.

From the research you have done in CHAPTER TWO, and your observations, you will know whether the landscape and the stream have changed over time and the stream bed dropped or altered course along with changes in water flows. Before you restore the 'auwai system, consider the following:

If you do have an 'auwai but due to landscape or stream changes, it is not functional, is there a way to fix it?

It may be that the stream and the land have changed too much for the ancient system to still work. If you do use PVC, laying the pipe in a trench and covering it with sod will provide some protection from sun (UV light breaks down plastics) and from mishaps with sharp tools. It will also help keep water cool. Before you bury your pipe make sure all the joints are well sealed.

If you need to create a new 'auwai, where will it be located?

- ❑ Walk and map out the path of the proposed 'auwai until you find the most suitable route.

Many ancient 'auwai covered long distances, difficult terrain, and required numerous people to build and maintain. One irrigation ditch described by W.C. Bennett in 1931 on the north side of the Koai'e River on Kaua'i was 8 miles inland deep in Waimea Canyon, ran for about 400 feet around a cliff and was elevated in some places up to 20 feet above the stream bed. Kikī-a-Ola is probably the most famous 'auwai endeavor in the Islands. The stone for this ditch was carried from 6 miles away. It was said ka po'e Menehune built it in a single night.

If your 'auwai covers a long distance, you will need to pay more attention to proper leveling. Simple tools can help you so that water flows properly into your lo'i system and out again. You might be able to borrow a transit to determine what point in the stream will allow diverted water to flow into and out of your lo'i by gravity. A hand held sight level can be bought for a few dollars or you can use a carpenter's level on top of a rock, sighting along the top of it from point to point all the way up your 'auwai.

P. Levin



**ROCKS IN THE STREAM.**

Rocks of all sizes in a stream serve to protect the stream bed and your lo'i system. They break up the energy force of fast water. They are also prime habitat for 'o'opu, 'ōpae, hī'iwai, freshwater limu and other native freshwater flora and fauna. Removing a lot of rock from the section of the stream that serves your lo'i increases the risk of scouring and undercutting. It also leaves a gap in supportive habitat for native species between the area above and the area below your site.



D. COOKE

Kaipo Faris, a stream water quality specialist and taro farmer, "reseeding" hihiwai into a stream.

- Use gravity to move your water. Traditional lo'i systems were all designed to make use of gravity flow. Pumping water may be considered an alternative for dryland irrigation if you have access to agricultural water rates or your own well. City water is cost-prohibitive. Can you afford the costs and maintenance of a pump dependent system?

If your 'auwai is still usable but damaged, can you repair it without causing further deterioration?

If it is stone lined, where will you get your stone for repair work?

- Create a way to close off the water coming into and going out of your lo'i when you are working on it to prevent the flow of muddy water back into the stream. A good sized pōhaku usually works. Rotating the mouth of the pipe upward or using a rubber "cap" are two additional easy methods.



P. Levin

You can shut off your water at your māno or at the entrance to the lo'i itself (pukawai) by having a bypass ditch.

- Wait to re-establish water flow until the mud has settled out.
- Find a way to get the water from your lo'i back into the stream from which it was taken.

Is the exit 'auwai still functional? Will you need to repair it or do you need to make a new exit path from your lo'i?

Is there room along the exit 'auwai for silt to filter out of the water before it re-enters the stream?

- Consider running the outflow water over cobbled stones or through a patch of hō'i'o (pohole), native ferns or makaloa to help cool and cleanse the water before it returns to the stream.



P. Levin

## 7. THE MĀNO

### A. LOCATION

- If you are using the original ‘auwai , see if you can find the original māno (rock dam or other type of diversion) location that raised the water level and allowed it to flow into the ‘auwai.

- If there have been changes in the stream bed and water flow, you may have to mitigate the original diversion to bring water in.

Can you repair the original diversion to use again?

If you can't repair it, will you need to relocate the māno?

If the location of the māno will be different, what is the appropriate point for your diversion now?

- Before you make or open a new diversion consider the following:

Is there a natural pool you can use as a diversion point? Pools will usually have a naturally occurring secure boulder dam.

Is there a point where you can get a steady slow fall so that water will flow easily into your ‘auwai ?

Will you need to mitigate the connecting ‘auwai for the system to run smoothly?

Is there a bend in the river or stream that will protect your intake when flooding occurs?

Your location along the stream will make a difference in the location and angle of diversion you may need in order to ensure that water does not rush into the ‘auwai or pipe too fast. If the māno is on an outside bend of the stream, leave a wider buffer zone between the intake and your lo‘i to allow flood waters to bypass your lo‘i and go over the dam.

- Mitigate for natural flooding that may occur from rain events in your lo‘i system.
- Plan for a diversion that does not impact negatively on your stream or your neighbors. Understand proper design for stream life.

#### YOUR MĀNO AND NATIVE FRESHWATER FAUNA

‘O‘opu, hihīwai and ‘ōpae all lay eggs on rocks. They hatch within a few days or a few months depending on the coldness of the water. ‘O‘opu, hihīwai must get to the ocean within 3 days or they will die and floating gets them there fastest!

So, in an amazing design of nature, tiny ‘o‘opu and hihīwai can't swim when they hatch; they can only float. ‘O‘opu do it with their heads up and their tails hanging down. These hatchlings float to the swiftest part of the stream and hitch a ride to the ocean.

Because they float at the very surface of the water it is important to place your intake pipe far enough below the surface of the water to prevent suction at the top, or face it downstream, to deflect the babies away from the pipe. There is no problem with adult fish. They are strong swimmers.

‘O‘opu float around in the ocean as part of the plankton pool for months. As soon as they return and hit fresh water they begin to metamorphasize. Their mouths actually move from the top of their heads (good for surface feeding) to the bottom (important if you are a bottom feeder), they change color (camouflage) and their tails turn. They have no choice but to go upstream! When hihīwai return their shells begin to harden and they crawl, only at night, all the way back home. That is why it is critical to keep streams clean, flowing and open from makai to mauka!



## 7. THE MĀNO

### B. REHABILITATION/CONSTRUCTION

- ❑ When rebuilding your intake, always leave enough water to maintain stream life. Physical structures should allow native freshwater fauna, such as ‘o‘opu, ‘ōpae, and hīhīwai to move freely up and down the stream.
- ❑ Consider using high-density polyethylene or PVC pipe for your intake even if you have an ‘auwai that is nearly intact. A pipe intake will make it easier to control the amount of water flowing into your system, intake velocity, and prevent stream animals from being sucked into your ‘auwai, especially larval stage ‘o‘opu, hīhīwai and ‘ōpae. The best way to make a pipe diversion ‘o‘opu friendly’ is to place the mouth of the pipe below the stream surface level.



P. Levin

A simple but effective design is the use of a five foot section of pipe twice the diameter of a transmission line that conveys water into your ‘auwai. Drill one-inch holes in the middle three feet of the five foot section and cap the end. The water will be drawn into the pipe via the many small holes that you have drilled. In this way, the volume of water is distributed over many small “intakes” thus slowing the velocity of the water entering the pipe. A further benefit of this design is that you can locate the intake pipe about a foot below the surface of the intake pond. This avoids the rubbish that typically floats on the surface water and clogs your intake. Be sure to secure your intake pipe with a chain or cable to some large boulders upstream so that it won’t be swept away in a flood. A net or screen ‘sleeve’ over the end of your pipe will also help prevent rubbish and fauna from entering your lo‘i.



- ❑ If you choose to rebuild a traditional māno or rock dam diversion, be sure to use a breakaway design so that during flood events water will continue downstream. If it doesn't break away, flood waters may increase behind the dam and undercut banks or spill over with too much force. You can use organic material such as leaf litter to plug the leaks in the dam to bring water levels up. Then, if the dam breaks, nothing that doesn't already belong in the river will be taken downstream by the water.



P. Levin



P. Levin



P. Levin

- ❑ In areas with extremely small streams, or limited water availability, there just may not be enough water to grow healthy kalo without having a negative impact on the stream. In this case, consider alternative irrigation and planting practices to manage your water-use and at the same time protect use of the stream by native organisms and other down stream users. This will of course have to be determined on a case-by-case basis. *Native Planters in Old Hawaii* (Handy and Handy 1990) is full of examples of these alternatives.



P. Levin

## 8. LO'I PREPARATION

### A. EARTH BANKS AND STONE WALLS

As you begin this important stage of your project take the time to let the land speak to you. Be prepared to go slow and be observant. Look at the lo'i and take notice of how the kūpuna built the walls and terraced the land.



P. Levin



P. Levin

- Build your banks wide enough to allow easy access between lo'i for yourself and your tools. As a general rule wide banks are less likely to leak and more forgiving of damage from crayfish and rotting tree roots. In some places, such as Waiapuka, Hawai'i the banks were intentionally narrow because of the steepness of the sites.
- Be sure to pack the soil that is put on the banks so that it is firm and will become watertight.
- Make the banks high enough to hold water. Use the subsoil from inside the lo'i to build the banks up if needed.
- Repair retaining rock walls as needed.

Carefully observe the style of wall construction at your site. Do your best to duplicate this when rebuilding. Stone wall styles differed from place to place. If you are unsure of how to preserve these works of art, consult with the kūpuna and stoneworkers from your ahupua'a before you seek outside expertise.

Do you need to replace missing pōhaku in your walls?

If your closest source for rock is in the stream at your sight, be mindful that removing stones will change the "topography" (shape) of the stream bed and the water will move accordingly. Be careful not to expose the banks or stream bed to increased risk of erosion, or your intake to silt buildup during rain events.

- Keep your banks covered with grass, or other plants, to control erosion. Keep banks well-trimmed to prevent plants from growing into and plugging up your 'auwai and lo'i system

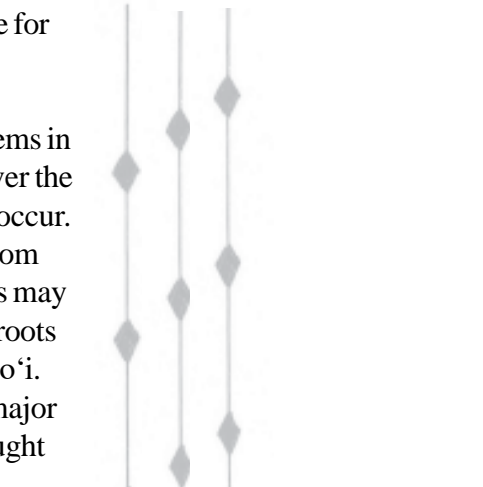


C. Wichman

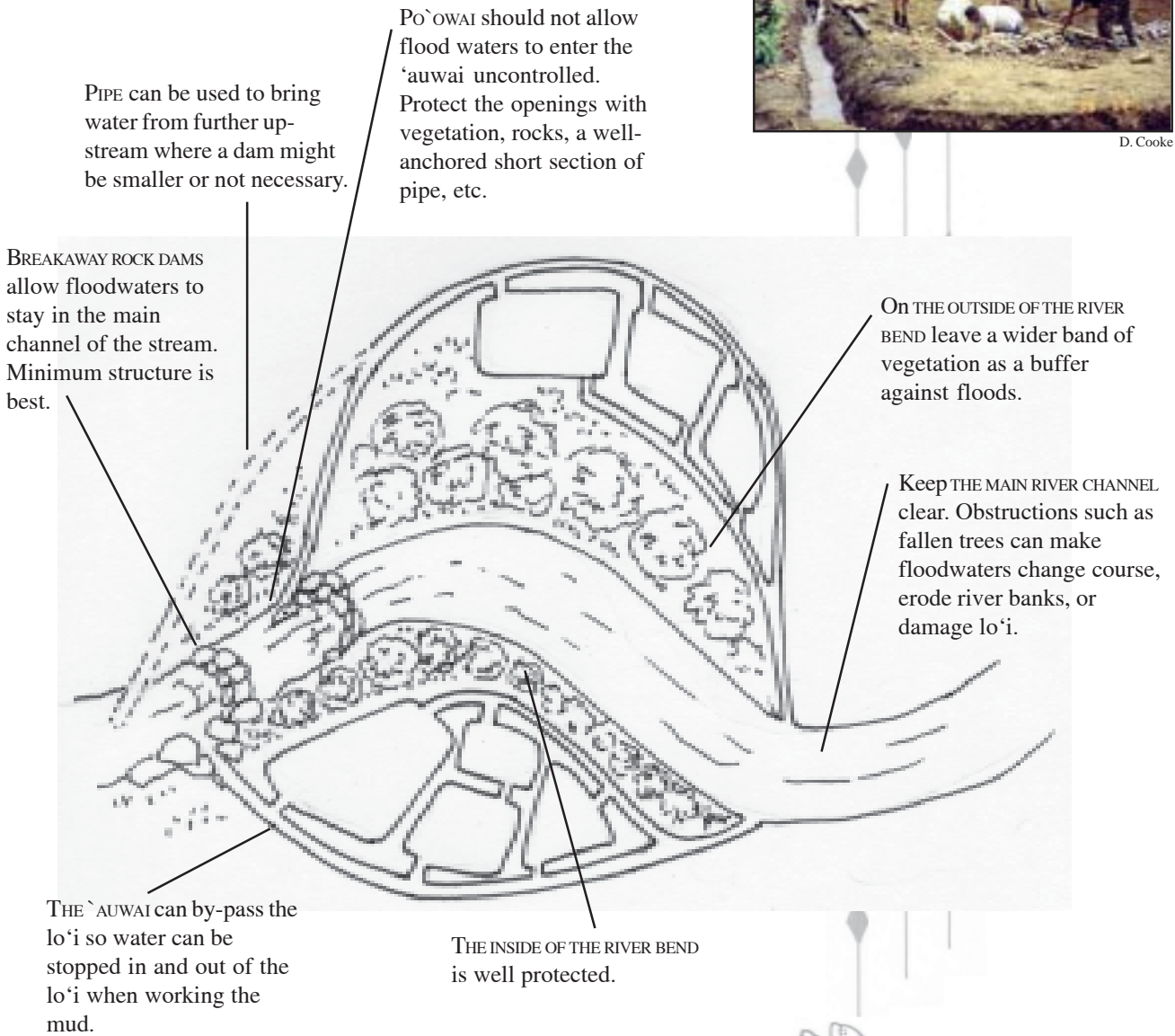
- Check for and minimize seepage and major leaks.

Lo'i are living sites that require continued attention and maintenance for as long as you grow kalo in them.

Each situation is different, but often it may be best to leave root systems in the walls and just remove the above ground portion of the trees. Over the years as they rot they may create leaks. Take care of these as they occur. Some seepage is a normal part of a lo'i system, often leaking only from one patch into the next, and causing no problems at all. Larger leaks may become problematic. However, don't feel you need to remove the roots of all trees from your stone walls at this stage of rehabilitating your lo'i. Large machines that can be used to remove tree stumps can cause major damage to the structure of the lo'i bank and walls. Give careful thought to this before you decide what to do.



D. Cooke



**PREPARING THE PATCH**

Kamakau (1976:34) describes this task in historic times as a day of great activity. “On the day of treading the lo‘i was filled with water, and the owner of the patch made ready plenty of “food” (poi), pork, and “fish.” It was a great day for the men, women, and children, and no chief or chiefess held himself too tabu to tread in the patch. Every man, woman and child bedecked himself with greenery, and worked with all his might - trampling here and there, stirring the mud with his feet, dancing, rejoicing, shouting, panting and making sport. This treading was done so that the water would not sink into the soil, and to allow the taro to grow. The taro was not planted until the next day, when the mud had settled to the bottom.”



P. Levin

**8. LO‘I PREPARATION**  
**B. BRINGING THE WATER IN**

- Before you let the water come into your lo‘i for the first time you need to think about which patches you will plant first and where the water will go when it exits those lo‘i.
- Prepare the lo‘i to hold water before you bring water through the delivery system.
- The accumulation of organic matter and silt over the years will have changed the topography of the patch. Your first step will be to level the soil. A tiller is a good tool to loosen up the soil so that it is easy to work with. Old style was an ‘ō‘ō or a hoe-like adze.



P. Levin



D. Cooke

- Before you begin to actively move soil around, shut the exit pukawai, so that muddy water will stay in the patch as you work.
- Allow enough water into the system to flood the lo‘i you want to prepare. This may take hours or days for new lo‘i that are very dry.

As the water level rises, move dirt around from high and dry spots to low areas. When you anticipate that the water in the lo‘i is sufficient to just cover all the surface when the mud is completely leveled, shut the inflow water as well. You can always add more water if needed.

- Now that you have water in your lo‘i, re-pack the banks and stomp the soil until it becomes soft mud. This may take some time, but, it is an important step that will insure that the bottom of your lo‘i is “sealed” and that your banks are water tight.

- ❑ Drag a heavy metal rake or flat board across your newly softened mud to level it. Observe the high and low spots. You will level several times as you prepare your lo'i.



C. Wichman

- ❑ Once your lo'i are sealed, it is a good time to add organic matter to build the soil. Organic matter needs time to break down adequately, either in your patch or your compost pile. Stomp or till it into the soil, then allow your lo'i time to "process" it.
- ❑ Do not return the flow of water into your lo'i until all of the mud has settled out of the water. This is a good time to observe water flow and leaks and to level the mud once again.
- ❑ If your lo'i starts to bubble after several days, you might need to dry it out to allow the organic matter to get enough oxygen to completely break down. Once you organic matter is broken down and you have leveled your lo'i you are ready to kanu i ke kalo (plant).



C. Wichman



C. Wichman

**WHAT IS ORGANIC MATTER?**  
Organic matter comes from living things - leaves, wood, flowers, fruits, egg shells, coconut husk - the stuff the earth lays down naturally to restore its soils (whether animal or plant origin; green or decayed) . Organic in agriculture also means produced without chemical fertilizers, pesticides, herbicides, antibiotics or growth hormones. It is interesting to note that Webster's Dictionary also defines organic as "forming an integral element of a whole."

**COMPOST?**  
Decayed organic matter used for rejuvenating and conditioning the soil.

Organic matter should be well decomposed before you turn it under. If it is still green, or in the process of breaking down, nutrients in the soil will expend themselves completing the composting process. Nitrogen, particularly, will be less available to plants when this happens.

**MULCH?**  
A protective covering spread over the ground to reduce evaporation, maintain even soil temperature, prevent erosion, control weeds, or enrich the soil. For most of us, mulch is also synonymous with organic matter.

**NOTE:** The phrase "black mulch" is not organic. It actually refers to black plastic that is used to keep weeds down.



**A THOUGHT ABOUT THE USE OF CHEMICALS:**

Our coastal reefs (and hence our fisheries) have taken a beating from too much nitrogen fertilizer and soil runoff. Over a century of heavy chemical applications have leached Hawaii's soils and carried contaminants into our ground water. That will take decades to undo. Just as important, kalo farming involves whole families – chemicals and kids or kūpuna don't mix. We encourage you to be organic wherever you can. There are many alternatives.

Our kūpuna were organic practitioners. They understood the complex relationships of the environment. While chemicals are labor saving, in the long run going organic represents the least possible risk to yourself, your family, community and the ecosystem and exempts you from lots of regulations.

## 9. FROM KEIKI TO HARVEST

It is beyond the scope of these guidelines to provide a manual on “how to grow” kalo. That is something that all farmers will learn in the process of doing, watching and talking to others; in the process of growing. There are things that you will only learn after you've established a relationship with the land and observed many cycles and seasons. However, there are just a few more things you should keep in mind as you embark upon this journey of learning and growth.

- KEEP GOOD RECORDS.** Observe your lo'i and listen to the 'āina. Track the seasonal changes in your lo'i system and your surrounding ecosystem. Record what you do, crop after crop, year after year - this will become invaluable information.
- BE SURE TO GET HEALTHY, DISEASE AND PEST FREE HULI TO START WITH.** To avoid transmitting pests, weed seeds, and diseases, check carefully before you accept huli from anywhere. This protects all of us. Newly hatched apple snails are especially tiny and often hide unseen in the stalk of the kalo plants. Keep a record of your taro huli 'genealogy'. Keep track of the varieties, sources, and keiki.
- MINIMIZE DISTURBANCE IN THE LO'I.** There is a balance between keeping control of the weeds and limiting the disturbance of the kalo roots. Mulch weeds back into the lo'i either by composting first or stomping them right in. Learn as you go.
- CONTINUE TO KEEP STREAM WATER CLEAN.** Before you pull weeds, harvest or otherwise disturb the mud, close the exit puka wai (water outlet) to your lo'i. Allow mud to settle before you open it again.
- KEEP NUTRIENTS IN THE LO'I.** When it is time to harvest, clean off as much of the mud and side roots from your corms in the lo'i. As you trim your huli, return old leaves to the soil. Stomp any leaf or stems you aren't going to use for food back into the mud to “feed” the next crop. The makua feeds the next generation of 'ohā.
- OVER TIME, MAINTAIN THE FERTILITY OF YOUR LO'I.** Allow it to go fallow and enrich it with compost. Let the weeds or a 'green manure' crop grow to be tilled in later. Allow yourself the time to grow kalo in a traditional manner. Over the long-term your lo'i will stay healthy and continue to produce well.

- PLAN FOR THE NEXT CROP.** If your patch doesn't have disease yet, or not much, sort the huli you will use for your next planting. Discard the ones with disease away from your patch.
- MANAGE GATES TO PROTECT YOUR `AUWAI AND LO`I SYSTEM.** Control water flows during heavy rains.
- BE MINDFUL OF THE TIMING OF WORK.** Don't let it pile up on you. Pull weeds when they are small. Regular, consistent work is the key to maintaining your system over the long term.
- KEEP IN CONTACT WITH THOSE WHO HELPED YOU IN THE REHABILITATION PROCESS.** Remember them at harvest time. Harvesting is a communal thing. Share with kūpuna and others who have shared with you.
- BE A RESPONSIBLE USER OF THE WATER.** Be aware of your kuleana to the stream and the community.

Congratulations! You have helped to keep a significant aspect of Hawaiian culture alive. The Hawaiian lo'i system was unsurpassed throughout Polynesia. Indeed, to keep this work alive is a vital link between past, present and future generations.

*E 'onipa'a i ke kalo. Kanu o ka 'āina.*



T. Takamiya

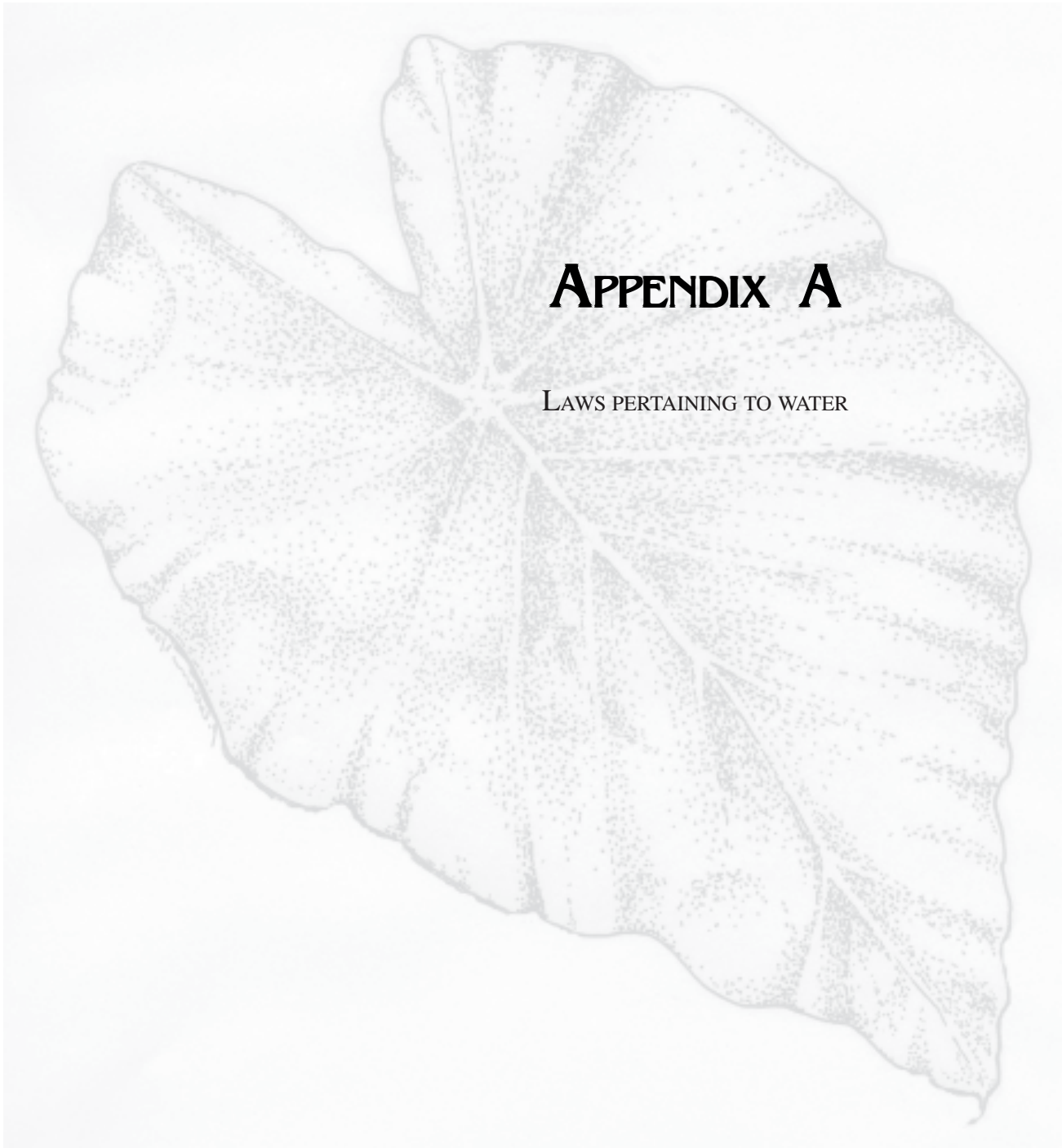
He keiki aloha na mea kanu.  
*Beloved children are the plants.*

It is said of farmers that their plants are like beloved children, receiving much attention and care.

**PAU PONO.**



K. M. Davis



# APPENDIX A

LAWS PERTAINING TO WATER

[this page left intentionally blank]

# **Hawai'i State Water Law Protecting Native Hawaiian Interests:**

## **A Primer**

*by Joyce E. McCarty & Elizabeth A. Ho'oipo Kalaena'auaookalani Pa Martin*

A true understanding of Hawaiian tradition and custom related to water is still in the early stages of development. Just as water is an integral part of life, so too is it an integral part of most, if not all, Hawaiian tradition and custom. The right to use water has always been one of the most important rights associated with land. Contrary to many western cultures, traditional Hawaiian concepts of water and land use are not tied to concepts of ownership. Hawaiian tradition and custom did not recognize inalienable title to water in relation to land use. Water, according to tradition, belongs to Kāne-i-ka-wai-ola. The ali'i nui, vested with divine power and authority, did not exercise personal dominion over water, but rather served as a trustee for the common good. Water, like sunlight, a source of life to land and man, is the possession of no man, even the ali'i nui or mō'ī.

Pua Kanaka'ole Kanahale, an expert in Hawaiian culture, described Hawaiian traditions relating to water:

Kāne is the chief deity among Hawaiian gods. The name Kāne is the male symbol for the procreative force. The word 'Kāne' means both 'male' and 'man,' and the god Kāne. Kāne is the god of procreation and was worshipped as ancestor of both chief and commoners. . . . Kāne has many benevolent forms; however, the form most associated with Kāne is that of freshwater, especially freshwater from the atmosphere and surface water of the earth. The many cloud forms from the horizon to the tops of the mountains . . . and the accompanying rainbow are Kāne forms. The very act of this water penetrating the earth is very male. The movement of the water from the upper to the lower valley is also male. The interaction of the male water movement and penetration with the female element or earth is the onset of reproduction, the act of reproducing life on earth.

. . . Our instinct to protect Kāne, our life force, is our basic instinct of survival. To have the abundance of Ka wai a Kāne or the water form of Kāne is to have an abundance of food. It was a blessing to live in the realm of Kāne or with the flowing water.

Under State law, Hawaiian water rights reside in the constitutional, statutory and common law of Hawai'i and recognize the importance of water to the survival of Hawaiians and their cultural heritage. The general framework of the state legal protections for Hawaiians is set forth in Article XII, Section 7 of the Hawai'i Constitution which provides:

The State reaffirms and shall protect all rights, customarily and traditionally exercised for subsistence, cultural and religious purposes and possessed by ahupua'a tenants who are descendants of native Hawaiians who inhabited the Hawaiian Islands prior to 1778, subject to the right of the State to regulate such rights.

The Hawai'i Revised Statutes adopts the common law of England as the law of the state with very significant exceptions. Section 1-1 establishes Hawaiian custom and tradition as a primary source of law in the state:

The common law of England, as ascertained by English and American decisions, is declared to be the common law of the State of Hawai[']i in all cases, except as otherwise expressly provided by the Constitution and laws of the United States, or by the laws of the State, or fixed by Hawaiian judicial precedent, or established by Hawaiian usage; provided that no person shall be subject to criminal proceedings except as provided by the written laws of the United States or of the State.

Section 7-1 expressly lists some of the specific custom and tradition that falls within the larger concept of Hawaiian traditional and customary practices:

Building materials, water, etc.; landlords' titles subject to tenants' use. Where the landlords have obtained, or may hereafter obtain, allodial titles to their lands, the people on each of their lands shall not be deprived of the right to take firewood, house-timber, aho cord, thatch, or ti leaf, from the land on which they live, for their own private use, but they shall not have a right to take such articles to sell for profit. The people shall also have a right to drinking water, and running water, and the right of way. The springs of water, running water, and roads shall be free to all, on all lands granted in fee simple; provided that this shall not be applicable to wells and watercourses, which individuals have made for their own use.

The Hawai'i Supreme Court has addressed the nature of certain Hawaiian traditions and customs in a number of cases where it had been asked to address the protection of traditional and customary practices under state law. Most recently, in *Public Access Shoreline Hawai'i v. Hawai'i County Planning Commission (PASH)*, 79 Hawai'i 425, 903 P.2d 1246 (1995), the court emphasized the obligation of a state agency to preserve and protect native Hawaiian rights. In its consideration of an action by the Hawai'i Planning Commission arising under the Coastal Zone Management Act ("CZMA"), the court concluded that the "legitimate customary and traditional practices must be protected to the extent feasible in accordance with article XII, section 7" and that "the State does not have the unfettered discretion to regulate the rights of ahupua'a tenants out of existence" [*PASH*, 79 Hawai'i at 451, 903 P.2d at 1272]. The court reiterated that the native Hawaiian rights protected by Article XII, Section 7 of the constitution may extend beyond the ahupua'a in which a native Hawaiian resides and that the rights protected under the constitution were not limited to those practices specifically enumerated in HRS § 7-1. The "reasonable exercise of ancient Hawaiian usage is entitled to protection" under the constitution. Moreover, the rights remain intact "notwithstanding arguable abandonment of a particular site, although this right is potentially subject to regulation in the public interest." *Id.*

The state Constitution requires the Commission on Water Resource Management to "protect ground and surface water resources, watersheds and natural stream environments" [Const. art. XI, § 7]. Because traditional and customary native Hawaiian agricultural, cultural, and religious practices depend upon clear and abundant water resources, there is a strong relationship between the viability of Hawaiian practices and the manner in which the Water Commission carries out its mandate.

The protection of Hawaiian tradition and custom runs throughout the state Water Code. The overriding policy of the Water Code is the protection and management of water resources in the public interest. As Section 2(c) of the Water Code establishes that "the protection of traditional and customary Hawaiian rights . . . [are] . . . in the public interest," the interests of Hawaiians are at the core of the Water Code. Thus, where the Water Code requires that an applicant for a water use permit must show that a proposed use of water is in the public interest [§ 49 (a)], the applicant must establish that the proposed use will not abridge or deny traditional and customary Hawaiian rights.

Similarly, Section 2 of the Water Code requires that "adequate provision shall be made for the protection of traditional and customary Hawaiian rights, the protection and procreation of fish and wildlife, the maintenance of proper ecological balance and scenic beauty, and the preservation and enhancement of waters of the State for municipal uses, public recreation, public water supply, agriculture, and navigation.". These criteria, including the protection of Hawaiian custom and tradition, must inform every decision of the Water Commission.

A basic tenet of the Water Code is that permits for the use of water resources should be provided primarily, and in some circumstances only, for "beneficial use." Specifically included as a beneficial use is "[t]he protection of traditional and customary Hawaiian rights." [§3]. In conjunction with general provisions of the Water Code, Part IX of the Water Code relates specifically to the rights of Hawaiians. The Water Code mandates that the Commission must protect traditional and customary Hawaiian rights. This is achieved through general prohibitions against the Commission's taking actions that would abridge the rights of Hawaiians and through affirmative duties of the Commission to act in a manner that protects the rights of Hawaiians. For example, Section 101(c) protects all traditional and customary Hawaiian practices or usages associated with water, specifically including the gathering of certain items and the cultivation of taro.

Section 5(3) of the Water Code requires the Water Commission to "establish an instream use protection program designed to protect, enhance, and reestablish, where practicable, beneficial instream uses of water in the State." An "instream flow standard" establishes the quantity or flow of water or depth of water which is required to be present at a specific location in a stream system at certain specified times of the year to protect fishery, wildlife, recreational, aesthetic, scenic, and other beneficial instream uses. Significantly, among the items enumerated to protect under Section 101(c) are hīhīwai, 'ōpae, 'o'opu, and limu which are found in streams and estuaries and require a healthy stream environment for their nourishment and growth. In order to protect the habitat of these beings (absent which the right to gather is meaningless), the Commission must establish instream flow standards that ensure an adequate flow to support such life. Section 174C-31(g) requires the Commission to condition water use permits "in such a manner as to protect instream flows and maintain sustainable yields of groundwater. . . ." Similarly, the mandate that the Commission preserve and protect practices and usages restricts the authority of the Commission to issue water use permits that could have a potentially adverse impact on these habitats.

An important, but under-utilized, tool available to the Water Commission is the authority to make reservations of water under section 49 of the Water Code. Section 49(d)

authorizes the Water Commission to "reserve water in such locations and quantities and for such seasons of the year as in its judgment may be necessary." The Commission is authorized "to establish reservations of water in water management areas in such quantities as are deemed necessary for purposes which are consistent with the public interest." Under section 2(c), the protection of traditional and customary Hawaiian rights is declared by the Water Code to be in the public interest. Thus, reservation of water necessary to protect the traditional and customary rights of Hawaiians is an appropriate exercise of the Water Commission's authority.

The Water Code, the Hawaiian Homes Commission Act ("HHCA") and other state law work together in providing adequate water for activities on Hawaiian home lands. The Water Code requires that planning decisions of the Water Commission "incorporate and protect adequate reserves of water for current and foreseeable development and use of Hawaiian home lands." Similarly, Section 220 of the HHCA requires that sufficient water be reserved to meet current and foreseeable needs of water for Hawaiian homesteaders.

The state's minerals and water rights law requires that the Department of Land and Natural Resources ("DLNR") and the Department of Hawaiian Home Lands ("DHHL") consult with "affected beneficiaries" in order to "develop a reservation of water rights sufficient to support current and future homestead needs" before it executes a new lease or renews an existing lease of water rights. Section 49(a) of the Water Code requires that applicants for water use permits must show that the proposed water use will not interfere with the rights of DHHL. Water use permits contain a condition that all water use rights granted under the permit are subject to the rights of DHHL. In addition, the Water Code requires the Commission to develop a Hawai'i Water Plan, which must incorporate current and foreseeable development and use needs of DHHL.

DHHL has authority to take action to provide assurances that lessees will have adequate water for the activities on homesteads that are envisioned under the Act. "The Department is authorized to carry on any activities it deems necessary to assist the lessees in obtaining maximum utilization of the leased lands, including taking any steps necessary to develop these lands for their highest and best use commensurate with the purposes for which the land is being leased." [§ 219.1]

DHHL also may demand the right to use, free of all charge, any water necessary for livestock, agriculture, aquaculture or domestic needs, from:

- all water licenses issued by the Bureau of Land & Natural Resources;
- all government-owned water not covered by license; and
- all government-owned water covered by licenses issued prior to the enactment date of July 9, 1921 which contain a reservation in favor of the public.

[HHCA § 221(d)]. To acquire government-owned water that is covered by a license issued before the passage of the HHCA (and thus, which does not include a reservation of rights for the benefit of the public or to acquire privately-owned surplus water), DHHL may exercise the right of eminent domain. [HHCA § 221(c)(2)]. The HHCA also gives DHHL the right to "develop, use, contract for, or acquire" any ditch or pipeline

constructed for the distribution and control of water necessary for use by the Department.  
[HHCA § 221(e)]

The HHCA bestows upon DHHL specific rights with respect to water on Kaua'i and Moloka'i and revenues from water leases:

- the right to use all government-owned surplus water tributary to the Waimea River on Kaua'i that is not covered by a license or which is licensed after July 9, 1921, free of charge for irrigation purposes;
- "a prior right to two-thirds of the water developed for the irrigation and water utilization project by the tunnel development extending to Waikolu valley and ground water developed west of Waikolu valley" for actual domestic and agricultural water needs. U.S. Congressional grant-in-aid payments are available for construction of the Moloka'i Irrigation and Water Utilization Project; and
- DHHL derives thirty percent (30%) of the state receipts from state water licenses and from leases of sugarcane lands [§ 1].

This article is not intended to provide an exhaustive review of the sources of legal protection for the water rights of Native Hawaiians. In addition to the provisions of the Water Code and the HHCA, numerous other laws provide protections to Hawaiians with respect to water. Many laws contain provisions such as those in the Coastal Zone Management Act (which were at issues in PASH) which protect places considered sacred by Hawaiians, or which have historical significance to Hawaiians. Such protections may augment more specific protections for Hawaiian traditional and customary practices, as well as specific provisions dealing with rights to water.

Moreover, Hawaiians are entitled to those rights under Hawaiian law which inure to the benefit of certain landowners and possessors, such as riparian rights , correlative rights , and appurtenant rights. And, as residents of the state, Hawaiians are entitled to the proper stewardship and management of all natural resources in the state which, under state law, are held in the public trust by the state.

ANCIENT HAWAIIAN WATER RIGHTS  
AND SOME OF THE CUSTOMS PERTAINING TO THEM.

[Written for the HAWAIIAN ANNUAL by Mrs. Emma Metcalf Nakuina, Commissioner of Private Ways and Water Rights, District of Kona, Oahu.]

ALL *auwais* (water courses), had a proper name, and was generally called after either the land, or the chief of the land that had furnished the most men, or had mainly been instrumental in the inception, planning and carrying out of the required work. All *auwais* tapping the main stream were done under the authority of a *Konohiki* of an *Ahupuaa*, *Ili* or *Ku*.<sup>2</sup> In some instances the *konohikis* of two or three independent lands—i.e. lands not paying tribute to each other—united in the work of *auwai* making, in which case the *konohiki* controlling the most men was always the recognized head of the work.

*Auwais*, were generally dug from *makai*—seaward or below—upwards. The *konohiki* who had the supervision of the work having previously marked out where it would probably enter the stream, the diggers worked up to that point. The different *ahupuaa*'s, *ili*'s or *ku*'s taking part in the work, furnished men according to the number of cultivators on each land. There was no limit though to the number of laborers any land might furnish, and it often happened that a small *ku* or *ili* was sometimes represented in the *auwai* making by more men than a much larger land or *ahupuaa*, and would thus become entitled to as much or more water, at the distribution of the water privileges, than were assigned larger tracts.

The dams were always a low loose wall of stones with a few clods here and there, high enough only to raise water sufficiently to flow into the *auwai*, which should enter it at almost a level. No *auwai* was permitted to take more water than continued to flow in the stream below the dam. It was generally less, for there were those living *makai* or below the same stream, and drawing water from it, whose rights had to be regarded.

Any dam made regardless of this well recognized rule, were

<sup>1</sup> Landlord or sometimes a steward representing him; term also applied to the duties that would be required of the landlord by the King.

<sup>2</sup> Terms generally used for land divisions according to size or area, although not invariably so.

levelled to the rock by the water right holders below, and at any rebuilding, delegates from each dam below were required to be present to see that a due proportion of water was left in the stream.

The general distribution of the quantity of water each independent land was entitled to was in proportion to the quota of hands furnished by each land, but subject to regulations as to distance from source of supply. This quantity was regulated by the time each had in the water rotation or division, when such land would take all or almost all the water of the *auwai* for the period of time allotted to it. This time varied in the cases of *mooaina*, *ku*, *ili* or *ahupuaa* from a few hours, half a day, a day, night, or both, to two or three days. The divisions of the day were regulated by the sun, the night by the stars.

The *konohiki* of each independent land subdivided his water time among the holders of *mooainas* (now *kuleanas*) on his *ahupuaa*, *ili* or *ku*.

The *konohiki* of the land controlling the most water rights in a given *auwai* was invariably its *luna*. He controlled and gave the proportion of water to each *mooaina* or single holding of the common people cultivating on that land.

The quantity of water awarded to each *mooaina* was according to the amount of work expended on the *auwai* and *mano* (dam) by the occupant of that *mooaina*, or by his family, as has been already stated.

Thus, a strong middle-aged man having three or four grown up sons living on the land, and sharing in whatever *konohiki* work was undertaken, would naturally be entitled to more water than the one who had only his own personal labor to depend on in any work which was for the common good. The enterprise and industry of an individual holder, while having an effect on the quantity of water he was entitled to, was subject to certain rights to be claimed. For instance, a strong able-bodied man who had not only worked himself at the opening of the *auwai* but had also induced others to help as his quota to the *konohiki* work, but had neglected to claim or utilize the amount of water he was entitled to, using only enough to irrigate the *koele*, or *konohiki* patch in his holding and one or two others for his own use, would, after a while be restricted

to the landlord's share, or patch cultivated for his

can

only of such quantity of water as would irrigate those *lois* which it had become customary for him to cultivate.

In ancient times the holders of a water right were required whenever it became their turn in the water rotation or division to go up with the *luna wai* (superintendent) to the water-head or dam to see that it was in proper condition; follow down the *auwai* from there, removing all obstructions which may have fallen in or had been carried down by the water during the night from the *kahawai* or mountain stream; shut off all branch *auwais* or runlets from the main *auwai*, except those conducting water to *lois* entitled to water at the same time, the *luna wai*—who should be with him during all this time—making the necessary division by means of a clod, stone or both; the water holder continuing to follow the water until it entered his *lois* and the *koele* in his charge.

An *ili* or *ku* may have one or two days and nights to itself, which time is subdivided among its own *mooainas*, and is the time, or portion, in the water rotation that was held by the different *kuleanas* at the time of the Land Commission. Instances occurred where *kuleana* owners, by some means, obtained more water than was their due under the *konohiki*, but to hold good, it must have been for some service or recognized benefit to all the shareholders.

The *konohiki* rights in the division of water pertaining respectively to *ahupuaa*, *ili* or *ku* remain the same, whether the land was obtained directly from the chiefs, or from the Government as Grants. The old *konohiki* water right went with the land unless the owner had previously formally relinquished, transferred, divided, or neglected it for a period of over twenty years.

Bordering on the upper portions of most *auwais* are small *lois* limited in size and number, generally on a hillside, or on the borders of a gulch. These *lois* are generally awarded *kulu* or drops; that is, they are entitled to continual dribbles of water, and no one having a water share may turn the water entirely away from them unless, in times of scarcity, it should be seen that these *lois* or *loi* were full to overflowing.

*Lois* entitled to *kulu* water have no time set apart in the regular rotation. Holders of *kulu* *lois* were subject to all the *auwai* duties.

It was a strictly enforced custom, that should any water right holder neglect to go, or furnish a substitute at the periodical *auwai* cleanings, repairs of dam, etc., water would be withheld from the land of the absentee until such time as he should see fit to resume work for the benefit of what might be termed the shareholders of that *auwai*. Independence in the matter of performing, or neglecting the water duties was very rarely indulged in by the ancient Hawaiians, as the consequences were apt to be disagreeable, for, by the time he was ready to resume them, it would perhaps happen that the landlord's attention had been directed to the neglected condition of his *mooaina*, or the *Koale* under his charge, and some fine morning he might receive a peremptory order to vacate the holding and thus be deprived of both land and home, and become a *kuewa*, (an outcast) a condition very much dreaded by the Hawaiian agriculturist, who generally inherited his holding from ancestors who had lived on the land in successive generations, paying tribute of service and produce to successive *konohikis*.

It sometimes occurred that a land originally entitled only to a small portion of water, but afterwards held or presided over by an industrious, energetic man, whose popularity attracted many to live under him, would be accorded an increased supply in consequence of his promptly furnishing as many or more hands than some land entitled to more water than his. After this had continued some time, the water-luna would recognize the justice of an increased supply for his land, and would either take a portion of water from any land failing in its due quota of hands, or as was more frequently done, simply adding a day, night, or both to the rotation; letting his land have the added time.

Any one in the olden times caught breaking a dam built in accordance with the Hawaiian's idea of justice and equity, would be slain by the share holders of that dam, and his body put in the breach he had made, as a temporary stopgap, thus serving as a warning to others who might be inclined to act similarly. Such a deed with this provocation was never openly resented, unless the one killed was a person of considerable consequence, in which case his death might precipitate a small local war.

Tradition has it though, that, in the days of the GREAT KAME-

hameha, if any chief of any district during times of peace presumed to trample on the customs honored by usage pertaining to agriculture, fishing, or any form of labor conducing to the benefit of the people, the great chief or *makua*, as he was fond of being styled, would promptly order the enforcement of the customary penalty, even on one of his immediate retainers.

Another custom well recognized and universally acquiesced in was, during the scarcity of water in dry seasons, the right of the luna wai to take water from parties having an absolute right on a given day, after their patches or *lois* were full but before their time had expired; and turn it on to any *loi* that was suffering whose turn in the rotation had not arrived. This right of the water-luna was being insisted on and exercised in some districts as late as ten years ago, and may be yet in some of the outer districts.

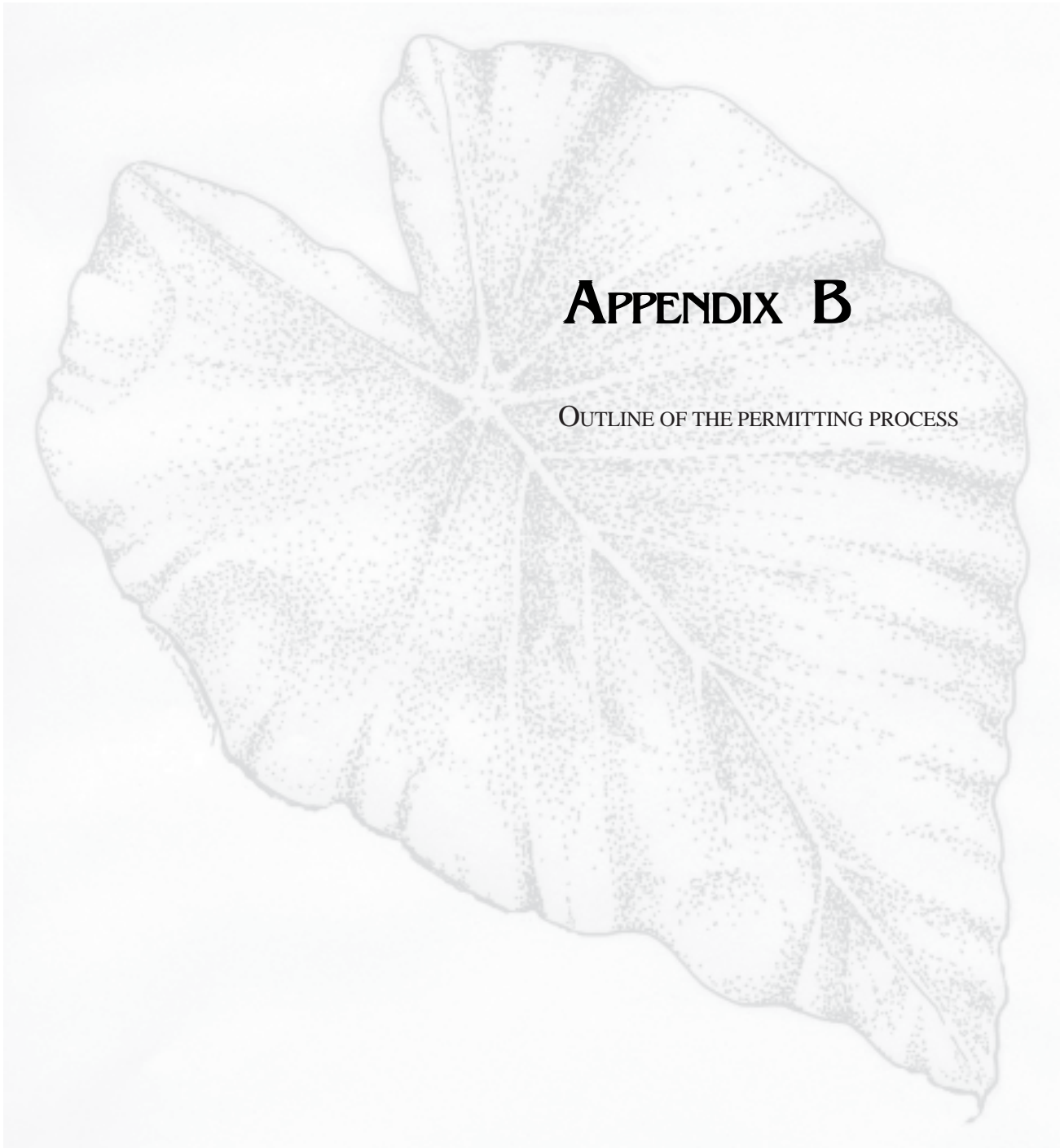
Water rights were primarily for *lois*, that is, for kalo culture. potato patches, bananas or sugar cane had no recognized claim on a water right in the rotation. The cultivation of these, regarded as dry land crops, were invariably during the rainy season except in the *Koolau* or wet districts. Sugar cane and bananas were almost always planted on *loi* banks (*kuauna's*) so as to ensure a sufficiency of moisture from the seepage or ooze between them.

In good seasons when there was plenty of water in summer, surplus water was sometimes led on to kula land and a second crop of potatoes planted, but this was never done if any *loi* or *lois* should be needing the water.

There were some curious beliefs, superstitions and rites, connected with *mano* making and water supply. When the digging of an *auwai* was completed to the satisfaction of the luna in charge of the work, a day would be set for the building of the dam. This was an occasion for rejoicing and feasting, and was never hurriedly done. The water *kahuna* or priest had to be first consulted in regard to a favorable day, which being settled, the *konohiki* was required to furnish a hog large enough to supply a good meal to all the workers of the *auwai*, red fish (*ahuluhulu*), *amaama* and *aholehole*, as well as *awa mot* for the use of the priest at the opening ceremonies, (corresponding to the box containing papers, pictures and relics in the

modern laying of a corner stone, or the bottle of champagne in the christening of a vessel); kukui-nut and *pai gaboro*. On the appointed day all the workers decked with *leis* (wreaths) of swamp fern, kowali (*convolvulus*), or yellow and green banana leaves split through the midrib, proceeded to the end of the *auwai* nearest the spot chosen for the dam, each one bearing a stick of firewood for the *imu* or oven in which the hog and other articles of food was to be baked. The *imu* was made in the *auwai* near the point where the water was to enter it; the hog, luau, potatoes and kalo, or taro were placed in it, and while these were cooking, the awa root was chewed or pounded and strained, and the fish *lawalued* (Wrapped in ti leaves and roasted over coals.)

When everything was cooked and in readiness, the water *kahuna* took the head of the hog, the fishes, and the bowl of awa juice, and going to the place where the dam was to be built made an offering of these to the water *Akua* or God. An invocation would be made and a petition that the local water god or goddess would take the dam and *auwai* under his or her especial protection, not only sending or causing a good supply of water to fill the stream at all times, so that her votaries might be blessed with good and abundant crops, but also to guard against both drought and floods as being disastrous to the planting interests. At the conclusion of his invocations he would sprinkle a few drops of awa juice in the stream; eat the eyes, ears and snout of the hog, the eyes and gills of the fishes in the name of the local deity, and return to the feast which had been spread on the bank of the new-made *auwai*, when every one was free to partake. Everything edible at this feast of consecration had to be consumed either by the people or by their dogs. All the refuse was buried in the *imu*; the dam built in a few minutes, and the water turned in to the new *auwai*; flowing directly over the now submerged *imu*. The younger folks would likely indulge in bathing in the pool formed by the dam, while the older ones with the *konohehikis* and invited guests would follow the water through the new-made *auwai*, and singers of both sexes would chant songs composed in honor of him who had planned and carried out the beneficent undertaking that would be the means of a supply of food for many.



# APPENDIX B

OUTLINE OF THE PERMITTING PROCESS

[this page left intentionally blank]

## **THE REGULATORY PROCESS**

or

**THEY WANT ME TO DO WHAT ?!**  
(just kidding)

The renewed use of lo‘i kalo may represent a simple economic opportunity or a cultural ritual. One farmer may be planting a field while another is renewing spiritual bonds with aumakua. Renewing the traditional use of lo‘i kalo may require understanding about Hawaiian protocol and the network of social obligations that kept these agriculture systems working. Traditional and modern agriculture skills must be combined to practice the best land and water management possible. Ho! So much going on in one little taro patch!

Lo‘i kalo are interesting for a wide variety of reasons. They are historic sites and they are Native Hawaiian cultural features. They require moving large volumes of water out of streams and back again. They are usually located in riparian areas, floodplains, and conservation zones. If they are kuleana lands, they have native rights attached to them and may have multiple interest holders. If they are on ceded lands, they may have multiple claimants. If they have not been used for a long time, they may retain a wealth of archaeological information. Once rehabilitated, they are wetland environments that provide habitat to native birds and other wildlife. They are culturally, environmentally, socially and historically sensitive, and rightly so.

This explains why many regulatory agencies and others interested in preservation and protection of resources may take an active interest in what you are doing. If they do, you should be prepared to provide assurances that your work will not harm sites or environment. If you do your homework before beginning, keep good records as you proceed, and manage your farm in a PONO manner, you will likely have the right answers if asked.

The common ground we share is maintaining the life of the land. Taro farmers have a direct role in stewardship of resources that are part of the public trust. Government has a role in helping assure proper management of the public trust resources. Agency people who are interested in your rehabilitation work can eventually become partners who contribute information, expertise in their field and valuable advice.

**BE AWARE OF PERMITS, AGENCIES AND COMMUNITY  
THINGS THAT MAY TRIGGER INTEREST IN YOUR WORK**

The following list of questions, permits and permissions will help you prepare.

Is the lo‘i on kuleana land?

- CWRM Checklist for Information Supporting an Appurtenant Right.  
*Once established, a permit application based on appurtenant rights cannot be denied.*
- ‘OHANA Make sure you have permission for use from *all* the right people with an interest in this kuleana.

Is the lo‘i on State of Hawaii land?

- DLNR Right of Entry permit.
- Native Hawaiian Legal Corporation *If located on ceded lands, and not being used, a special condition may exist that a request for entry by a Native Hawaiian to grow taro for subsistence purposes may not be refused.*

Is the lo‘i in a conservation district?

- DLNR Land Division Conservation District Use Application (CDUA)
- CDUA for DLNR requires an Environmental Assessment (EA) to be attached. *If approved, and there are no adverse comments from the community during the comment period, then you receive a CDUP, a Permit to Use Conservation District lands and resources!*

Are your lo‘i existing from ancient times?

- DLNR - State Office of Historic Preservation Existing lo‘i systems may be registered with SHPO. If so, a preservation plan will need to be done and monitoring required.

Generally, all lo‘i systems take water from a stream and recycle water back into the stream, and therefore you will need to check if you need the following:

- ACOE (Army Corp of Engineers) A letter describing your planned work may trigger a permit per section 404 of the Clean Water Act. Up until 2003, if the total area to be restored to use is less than one-acre, then the ACOE’s GP-95-003 General Permit for lo‘i kalo Restoration could be used. At this time, it is unknown whether this form will be renewed or not.

*If there is no in-stream dredging they will likely consider your lo‘i restoration a benign use that poses no harm to environment or people, and will send you a “go ahead” letter. Keep that on hand to show the Dept of Health, since they are in charge of water quality.*

- ❑ Dept of Health *If ACOE doesn't give you a letter (they have concerns), then you need to also provide the DOH with a Best Management Practices plan.*
- ❑ DLNR-Division of Aquatics *What aquatic life is in your stream? How can you manage your water use so that you don't affect their life cycles?*
- ❑ DLNR-CWRM Stream Diversion Works Permit *What kind of diversion is it? Who will build and who will maintain it? Who is the landowner (signature required)? What's the average annual stream flow? How much will you take and for what use? How will you control and measure flow?*
- ❑ DLNR-CWRM Stream Channel Alteration Permit *Will you be filling, excavating, dredging or disposing of anything in the stream channel? What will construction methods, time and temporary facilities be? Do you have liability coverage for the construction period? They ask for a topographic site plan, location map, and proposed construction plan. What are the possible alternatives and their relative costs and benefits?*
- ❑ DLNR-CWRM Petition to Amend Interim Instream Flow Standard *You will need to establish your streamflow by month. Then, how much water you plan to remove from the stream, how much you return to the stream after it flows through the lo'i. You need to know what other users are taking water from the stream, and for what purpose(s). Finally, what impact will your use have on stream health? The CWRM considers water flowing through an 'auwai to lo'i kalo to be a reasonable and beneficial instream use.*
- ❑ DLNR-CWRM *If appurtenant water rights are claimed, they ask you to fill out their Water Claim form and attach it to the above application(s).*
- ❑ County level, Coastal Zone Management (Special Management Area) *Another letter or phone call describing your planned work to the County Planning Department. They will determine if your work poses a threat to coastal ecosystems (fertilizer, mud, pesticides, insecticides, warmed water, or other pollutants coming from your lo'i down the stream to the ocean).*

Other permits which may be asked for at the County level (this is left to their discretion, based on your description of the work you plan to do):

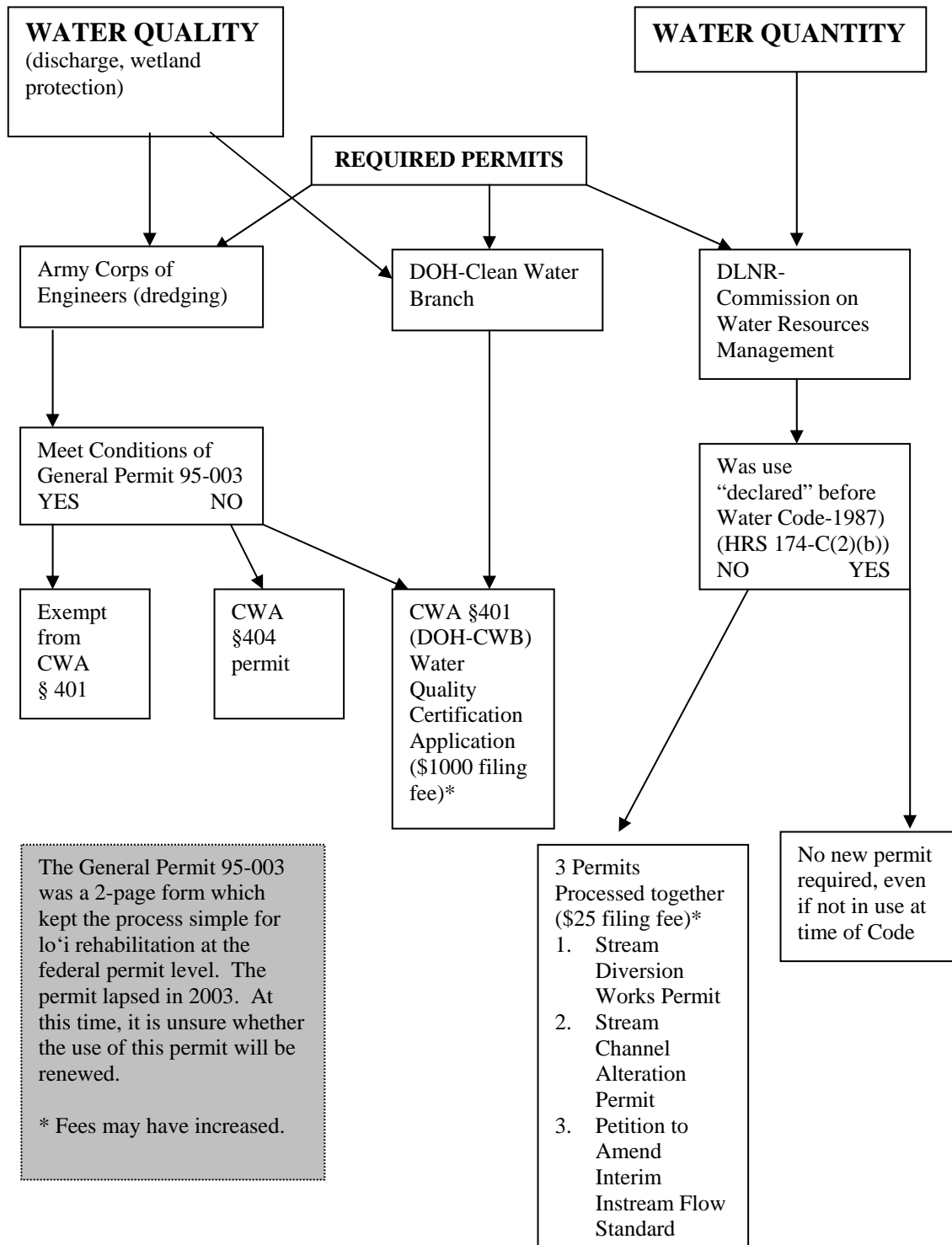
- ❑ County grading permit (Soil and Water Conservation District)
- ❑ County flood ordinances (SWCD) *Are you in a flood zone?*
- ❑ County discretionary permit(s)
- ❑ Community Plan *Check your community plan to see what is planned or desired for your area. These plans are reviewed every ten-years.*

- Special Management Areas *Generally areas near the shoreline. Cultivation of kalo, if managed properly, is not considered something that would pose a problem to coastal waters or shoreline areas.*
  
- COSTS for permits include filing fees and reproduction costs for the number of copies each agency or department requires.

*Given the high scenic value of restored lo'i kalo, and their value as restored habitat for native aquatic birds and other fauna, you may want to suggest that permit fees be waived in lieu of restoration work done and on-site wetland management that you will be providing at no cost to the government!*

If you are not changing the original agriculture system, not using chemicals, and limiting technology to small, appropriate equipment, your presence on the land should be considered low-impact and require few, if any, permits or other type of regulation. Think about how best to nestle into the environment when planning your kalo-culture.

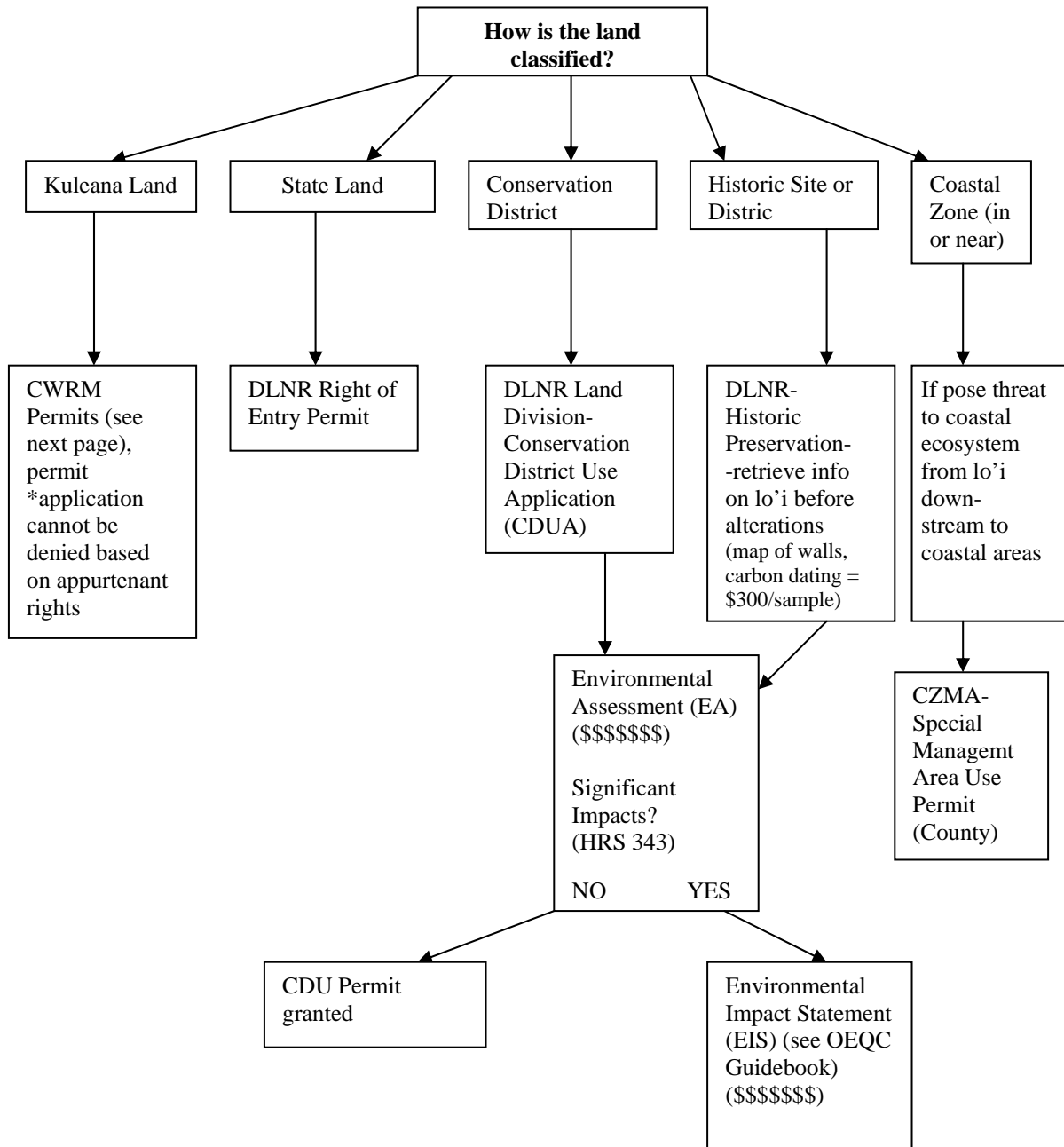
## REQUIRED PERMITS FLOWCHART



The General Permit 95-003 was a 2-page form which kept the process simple for lo'i rehabilitation at the federal permit level. The permit lapsed in 2003. At this time, it is unsure whether the use of this permit will be renewed.

\* Fees may have increased.

## LAND CLASSIFICATION FLOWCHART





# APPENDIX C

MULCHING PRACTICES AND COMPANION  
PLANTS FOR THE LO`I

[this page left intentionally blank]

# TRADITIONAL MULCHING PRACTICES IN OLD HAWAII

by Penny Levin<sup>1</sup>

Mulch is plant material which either falls to the ground naturally (eg. leaves dropping) or is cut and gathered to a place, and eventually decomposes (compost) back into the soil. The organic matter provided by the mulch helps water seep into and stay in the soil like a natural sponge. As a soil surface covering, it harvests dew and provides slow release nutrients to plants, reduces erosion by slowing down water on the surface of the soil and prevents soil from blowing away. Mulch loosens up the soil so it can “breathe” and that helps plant roots to go deeper. More than anything, mulches create new soil in the process of healing old soil surfaces.

In many cultures, including Hawaiian, one of the most sacred things a farmer might do is to mālama ‘āina; to care for the land so that its health, and hence the health of the community, was ensured. Chants and ‘ōlelo no‘eau are recorded for the calling of rain; the planting of the field; the requests for a good harvest. Documents record the planters techniques, and the things he used, but if there are oli for the mulching; it is perhaps, the quietest part of the practice.

The most indepth English-language source published to date for farming practices in the Islands is Handy and Handy’s *Native Planters In Old Hawaii: Their Life, Lore, and Environment* (revised edition 1991). With the collaboration of Mary Kawena Pukui, this book brings together many of the older works known (including Iokepa [from the Kelsey interviews], Kalokuokamaile, Kamakau, Kepelino, and Malo), as well as interviews with planters and documentation from each island.

Mulch (pulu) was considered an important resource by Hawaiians from which all things could be renewed and without which renewal was difficult. The following ‘ōlelo no‘eau documented by Mary Kawena Pukui (1983) illustrates this clearly.

Pau pulu, ‘a‘ohe lau kanu.

*Gone, mulch and all; with not even a sweet potato slip to plant.*

Utter destruction, with nothing left for a new start.

## TIMING AND PREPARATION OF THE LAND

The timing and proper preparation of the earth before planting is critical to a good harvest. One ‘ōlelo no‘eau asks a person in response to his request for food; “Ihea ‘oe i ka wā a ka ua e loku ana” (*Where were you when the rain was pouring?*). If a person answered that he was *not* absent from his land during the time of the rains (and therefore hadn’t cared for his crops well) he was considered negligent of his responsibilities as a farmer (Pukui 1983).

---

<sup>1</sup> Adapted from Levin. 1997. A paper on dryland mulching practices prepared for the Restoration Program; Kaho‘olawe Island Reserve Commission.

Mulching, unlike planting, can occur at all times of year, but it is most especially important prior to the rainy season. Traditionally, mulching occurred at least several months before planting, and sometimes several years before, to allow organic matter to break down into a form that the soil and the plants could readily use. In extremely dry climates mulch materials take far longer to break down.

Proper timing was necessary throughout the growing season, not just in preparing the field. Many examples in *Native Planters* describe the practice of clearing fields as only the first stage in the preparation of the land. It was followed by mulching; sometimes burning just before or after planting; followed again by mulching.

Handy and Handy (1991:89) wrote:

In preparing the ground for planting, after it had lain fallow, they flooded the soil, softened it with the digging pole, then pulled up the grass and weeds and stamped them deep into the mud. The same thing was done at each weeding and when old leaves were stripped off the taro plants. When a piece of ground was exhausted (pahulu), quantities of hau and kukui branches and leaves were pressed into the mud and allowed to rot before final digging and leveling for planting.

Kamakau (in Handy and Handy) described his observation of dryland farming this way; “the field was burned over, then mulched...When roots were sprouting, earth was pressed around the huli and the field was mulched [again]. Then, after three or four leaves had opened, the [dry mulch covering the] whole field was burned over, “regardless of the green taro leaves.”” Mulch was laid on again. Then the taro would grow “so luxuriantly that a man could be hidden among the leaves.”

The attendance to mulch did not end there. A second ‘ōlelo no‘eau recorded by Pukui from Kamiki (Ka Au Hou, August 16, 1911) describes the need for constant “preparation.”

“I luna no ka ua, wehe‘e ke pulu o lalo.  
*While the rain is still in the sky, clear the field below.*  
In dry places, farmers cleared the fields when they saw signs of rain so the water would soak the earth.

This saying was used in reference to hāpu‘u fern mulch, which needed to be drawn away from the plants during rain and closed again during sunny days. In areas where rain was uncertain such attention to timing required constant and daily work (Handy and Handy 1991:104).

Upland cultivation (kula) imitated the natural mulch of the forest floor by building mounds of organic matter which held in moisture. Planting in forest patches made use of existing humus in the ground.

## TRADITIONAL MULCH MATERIALS

In forest plantings, tree ferns were probably one of the first mulch sources. Banana appears to have been a significant mulch source for dryland and upland farming in Hawai‘i; although bananas, a cultivated crop, were initially more scarce than naturally occurring plant materials. Banana stalk holds a great deal of water, provides cooling insulation to the soil and acts as a liner for retaining moisture in planting pits. Other plant species used in preparing the soil or planting pits included the ‘ama‘uma‘u or hāpu‘u fern, kukui, ‘ulu, hau, or lauhala (pandanus leaves), coconut husk and fronds (niu), ki, ginger, or organic “rubbish” in general. The ‘ākōlea ferns, ‘ie‘ie and kohekohe grass have also been described as mulch sources. Old kalo leaves (lāele) were thrown back into the lo‘i.

Kukui and hau leaves and branches were a significant mulch source in wet areas and were deliberately planted and cultivated adjacent to lo‘i kalo for this purpose. It is reasonable to consider that as natural forest mulch resources receded from around cultivation and habitation sites, that planting, managing and harvesting a “mulch crop” would have been the next step. Kukui and hau required regular harvest to keep them in check and today these species are found overgrown in many wet, riparian areas.

Kepelino (Ibid 1991:106) writes “Good trash for filling is the aeki fern, the mana fern, the tree-fern, the ginger leaf and the coarse grass called kukaepua’a or “pig’s dung.” These are the best kinds of trash for fertilizing; they produce food. Other kinds are also of some value.” He notes that of all of these, only the grass would sprout. During the rainy season, after application of the grass mulch, a planter would need to revisit his patch and pull the new shoots after only two days time. Of honohono grass, he wrote “the honohono is a bad weed; one cannot kill it and it will kill the taro.”

‘Ilima shrubs tied with morning glory vines and bulrushes were both the mulch and the mound material for kalo grown in swampy areas. Woven into tight bundles, and heaped with “trash” (organic matter) and mud they floated in the deeper water. As these plants decomposed they also fed the kalo.

Heavy mulching using pili grass or “fields of hay” were used in dry taro areas along the Kona coast. Yen (1974) records for the Pacific region “the practice of immediate return to the soil of sweet potato vines after harvest” in much the same way that the leaves of taro are returned to the lo‘i at harvest.

Fire served to give a field a source of potash (or lime) which helped balance out the pH of the soil and provide immediate nutrients to crops.

Rocks were used as a mulching source in such arid regions as the Kona coast on Hawai‘i and the Wai‘anae coast on O‘ahu, where little vegetation, organic matter or soil were available. Kuaiwi (rock mulching) was described by Emerson as rocks covered with long grass. When the surface rocks in the mound, warmed all day by the sun, came in contact with cooler night air, moisture formed. Plant material stuffed between the pockets in the rocks decomposed and retained this moisture. During the day, the undersides of the mound remained cool. Yen also records rocks placed under plants to mound them

throughout the Pacific. The rocks enhanced moisture retention and cooled the underside of the plant.<sup>2</sup>

Non-native grasses, herbaceous plants and shrubs, leaves and small branches of trees, all represented mulching resources as flora in the Islands changed, but it was, as Kepelino pointed out, important to collect and use materials *prior to the seeding months*

#### TRADITIONAL MULCHING PRACTICES

Mulching practices were not limited to laying organic matter on the ground or into planting pits. At least one record describes how “layers of the fibrous sheath [of banana] were wrapped around the earth ball of any plant readied for transplanting when coconut-leaf sheaths were not available.” The use of organic matter in this way acted almost as a “starter mulch,” providing initial moisture and nutrients.

The *kula* or *kohala* (uplands) planting system is one of the fine tuned arid land agricultural systems of Hawai’i.<sup>3</sup> It is here that the ancient ‘ulu forests were created. Hawaiians made use of intensive mulching in these regions to ensure the survival of the ‘ulu trees and understory crops. Banana and grasses were a primary source for the mulch. The leaf litter in the *kula* system provided excellent soil supplement. Because of the intense care of these lands, what was before primarily rock and scrub land now marks the rain/fog belt on the Kona coast.

Dryland taro fields were mulched before and after planting. Typically, when the first two or three leaves unfurled, the second mulch layer was applied. On the windy slopes of Kohala, fields were covered with cut grass to retain moisture. Pit planting was also used in these upland regions with a similar strategy. Menzies (1920) describes the soil preparation:

Generally 2 or 3 [*huli*] planted together in a hole about 9 inches below the surface of the ground. These holes were about 4 feet apart, and as the plants grew up, the earth is gathered around their stems in the form of a basin to retain the water, either from rain or otherwise, about their roots. The whole field is generally covered with a thick layer of hay, made from long, coarse grass or the tops of sugar cane, which continually preserves a certain degree of moisture in the soil that would otherwise be parched up by the scorching heat of the solar rays...

Raised stone “wells” are found in Kona area (Kohanaiki). The structures are 3-4 feet high, 4-6 feet across, round, with fairly thick walls. Mulch was piled into these “wells” and ‘uala, ipu and possibly taro and banana grown inside. The ability to produce food in the hot, coastal climate with little rainfall was probably based on dew collection and hand

---

<sup>2</sup>. Some of best examples of this technology are at the Amy Greenwell Botanical Garden, Hawai’i. Maurice Major, anthropology department Bishop Museum, is an excellent resource regarding this system and other Kohala planting techniques.

<sup>3</sup>. The best examples are located near Kona and Lapakahi on the Big Island. Kelly (1983:62) states; “Hawaiians developed the breadfruit orchard and secondary plantings within it to take advantage of conditions at the interface of [*kula* and ‘*apa’a*] vegetation zones.”

watering rather than rainfall catchment. The black volcanic rock ‘sweated’ and released moisture during the cooler evening period when it was most advantageous to the plants. The mulch inside retained the moisture and trapped dew so that plants would have access to water. In addition, water carefully gathered in gourds from underground or coastal freshwater seeps may have supplemented these plantings. Variations using hāpu’u, banana or other logs also exist. In the *pa pulupulu* (tree fern clearings), the ‘*umoki*’ method consisted of prying over tree ferns with an ‘ō’ō and planting in the hole left by the root. Planting in-between in the thick “rubbish” was called ‘*ōhiki*’.

In extremely dry areas “where earth was scarce and must be brought in to make mounds amidst the rocks or lava holes”, a *pu’epu’e* method of planting was sometimes used which took advantage of holes and hollows in rocks. “Soil “mould” or mulch and decaying lava rock retained moisture” (Kelly 1983).

In wetter areas farmers took advantage of more abundant leaf litter resources. *Pa kukui* (kukui clearing) was a method of mulching/planting which was used in or at the edge of the forest or within a kukui grove. The leaves were placed in large holes, along with four branches (placed leaves down; stem up) and covered with soil for a number of weeks until the leaves decayed. A branch was pulled to determine if the leaves had decomposed and the pit ready for planting. The taro was planted into the decayed matter. “A plant thus handled may grow to seven feet and over and the taro may weigh twenty pounds and over. According to the depth of the fertilizer, so is the height and size of its growth...” (Handy and Handy 1991:105-6; Kepelino 1932). When the taro began to develop, the patch was covered with mulch and the original holes filled up again with “trash.”

The *pa hala* (pandanus clearing) method of planting was described to Mary Kawena Pukui by Joseph Ilala’ole as follows:

Make holes in the *a’a* (broken lava) by taking out some of the stones. Be sure that the place chosen is in a *pu hala* grove, to save the labor of hauling *hala* branches into the patch later on. Fill the holes with whatever weeds can be found and leave them there for six weeks or more. The weeds rot and make soil. When the weeds have rotted away, the taro *huli* are wrapped in *lau hala* (hala leaves) to keep them moist and are planted. When three or four leaves have appeared on each *huli* then it is time to cut down the *pu hala* to let in the sun. The branches of the *hala* are cut off and the patch covered with them until there is not a trace of the taro to be seen. This is left until sufficiently dry to set on fire. The fires does not hurt the taro much as the *huli* were already well rooted. The *hala*, reduced to ashes, gives the taro the needed nourishment and they grow so tall that a man can be hidden under their leaves.”

In the planting of wauke, Handy and Handy recorded that “it was... recommended that after the land was cleared for planting the surface be covered with [banana] leaves to rot and serve as fertilizer...When the young plants have rooted and are sprouting, the patch is weeded and moist leaf mould heaped up around the plants.”

## STRATEGIC MULCHING

Loosening soil and laying down leaf or grass litter enhances natural decomposition processes. Mulch is a holistic approach for long term, slow release provision of nutrients to plants, improved soil content, long-term moisture retention capacity, soil cooling capabilities and for reduced erosion.

Each of the traditional planting methods has in common the use of mulch as an important element in successful plant growth and food production. Use of Hawaiian planting techniques reaffirms the viability of traditional knowledge. It also serves as a teaching ground for relearning traditional land care practices.

Planning to plant is just as important as the planting itself. The desire for rapid results should be balanced with taking the time to set in place all of the things needed to ensure stable, healthy plant growth and survival in the long term. Mulch wherever possible long before planting; prepare the earth to increase the chances of survival for each native plant that returns to the land.

## REFERENCES

- Handy, E.S. Craighill and Elizabeth Green Handy. Revised edition 1991. *Native Planters In Old Hawaii: Their Life, Lore and Environment*. Bulletin 233. Honolulu: Bishop Museum Press.
- Handy, E.S. Craighill. 1949. *The Hawaiian Planter – Volume I: His Plants Methods and Areas of Cultivation*. Bulletin 161. Honolulu: Bernice P. Bishop Museum.
- Kelly, Marion. 1983. *Na Mala O Kona: Gardens of Kona. A History of Land Use in Kona, Hawai'i*. Report no. 83-2. prepared for Department of Transportation, State of Hawai'i. Honolulu: Bernice Pauahi Bishop Museum Department of Anthropology.
- Menzies, Archibald. 1920. *Hawaii Nei 128 Years Ago*. Honolulu: W.F. Wilson, ed.
- Pukui, Mary Kawena. 1983. *‘Ōlelo No’eau: Hawaiian Proverbs and Poetical Sayings*. Special publications no. 71. Honolulu: Bishop Museum Press.
- Yen, D.E. 1974. *The Sweet Potato And Oceania: An Essay in Ethnobotany*. Bernice P. Bishop Museum Bulletin no. 236. Honolulu: Bishop Museum Press.

## COMPANION PLANTS FOR THE LO'I

Handy and Handy (1991:95) write; “The banks (ku‘auna, ika, kaika, or kuaio) of the old terraces were not the mere grass-covered retaining walls and footpaths that they are today. On the banks the wet-taro farmers planted important subsidiary crops: bananas, sugar cane, arrowroot, and ti plants, the leaves of which had many uses and the roots of which appeased hunger in famine times. Kamakau says that the old planters took great pride in the planting of their banks”



Source: Bishop Museum.



P. Levin

Not all banks were planted. W.C. Bannett (19312:20) described steep sloped areas where the banks were “just a row of large stones” because there was no room to safely make wider banks or plant on them.

In addition to the plants described by Kamakau, wauke (paper mulberry), various lā‘au lapa‘au (medicinal plants), dye and cordage plants, vegetables and mulch trees such as hau and kukui were tended along the edges of the lo‘i. While ‘uala was well suited to the drier areas of each island, at least today, they are also a part of many lo‘i complexes, along with ‘ulu, (breadfruit), ‘ōhi‘a ‘ai (mountain apple), papaya, nioi (chili peppers), hō‘i‘o, ongchoi and watercress, and other vegetables.

In planting on banks and around the edges of your patches, be mindful of the structure and root system of the plants you choose. Set trees well back from the banks so that they don’t intrude into, or shade out, the lo‘i. Consider planting them in riparian areas as an alternative. Wauke also has long roots and produces sucker shoots that can interfere with or overrun the banks. Choose your planting sites for wauke carefully and manage well. Gingers and heliconia are sometimes planted on lo‘i banks today; however, these species are especially vigorous and difficult to control. The dense root masses are extremely hard to remove and you may end up destroying the integrity of your banks in the process!

The harvest of root crop producing plants such as ‘uala and ‘awa will disturb the soil so planting on the banks between or near to your lo‘i is not recommended. Set aside an adjacent area where no leakage to the banks will occur.

For banks that border right along the stream, especially steep banks, choose perennials with strong root systems to



P. Levin

minimize disturbance and hold the banks during heavy rains.

Consider the amount of shade the plants will produce. Will they make too much shade over the kalo and inhibit growth? You may want to select one place specifically to provide a nice shady spot while you rest from your work. Bananas along the 'auwai will keep water cool.

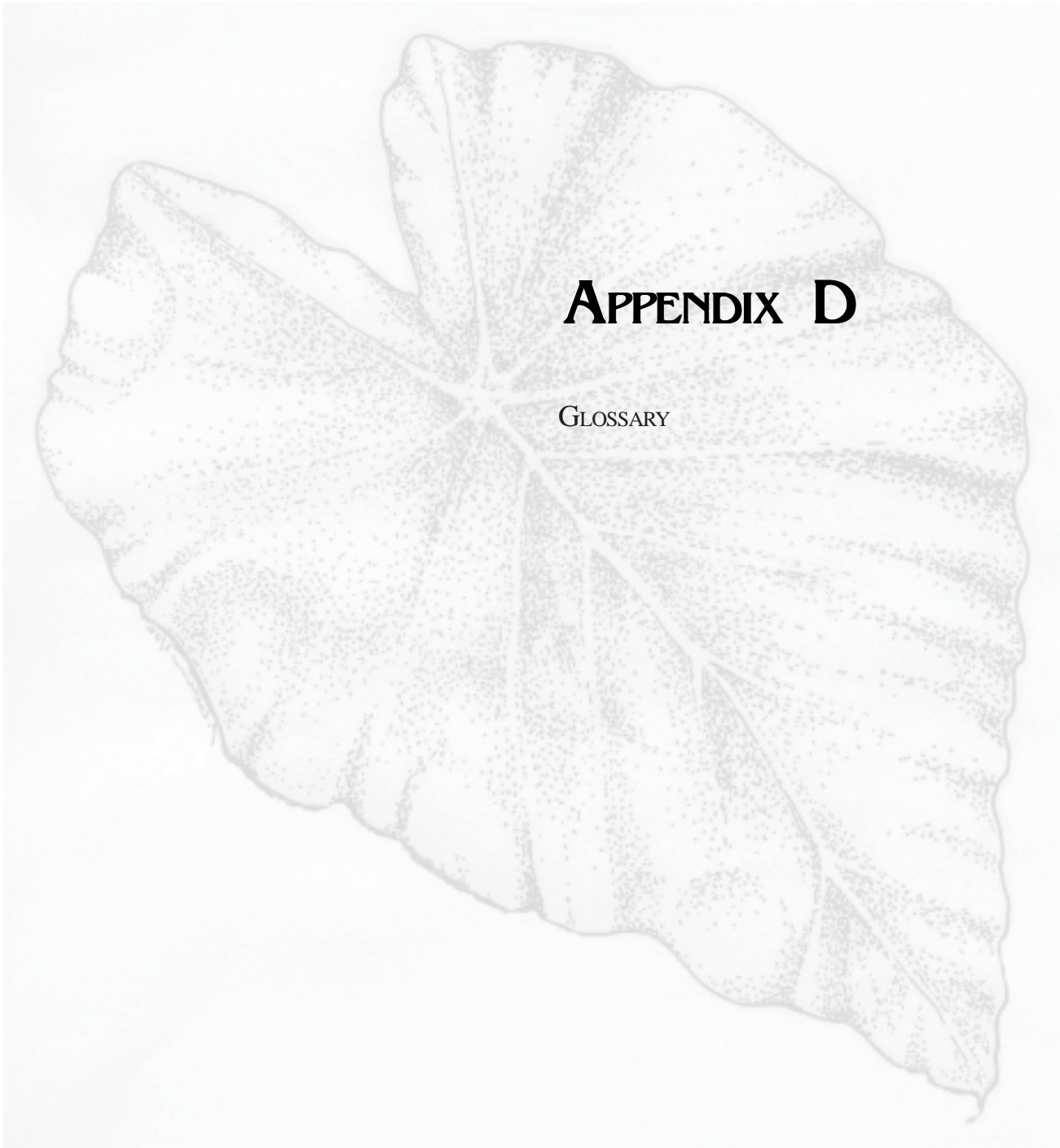
Manage mulch crops so that they can be regularly trimmed to feed lo'i soils and enrich your other plantings. With hau and kukui be vigilant of seedlings and suckers that may sprout. Every part of these plants has a use, but it can sometimes be hard to keep up with them!



P. Levin



P. Levin



# APPENDIX D

## GLOSSARY

## GLOSSARY<sup>1</sup>

<b>‘āina</b>	Land, earth.
<b>‘auwai</b>	A ditch or canal; a canal or channel that conveys water from a stream into a lo‘i or draws water away from a lo‘i back into a stream.
<b>heiau</b>	Pre-Christian place of worship, shrine.
<b>honohono</b>	Wandering Jew or dayflower ( <i>Commelina diffusa</i> ), a creeping weed frequently found around taro patches.
<b>huli</b>	Taro top used for planting; shoot.
<b>kahawai</b>	Stream, creek, river, whether wet or dry.
<b>kalo</b>	Taro.
<b>kāmole</b>	Primrose willow ( <i>Ludwigia octivalvis</i> ), a perennial weed in taro patches and wet places.
<b>kanu</b>	To plant.
<b>keiki</b>	Child, offspring, descendant, progeny; shoot or sucker, as of taro; a young taro plant.
<b>koa haole</b>	Lead tree ( <i>Leucaena leucocephala</i> ), a shrub or small tree originally introduced to Hawai‘i as a nitrogen-fixing cattle fodder; now highly invasive.
<b>kuāuna</b>	Bank or border of a taro patch; stream bank.
<b>kupuna</b>	Grandparent, ancestor, relative or close friend of the grandparents’ generation; elders; starting point, source.
<b>kūpuna</b>	Plural of kupuna.
<b>lā‘au lapa‘au</b>	Medicine; medicinal plants.
<b>limu</b>	A general name for all kinds of plants living under water, both fresh and salt; algae.
<b>lo‘i</b>	Irrigated terrace, especially for taro, but also for rice; paddy; patch; a system or series of patches.
<b>makai</b>	On or towards the sea; in the direction of the sea.
<b>māla‘āi</b>	Taro patch, food garden.
<b>mālama</b>	To take care of, tend, attend, care for, preserve, protect, maintain; to keep or honor.
<b>mālama ‘āina</b>	To care for the land.

---

<sup>1</sup> Source: Pukui, Mary Kawena and Samuel H. Elbert. 1986. *Hawaiian Dictionary*. Honolulu: University of Hawai‘i Press. Definitions provided here are in the context of their use within the text.

<b>mana‘o</b>	Thought, idea, belief, opinion; ho‘o mana‘o, to remember, recall, reflect deeply on.
<b>māno</b>	Dam; stream or water source; headwaters; a place where water is directed for distribution into channels; a channel; a diversion or intake; a rock dam or other feature (and its location) that brings water into the ‘auwai from the stream.
<b>mauka</b>	Inland, upland; towards the mountains.
<b>mele</b>	Song or chant of any kind; poem, poetry.
<b>moku</b>	District, island, section.
<b>mo‘olelo</b>	Story, tale, myth, history, tradition, literature, legend.
<b>nā po‘e kahiko</b>	The people of old.
<b>‘ohā</b>	Taro corm growing from the older root; sucker, shoot; tender plant; offspring.
<b>‘ohana</b>	Family, relative, kin group; related.
<b>oli</b>	Chant that was not danced to.
<b>pā pōhaku</b>	Stone wall.
<b>pae pae pōhaku</b>	Stone wall (Kaua‘i).
<b>pōhaku</b>	Stone or rock.
<b>puka wai</b>	Water outlet; point in the bank where water exits from a lo‘i.
<b>wahi pana</b>	Legendary place.
<b>wai</b>	Water.
<b>waiwai</b>	Goods, property, assets, valuables; wealth.