HAWAII FOREST INDUSTRY ASSOCIATION

HEALTHY AND PRODUCTIVE FORESTS INITIATIVE
WORK IN PROGRESS - May 6, 2021

Abstract

Strawberry Guava Control Methods

Strawberry guava (*Psidium Cattleianum*) currently covers 600,000 acres on Hawaii Island. Native plant biodiversity, economic, recreation, and cultural opportunities have been lost on these lands. Hawaii Forest Industry Association (HFIA) is developing an economically feasible program for landowners to control and/or remove the Strawberry guava on at least 80% of the land it currently inhabits by 2040. Project planning has been completed. Methods which we believe to be both efficacious and economically practical have been developed. Testing has begun. Further trials are scheduled for 2021 and 2022. In 2023, HFIA will begin demonstrations of the methods at operational scale for forestland owners.

The methods to be utilized are: Biocontrol, Clear Clusters, and Mechanical Removal. Biocontrol utilizes *Tectococcus ovatus* insects. The insects suppress guava vigor by 80%, rendering it non-competitive with native vegetation. The Clear Clusters method mechanically removes biologically weakened guava clusters in mosaic patterns intermixed with indigenous forest and replaces them with indigenous forest plants. Mechanical Removal will be utilized where Strawberry guava has completely overtaken an area. Process and outcomes will be consistent with appropriate conservation standards, landowner's objectives, and zoning.

Program planning has received the support of various agencies. DOFAW is providing GIS data. USFS is supporting with entomology and biocontrol advice. USGS is supplying vegetation type maps. UH Hilo provides technical forestry information and advice. Volcano Helicopters has provided helicopter time for initial distribution trials. Glenwood Ranch has offered suitable land for insect gall production. Foresters at HFIA manage economic feasibility.

1 ISSUE STATEMENT

Hawaii's Invasive Woody Species

The US Forest Service estimates that 600,000 acres (almost 1,000 square miles), have been infested by strawberry guava on Hawaii Island. Statewide, the total is 1.1 million acres (around 2,000 square miles). It is present on all major Hawaiian Islands and across the Pacific tropics. The US Forest Service believes strawberry guava could eventually cover half of Hawaii Island. The situation is exacerbated by advancing Rapid `Ōhi`a Death (ROD). The Healthy and Productive Forests Initiative will focus its efforts on Hawaii Island and make all lessons learned from our efforts available to others.

The loss of most of Hawaii's low elevation Ohia-Koa forest ecosystem is an environmental and cultural tragedy. Mid-elevation Ohia-Koa forest are now under heavy pressure from invasive species and the invasion of the more intact higher elevation stands has begun.
It is because of this unfolding catastrophe that the Hawaii Forest Industry Association created the Heathy and Productive Forests Initiative. It is our opportunity to work with many organizations and individuals already engaged in the issue to reverse the ongoing loss of over a

half a million acres of indigenous forest on Hawaii Island and a like amount in the remainder of the state.

HFIA recognizes and celebrates the improved status of some of Hawai'i's forests led by members of the Hawaii Conservation Alliance and those members of Hawaii's Watershed Alliance and the large landowners and ranchers that have made improvements in their lands and forests health and productivity. HFIA also recognizes that difficult choices have been made as to where scarce resources are devoted to stewarding our forests.

The Healthy and Productive Forests Initiatives is focused on the blight of strawberry guava. While large areas on Hawaii Island have been overtaken by other invasive woody species as well, HPFI has decided to focus its initial efforts on this single species due primarily to the vast expansive of land it covers.

The effects are largely unseen by the public because most of the affected area is in closed and un-roaded forests. Control efforts to date have been small scale with limited impact. Most Hawaii residents do not recognize invasive species or know what should be growing in that space.

Damage done by strawberry guava includes:

- partial or complete loss of native habitat
- damage to proper functioning of watersheds
- soil erosion
- near or total barrier to entry by people for recreation, management or science
- suboptimal carbon sequestration
- creation of habitat for pigs which make wallows creating avian flu carrying mosquitoes
- creation of habitat for fruit flies which degrades surrounding land potential as orchards
- loss of opportunities for grazing and forestry
- loss of traditional and customary practice opportunities for Hawaiians
- loss of biodiversity
- loss of economic value of land and natural resources
- creation of a barrier to regeneration of `Ōhi`a, which is now threatened by Rapid Ohia Death

When infestation is complete, and the Ohia – Koa forests are smothered and replaced by strawberry guava and the site no longer performs once significant environmental services and no longer performs as a cultural landscape as it once did. Rotting fruit, mud, foul smelling pig wallows, mosquitoes and fruit flies have replaced the low-elevation Ohia – Koa forest. There is also a loss of access to cultural sites and a cultural landscape. The hunting experience is greatly diminished even if there is game. Other community recreational opportunities are lost. Additionally, the loss of rural economic development is enormous as much of the land was intended to be used for commercial purposes.

The Healthy & Productive Forests Initiative is now gathering resources to support a full-scale effort to restore Hawaii's invaded forest lands to health and productivity.

2. ACKNOWLEDGMENTS

The Healthy and Productive Forests Initiative relies on research and studies by US Forest Service scientists at the Institute of Pacific Island Forestry, Hawaii State Department of Agriculture and Hawaii State Department of Land and Natural Resources, Division of Forestry and Wildlife. It would not be possible to proceed in this effort without their substantial foregoing work.

3. PARTICIPANTS

The Healthy and Productive Forests Initiative is managed by the Hawaii Forest Industry Association in cooperation with the University of Hawaii, Department of Land and Natural Resources, Institute of Pacific Island Forestry (US Forest Service) and numerous conservation groups. See Appendix E

4. VISION AND MISSION

Vision Statement

The Healthy and Productive Forests Initiative envisions that 90% of Hawaii Island forest lands will be sufficiently free of invasive species by 2040 that they produce both valuable goods from the forest and produce desirable environmental services. Environmental services will include native species conservation, carbon sequestration, and hydrological services. As a productive forest, some of these lands will also provide raw materials for wood utilizing enterprises. Our communities will enjoy enhanced recreational and traditional uses through improved access to the forest. A well-managed forest will increase aesthetic values and reduce risks from disease vectors such as mosquitoes.

"Forest Land" is used here to mean: Land which is capable of supporting closed canopy forests, where zoning permits the practice of forestry, and where owners have not dedicated the land to other productive and permitted uses such as agriculture. To achieve these goals, the Healthy and Productive Forests Initiative will solicit input, assistance and permissions from foresters, landowners, academics, public officials, and regulatory agencies.

Mission Statement

The Healthy and Productive Forests Initiative mission is:

1. to develop and demonstrate at operational scale various methods for rehabilitating forests threatened by invasive species in Hawaii, particularly strawberry guava.

2. to disseminate to government officials and the public information on the costs and lost opportunities represented by weed infested forests.
3. to disseminate efficient, effective techniques and forest management methodologies developed in this effort to Hawaii forest landowners and encourage immediate action.

The methodologies and projects to be developed will:

- be compliant with applicable zoning laws and other regulations.
- be economically feasible.
- be consistent with landowners' objectives.
- result in healthy and productive forests.
- be coordinated with the work of public agencies and private organizations.

5. CURRENT STATUS

Environment

Damage to the environment includes:

- loss of proper functioning of watersheds.
- suboptimal carbon sequestration.
- loss of biodiversity.
- soil degradation.
- Partial, in some cases complete, loss of native habitat.

Geographic

- 600,000 acres of Hawaii Island haves been infested by strawberry guava (USFS)
- The area continues to increase and could expand to 50% of Hawaii Island (USFS)
- The situation is exacerbated by advancing Rapid 'Ohi'a Death (ROD)

Social

Societal losses include;

- Loss of opportunities for grazing and forestry
- Loss of traditional and customary gathering opportunities for Hawaiians
- Nearly total barrier to entry by people for recreation, management, or science
- Effects largely unseen by the public because most of the affected area is in closed and non-roaded forests, and because many Hawaii residents do not recognize invasive species.

Politics/Awareness

- Healthy and Productive Forests Initiative anticipates substantial challenges and issues in resolving the issue, both political and biological. The slow-moving scourge aspect and being out of sight takes this issue off the front page and out of most resident's awareness. Reality is that if the infested area quit growing tomorrow it would take 20 years at a mind-boggling rate of 80 acres per day to clean it up. This invasion of the native forest has been

many years in the making, progressing slowly across the islands, rarely seen except by the conservation community, year in and year out.
One reason heard for lack of serious action to date is high cost. However, it may be significantly less expensive than previously believed by incorporating efficient commercial scale technologies. As time passes, the infestation grows both in area in degree, and will becomes more expensive to deal with. Solutions can be partially funded by extracting invasives for use as biomass and use of dead and dying high value trees for lumber.

Some solutions will take significant political will and money. The solutions will often be complex and situation specific. Effective solutions will involve multiple agencies effectively cooperating. They must, of course, be supported by credible, current, relevant data.

The project will require a public information campaign encompassing the total issue, not simply the removal of invasive trees. The approaches must come at efficient commercial scale. In some lands areas such as former sugar or papaya plantations the only feasible solution to restore a given acre will be to remove the existing biomass and start with a clean slate. This must be done at scale to economically regain control of older infestations that entirely dominate the area.

6. FOREST UTILIZATION AND MANAGEMENT

People look to forests to provide many goods and services, both vital and life enhancing. Primary uses and services include:

- Watershed management
- Raw materials for construction, energy, and paper production
- Climate and weather moderation
- Hunting and gathering as sustenance cultural practices and recreation
- Preservation of rare and desirable species of both plants and animals
- Recreation and spiritual renewal

Land for Human Use

Hawaii Island is indeed big, but there is relatively little land available for use for housing, agriculture, or private business. 76% of the island is held by government agencies or large trusts. 52% of the island is in conservation zones. Much of what remains is rendered unusable by being overrun with strawberry guava.
The remaining small quantity land potentially usable by humans drives high land prices in which is a barrier to home ownership, agriculture, and commerce.

The art of forest management requires balancing these widely diverse demands and needs with the desires of the forest landowners. This balancing must account for the biological potential of any tract considering the soil, climate, and biological circumstances. It is axiomatic that not every tract can meet every need or every wish. And so decisions are made by political bodies,

usually through a zoning process about what the primary functions and services of a given area will be. In Hawaii, the legislature created districts with sub zones in the early years of statehood with descriptions of their legislative intent of the primary uses of those lands. The use of forests is addressed in Conservation subzones and Agriculture districts.

A list of affected acres by owner and zoning prepared by HFIA and DOFAW is found in Appendix F. Additional layers and mapping will be added which will include access routes and detailed land cover maps and land cover types.

Zoning on Hawaii Island

The Healthy and Productive Forests Initiative relies on legislative intent for the use of land as expressed in zoning designations. The applicable districts, sub zones, Hawaii Island acres and their legislatively mandated uses are declared in Hawaii Administrative Rules (HAR):

CONSERVATION DISTRICT, HAR TITLE 13, Chapter 5

Protective (P) subzone 357,668 acres

Purpose: To protect valuable natural and cultural resources in designated areas such as restricted watersheds, marine, plant, and wildlife sanctuaries, significant historic, archeological, geological, and volcanic features and sites.

Limited (L) subzone 171,322 acres

Purpose: To limit uses where natural conditions suggest constraints on human activities, land susceptible to inundation by tsunami, flooding, volcanic activity, or landslides. Permitting treated similar to (P).

Resource (R) subzone 734,778 acres

Purpose: To ensure, with proper management, the sustainable use of the natural resources of those areas including (1) land for parks and future parks (2) lands suitable for growing and harvesting of commercial timber or other forest products (3) lands suitable for outdoor recreation uses such as hunting, fishing, hiking, camping, and picnicking.

General (G) subzone 68,113 acres

Purpose: To designate open space where specific conservation use may not be defined, but where urban use would be premature. Includes lands suitable for farming, flower gardening, operation of nurseries or orchards, grazing and accessory facilities.

AGRICULTURE DISTRICT County Code Chapter 25 .205

Agriculture (A) 1,200,000 acres

205-4.5 Permissible uses within the agricultural districts**.** Within the agricultural district, all lands with soil classified by the land study bureau's detailed land classification as overall (master) productivity rating class A or B shall be restricted to the following permitted uses:

(1) Cultivation of crops, including crops for bioenergy, flowers, vegetables, foliage, fruits, forage, and timber, and
(2) Game and fish propagation,
(3) Raising of livestock,
(4) Farm dwellings

7. OPERATION STRATEGY

The Healthy and Productive Forests Initiative proposes three basic approaches to control strawberry guava. We offer these proposals to encourage discussion, critique, development of additional proposals, and then action on this pressing issue. The approach selected for a given stand will be dependent on circumstances including topography, biological conditions, access, zoning, and soil conditions. A qualified forester would write the specific prescriptions for each stand. We strongly encourage innovation by all parties involved, both in improving these methods and developing new ones.

Effective Solutions will:

- Recognize and capitalize on the positive value of invasive woody material as biomass and other higher value products.
- Likely involve complex multi-agency solutions.
- Include combinations of mechanical, chemical and biological methods.
- Take significant political will and money.
- Often be complex and/or situation specific. There are no known silver bullets.
- Energize the reuse of tens of thousands of acres that are now in poor condition.
- Involve agriculture, commercial forestry and agro-forestry methods as appropriate.
- Greatly improve public access and awareness of the forest at lower elevations.

THREE TREATMENT METHODS

Biocontrol

The biocontrol method is to distribute strawberry guava's natural enemy, *Tectococcus ovatus* (*T. ovatus*) insects. This is done by placing leaves bearing galls of *T. ovatus* into the crowns and flushing foliage of strawberry guava. Subsequently, over a period of several years, *T. ovatus* will increase to levels that reduce growth and fruiting of affected trees. The objective of applying biocontrol is to suppress strawberry guava population growth and spread, and to render guava trees less competitive with other vegetation. This step is targeted at regaining control of the canopy where possible and, at a minimum, substantially reducing the spread.

We recommend biocontrol in all areas large enough to treat and distant enough from residences to avoid unnecessary confrontations. Many areas will require follow-on treatments tailored to ground conditions, zoning, and landowner's management objectives.
We expect biological control to be a multi-year project of applications, testing results, and adjusting. The distribution will be by primarily by helicopter in strips. It will be necessary to establish sources for inoculated *T. ovatus* leaves by heavy pruning in existing trees and inoculating leaves when they flush from sprouts. Initial priorities would be:

- Leading edges of ongoing invasion
- Critical habitats
- Areas with sufficient native forest to recover if strawberry guava pressure is relieved
- Areas remote from populations

Biocontrol will significantly reduce the vigor of, but not kill strawberry guava. Reduced vigor will substantially reduce the congoing spread. Where there are remaining indigenous species, it will tip the competitive balance. Where mechanical removal is needed it will reduce and slow resprouting. More detail is in Appendix B.

Clear and Plant
In this method, strawberry guava is mechanically removed and replaced with a high value hardwood plantation of either indigenous or exotic species, or with agriculture crops. This method will be utilized primarily in the agriculture district and, in some cases, in the conservation district, resource and general subzones. Cleared ground can be planted with either high value exotic hardwoods or indigenous species such as koa, depending on the preferences of the landowner and biological feasibility. If the landowner prefers, and where the land use district is appropriate, an agriculture or agroforestry crop can be planted.

Clear and Plant is indicated where:

- Strawberry guava entirely occupies the site, or, if left unmanaged, will entirely occupy the site.
- The topography and soils are suitable for use of heavy equipment.
- The soils are reasonably fertile.
- The land is accessed by roads, or can reasonably be accessed.
- Zoning is in the agriculture district or conservation district, Resource or General subzone.
- The land is at mid and low elevation.

Alternative methods for Clear and Plant include:

- Scarification and windrowing with dozers equipped with deep tooth brush rakes
- Uproot and pile using an excavator equipped with a brush grapple.
- Crush and spray utilizing roller/choppers pulled by a dozer and follow up heli-spraying.
- Mulch using an excavator equipped with a mulching or "masticating" head
- Manage re-sprouting, if needed, with either biocontrol or herbicides if necessary

Side by side trials of the alternative methods are needed. Our initial preference is for excavator-based methods because there would be less equipment travel on soils.

We expect funding for this method would come from a combination of State of Hawaii funding, some receipts from salvaged timber sales, and private funding.

Clear Clusters
In the clearing clusters method, strawberry guava clusters which are interspersed in indigenous forests are mechanically removed and replaced with native species.

Method for Clear Clusters:

- First inoculate with *T. ovatus* to control strawberry guava remaining after treatment.
- Mechanically remove strawberry guava clusters as in Clear and Plant method
- Protect healthy native trees from incidental damage
- Salvage dead and dying timber if present
- Leave soil adequately disturbed to allow for dormant koa seed, if present, to sprout
- If koa seed is not present, plant native species as local circumstances indicate and find opportunities to incorporate lesser known indigenous species

Clear Clusters is indicated where:

- Strawberry guava has invaded native forest land and controls significant area in a mosaic pattern.
- Topography and soil are suitable for use of heavy equipment
- Zoning is Conservation Resource or Agriculture
- Road access exists or can be developed

Funding for this method on State lands would come from a combination of State funding and receipts from salvage timber sales when operating. On private lands funds would come from a combination of public funding and proceeds from salvage timber sales.

THREE GEOGRAPHIC REGIONS

We define three identifiable regions of strawberry guava differentiated by elevation. The three populations each have distinct patterns of land ownership, landowner objectives, land use zoning, density of guava stocking, degree of intermingled native forest, access, proximity to populations, and age of stands. The differentiation into three types is a useful construct but by no means absolute.

High Elevation -3,000' – 4,500'

Land ownership:	State, Federal, institutions
Estimated acres	100,000
To be treated	100% - 100,000 acres
Owner objectives	Species conservation, watershed, traditional practices
Zoning	Conservation Resource/General/Protection
Stand continuity	Spotty, moderate

Stocking density	Light to moderate
Stocking progression	Incipient
Native forest presence	Dominant
Access	Poor to very poor
Residential proximity	Very remote

Mid-Slope	**1,500'-3,000'**
Land ownership	State, institutions, private, federal
Estimated acres	200,000
To be treated	75% - 150,000 acres
Owner objectives	Native species restoration, watershed
Zoning	Conservation Resource/General/Protective Agriculture
Continuity	Discontinuous mosaic patterns, patches
Stocking density	Scattered to dense
Stocking Progression	Well established
Native forest presence	Dominant to co-dominant with weeds
Access	very poor to fair
Population proximity	Remote, somewhat distant

Low Elevation 0'-1,500'	
Land ownership	Private, institutions, State
Estimated acres	200,000
To be treated	40% 80,000 acres
Owner objectives	Economic return, native species restoration
Zoning	Agriculture, Conservation Resource/General/Protective
Continuity	Small discontinuous blocks, large blocks
Stocking density	Light to very dense
Stocking progression	Long established (weed forest), established, incipient
Native forest presence	Suppressed, Rare
Access	Fair to good
Population proximity	Close, somewhat distant, distant,

PRIORITIES

The first control priority is biocontrol because we believe biocontrol can achieve a significant degree of control much faster than other methods and at low cost.

The first biocontrol priority for dispersing *T. ovatus* would be high elevation stands because:

- High elevation areas have the greatest intact native forests and so have the greatest opportunity for protecting sensitive native forest.
- Land ownership is concentrated, simplifying operations. The great majority is DOFAW land with additional ownership in Federal agencies and institutions. Large ownerships will be economically efficient to operate in.
- Progress of infestation is mauka. Establishing a robust *T. ovatus* population will develop a "fire line" stopping further geographic advances.

- We will certainly run into some opposition locally. This area will receive the least attention and is the most politically defensible as a pure native forest protection operation.

The second biocontrol priority is to clear clusters in mid-slope areas. Mid slope areas have strong native forest components but are in a mosaic pattern with strawberry guava.

The objective in this area is to slow, and in some instances halt, the advance of the guava in over topping and suppressing native forests and to biologically weaken the guava. To restore native forests additional on-the-ground work will often be required as described in the stand removal method. The difficulty of this work will be lessened, and the success improved by having significantly weakened the strawberry guava prior to starting ground operations.

Third Biocontrol Priority

The low elevation stands are in two primary types: One is areas when the strawberry guava has completely overtaken the landscape and little or no native vegetation remains. The second is new invasion areas, primarily in pasture. Where the strawberry guava has completely overtaken the area, it may prove helpful to weaken the guava biologically before mechanical treatment to reduce secondary regeneration. Ownership is mostly private, and tracts are often small and scattered. Spreading by hand may prove feasible in small areas. Drone operations also may be practical. But logistics will require case-by-case considerations. For example, helicopter distribution near homes would create issues.

The above priorities are preferences, but pragmatic concerns such as permitting and funding may override preferences. The philosophy of take the door that is open rather than rather than waiting for the locked door you prefer may often take a large part in decision making.

APPENDIX A

Biocontrol Operation Plan

This is an initial plan to outline an affordable and effective methodology to deploy *Tectococcus ovatus* ("*T. ovatus*"), a biological control, to manage *Psidium cattleianum (*strawberry guava) on Hawaii Island. Biocontrol is a critical component of controlling strawberry guava in native forests, and in replacing stands of strawberry guava where the land can be used for cultivation or commercial forestry.

T. ovatus can be dispersed by placing galled leaves which contain reproductive females near flushing strawberry guava leaves. There have been several methods of dispersing leaves containing live *T. ovatus* proposed, including:

- Distribution by hand using a bolo-like arrangement to place galled branches in treetops
- Utilizing drones placing at the edges of land cleared of strawberry guava for forestry or agriculture
- Distributing the galled leaves or branchlets using helicopters

While there will be circumstances where manual techniques will be the best choice, we believe helicopter broadcast will be by far the most effective and cost-efficient distribution method. This is a very large project where work is constrained by a brief leaf flushing season of April and March. We estimate 400,000 to 500,000 acres need to be treated.

To cover this ground on foot on a spacing of 200 feet between placements (one site per acre) for example would involve somewhere between 15,000 and 20,000 miles of foot travel in often very difficult conditions. Forest workers can cover less than a mile a day in these areas because many stands are nearly impenetrable. Considering the scope of the infestation, this would take many, many years, all the while losing additional land to this scourge as it continues to advance. This plan is based on the research published in the Hawaii state Environmental Assessment and from the post release work of Tracy Johnson of the USFS. The purpose is to apply the lessons learned from the science done to date. It also relies on input from helicopter operators, heli bucket manufacturers, and personal knowledge and experience. It is intended as a guideline to focus necessary detailed planning.

Drones are feasible in limited areas because many flight lines will be quite long and will require the capability of carrying large amounts of *T. ovatus* leaves. Also, drones must be in sight of the operators. We estimate 4,000 miles of helicopter flight line for the high elevation area and 6,000 miles of line in the mid-slope area.

Gall Production Conceptual Plan

- We propose to convert an existing strawberry guava stand into a guava gall orchard by cutting a stand down to approximately two feet in height and then inoculating the resulting sprouts with *T. ovatus*. A site has been located and reviewed for the first gall orchard.

- The cutting would be done with an arm mounted mulching head on an excavator or similar chassis.
- Guava stands carry 3,000 to 7,000 trees per acre. Cut stems will usually sprout from three to six stems.
- A stem normally has 50 or more leaves. We estimate that an acre could produce a million leaves. If half of the leaves are galled, the yield would be 500,000 leaves, requiring two acres to support the project.
- Sites would need to be clear of little fire ants and ROD to avoid disseminating these pests

Because these numbers are preliminary, current thinking would be to double them for planning purposes – therefore we would plan on four acres of pruned, galled strawberry guava to support the project.

Method of Dispersal

The primary proposed method is by helicopter bucket modified with a "ram air" system to handle galled leaves. The proposed flight pattern is parallel flight lines flown at right angles to prevailing trade winds direction for additional dispersal. Flight lines would be on 150 foot centers with an assumed dispersal width of 50 feet. Flights would be high enough from the ground to minimize the impact prop wash would have on lodging the leaves in treetops.

We have considered three alternate helicopter spreading techniques:

- Broadcast single or double leaves by heli bucket
- Broadcast by hand from the helicopter
- Broadcast mesh bags by hand

Methods:

- Blanketing the area where strawberry guava is dense would be more efficient than seeking out concentrations that are not all visible from the air or with remote sensing. Where concentrations are less dense remote sensing will likely play a helpful role in designing application projects.
- Concentration of leaves on direct treated acres would be around 40 per acre. This would be around 5 to 10 times the recommended concentration but assures contact of distributed leaves with the scattered tree tops. We believe distribution costs will not change significantly with the volume of leaves dispersed but with miles flown.
- Alternatively distribute branchlets with leaves attached. This method has been tried and found to work. But likely individual leaves or small leaf cluster will be more logistically feasible.

Assumptions:

- Project specifications assume subsequent spread of *T. ovatus* 30 feet upwind and 70 feet downwind.
- Distribute 40 galled leaves per acre with an expected 30% tree top landing in scattered trees and 60% tree top landings in dense populations.
- Four seasons to complete

- 70 flight hours per season
- 1 million galled leaves per season required
- Distribution cost estimate $6 – $10 per acre plus cost of growing and handling galled leaves and project management.

Timeline

Completed	Develop strategic plan
	Gain consensus on basic assumptions with key cooperators
	Prepare project area zoning and ownership list
	Strategic plan introduced to stakeholders
	Trials of various leaf/ branchlet dispersal configurations
	First gall orchard site identified
	Operator identified
2021	
	Locate three additional sites for growing galled leaves.
	Fundraising for trials and tests
	Cut Guava for T Ovatus production site
	Obtain buy-in with major landowners
	One acre gall production trials
	Dispersal testing
	Recalibrate based on data
	Detail operation plans and refine budgets
	Commence Environmental impact statements
	Locate operational funding sources.
	Build out – gall production
	Negotiate ops contracts
2022	
	Operational Scale testing
	Detailed plans for 2023 operations
2023	Full operations

APPENDIX B

CLEAR CLUSTERS OPERATION PLAN

A great deal of the mid-elevation forest is a koa-ohia-strawberry guava mix. Species typically occur in clusters. The eventual outcome of this mix is occupation of most of remaining native forests by invasives, primarily strawberry guava. All stages of invasion are present from incipient through complete control by the guava with a significant portion of the koa is already dead and dying. Strawberry guava appears to be headed for an inexorable take over as the predominant species unless managers of the land energetically intervene soon.

The clear clusters method aims to achieve four goals:

- Mechanically remove clusters of strawberry guava in a manner that will allow dormant koa and ohia seed to sprout and occupy the site
- Harvest dead and dying koa to support the forest products industry as directed by legislative intent and as acknowledged as a primary goal by DOFAW.
- Provide access for both recreation (as directed by legislative intent) and for future ground based invasive species control efforts.
- Provide a steady and substantial income stream to finance additional conservation efforts

Sequencing of various aspect of the plan would be:

1) Treat the entire area with bio-control to slow the advance of the strawberry guava, reduce the ongoing damage, and supporting future mechanical removal.
2) Develop a detailed forest inventory utilizing remote sensing and ground truthing.
3) Begin construction of an all-weather low-density road system to provide access. Road density could be in the order of a mile per 1000 acres and would, where feasible, be located as ridgetop mauka-makai roads.
4) Initiate a koa re-introduction marketing effort to a broad market.
5) Begin harvest of dead and dying koa, primarily in clusters.
6) Mechanically remove remaining strawberry guava in the vicinity of harvest to enable sprouting of dormant koa seed. Seek opportunities to regenerate with ohia. Design silviculture efforts toward control of the overstory layer by native species.
7) Begin construction of forwarder trails for access from primary roads. (not for public vehicle use)
8) Monitor previous harvest sites for need of supplemental planting or for pre-commercial thinning of new koa.
9) Seek opportunities for establishing either native or commercial species for the mid-canopy level.

Harvest goals.

Preliminary estimates are that there are around 150,000 acres of koa for which the approach is appropriate. If the project were to remove 1 mbf per each acre and the re-entry rates were on a 20 year cycle the annual harvest would be 7 million board feet. Our current estimate is that the sustainable yield is closer to 20 MMBF. Log sale values should be no less than $5 per board foot. Target for annual revenue is mid 8 figures.

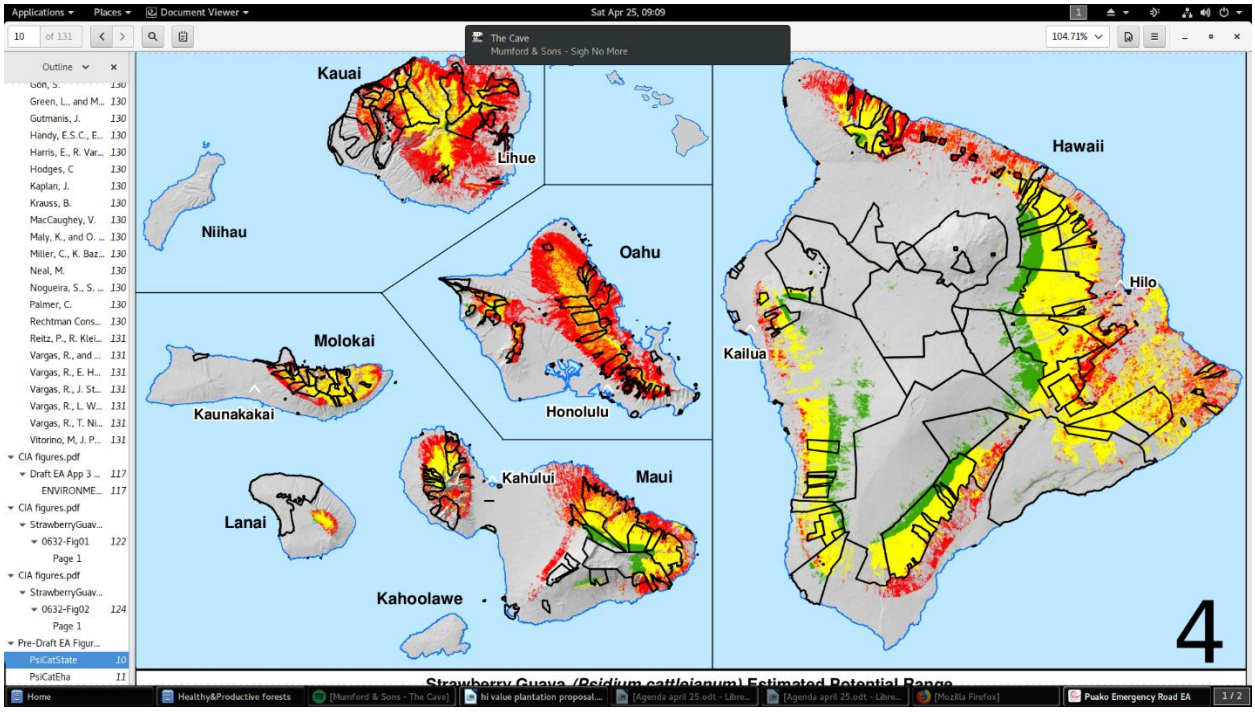
APPENDIX C

Full Stand Removal Plan

to be written

APPENDIX D

Maps



Red - Confirmed guava stands , 2010

Yellow- Suspected guava stands 2010

Green- Believed to be outside of Strawbrry guava range

Appendix E

Permits, Environmental Assessments, Public Outreach

The following is a review from reading the statutes. It is not legal advice. Prior to operations, seek legal advice.

- **Research on methods of growing and distributing T. Ovatus**

Research is specifically excluded from activities requiring an Environmental Assessment under Title 19, HRS Health Chapter 343-5. Any research done on State land will require a state permit.

- **Release of T. Ovatus**

The introduction of T. Ovatus in 2011 was subject to an Environmental Assessment because it involved the use of State lands and state funds per Title 19, HRS Health Chapter 343-5. If T. Ovatus is released on state land it should covered by the FONSI previously granted by DLNR. Activities on private Conservation District land requires an Environmental Assessment for "use" of the land. The Biocontrol Plan is to protect the land, not to "use" it. Protecting the land is not "enjoying the benefits or profits of real property" as "use" is defined. Therefore, no Environmental assessment should be required for release of T. Ovatus on private land in the Conservation district. This assumption should be confirmed with counsel.

The original research on T. Ovatus involved importing and releasing an organism new to Hawaii, subjecting it to permit requirements from Department of Agriculture, Plant Quarantine Branch and a permit from USDA, APHIS. Representatives from both Department of Ag and APHIS say that the insect is now in Hawaii and released, so no further permits are needed.

- **Activity on the ground – Conservation R subzone**

Ground activity on Conservation resource zoned land will most likely require an environmental assessment or environment impact statement under HRS Chapter 343-5.

Activity on the ground – Agriculture district

Most ground disturbing activity on ag land requires a grubbing and grading permit. As an alternative, a management plan approved by Soil Conservation Service can be obtained with the assistance of SCS.

Community Outreach

- **Research phase**

Healthy and Productive Forest Initiative will inform and seek advice from community leaders and officials from various constituencies throughout the research phase. We believe widespread community involvement before there are specific plans, commitments, or funding would be disruptive and confusing to most people involved. Large scale information programs conveying that we "may do this or might do that" would be counterproductive.

- **Operational research**

At the operational scale research phase involving aerial operations we would recommend adding neighbors of affected land and any additional officials who may have some jurisdictional interests. At this stage there are no specific plans to be communicated, nor are there commitments by landowners to proceed.

- **Aerial Operations**

Prior to aerial operations beyond the scope of trials it would be appropriate to conduct community information programs and to take and consider input.

- **Operations involving Environmental Assessments (Conservation P subzone)**

Any operation involving an EA will require extensive community communication and input.

- **Ground operations not involving Environmental Assessments (Ag district)**

Operations in agriculture district lands should be regarded as any other operation on agriculture land. The plans will become part of the public record as a function of filing a conservation plan. Beyond that, it should be up to the landowner to decide what he wishes to convey to his neighbors, and what he does not.

APPENDIX F

Ownership and Zoning

Known and Potential Strawberry Guava Infestation Acres on Hawaii Island Largest 32 Land Owners

	CONSERVATION				AGRICULTURE		
Land Owner	**Resouce**		**All Other (Protecton, Limited, General)**				
Largest to Smallest Total Ownership	**Known**	**Potential**	**Known**	**Potential**	**Known**	**Potential**	**total**
Govt. State	19,497	95,953	19,390	142,087	18,858	52,514	348,299
Govt. Federal	2,334	64,430	10	16,891	411	5	84,081
Kamehameha Schools	1,816	9,198	6,260	13,657	20,217	26,780	77,928
Waipio Terrace	396	10,641	0	9	157	1,033	12,236
W.H. Shipman	112	29	0	0	2897	6946	9,984
The Nature Conservancy	13	1042	2	1329	0	6607	8,993
Parker Ranch	51	55	290	341	2,769	2,558	6,064
Govt. State DHHL	141	105	169	2	2,046	3,547	6,010
Halawa	22	2	520	1732	2810	64	5,150
E.C. Olson	4	5	0	0	3218	1796	5,023
Hilo Family Farms	146	2,515	399	1,438	22	284	4,804
McCandless Ranch	0	0	0	0	297	3724	4,021
E.M. Stack	0	0	0	0	228	2481	2,709
Govt. County of Hawaii	61	9	3	7	1,581	835	2,496
Bang Han So Temple	0	0	0	0	1,276	964	2,240

Laupahoehoe Nui	0	0	647	0	0	1,456		2,103
Watumull Inv.	55	4	0	0	187	1710		1,956
New Moon Fdn.	1	0	1,472	0	0	0		1,473
Ka'u Mahi	0	0	0	0	1,314	87		1,401
Kapoho Land & Dev.	0	0	76	583	375	363		1,397
Ponoholo Ranch	0	0	0	0	330	743		1,073
Kahua Ranch	0	0	0	0	309	686		995
Omaomao	0	0	0	0	353	530		883
Queen Liliuokalani Trust	13	0	18	0	831	0		862
Le Cheval Rogue	0	0	0	0	525	307		832
W.J. Paris Sr. Tr.	0	0	0	0	275	374		649
Ka'u Sunshine	0	0	32	0	480	120		632
Pearl Street Two	0	0	0	0	218	390		608
Kukaiau Ranch	0	0	0	0	215	392		607
Glory to Yahuwah	0	0	0	0	503	103		606
Palani Ranch					359	124		483
Kau Royal Hawaiian Coffee	0	0	0	1	343	44		388
EWM Enterprises	1	50	0	0	335	0		386
Subtotal	24,663	184,038	29,288	178,077	63,739	117,567		597,372

Data supplied by State of Hawaii Department of Land and Natural Resources
Dr. Jonathan Price, UH Hilo Department of Geography.

APPENDIX G

Hawaii Forest Industry Association

Established in 1989, Hawai'i Forest Industry Association (HFIA) is a nonprofit corporation founded by people dedicated to responsible forest management. HFIA's programs promote healthy and productive forests, actively manage forest restoration projects for clients such as Kamehameha Schools and the Department of Hawaiian Homelands and supports Hawaii's forest products industry. HFIA has 280 members, located both in Hawaii and on the mainland.

HFIA's purposes are to:

- Manage and encourage sound forestry practices for the benefit of our forests and the forest industry;
- Promote the health of Hawaii's forests;
- Promote public relations for the Hawai'i forest industry and to stimulate interest, use and involvement in the forest products industry;
- Provide members and others with opportunities for dialog, education, advancement, and improvement in all aspects of the Hawai'i forest industry;
- Promote, foster and develop industry standards, research and development, quality control and industry integrity in the State of Hawai'i;
- Articulate and advocate as a focused voice the needs and interests of the forest industry before local, state and federal governments; and
- Operate as an official trade association of the Hawai'i forest industry for the purpose of
- promoting a common business interest.

HFIA's many projects and activities include:

- Hosting our annual woodworking exhibition Hawaii's Woodshow and associated Workshops;
- Promoting Hawaii's Wood branding program;
- Restoring endangered dryland habitat in North Kona;
- Honolulu Zoo Children's Discovery Forest;
- Keauhou Bird Conservation Center Discovery Forest;
- Pana'ewa Zoo Discovery Forest;
- Conducting Young-Growth Koa Wood Quality Assessment Study;
- Sponsoring Symposia and Workshops;
- Offering professional training; and
- Serving as an advocate for Hawaii's diverse forest industry.

Directors and Staff

DIRECTORS

Officers
Don Bryan, President
Peter D. Simmons, Secretary
Wade Lee, Treasurer
Guy Cellier, Vice President

Kauai
Jeremy Campbell
Gilles Lebbe

Oahu
Michael Tam
Jorma Winkler

Maui
Thomas Calhoun

Hawai`i
Nicholas Koch
Peter D. Simmons

At-Large
Don Bryan
Jeremy Campbell
Guy Cellier
Irene Sprecher
Aaron Hammer
Tai Lake
Wade Lee
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Ron Wolfe
Aileen Yeh

STAFF

Executive Director
Heather Gallo Simmons

Membership Outreach Services
Aspen Billiet

Dryland Site Manager
Wilds Pihanui Brawner

Dryland Restoration Technician
Kekaulike Tomich

Dryland Outreach Coordinator
Yvonne Yarber-Carter

Cultural Educator
Keoki Apokolani Carter

Cultural Educator
Ku'ulei Keakealani

Dryland Outreach Assistant
Lehua Alapai

For additional information please visit: https://hawaiiforest.org

APPENDIX H

HEALTHY AND PRODUCTIVE FOREST INITIATIVE - BASIC ASSUMPTIONS

The following are the shared beliefs of advisors to Hawaii Forest Industry Association's' Healthy and Productive Forest Initiative. Agree to in a video conference Jan 26, 2021

Participants:

Steve Bergfeld	Department of Forestry and Wildlife	Hawaii Branch manager
Don Bryan	Hawaii Forest Industry Association	President, Forester
JB Friday	UH Hilo	Extension Forester
Christian Giardina	US Forest Service	Research Ecologist
Jim Jacobi	US Geologic Survey	Biologist
Tracy Johnson	US Forest Service	Research Entomologist
Peter Simmons	Hawaii Forest Industry Association	Founder
Irene Sprecher	Department of Forestry and Wildlife	Program Manager
Ron Wolfe	Hawaii forest Industry Association	Forester

THE SITUATION

Strawberry guava is the largest single threat to Hawaii's forest. Strawberry guava covers a massive amount of real estate and is moving fast. Multiple other invasives compound the issue.

GOALS

The primary goal of The Healthy and Productive Forest Initiative is <u>enabling or restoring higher value land uses</u> where such uses are impaired or prevented by the presence of Strawberry guava.

HFIA role is to participate in the development, testing, and demonstration of techniques.

LEGISLATIVELY ACKNOWLEGED OR MANDATED GOALS

Native species and species habitat conservation

Watershed protection

Commercial forestry

Expanded agriculture

Parks, and recreation including hunting and fishing

Native Hawaiian cultural opportunities.

ADDITIONAL SOCIETAL VALUES

Job creation

Invasive species suppression

Carbon sequestration

Island self-sustainability

The goals for any given land parcel would be consistent with legislative intent as expressed in zoning regulations and other applicable law and regulation.

Within the context of mandated goals and physical and climatic characteristics, landowners will have their own objectives.

GOALS BY LAND ZONING CATAGORIES

Conservation protection lands (P), and Natural Area Reserves, Federal lands, and designated critical habitat

Primary goals:

Native species and species habitat conservation

Invasive species suppression

Typical secondary goals

Watershed protection

Conservation Resource lands (R)

Primary goals

Commercial forestry

Park and recreation opportunities

Native cultural practices and gathering

Typical secondary goals

Native species habitat conservation

Watershed protection

Invasive species suppression

Carbon sequestration

Island self-sustainability

Agriculture lands

Primary goals

Expanded agriculture

Island self-sustainability

Job creation

Soil and watershed protection

Typical secondary goals

Invasive species suppression

TOOLS

Various tools have been proposed for dealing with s. guava. The selection of the appropriate tool or tools in each circumstance would consider:

- Effectiveness of the tool for its purpose
- Cost effectiveness of the tool
- Quality of the knowledge base supporting each tool
- Landowners goals for the land
- Value to the landowner of the opportunity being restored.

Biocontrol

Tectococcus can be a highly effective tool to control S guava.

The science around Tectococcus is solid

Aerial distribution is both the quickest and least expensive way to disperse it

Work is needed on techniques for producing and distributing galls.

If biocontrol distribution is aerial based, costs are estimated at < $25 per acre

Mechanical

Three methods are available.

Scarification using tractors pushing with brush rakes

Grinding standing trees with excavator arm mounted grinder heads

Pulling (weeding) using excavator arm mounted brush grapples

Experience on Hawaii Island shows that limiting equipment weight and ground pressure can prevent soil damage.

It appears that methods using excavators which work while stationary may be preferable to crawlers which work while moving.

Mechanical work can be complete removal, as has been successfully done on agriculture lands in Puna, or done in small patches concurrent with salvage logging of dead and dying trees.

Mechanical removal is running $1,500 to $2,500 per acre treated, depending on ground conditions.

There are numerous examples of success with mechanical methods.

Hand applied Chemicals

Chemical control applied directly to fresh stumps or to frilled cambium.

Treatments are very expensive

No evidence yet of enduring successes

Harvest dead and dying trees w/ scarification of S. guava clusters.

Dead and dying koa, plus potential dead and dying Ohia, are ground harvested.

Openings are partial, typically using < 30% of the ground

Harvesting is supported by a system of rocked all weather roads and dedicated forwarder trails.

Initial estimates are a given acre would entered on a 20 year cycle

Sustainable annual net revenue potential is estimated in the mid to low 8 figure range island wide, net of invasive control and management

Roads are used for recreation, hiking, hunting, access for cultural purposes, and access for protection from future invasives.

Koa tends to naturally sprout very prolifically in disturbed ground and requires openings

Ohia regeneration will also require crown openings.

A silviculture priority will be control of the canopy. Management strategies could include agro-forestry, silvo-pastoral systems, or other regimes consistent with landowners' objectives.

PROPOSED METHODS BY ZONING

Conservation protection lands (P), Natural Area Reserves, et. al.

Biocontrol

Other techniques as designated by managers of those lands

Conservation resource lands (R)

Primary tools

Biocontrol

Mechanical restoration of areas of invasive species

Harvesting dead and dying commercial species to fund access for harvest, invasive species control, and recreation.

Secondary tools

Chemical control of invasives if needed

Agriculture lands

Primary tools

Biocontrol

Mechanical removal of invasive species

Secondary tools

Chemical control of invasives if needed.

PROPOSED TIMING

Biocontrol

2021	Develop methods Mapping via remote sensing
2022	Proof of concept -operation scale tests Public information program
2023	Full scale operations

Harvest Plus Scarification of Clusters

2021	Research in previous logging sites Technique trials Distribute galls in future trial areas
2022	Proof of concept operation scale tests
2023	Permitting and begin operations.

Mechanical scarification of solid guava patches

2021	Research on previous work areas Trials of newer techniques
2022	Demonstration of techniques for landowners