COST OF PRODUCTION AND MARKET OPPORTUNITY FOR VETIVER GRASS

Prepared for
O'ahu Resource Conservation & Development
99-193 Aiea Heights Drive
Aiea, HI 96701

by the
Agribusiness Incubator Program
University of Hawaii

Agribusiness Incubator Program

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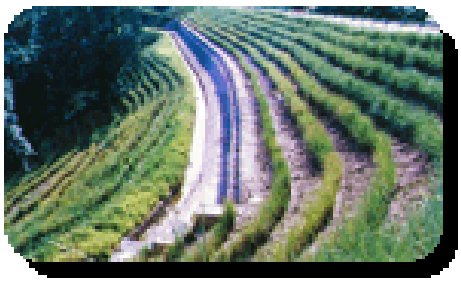
Executive Summary

Vetiver has proven itself as a very cost-effective method to reduce soil erosion and stabilize steep slopes. The USDA Natural Resources Conservation Service has included the planting of vetiver grass as a best management practice (BMP) for Hawaii farms and is recommending usage within conservation plans.



Small amounts of 'Sunshine' vetiver *(Chrysopogon zizanioides)* have been available from the USDA Hoolehua Plant Materials Center (PMC) on Molokai, for testing and grower increase, and the Hawaii Agriculture Research Center (HARC) Kunia Substation. The PMC, however, has completed its task of testing this species and has plans to reduce production of vetiver. Limited supplies available from the PMC and HARC can no longer meet the growing demand and there is currently only one known established commercial vetiver supplier.

The purpose of this report is to analyze the cost of vetiver production and market opportunities for the island of O'ahu.

Cost of Production

The estimated cost to grow vetiver reveals the following:

- Total cost will equate to $0.53 per slip.
- If charging $1.00 per slip, expected profit per slip is $0.47. Annual operating profit for a 1/2 acre production will total $51,426.

The estimated cost to install vetiver reveals the following:

- The cost to install 200 linear feet of vetiver is $1,840.
    - This equates to $9.20 per linear foot.
- The cost to install 1,000 linear feet of vetiver is $6,432.
    - This equates to $6.43 per linear foot.
- The cost to install 2,000 linear feet of vetiver is $11,235.
    - This equates to $5.62 per linear foot.
- The cost to install 4,000 linear feet of vetiver is $22,072.

- This equates to $5.52 per linear foot.

A reduction in the per day equipment charge significantly reduced the per linear foot cost when comparing a 200 foot installation and a 1,000 foot installation.

Market Opportunities

To determine the demand of vetiver on O'ahu over the next 5 years, 3 markets were analyzed: Government, Large Private Landowners, and Farms. The aggregate demand and financial estimates from the three markets is estimated as follows:

Year	Slips	Revenue (at $1 per slip)	Profit
1	442,110	$ 442,110	$ 207,792
2	1,198,932	$ 1,198,932	$ 563,498
3	1,961,111	$ 1,961,111	$ 921,722
4	2,567,178	$ 2,567,178	$ 1,206,574
5	2,717,624	$ 2,717,624	$ 1,277,284
Total	**8,886,955**	**$ 8,886,955**	**$ 4,176,869**

The demand and revenue/profit potential for installation services varies among the 3 analyzed markets and the total is estimated as follows:

Year	Feet	Revenue	Profit
1	49,616	591,268	295,634
2	203,927	2,314,415	1,157,208
3	360,248	4,061,415	2,030,707
4	477,954	5,371,766	2,685,883
5	498,841	5,613,234	2,806,617
Total	**1,590,587**	**$ 17,952,098**	**$ 8,976,049**

Conclusion

As vetiver increases its reputation as an effective method to reduce soil erosion and stabilize steep slopes, the demand for the plant and installation services will continue to increase. Based on the analysis of the cost and market opportunity, vetiver can be a profitable crop for growers.

Contents

Introduction

Background and Objective

'Sunshine' vetiver is a non-fertile, non-invasive perennial grass with a dense web of roots that binds soil and penetrates vertically to 15 feet. It thrives in the tropics, growing in a variety of inhospitable soils with low regard for fertility, salinity, pH, and drought. When planted in strips, vetiver forms a vegetative barrier that slows the velocity of water and traps sediment and debris. Decades of use in the tropics confirm that vetiver, when used as a vegetative barrier, is a very cost-effective method to reduce soil erosion and stabilize steep slopes.

Its proven success has led the USDA Natural Resources Conservation Service (NRCS) to include the planting of vetiver as a best management practice (BMP) for Hawaii farms.

Small amounts of 'Sunshine' vetiver have been available from the USDA Hoolehua Plant Materials Center (PMC) on Molokai, for testing and grower increase, and the Hawaii Agriculture Research Center (HARC) Kunia Substation. The PMC, however, has completed its task of testing this species and has plans to reduce its production of vetiver. Limited supplies available from the PMC and HARC can no longer meet the growing demand and there is currently only one known established commercial vetiver supplier.

Preliminary estimates from the Kunia and Waialua areas, gathered by the NRCS, indicate a need for over 100,000 lineal feet on just a few of the farms. In addition, the NRCS believes that other farms, the Hawaii Department of Transportation and Department of Land and Natural Resources, and the US Department of Defense agencies would likely be end-users of vetiver grass if it were available at a reasonable cost.

In late 2008, the O'ahu Resource Conservation & Development Council (ORC&D) was awarded a grant to evaluate, promote and advance the adoption of vetiver grass as a conservation resource, and encourage its production on a commercial scale. The project seeks to establish/conduct the following:

- Agronomic field guides for propagation.
- Economics of propagation information for potential commercial scale or contract production.
- At least two field days for potential producers to share propagation guidance.
- Market opportunities that provide links and contact lists for those needing plant materials and those interested in providing plant materials.

The goal of the project is to:

- Evaluate, promote and advance the adoption of vetiver grass as a conservation resource to reduce sediment transport in areas needing critical area treatment. By establishing a field site (or sites) that demonstrates profitable propagation techniques, information can be shared with nurseries and grass farms in the form of field guides for establishment, propagation and replanting as a conservation practice, and publications/literature for farmers, NRCS, and other agencies/ organizations.
- Inventory current and projected 1-5 year demand on O'ahu for vetiver plant material. This information will be shared with nurseries and grass farmers so they can better evaluate market opportunities.
- Compile propagation costs and market prices for vetiver.
    - Measure growth performance of vetiver.
    - Increase adoption/transference of this technology to farmers/public through appropriate literature and/or publications.
    - Identify and document effective establishment techniques for the propagation of vetiver grass for resale.

This report fulfills the goals relating to vetiver cost of production and market opportunities for the island of O'ahu.

Vetiver Grass

Vetiver (Chrysopogon zizanioides) has been utilized for medicinal purposes, energy production, bioremediation, mat and basket production, landscaping, hedgerows, firebreaks, insect repellent, scented oils, perfumes, and soaps. Its primary use in Hawaii, however, has been for soil and water conservation.

Use as a Vegetative Barrier for Erosion Control

Vetiver is a quick growing grass, suitable for most soil conditions, and has a deep root system that provides structural strength in a short period of time. When planted in a row, vetiver can be an effective, inexpensive, low maintenance method to minimize soil erosion. After initial planting, a single vetiver slip quickly multiplies and when properly planted, connects to adjoining plants to create a thick, sturdy grass hedge. The deep and wide hedge slows and spreads water runoff, forming terrace-like benches at the face of the hedges. In addition, the thick and deep root system keeps the plant relatively fixed during high velocity water flows.

Alternatives to Vetiver Grass for Soil Erosion

Soil erosion can also be mitigated using the following techniques:

- **Diversion berms** are mounds of earth used to deflect water. They can be used to move water to a less erodible area. Soil loss can occur from the berms themselves, and berm creation typically requires heavy machinery.

- **Construction methods** include using reinforced concrete structures or ditches. Fixed structures can be expensive to install, brittle, costly to repair and maintain, and are usually unsustainable.

- **Other Vegetative Materials** such as bana grass, wild cane, pili grass, and lemon grass can also be used for vegetative barriers. However, 'Sunshine' vetiver is the only plant to receive a variance from the standard minimum width of 36 inches to 12 inches. Thus, a single row or a closely planted double row of vetiver will suffice where multiple rows of other species are needed. A minimum amount of crop land is devoted to these single-row vegetative barriers.

Advantages of Using Vetiver for Erosion Control

The major benefit of vetiver over conventional engineering is its low cost and longevity. It is estimated that the cost of installation is 30% of the cost of traditional construction methods (Troung, Van, and Pinners, 2008: 30). In addition, vetiver has the following advantages (Troung, Van, and Pinners, 2008: 30):

- Vetiver provides a natural, environmentally-friendly way to control erosion and stabilize land and 'softens' the harsh look of conventional rigid engineering measures such as concrete and rock structures. This is particularly important in urban and semi-rural areas where local communities may criticize the unattractive appearance of infrastructure development.

- Long-term maintenance costs are low. In contrast to conventional engineering structures, green technology improves as the vegetative cover matures. Therefore, the use of vetiver is particularly well suited to remote areas where maintenance is costly and difficult.

- Vetiver is very effective in poor and highly erodible and dispersible soils.

Disadvantages of Using Vetiver for Erosion Control

The main disadvantage of vetiver is its intolerance to shading, particularly within the 3-6 month establishment phase. However, due to sun availability in Hawaii during most of the year, appropriate planning can reduce this risk. In addition, vetiver has the following disadvantages (Troung, et al, 2008: 31):

- Vetiver is effective only when the plants are well established. Effective planning requires an initial establishment period of about 2-3 months.

- Vetiver hedges are fully effective as a vegetative barrier only when plants form closed hedgerows. After establishment, gaps between clumps must be minimized or eliminated.
- It is difficult to plant and irrigate vegetation on very steep slopes, although this would also apply to alternatives.
- Vetiver requires protection from livestock during its establishment phase.

Project Research Approach

To determine the cost of production associated with growing and installing vetiver and the market demand, the following research was conducted:

1. Interviewed key contacts (see *Appendix, Research Sources, Subject Matter Experts*).
2. Reviewed existing documentation (see *Appendix, Research Sources, Publications*).

Details on the research activities undertaken are included in the relevant sections of this document.

Approach to Findings

Information outlined in this report is based on a combination of research and experience from the aforementioned sources and the authors. Market demand estimates are limited to the O'ahu market only. Obtaining market demand was complicated by the fact that many sources were not able to provide specific information for use. In lieu, estimated demand numbers based on stated acreage were utilized.

The cost and market demand of maintaining vetiver as a service was also considered. Because vetiver requires minimal maintenance, there was a low interest level in this service and further analysis was not conducted.

Cost of Production Estimate for Growing Vetiver

Growing Vetiver for Commercial Production

The growing method currently used at the USDA NRCS Hoolehua Plant Materials Center (PMC) was used to determine appropriate production requirements and costs associated with growing vetiver for commercial production. Note that additional experience with vetiver may lead to new information and improved production techniques.

Although this planting/growing method was used for consideration in commercial production, it should not be used for advice with placement of vetiver for soil mitigation purposes. For advice in planting vetiver for soil erosion mitigation, contact the local NRCS office.

Using current growing methods, the Hoolehua PMC staff provided recommendations for commercial vetiver production and the Cost of Production figures assume adherence to these recommendations.

- General
    - Plant in three phases with new vetiver planted every 6 months. Harvest at 12 months to allow the land to remain fallow for a period of 6 months and be adequately rotated. Re-till land prior to replanting.
    - Basic farm machinery (see below) is needed to prepare land, control weeds, and cut and harvest vetiver.
    - Growers should plan for a 10% mortality rate. The plant output numbers noted in the analysis have taken this into account.
- Initial Startup/Planting
    - Use a clear, relatively level area with open sun for planting.
    - Use a tractor for land preparation and plant removal. It is the preferred method and is the method used in the accompanying Cost of Production Estimate. Manual methods can be used; however, this will increase the labor hours.
    - Ground preparation includes plowing, amendment addition, and tilling.
    - A specific soil type is not essential. Soil testing, however, should be conducted to determine effective amendments.
    - A specific fertilizer formula is not consistently recommended. At a recent planting, the PMC used Triple 16 fertilizer when initially planted and is used in the Cost of Production Estimate.

- Install a drip irrigation system for supplemental watering.
- Prior to planting, soak soil overnight.
- Plant by hand and place each slip 1 foot apart within the row.
- Place rows 6-8 feet apart (depending on the type of equipment that is needed to remove and maintain plants).

- Post Planting
  - After initial planting, soak vetiver daily for three weeks to establish the root system.
  - After establishment, irrigate once per week for one hour with drip tape.
  - Hand weed once per month.
- Plant Removal
  - Use a tractor to cut out a root ball about 1 foot deep.
  - Plants can be harvested as early as 6 months. The ideal harvesting period is between 12 and 18 months. The plants should not remain in the ground beyond 24 months as slips become tight and roots become deeply rooted, making the removal and hand splitting difficult to manage.
  - Manually split and clean plants and remove most of the root.
  - Plant output:
    - 6 months: 20 slips produced per initial plant
    - 12 months: 50 slips produced per initial plant
- Other Notable Information
  - Currently vetiver cannot be imported into Hawaii without fulfilling a 1-year quarantine period.
  - Vetiver can be exported to other states if the grower has a Hawaii Department of Agriculture certification.
  - Growers can consider placing vetiver in pots instead of the ground. Although this may allow for easier plant removal, the PMC has not tested this growing method and its effects on plant volume.

- Growers can consider growing vetiver hydroponically. Although this may allow for easier plant removal, the PMC has not tested this growing method and its effects on plant volume.

Crop Plot Plan

In determining the Cost of Production Estimate, commercial production on ½ acre of land was used. The following is general information about the land, number of plants, and slip production for the ½ acre:

Square Feet Per Acre	43,560 square feet
Square Feet per ½ Acre (rounded)	20,000 square feet Assume area used is 100 feet x 200 feet
Plants per Row	100
Number of Rows (planted 6 feet apart)	33
Number of Plots	3
Number of Plants Per Plot	1,100
Slips Produced From Each Plant in 12 Months	50 (includes a 10% mortality)

The following plot plan was used in the calculation:

	Plot #	Number of Plants	Rows	Harvest	Yield	Next Planting Schedule
January-2010	Plot1	100	1	Jan-11	4,000	Jan-2012
July-2010[1]	Plot1	1,000	10	Jul-11	50,000	Jan-2012
2011 Harvest Total		**1,100**	**11**		**54,000**	
January-2011	Plot2	1,100	11	Jan-12	55,000	Jul-2012
July-2011	Plot3	1,100	11	Jun-12	55,000	Jan-2013
2012 Harvest Total		**2,200**	**22**		**110,000**	
January-2012	Plot1	1,100	11	Jan-13	55,000	Jul-2013
July-2012	Plot2	1,100	11	Jul-13	55,000	Jan-2014
2013 Harvest Total		**2,200**	**22**		**110,000**	
January-2013	Plot3	1,100	11	Jan-14	55,000	Jul-2014
July-2013	Plot1	1,100	11	Jul-14	55,000	Jan-2015
2014 Harvest Total		**2,200**	**22**		**110,000**	

[1] The initial planting includes 100 free plants from the Hoolehua PMC. Six months after the planting, 1,000 slips are removed from the sides of the starter plants and replanted.

Financial Analysis

The Cost of Production Estimate revealed the following (see *Appendix* for the detailed Cost of Production Estimate):

- During the first year of operation:
    - Total direct cost incurred during the first year of operation is $16,985.
    - Total labor hours incurred during the first year is 1,184 ($15,948, or 94% of the total direct cost).
- At full production:
    - 2,200 plants will be planted annually.
    - 110,000 slips will be harvested annually.
    - Annual direct costs will total $36,214.
    - Labor represents 93% of direct costs.
    - Direct cost per slip will total $0.33.
    - Total cost (with estimated indirect costs added) per slip will equate to $0.53.
    - If charging $1.00 per slip, expected profit per slip is $0.47. Annual operating profit will total $51,426.

Assumptions

The following assumptions, based on planting methods at the Hoolehua PMC, were used when developing the Cost of Production Estimate for growing vetiver:

- Initial area is cleared for planting.
- Planting area is ½ acre (100 ft. x200 ft. area). There are 100 plants in each of 33 rows.
- Plants are placed 1 foot apart within each row. Rows are placed 6 feet apart (center to center).
- Ground preparation is only done in the area targeted for planting (except for the initial planting where the 1/6 acre is prepared).
- The Hoolehua PMC provides 100 started plants free of charge. Note that Hoolehua PMC has completed its task of testing this species and has plans to reduce production of vetiver in the near future.

- The initial planting includes the 100 free plants from the Hoolehua PMC. Six months after the planting, 1,000 slips is removed from the sides of the starter plants and replanted.
- Eleven rows are planted every 6 months for adequate rotation. Land lays fallow for 6 months after each harvest.
- The Pacific Business News (dated: 2/23/09), noted average wage for field workers in small farms as $10.36. This dollar amount is used for labor costs.
- Thirty percent is added to labor costs for employee benefits and insurance costs.
- Soil test is estimated at $21 for the report plus $10 for shipping or deliver to CTAHR. Information on soil testing can be found at www2.ctahr.hawaii.edu/adsc/
- Ground preparation assumes use of 2 blade plow and includes the following per acre time estimates:
    - Plow (16 hours)
    - Breaking clods of dirt with disk (3 hours)
    - Adding amendments (lime/phosphorous/nitrogen) (3 hours)
    - Roto-till (8 hours)
- Drip irrigation setup includes pulling lines, stretching, hooking fittings, and pegging lines.
- Water cost is estimated at $2.66/1000 gallons (.00266 per gallon).
- A tractor is used for plant removal. (Note: hand removal is an option but it will increase labor hours.)
- Cost per slip is based on full production.
- The nursery had a 5 acre production and vetiver accounted for 10% of overall farm production. Indirect Costs are allocated at this level.
- Disposal costs are not factored into the estimate.
- All plants are sold at one year of age. However, costs for maintaining plants for an additional 6 months are factored into the estimate.

Cost of Production for Installation

Installing Vetiver for Soil Erosion Mitigation

In addition to determining the cost of production for growing vetiver, the cost and market opportunity of installing vetiver as a service was explored.

Financial Analysis

The Cost of Service Estimate revealed the following (see *Appendix* for the detailed Cost of Service Estimate):

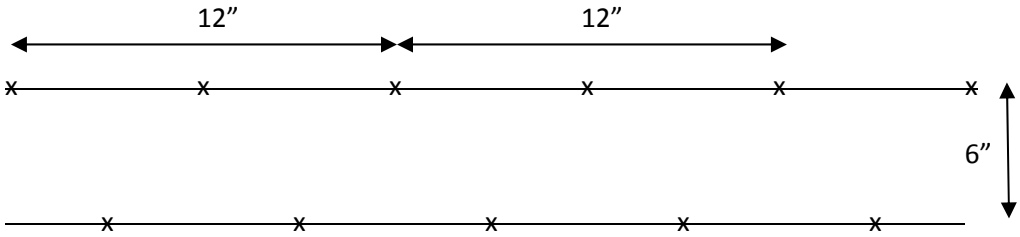
- The cost to install 200 linear feet of vetiver is $1,840.
    - This equates to $9.20 per linear foot.
    - Labor costs total $577 (31% of total direct costs).
- The cost to install 1,000 linear feet of vetiver is $6,432.
    - This equates to $6.43 per linear foot.
    - Labor costs total $2,560 (40% of total direct costs).
    - A reduction in the per day equipment charge significantly reduced the per linear foot cost when comparing a 200 foot installation and a 1,000 foot installation.
- The cost to install 2,000 linear feet of vetiver is $11,235.
    - This equates to $5.62 per linear foot.
    - Labor costs total $5,038 (45% of total direct costs).
- The cost to install 4,000 linear feet of vetiver is $22,072.
    - This equates to $5.52 per linear foot.
    - Labor costs total $22,073 (46% of total direct costs).

Assumptions

The following assumptions were used when developing the Cost of Service Estimate:

- Three employees are available to work on the project.
- Initial area is cleared for planting.
- Land grade is not prohibitively sloped.

- Purchaser provides at least 3 weeks between order and installation. This allows the nursery to root the plants prior to installation.
- A trough is dug with a plow attached to a small tractor.
- Equipment is rented (vs. purchased). Delivery charges are quoted for a location in Kunia.
- Estimated rental cost is $400 per day or $1,150 per week with a $250 delivery charge.
- Planting is done by hand.
- Four vetiver slips are planted in each 6” x 12” area (for purposes of this report, this area will be referred to as a linear foot since the plants will connect to form one row). Vetiver is planted in 2 rows (6" apart) with vetiver 6" apart offset in each row (see following diagram, where “x” indicates vetiver slip planting).



- To ensure establishment, site visits are conducted 3 times per week for the first 3 weeks.
- Land owner is responsible for irrigation installation and plant watering.
- Indirect costs are not included in the per linear foot estimate.

Market Analysis – Sale of Vetiver Plants

Definition of Markets

To determine the demand of vetiver on O'ahu over the next 5 years, the following markets were defined for the purpose of market segmentation. Each of these markets were assumed to have a significant aggregate need to mitigate soil erosion caused by surface water flow, and thus be candidates for vetiver purchase/implementation.

- **Government**: including federal, state, and city government lands that may use vetiver for soil erosion control along roads, parks, watershed reserves, and other public properties on the island of O'ahu.
- **Large Private Landowners**: such as Kamehameha Schools, Campbell Estate, and Castle and Cooke who have landholdings over 10,000 acres on O'ahu.
- **Farms**: privately operated farms on O'ahu (does not include land in the Large Private Landowner market).

Market Research

Significant effort was made in gathering market demand information from a wide representation (see *Appendix, Research Sources, Subject Matter Experts*) in each of the defined Markets. Each of the contacted Subject Matter Experts was asked to provide information on a number of questions (see below and *Appendix, Solicitation Letter*).

Due to the low general familiarity with vetiver, the questions were designed to provide quantitative information on the scope of need that vetiver might address, in addition to other information useful for selling vetiver. Data was solicited from 31 organizations/individuals with 16 providing feedback. Respondents, however, were often not able or willing to provide answers to some of the quantitative volume questions, in part due to the lack of summary/total information for their respective organizations.

Marketing Survey Questions

- How is your organization currently managing soil erosion and stabilizing steep slopes (structural: berm/concrete or vegetative method)?
- How many Total linear feet are managed by your organization (or boundary feet or total sq ft of properties / number of properties) on O'ahu?
- What percentage of Total are sloped lands?
- What percentage of Total may need soil erosion control or slope stabilization?
- Are there O'ahu projects planned in the next 5 years to manage soil erosion and stabilize slopes (obtain details on size of project and method, if possible, as well as approximate timing)?
- Are there any current O'ahu initiatives to manage soil erosion and stabilize slopes?
- Are soil erosion/slope stabilization responsibilities managed by your organization or lessee?
- Would your organization consider evaluating vetiver to manage soil erosion/stabilizing slopes and what would be the primary decision points?
- Would your organization make vetiver purchase decision directly or is this determined by a third party (contractor)?
- Would your organization install or contract out installation for O'ahu implementations?
- What are the requirements to award project (license/insurance/etc)?
- What is the contact information for individual/department that would make purchasing decisions for O'ahu projects?

Market Size and Demand

Vetiver has not yet gained status with most markets as a de-facto option for water diversion or soil erosion mitigation. As such, direct demand estimates are not available. In order to provide a proxy for direct demand, the following approach was developed:

For markets where only acreage data is available:

- Square root of 43,560 (one acre in square feet) = 209 (horizontal length in feet of acreage in the shape of a square)
- Number of acres under management x 209 = **A** (linear feet of acreage assuming one row per acre).

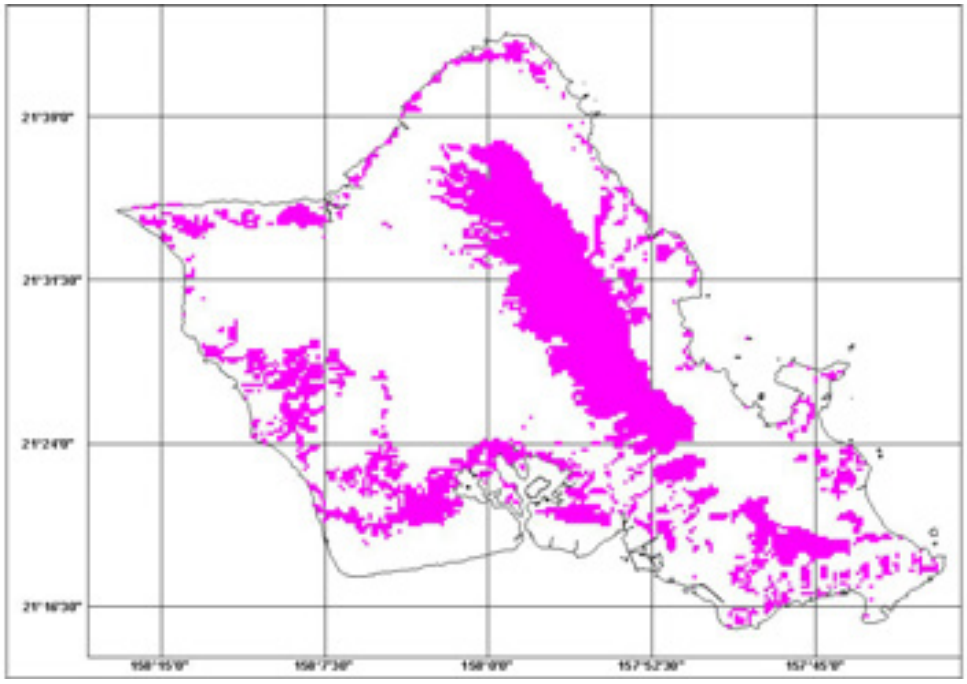
- **A** x **B** (modifier per market sub segment to reflect relative vetiver applicability—detailed per sub segment) = **C** (estimated candidate for vetiver in linear feet). Note that default value of **B** has been valued at 25% based on K Factor findings below.

- **C** x 4 (prescribed number of vetiver plants per lineal foot) = Number of vetiver plants for that market sub segment.

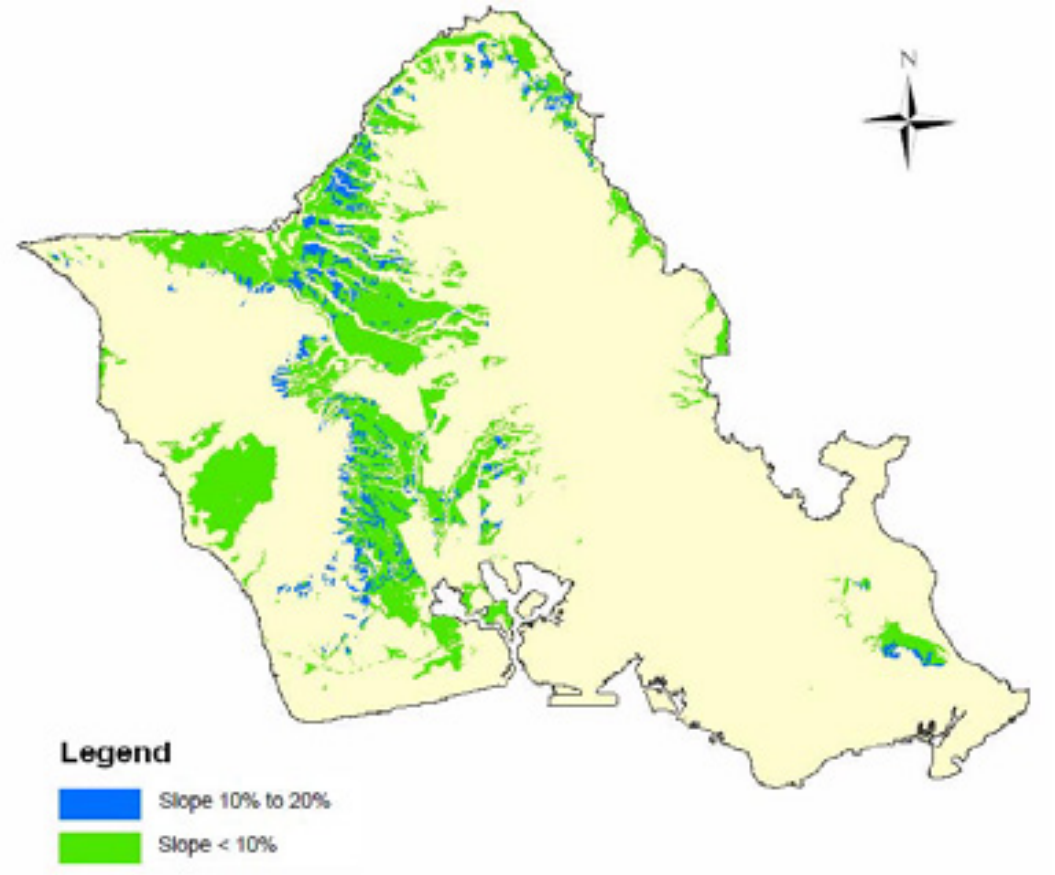
The authors attempt to be conservative in this approach in that it assumes only a single line of vetiver planted horizontally across an acre of square land (a variety of parcel size would tend to have greater horizontal length on average than the square root of an acre) . Also, just 25% of the acreage is deemed the base modifier for vetiver candidacy as determined by the K Factor analysis. Furthermore, market unfamiliarity, resistance to change, non-open areas, and other factors are taken into account and the modifier is thus typically reduced from the base. Finally, the total acreage used for the estimates is understated due to limitations of the research (incomplete accounting of total acreage for any given market).

In order to serve as a form of validation, the authors used the Hawaii Natural Resources Information System (HNRIS) software from the College of Tropical Agriculture and Human Resources, University of Hawaii, to analyze the number of acres on O'ahu with soil with 'Moderate' or greater 'K factor' (see *Appendix, K Factor*) as a gross indicator of candidacy for vetiver.

By the above analysis, 99,328 acres on O'ahu have a K Factor of 0.25 or greater (the threshold for 'Moderate' erodibility) as shown in the shaded areas of the map below. This represents roughly 25% of the total O'ahu acreage of 384,043 acres.



Effort was made to identify acreage exceeding certain grades/slopes as this would be another form of gross validation (NRCS estimates 3%-12% as a working figure), but the HNRIS and NRCS GIS systems could not provide this information. As a point of reference, a study by Kinoshita and Turn for the Department of Business, Economic Development and Tourism, provides a visual representation of certain grades/slopes for agricultural land on O'ahu (below).



The following table contains acreage per slope range information but applies only to acreage with soils deemed suitable to sugar cane growth.

Table 2. Acreages of NRCS sugar soils by land designation and slope.

	Natural Resources Conservation Service, Sugar Soils				
	Total	Zoned Ag	Zoned Ag, State Owned	Zoned Ag, Large Land Owners	Zoned Ag, ALISH
Island	acres	acres	acres	acres	acres
Oahu	117,233	62,509	4,022	51,112	54,734
0-10% slope	101,540	54,003	3,322	43,561	47,099
10-20% slope	15,693	8,506	700	7,551	7,635
20%+ slope	0	0	0	0	0

Government

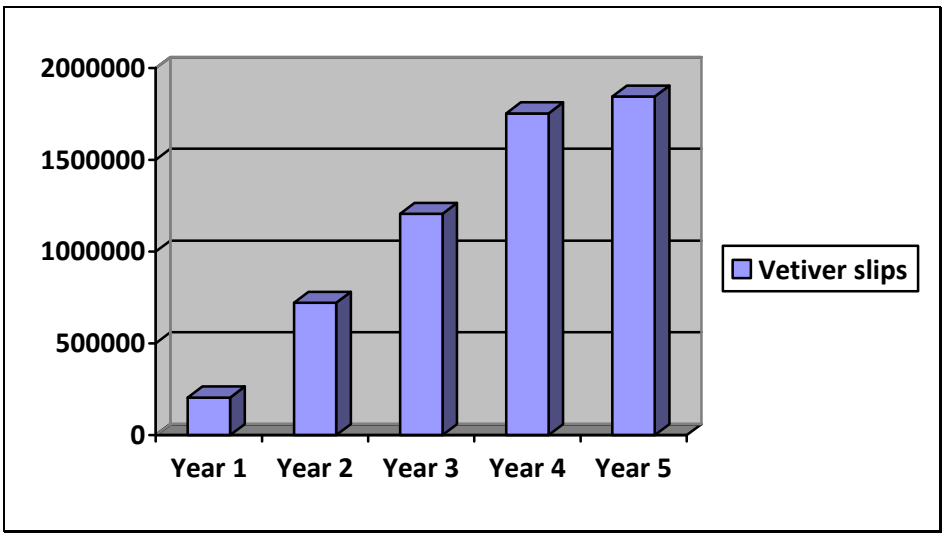
This market, consisting of Federal/military, State, and City and County of Honolulu agencies and organizations, represents the largest opportunity for vetiver plant sales. Some reasons stated by market interviewees that substantiate the strength of this market include:

- Customers in this market manage relatively large land areas.
- Customers in this market are especially sensitive to environmental concerns by policy and/or public interest and are thus more likely to address erosion issues.
- The use of natural methods for surface water diversion and erosion control is preferable for public perception considerations.

Currently there are two identified vetiver-using projects in the planning stages. The State Department of Transportation Services has a plan for using vetiver on a roadside slope on Kahekili Highway and is estimating the use of 13,000 vetiver slips (Chris Dacus). The City Department of Parks and Recreation (James Woll) has recently approved a vetiver pilot project on unspecified park land. In addition, interest in vetiver was expressed by the US Army Corp of Engineers (Russell Leong).

The market potential for vetiver slips in the government market is estimated to be (see *Appendix, Market Calculations, Government Demand*):

Year	Slips	Revenue (at $1 per slip)	Profit
1	205,672	$ 205,672	$ 96,666
2	720,623	$ 720,623	$ 338,693
3	1,206,056	$ 1,206,056	$ 566,846
4	1,753,013	$ 1,753,013	$ 823,916
5	1,844,351	$ 1,844,351	$ 866,845
Total	**5,729,715**	**$ 5,729,715**	**$ 2,692,966**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1000000
500000
0
Year 1
Year 2
Year 3
Year 4
Year 5
Vetiver slips

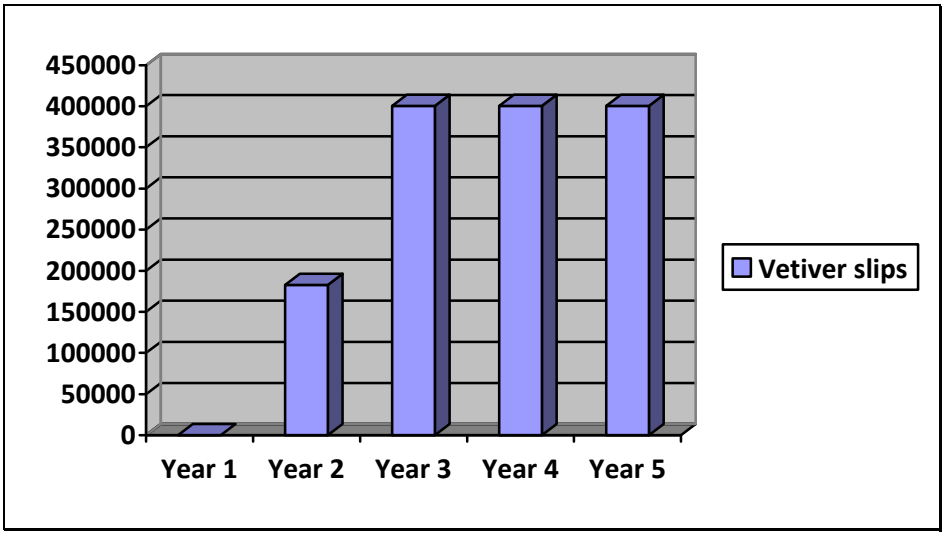
Large Private Landowners

The large private landowners on O'ahu are identified as Campbell Estate, Kamehameha Schools, Castle & Cooke Hawaii, and James Campbell Company Hawaii. These have land holdings on O'ahu of over 10,000 acres. Although these four landowners account for over 131,000 acres on O'ahu—a third of the total acreage—the demand for vetiver is estimated to be significantly lower than the government market due to a relatively lower motivation to utilize vetiver:

- Emphasis on compliance versus proactive erosion control.
- Less sensitive/subject to environmental concerns by policy and/or public interest than government market.
- High rate of tenant responsibility for erosion control.

The market potential for vetiver slips in the large private landowner market is estimated to be (see *Appendix, Market Calculations, Large Private Landowner Demand*):

Year	Slips	Revenue (at 1$ per slip)	Profit
1	0	$ -	$ -
2	182,762	$ 182,762	$ 85,898
3	400,399	$ 400,399	$ 188,187
4	400,399	$ 400,399	$ 188,187
5	400,399	$ 400,399	$ 188,187
Total	**1,383,959**	**$ 1,383,959**	**$ 650,459**



Farms

The Farms market includes privately operated farms on O'ahu (does not include that which fall under the Large Private Landowner market). For this market, past data from NRCS on vetiver recommendations and implementations provided a strong basis for estimating the modifier 'C' used in the demand calculations.

This market represents an active market for vetiver sales due for the following reasons:

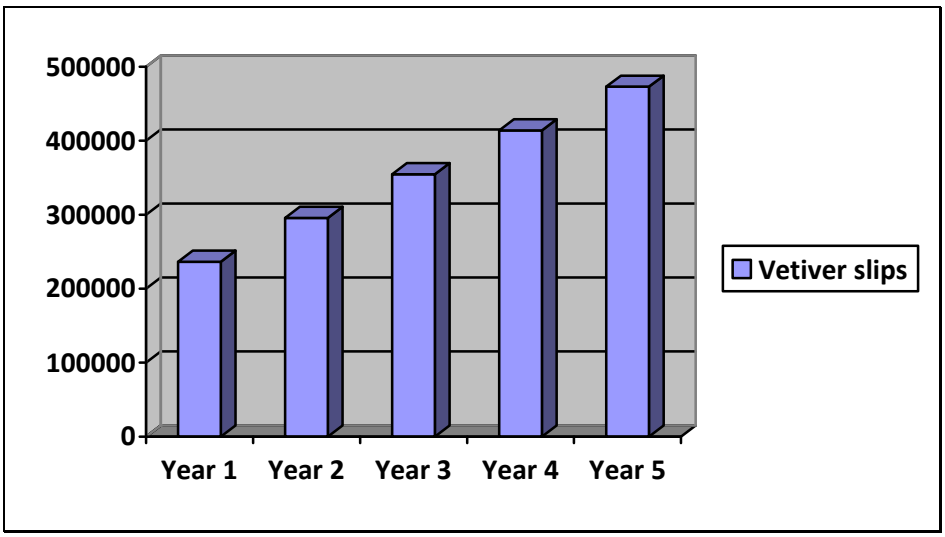
- Farmers have incentive to minimize soil loss due to their operational reliance on soil.
- Farmers have incentives to obtain and implement conservation plans from NRCS, including permit obviation and cost-share programs.

  The NRCS Conservation Reserve Program (CRP) and the Environmental Quality Incentives Program (EQIP) provide technical and financial assistance to eligible farmers and ranchers to address soil, water, and related natural resource concerns on their lands in an environmentally beneficial and cost-effective manner. The Programs encourages farmers to convert highly erodible cropland or other environmentally sensitive acreage to vegetative cover, such as tame or native grasses, wildlife plantings, trees, filter strips, or riparian buffers. Vetiver as a vegetative barrier is a NRCS-recommended best management practice that addresses some of the program objectives. Farmers receive an annual rental payment for the term of the multi-year contract. Cost sharing is provided to establish the practices.
- Vetiver use is a recommended Best Management Practice by NRCS, who provide conservation planning services to farmers.

This market includes some large farmers such as Del Monte and hybrid seed companies, some of which are already implementing vetiver for erosion control.

The market potential for vetiver slips in the farms market is estimated to be (see *Appendix, Market Calculations, Farms Demand*):

Year	Slips	Revenue (at $1 per slip)	Profit
1	236,438	$ 236,438	$ 111,126
2	295,547	$ 295,547	$ 138,907
3	354,656	$ 354,656	$ 166,688
4	413,766	$ 413,766	$ 194,470
5	472,875	$ 472,875	$ 222,251
Total	**1,773,282**	**$ 1,773,282**	**$ 833,442**


500000
400000
300000
200000
100000
0
Year 1
Year 2
Year 3
Year 4
Year 5
Vetiver slips

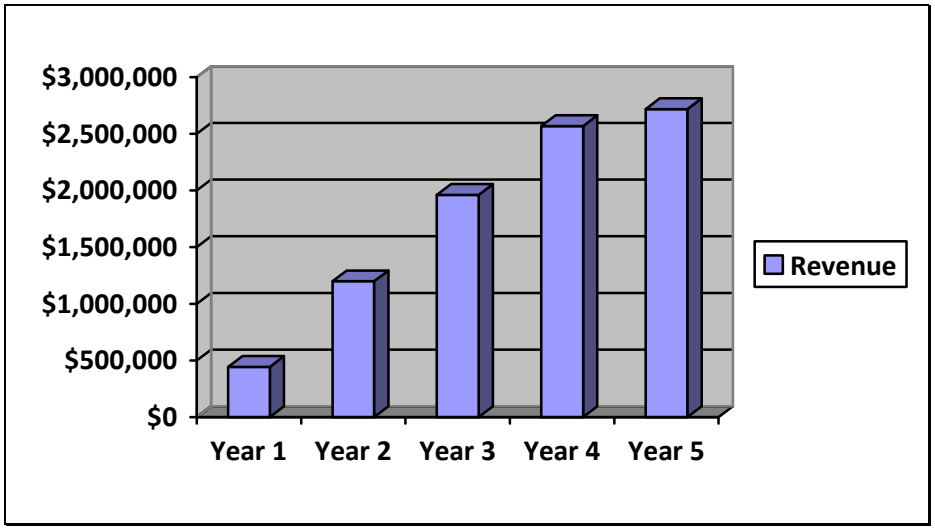
Total Market Potential

The aggregate demand from the three markets is shown below. The general year-over-year increases and sharp rise in the estimate between years one and two reflect assumptions that:

- Through the dissemination of information and field demonstrations by ORC&D and NRCS as part of this project, an increased awareness on the part of potential vetiver suppliers and customers will occur. The resulting increase in supply availability will enable an acceleration of vetiver implementation/purchases.
- As pilot projects and early implementations demonstrate success, confidence in vetiver and thus adoption will steadily increase.

Year	Slips	Revenue (at $1 per slip)	Profit	Acres of Vetiver
1	442,110	$ 442,110	$ 207,792	2.01
2	1,198,932	$ 1,198,932	$ 563,498	5.45
3	1,961,111	$ 1,961,111	$ 921,722	8.91
4	2,567,178	$ 2,567,178	$ 1,206,574	11.67
5	2,717,624	$ 2,717,624	$ 1,277,284	12.35
Total	**8,886,955**	**$ 8,886,955**	**$ 4,176,869**	

As a point of reference, note that a K factor of 0.25+ yields 83,038,208 vetiver plants using the base demand formula. The five year aggregate is less than 10% of that number.



The upward trend may be further supported by a Senate Concurrent Resolution (SCR - No. 176) being reviewed by various Senate committees (as of 4/16/09) requesting that the Department of Land and Natural Resources and the Department of Transportation research the use of vegetative erosion barriers, particularly vetiver grass, to minimize soil erosion and prevent the resulting runoff from damaging roads, streams, coastal waters, and reefs and to stabilize stream

banks, hillsides, and other threatened sites. The SCR requests that the Department of Land and Natural Resources submit a final report to the Legislature prior to the 2010 Regular Session.

Competition

Currently there is one known large commercial grower and two additional sources of vetiver plants in Hawaii as listed in the table below. The general assessment of the supply/demand balance is that there is insufficient supply of vetiver to meet the needs of projected conservation plan recommendations.

Potential competition for supplying vetiver would come most naturally from existing nurseries with in-ground growing methods.

Source - Location	Vetiver Pricing	Capacity	Notes
Vetiver Systems of Hawaii - O'ahu	Proprietary	Proprietary	Only known commercial grower in Hawaii.
Hoolehua Plant Material Center - Molokai	None	Limited	Distribution quantity limited to 100 slips per grower.
Hawaii Agriculture Research Center - O'ahu	.40-.65/slip	Limited	Research center with limited supply. Not established for commercial distribution but currently sharing in consideration of the low number of alternate sources. Plant removal is not included in the cost. Purchaser must remove plants on their own.

Market Analysis – Installation of Vetiver Plants

Definition of Markets

See *Market Analysis – Sale of Vetiver Plants, Definition of Markets* above.

Market Research

In addition to feedback from the research described in *Market Analysis – Sale of Vetiver Plants, Market Research* above, the following activities provided useful information for the analysis of the vetiver installation market:

- Publicly-available requests for proposals and bids on soil erosion mitigation projects demonstrated that the government market generally seeks to hire construction/implementation services, which is analogous to installation. This information also served as a comparison for pricing analysis.
- Analysis of a State Department of Transportation, Highways Division plan for roadside erosion mitigation involving vetiver supported the above finding, specifically for vetiver installation. In addition, the scope of specified vetiver installation informed demand estimates.
- Interviews with Subject Matter Experts with knowledge of vetiver installations provided insight of demand estimates for the Large Private Landowner and Farms markets.

Market Size and Demand

The linear feet demand estimates for the defined markets (see *Appendix, Market Calculations*) formed the basis for estimated vetiver installation demand. Applied to this figure is a per-market modifier to adjust for variability amongst markets for demand of contracted installation services versus customer installation (see *Appendix, Market Calculations, Installation Demand*).

For market potential calculations, the various markets are characterized by different assumptions of average vetiver installation project size and thus differing cost of service figures are utilized (see *Appendix, Market Calculations, Installation Demand*). Note also that these costs assume purchasing vetiver at the cost to produce, i.e., growing the plant material.

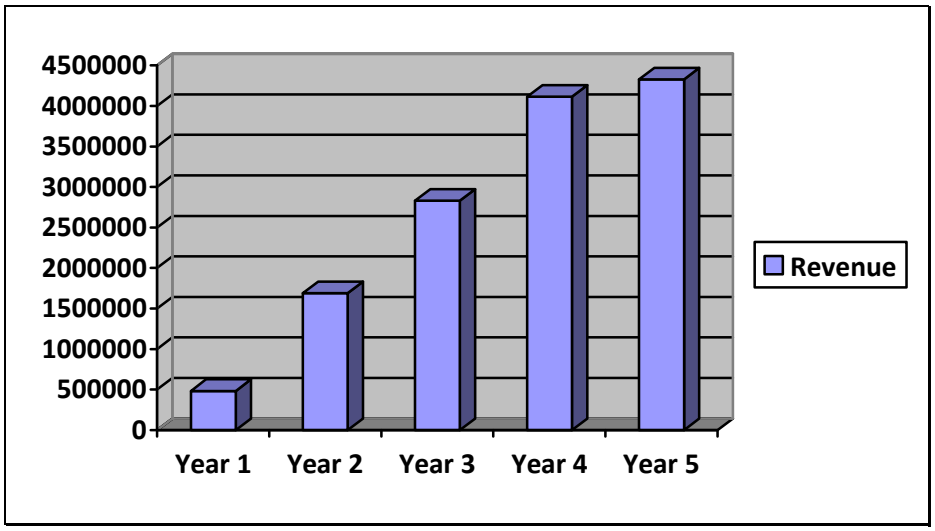
The pricing of the service for all markets, however, is set at the median analyzed markup of 100% due to the relative cost savings of vetiver versus traditional methods of erosion mitigation, and includes the vetiver plant material itself.

Government

For this market, projects will tend to be large and therefore costs from the 4,000 linear foot analysis (see *Appendix, Cost of Service*) were used.

Estimated Market Potential, Government

Year	Feet	Revenue (at 100% markup)	Profit
1	43,705	$ 482,507	$ 241,254
2	153,132	$ 1,690,580	$ 845,290
3	256,287	$ 2,829,408	$ 1,414,704
4	372,515	$ 4,112,569	$ 2,056,285
5	391,924	$ 4,326,846	$ 2,163,423
Total	**1,217,564**	**$ 13,441,911**	**$ 6,720,956**
Cost per linear foot (4,000 ft CoS analysis)	$ 5.52		
Selling price per linear foot (100% markup)	$ 11.04		



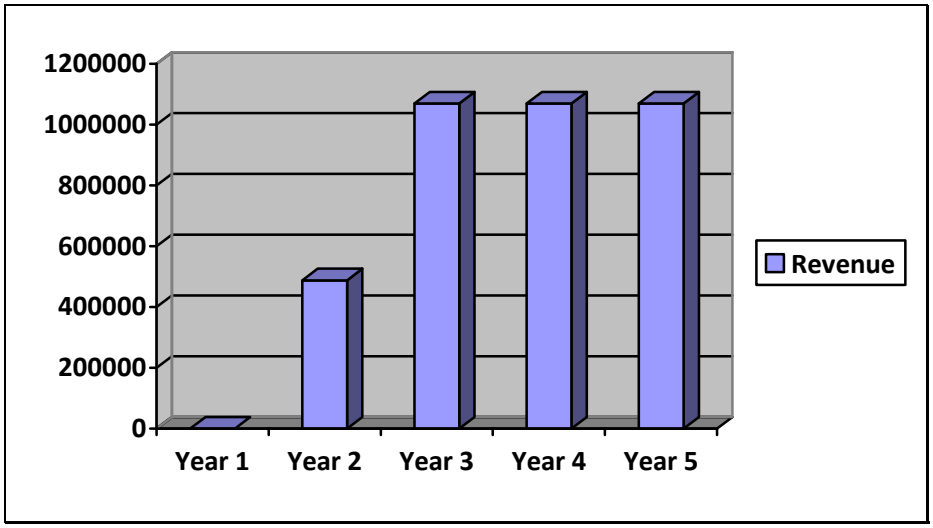
Large Private Landowners

For this market, projects will tend to be large but more conservative and therefore costs from the 2,000 linear foot analysis (see *Appendix, Cost of Service*) were used.

Estimated Market Potential, Private Large Landowner

Year	Feet	Revenue (at 100% markup)	Profit
1	-	$ -	$ -
2	43,406	$ 487,884	$ 243,942
3	95,095	$ 1,068,865	$ 534,432
4	95,095	$ 1,068,865	$ 534,432
5	95,095	$ 1,068,865	$ 534,432
Total	**328,691**	**$ 3,694,479**	**$ 1,847,238**

Cost per linear foot (2,000 ft CoS analysis)	$	5.62
Selling price per linear foot (100% markup)	$	11.24



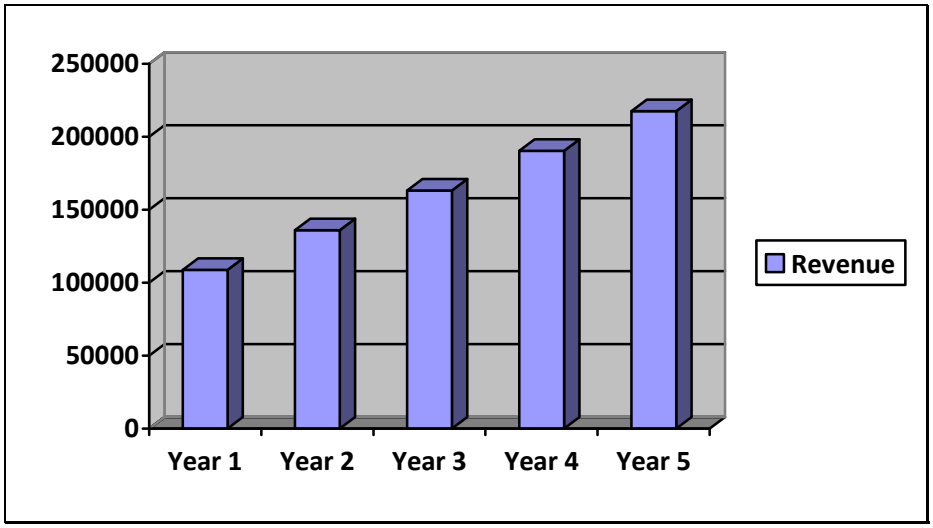
Farms

For this market, projects will tend to be smaller and therefore costs from the 200 linear foot analysis (see *Appendix, Cost of Service*) were used.

Estimated Market Potential, Farms

Year	Feet	Revenue (at 100% markup)	Profit
1	5,911	$ 108,761	$ 54,381
2	7,389	$ 135,952	$ 67,976
3	8,866	$ 163,142	$ 81,571
4	10,344	$ 190,332	$ 95,166
5	11,822	$ 217,523	$ 108,761
Total	**44,332**	**$ 815,710**	**$ 407,855**

Cost per linear foot (200 ft CoS analysis)	$	9.20
Selling price per linear foot (100% markup)	$	18.40

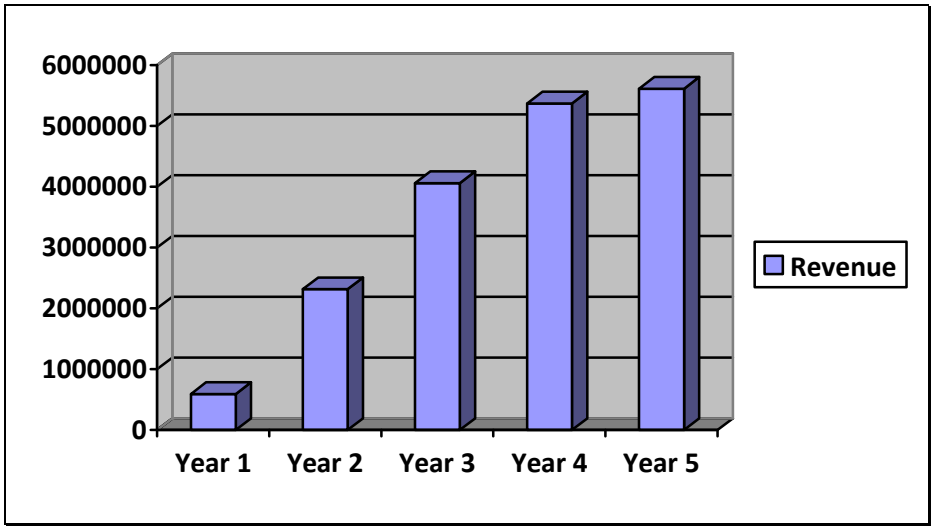


Total Market Potential

The aggregate market potential from the three markets is shown below. See also *Market Analysis – Sale of Vetiver Plants, Total Market Potential*).

Total Estimated Market Potential

Year	Feet	Revenue	Profit
1	49,616	591,268	295,634
2	203,927	2,314,415	1,157,208
3	360,248	4,061,415	2,030,707
4	477,954	5,371,766	2,685,883
5	498,841	5,613,234	2,806,617
Total	**1,590,587**	**$ 17,952,098**	**$ 8,976,049**



Competition

Currently there is one known commercial installer of vetiver in Hawaii, located on O'ahu. Potential competition for installing vetiver would include landscapers on O'ahu, particularly those with the ability to grow the plant material. Other requirements of an installer would include:

- Need for expertise on the implementation of vetiver to be effective for the intended purpose (erosion mitigation, surface water diversion, soil stabilization, etc.)
- Potentially a landscape contractor or other license, bonding, and/or participation on the GSA schedule to bid on government jobs.
- Other skills related to installation, including irrigation installation.
- A source for vetiver plant material.

Given that conventional (non-vetiver) alternatives are as high as $91 per square foot, competition with installers of these alternatives is not expected to come from price competition but rather customer acceptance of vetiver as a solution.

Source - Location	Installation Pricing	Capacity	Notes
Vetiver Systems of Hawaii - O'ahu	Proprietary	Proprietary	Only known commercial installer in Hawaii.

Interviews with Subject Matter Experts indicated low interest in post-establishment plant maintenance services (e.g., mowing/hedging vetiver). Therefore, the market was not analyzed.

Pricing Analysis – Sale of Vetiver Plants

A business should consider its competitors, suppliers, the availability of substitute products, and their customers when developing a pricing strategy. In the case of selling vetiver slips:

- Competitors: as indicated in the *Competition* section above, there is only one known commercial grower in Hawaii. Therefore, the current level of competition is low.

- Suppliers: the vast majority of direct costs associated with the sale of vetiver plants relate to labor. The reliance on suppliers has relatively no effect on the growing of the plant.

- Availability of Substitute Products: as indicated in the Alternatives to Vetiver Grass for Soil Erosion section above, alternatives include diversion berms, construction methods, and other vegetative methods. Berm and construction methods are readily available at a higher cost. The following examples provide information on recent Hawaii projects:

    - In 2004, the State reduced the degree of slope on a mountain at Castle Junction on Kalanianaole Highway from 70 degrees to 30 degrees. The project cost the state $7.8 million. This project included road modifications.

    - In 2008, the State Department of Transportation published a notice to bidders for slope stabilization near the Pali Highway. The project included providing slope stabilization using Anchor Mat System or equivalent, and providing erosion control mat and ground cover. The area is estimated at approximately 150 feet by 50 feet. The estimated construction cost was between $500,000 and $1,000,000. Bids amount submitted ranged between $622,000 and $745,000. This represents an average of $91 per square foot.

    Since other vegetative methods are not currently recommended by the NRCS in the Vegetative Barrier Conservation Practice, a competitive price analysis for vegetative alternatives was not conducted.

- Customers: the client base ranges from small farmers to government agencies. In the current economy, all clients are concerned with cost. Government clients, especially Federal, show particular interest in using a vegetative barrier instead of traditional construction materials.

Considering that there is minimal competition and limited information regarding competitor pricing, a business might consider using a cost plus markup strategy for determining pricing. The business can determine the desired profit level and add it to total costs to determine selling price.

Pricing Analysis – Installation of Vetiver Plants

Similar to the pricing analysis for selling vetiver, a business should consider the following factors when determining installation prices, which include the vetiver plant material itself. In the case of installing vetiver slips:

- Competitors: there are many experienced, licensed contract landscapers who could install vetiver. As of 4/1/09, there were 70 licensed landscape architects on O'ahu. The most recent Landscape Industry Council of Hawaii membership list reflects 105 members on O'ahu. Superpages.com lists 127 landscape contractors on O'ahu.

- Suppliers: other than labor, the cost of the vetiver slips account for most of the cost associated with installation. If the installer is also a grower (supplier) of vetiver, it will have an advantage over non-grower/installers since they can factor in a profit from the plant sale in addition to a profit from the installation service.

- Availability of Substitute Products: Farmers and landowners/government departments with adequate expertise and labor may opt to self install the vetiver. In addition, other landscapers may have an automated method which could reduce the labor costs associated with the installation.

- Customers: the client base ranges from small farmers to government agencies. In the current economy, all clients are concerned with cost.

Considering that there is a fair amount of competition in addition to the opportunity for the customer to install the vetiver on their own, a business might consider using competitor pricing as a benchmark for their own prices. They may consider pricing slightly below, above or the same as their competitors. A query of landscapers on O'ahu concluded that jobs are priced based on a cost plus strategy, ranging between 50 and 100%. Considering that there is no markup reflected for the cost of the plants in the Cost of Service estimates, it is recommended that the business consider markups on higher end of the range.

	200 LF	1,000 LF	2,000 LF	4,000 LF
Cost	$ 1,840	$ 8,482	$ 11,285	$ 22,071
Markup	50%	50%	50%	50%
Price	$ 2,760	$ 9,843	$ 16,852	$ 33,107
Markup	75%	75%	75%	75%
Price	$ 3,220	$ 11,256	$ 19,661	$ 38,624
Markup	100%	100%	100%	100%
Price	$ 3,680	$ 12,864	$ 22,470	$ 44,142

To ensure that prices remain competitive, the business should continually observe competitor pricing and strategy and adjust prices as necessary.

Appendix

Cost of Production Estimate – Analysis for Growing Vetiver

Direct Costs – First Year of Operation

A	B	C	D	E	F	G	I
			B X C		D+E		F X G
Task	Labor Cost / Hr	Labor Time (hrs) per Application	Labor Cost per Application	Material Cost per Application	Total Labor and Material Cost per Application	Number of Applications During Year	Total Labor and Material Cost
Land Prep:							
Soil Test (1)	$ 13.47	1	$ 13.47	$ 31.00	$ 44.47	1	$ 44.47
Ground Prep (2)	$ 13.47	5	$ 67.34	$ 53.00	$ 120.34	1	$ 120.34
Drip Irrigation (pull tress/stretching)	$ 13.47	4	$ 53.87	$ -	$ 53.87	1	$ 53.87
Initial Planting:							
Hand Plant 1100 Slips (3)	$ 13.47	22	$ 296.30	$ -	$ 296.30	1	$ 296.30
Weeding (4)	$ 13.47	10	$ 134.68	$ -	$ 134.68	12	$ 1,616.16
Watering (5)	$ 13.47	2	$ 26.94	$ 11.70	$ 38.64	56	$ 2,163.82
Plant Removal:							
Move drip line and remove bale with tractor	$ 13.47	92	$ 1,239.06	$ -	$ 1,239.06	1	$ 1,239.06
Pull apart and clean (7)	$ 13.47	720	$ 9,696.96	$ -	$ 9,696.96	1	$ 9,696.96
Handling/Packaging for pickup (8)	$ 13.47	106	$ 1,454.54	$ 300.00	$ 1,754.54	1	$ 1,754.54
						Labor and Material Cost	$ 16,985.31
					Labor and Material Cost per Plant in Full Production		$ 15.44
						Labor and Material Cost per Slip	$ 0.31
						Labor and Material Cost per Acre	$ 33,970.62

Notes:

1,100 slips are planted during the year, yielding 54,000 at harvest.

(1) Only 1/6 of an acre is prepped at each cycle. Soil sample will be completed for each 1/6 acre prior to planting. Cost of soil test from CTAHR is $21 with an additional $10 for shipping/deliver of soil.

(2) Based on HARC estimate: 16-16-16 fertilizer: $168/acre; lime: $60/acre; gypsum: $90/acre.

(3) Hoolehua PMC estimated 2 hours to plant 100 slips by hand.

(4) Hoolehua PMC estimated 8-10 hours/1100 plants per month. Frequency: weeding 1x per month per crop. Additional cycles included in case nursery needs to maintain 3rd plot for 6 months.

(5) Hoolehua PMC estimated 4gallons/plant/watering. Cost estimate: $2.66/1000 gallons (BOWS published rate). Frequency: 2 times per week for the 1st month then weekly. Additional cycles included in case nursery needs to maintain 3rd plot for 6 months.

(6) Hoolehua PMC estimated 5 min to remove each ball; 1100 balls = 92 hours.

(7) Hoolehua PMC estimated 75/hour; 54,000 slips = 720 hours.

(8) Estimated 1 hour per 500 slips.

Direct Costs – Full Production

A	B	C	D	E	F	G	I
Task	Labor Cost / hr	Labor Time (hrs) per Application	B X C Labor Cost per Application	Material Cost per Application	D+E Total Labor and Material Cost per Application	Number of Applications During Year	F X G Total Labor and Material Cost
Land Prep:							
Soil Test	$ 13.47	1	$ 13.47	$ 31.00	$ 44.47	2	$ 88.94
Ground Prep	$ 13.47	5	$ 67.34	$ 53.00	$ 120.34	2	$ 240.68
Drip Irrigation (put lines/stakes/clips)	$ 13.47	4	$ 53.87	$ -	$ 53.87	2	$ 107.74
Initial Planting:							
Hand Plant 1100 Slips	$ 13.47	22	$ 296.30	$ -	$ 296.30	2	$ 592.59
Weeding	$ 13.47	10	$ 134.68	$ -	$ 134.68	30	$ 4,040.40
Watering	$ 13.47	2	$ 26.94	$ 11.70	$ 38.64	138	$ 5,331.27
Plant Removal:			$ -	$ -	$ -		$ -
Move drip line and remove bells with tractor	$ 13.47	92	$ 1,239.06	$ -	$ 1,239.06	2	$ 2,478.11
Pull apart and clean	$ 13.47	754	$ 9,665.91	$ -	$ 9,665.91	2	$ 19,271.62
Handling/Packaging for pickup	$ 13.47	110	$ 1,481.40	$ 300.00	$ 1,781.40	2	$ 3,562.80
						Labor and Material Cost	$ 36,214.22
					Labor and Material Cost per Plant in Full Production		$ 10.48
						Labor and Material Cost per Slip	$ 0.33
						Labor and Material Cost per Acre	$ 72,428.43

Notes:

2,200 slips are planted during the year, yielding 110,000 at harvest.

(1) Only 1/6 of an acre is prepped at each cycle. Soil sample will be completed for each 1/6 acre prior to planting. Cost of soil test from CTAHR is $21 with an additional $10 for shipping/deliver of soil.

(2) Based on HARC estimate: 16-16-16 fertilizer: $168/acre; lime: $60/acre; gypsum: $90/acre.

(3) Hoolehua PMC estimated 2 hours to plant 100 slips by hand.

(4) Hoolehua PMC estimated 8-10 hours/1100 plants per month.

Frequency: weeding 1x per month per crop. Additional cycles included in case nursery needs to maintain 3rd plot for 6 months.

(5) Hoolehua PMC estimated 4gallons/plant/watering.

Cost estimate: $2.66/1000 gallons (BOWS published rate).

Frequency: 2 times per week for the 1st month then weekly. Additional cycles included in case nursery needs to maintain 3rd plot for 6 months.

(6) Hoolehua PMC estimated 5 min to remove each ball; 1100 balls = 92 hours.

(7) Hoolehua PMC estimated 75/hour; 54,000 slips = 720 hours.

(8) Estimated 1 hour per 500 slips.

Indirect Costs

Advertising	$	3,000
Bank Fees	$	250
Depreciation	$	11,119
Dues and Subscriptions	$	1,000
Entertainment and Promotions	$	1,000
Fees and Licenses	$	1,000
Fuel and oil (1)	$	9,000
Insurance - General/Auto (2)	$	4,000
M&E Repairs & maintenance	$	6,100
Management and Office Salaries (3)	$	97,500
Misc Expenses	$	5,000
Office Expenses (Supplies/Accounting)	$	10,000
Land Lease (4)	$	18,000
Taxes (Non payroll) (5)	$	45,000
Utilities (6)	$	24,000
Total annual overhead costs	**$**	**223,800**
Production area (in acres)		5
Indirect cost/acre	$	44,720
Indirect cost for Vetiver on 1/2 acre	$	22,360
Indirect cost per plant	$	$0.16
Indirect cost per slip	$	0.20

Notes:

(1) Estimated at $750 per month.

(2) Employee insurances are included in labor costs.

(3) Estimated $75,000 + 30% employee-related costs.

Labor wages are included in direct costs.

(4) Estimated $3,600 per acre/per year. (Cost of Mililani Ag Park is $200-$400 per acre/per month for 5 acres or less).

(5) Estimated 4% GET and 5% state/fed tax for $500,000 in revenues.

(6) Estimated at $2,000 per month.

Unit Sales Analysis

Sales analysis per plant	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Sales price per slip	$ 0.75	$ 1.00	$ 1.50	$ 2.00
Direct costs per slip	$ 0.33	$ 0.33	$ 0.33	$ 0.33
Unit contribution margin	$ 0.42	$ 0.67	$ 1.17	$ 1.67
Total indirect cost allocation per slip	$ 0.20	$ 0.20	$ 0.20	$ 0.20
Total cost per slip	$ 0.53	$ 0.53	$ 0.53	$ 0.53
Expected profit (loss) per slip	$0.22	$0.47	$0.97	$1.47

Notes:

Unit contribution margin reflects the amount available to pay for indirect costs.

Cost-Volume-Profit Analysis

Annual Production Volume	110,000	110,000	110,000	110,000
Average Sales Price Per Slip	$ 0.75	$ 1.00	$ 1.50	$ 2.00
Revenues at Forecasted Sales Volume	$ 82,500.00	$ 110,000.00	$ 165,000.00	$ 220,000.00
Direct Costs	$ 36,214.22	$ 36,214.22	$ 36,214.22	$ 36,214.22
Contribution Margin	$ 46,285.78	$ 73,785.78	$ 128,785.78	$ 183,785.78
Unit Contribution Margin	$ 0.42	$ 0.67	$ 1.17	$ 1.67
Indirect Cost Allocation	$ 22,360.00	$ 22,360.00	$ 22,360.00	$ 22,360.00
Total Direct and Indirect Costs	$ 58,574.22	$ 58,574.22	$ 58,574.22	$ 58,574.22
Break Even Units	53,139	35,394	19,098	13,383
Break Even Price Per Slip (Total Cost)	$ 0.53	$ 0.53	$ 0.53	$ 0.53
Operating Profit	$ 23,925.78	$ 51,425.78	$ 106,425.78	$ 161,425.78
Profitability	29%	47%	65%	73%

Cost of Service – Analysis for Installing Vetiver

Installing 200 Linear Feet of Vetiver

Plants Per Linear Foot	4
Total Linear Feet for Estimate	200
Total Number of Plants Needed	800
Estimated Days to Install	1

A	B	C	D B X C	E	F D + E	G	I F X G
Task	Labor Cost / Hr	Labor Time (hrs) per Application	Labor Cost per Application	Material Cost per Application	Total Labor and Material Cost per Application	Number of Applications during Installation Period	Total Labor and Material Cost
Plant Prep (1):							
Soak Plant and Change Water for 3 Weeks Daily Prior to Planting (2)	$ 13.47	7	$ 94.29	$ 1.12	$ 95.39	1	$ 95.39
Transportation/Prep:							
Drive to/From location and load/unload equipment (2 people) (3)	$ 13.47	3	$ 40.40	$ 18.50	$ 58.90	1	$ 58.90
Land Prep:							
Prepare trough (4)	$ 13.47	4	$ 53.87	$ 650.00	$ 703.87	1	$ 703.87
Initial Planting:							
Hand Plant Slips (5)	$ 13.47	10	$ 215.49	$ 425.99	$ 641.48	1	$ 641.48
Service:							
Drive to/From location (1 person)	$ 13.47	0.67	$ 9.02	$ 16.50	$ 25.52	9	$ 229.71
Site visit daily for 3 weeks (6)	$ 13.47	0.67	$ 8.96	$ -	$ 8.96	9	$ 80.61
Replace plants that are not growing (7)	$ 13.47	0.80	$ 10.77	$ 21.30	$ 32.07	1	$ 32.07
						Labor and Material Cost	$ 1,840.25
						Labor and Material Cost per Linear Foot	$ 9.20

Notes:

(1) Cost to remove plant from nursery is built into growing cost.

(2) Labor to change buckets daily (200 slips per bucket). Five minutes per bucket for 21 days.

(3) Drive and unload time estimated at 30 minutes in each direction/ per person. Location estimated 15 miles away. Estimated per mile rate at 55 cents.

(4) Time estimated at 50 linear feet per hour; equipment cost is $400 per day; $250 delivery charge to Kunia.

(5) Time estimated at 50 slips per hour/ per person. Material cost reflects total growing cost of each vetiver slip.

(6) Time estimated at 20 minutes per 100 feet. Visiting site 3 times per week for 3 weeks.

(7) Estimated 5% plant replacement rate.

Installing 1,000 Linear Feet of Vetiver

Plants Per Linear Foot	4
Total Linear Feet for Estimate	1,000
Total Number of Plants Needed	4,000
Estimated Days to Install	5

A	B	C	D B X C	E	F D + E	G	I F X G
Task	Labor Cost / Hr	Labor Time (hrs) per Application	Labor Cost per Application	Material Cost per Application	Total Labor and Material Cost per Application	Number of Applications during Installation Period	Total Labor and Material Cost
Plant Prep (1):							
Soak Plant and Change Water for 3 Weeks/ Daily Prior to Planting (2)	$ 13.47	35	$ 471.30	$ 5.59	$ 476.97	1	$ 476.97
Transportation/Prep:							
Drive to/From location and load/unload equipment (2 people) (3)	$ 13.47	3	$ 40.40	$ 18.00	$ 58.92	5	$ 294.62
Land Prep:							
Prepare / rough (4)	$ 13.47	20	$ 269.36	$ 1,400.00	$ 1,669.36	1	$ 1,669.36
Initial Plantings:							
Hand Plant Slips (5)	$ 13.47	80	$ 1,077.44	$ 2,129.97	$ 3,207.41	1	$ 3,207.41
Service:							
Drive to/From location (1 person)	$ 13.47	0.67	$ 9.02	$ 16.50	$ 25.52	9	$ 229.71
Site visit daily for 3 weeks (6)	$ 13.47	3.33	$ 44.89	$ -	$ 44.89	9	$ 404.04
Replace plants that are not growing (7)	$ 13.47	4.00	$ 53.87	$ 106.50	$ 160.37	1	$ 160.37
						Labor and Material Cost	$ 6,432.38
						Labor and Material Cost per Linear Foot	$ 6.43

Notes:

(1) Cost to remove plant from nursery is built into growing cost.

(2) Labor to change buckets daily (200 slips per bucket). Five minutes per bucket for 21 days.

(3) Drive and unload time estimated at 30 minutes in each direction/ per person. Location estimated 15 miles away. Estimated per mile rate at 55 cents.

(4) Time estimated at 50 linear feet per hour; equipment cost is $1150 per week; $250 delivery charge to Kunia.

(5) Time estimated at 50 slips per hour/ per person. Material cost reflects total growing cost of each vetiver slip.

(6) Time estimated at 20 minutes per 100 feet. Visiting site 3 times per week for 3 weeks.

(7) Estimated 5% plant replacement rate.

Installing 2,000 Linear Feet of Vetiver

Plants Per Linear Foot	4
Total Linear Feet for Estimate	2,000
Total Number of Plants Needed	8,000
Estimated Days to Install	10

A	B	C	D B X C	E	F D+E	G	I F X G
Task	Labor Cost / Hr	Labor Time (hrs) per Application	Labor Cost per Application	Material Cost per Application	Total Labor and Material Cost per Application	Number of Applications During Installation Period	Total Labor and Material Cost
Plant Prep (1):							
Soak Plant and Change Water for 3 Weeks Daily Prior to Planting (2)	$ 13.47	70	$ 942.76	$ 11.17	$ 953.93	1	$ 953.93
Transportation/Prep:							
Drive to/from location and loading/unload equipment (2 people) (3)	$ 13.47	3	$ 40.40	$ 16.50	$ 56.90	10	$ 569.04
Land Prep:							
Prepare trough (4)	$ 13.47	40	$ 538.72	$ 1,400.00	$ 1,938.72	1	$ 1,938.72
Initial Plantings:							
Hand Plant Slips (5)	$ 13.47	160	$ 2,154.88	$ 4,259.94	$ 6,414.82	1	$ 6,414.82
Service:							
Drive to/from location (1 person)	$ 13.47	0.67	$ 9.02	$ 16.50	$ 25.52	9	$ 229.71
Site visit daily for 3 weeks (6)	$ 13.47	6.67	$ 89.79	$ -	$ 89.79	9	$ 808.06
Replace plants that are not growing (7)	$ 13.47	8.00	$ 107.74	$ 212.00	$ 320.74	1	$ 320.74
						Labor and Material Cost	$ 11,235.05
						Labor and Material Cost per Linear Foot	$ 5.62

Notes:

(1) Cost to remove plant from nursery is built into growing cost.

(2) Labor to change buckets daily (200 slips per bucket). Five minutes per bucket for 21 days.

(3) Drive and unload time estimated at 30 minutes in each direction/ per person. Location estimated 15 miles away. Estimated per mile rate at 55 cents.

(4) Time estimated at 50 linear feet per hour; equipment cost is $1150 per week; $250 delivery charge to Kunia.

(5) Time estimated at 50 slips per hour/ per person. Material cost reflects total growing cost of each vetiver slip.

(6) Time estimated at 20 minutes per 100 feet. Visiting site 3 times per week for 3 weeks.

(7) Estimated 5% plant replacement rate.

Installing 4,000 Linear Feet of Vetiver

Plants Per Linear Foot	4
Total Linear Feet for Estimate	4,000
Total Number of Plants Needed	16,000
Estimated Days to Install	20

A	B	C	D B X C	E	F D + E	G	I F X G
Task	Labor Cost / Hr	Labor Time (hrs) per Application	Labor Cost per Application	Material Cost per Application	Total Labor and Material Cost per Application	Number of Applications During Installation Period	Total Labor and Material Cost
Plant Prep (1):							
Soak Plant and Change Water for 3 Weeks Daily Prior to Planting (2)	$ 13.47	140	$ 1,885.82	$ 22.24	$ 1,907.88	1	$ 1,907.88
Transportation/Prep:							
Drive to/from location and load/unload equipment (3 people) (3)	$ 13.47	3	$ 40.40	$ 18.50	$ 58.92	20	$ 1,178.08
Land Preps							
Prepare trough (4)	$ 13.47	80	$ 1,077.44	$ 2,550.00	$ 3,627.44	1	$ 3,627.44
Initial Plantings:							
Hand Plant Slips (5)	$ 13.47	320	$ 4,309.76	$ 8,519.09	$ 12,828.85	1	$ 12,828.85
Service:			$ -	$ -	$ -		$ -
Drive to/from location (2 people)	$ 13.47	1.34	$ 18.05	$ 16.50	$ 34.55	9	$ 310.92
Site visit daily for 3 weeks (6)	$ 13.47	13.33	$ 179.57	$ -	$ 179.57	9	$ 1,616.16
Replace plants that are not growing (7)	$ 13.47	16	$ 215.49	$ 425.99	$ 641.48	1	$ 641.48
						Labor and Material Cost	$ 22,071.00
						Labor and Material Cost per Linear Foot	$ 5.52

Notes:

(1) Cost to remove plant from nursery is built into growing cost.

(2) Labor to change buckets daily (200 slips per bucket). Five minutes per bucket for 21 days.

(3) Drive and unload time estimated at 30 minutes in each direction/ per person. Location estimated 15 miles away. Estimated per mile rate at 55 cents.

(4) Time estimated at 50 linear feet per hour; equipment cost is $1150 per week; $250 delivery charge to Kunia.

(5) Time estimated at 50 slips per hour/ per person. Material cost reflects total growing cost of each vetiver slip.

(6) Time estimated at 20 minutes per 100 feet. Visiting site 3 times per week for 3 weeks.

(7) Estimated 5% plant replacement rate.

Solicitation Letter

UNIVERSITY OF HAWAI'I AT MĀNOA

Agribusiness Incubator Program

To Whom It May Concern:

We are researching the market potential on Oahu for Vetiver use as a vegetative barrier to soil loss through diversion and/or deceleration of surface water. We would very much appreciate a few minutes of your time to discuss answers (including broad estimates) to some of our questions below.

Please contact Steven Chiang or Janel Yamamoto at 956-3530 or via email at janelnoy@hawaii.edu with the contact name of the appropriate person to interview.

Background

Vetiver is a sterile, non-invasive perennial grass with a dense web of roots that binds soil and penetrates vertically up to 15 feet. It thrives in the tropics, growing in a variety of inhospitable soils with low sensitivity to fertility, salinity, pH, and drought.

The use of Vetiver to control erosion has been included as a USDA Natural Resources Conservation Service (NRCS) best management practice for Hawaii farms. When planted in strips, Vetiver forms a vegetative barrier that slows the velocity of water and traps sediment and debris. Decades of use in the tropics confirm that Vetiver, when used as a vegetative barrier, is an effective method to reduce soil erosion and stabilize steep slopes.

Small amounts of Vetiver have been available from the USDA Plant Materials Center, but they cannot meet the growing demand. We are assisting NRCS with a project to study the cost of commercial production and installation and market potential for vetiver as a conservation resource. Information on propagation and establishment of Vetiver will be provided to potential growers, along with estimated costs of production and market opportunities.

Research Questions

- How is your organization currently managing soil erosion and stabilizing steep slopes (structural: berm/concrete or vegetative method)?
- How many Total linear feet are managed by your organization (or boundary feet or total sq ft of properties / number of properties) on Oahu?
- What percentage of Total are sloped lands?
- What percentage of Total may need soil erosion control or slope stabilization?
- Are there Oahu projects planned in the next 5 years to manage soil erosion and stabilize slopes (obtain details on size of project and method, if possible, as well as approximate timing)?
- Are there any current Oahu initiatives to manage soil erosion and stabilize slopes?
- Are soil erosion/slope stabilization responsibilities managed by your organization or lessee?
- Would your organization consider evaluating vetiver to manage soil erosion/stabilizing slopes and what would be the primary decision points?
- Would your organization make vetiver purchase decision directly or is this determined by a third party (contractor)?
- Would your organization install or contract out installation for Oahu implementations?
- What are the requirements to award project (license/insurance/etc)?
- What is the contact information for individual/department that would make purchasing decisions for Oahu projects?

Sincerely,

Steven Chiang, Director
Agribusiness Incubator Program
College of Tropical Agriculture and Human Resources, University of Hawaii

3050 Maile Way, Gilmore 115, Honolulu, Hawai'i 96822
Telephone: (808) 956-3550, Facsimile: (808) 956-3547, Web site: http://aip.hawaii.edu
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Revised Universal Soil Loss Equation (RUSLE) K Factor

RUSLE is a tool to measure rill and interrill (sometimes called "sheet and rill") erosion on the landscape. It is a multiplicative formula of R x K x LS x C x P in which R is a Rainfall factor, K is a soil factor, LS is a slope length and gradient factor, C is a management factor, and P is a practice factor.

The K-factor is a soil erodibility is soil erodibility factor which represents both susceptibility of soil to erosion and the rate of runoff, as measured under the standard unit plot condition. Soils high in clay have low K values, about 0.05 to 0.15, because they are resistant to detachment. Coarse textured soils, such as sandy soils, have low K values, about 0.05 to 0.2, because of low runoff even though these soils are easily detached. Medium textured soils, such as the silt loam soils, have moderate K values, about 0.25 to 0.4, because they are moderately susceptible to detachment and they produce moderate runoff. Soils having high silt content are most erodible of all soils. They are easily detached; tend to crust and produce high rates of runoff. Values of K for these soils tend to be greater than 0.4.

Organic matter reduces erodibility because it reduces the susceptibility of the soil to detachment, and it increases infiltration, which reduces runoff and thus erosion. Addition or accumulation of increased organic matter through management such as incorporation of manure or additions of mulch is represented in the C-factor rather than the K Factor. Extrapolation of the K-factor nomograph beyond an organic matter of 4% is not recommended or allowed in RUSLE. In RUSLE, factor K considers the whole soil and factor Kf considers only the fine-earth fraction, the material of <2.00mm equivalent diameter. For most soils, Kf = K.

Soil structures affect both susceptibility to detachment and infiltration. Permeability of the soil profile affects K because it affects runoff.

Although a K-factor was selected to represent a soil in its natural condition, past management or misuse of a soil by intensive cropping can increase a soil's erodibility due to sub-soil exposure on the surface. The K-factor may need to be increased if the subsoil is exposed or where the organic matter has been depleted, the soil's structure is degraded or destroyed, or soil compaction has reduced permeability. A qualified soil scientist can assist in making this interpretation.

From *Technical Guide to RUSLE use in Michigan*, NRCS-USDA State Office of Michigan. See also, "Predicting Soil Erosion by Water: A Guide to Conservation Planning With the Revised Universal Soil Loss Equation (RUSLE)", USDA ARS Agricultural Handbook Number 703 by K.G. Renard, G.R. Foster, G.A. Weesies, D.K. McCool, and D.C. Yoder, January 1997.

Market Calculations

Government Demand

Vetiver Demand on O'ahu, Government

			A	B	C	B	C	B	C	B	C	B	C	
Key	Customers with identified acreage	Acres	Formula Linear feet	Yr 1 Mod	Yr 1 candidate plants	Yr 2 Mod	Yr 2 candidate plants	Yr 3 Mod	Yr 3 candidate plants	Yr 4 Mod	Yr 4 candidate plants	Yr 5 Mod	Yr 5 candidate plants	Total 5 year
1	State Department of Health	85.71	17913	2%	1433	4.0%	2866	5.0%	3583	5.0%	3583	5.0%	3583	21.0%
2	US Army ITAM	53000	11077000	0%	0	0.5%	221540	1.0%	443080	1.5%	664620	1.5%	664620	4.5%
3	US Air Force	28000	5852000	0%	0	0.5%	117040	1.0%	234080	2.0%	468160	2.0%	468160	5.5%
4	US Navy	15000	3135000	0%	0	0.5%	62700	0.5%	62700	0.5%	62700	0.5%	62700	2.0%
5	US Marine Corp	2951	616759	0.5%	12335	1.0%	24670	1.5%	37006	2.0%	49341	2.5%	61676	7.5%
6	Hawaii Department of Agriculture	9450	1975050	2.0%	158004	3.0%	237006	4.0%	316008	5.0%	395010	6.0%	474012	20.0%
7	City Parks and Recreation	5000	1045000	0.5%	20900	1.0%	41800	2.0%	83600	2.0%	83600	2.0%	83600	7.5%
8	State Department of Transportation Services				13000	100.0%	13000	200.0%	26000	200.0%	26000	200.0%	26000	
					205,672		**720,623**		**1,206,056**		**1,753,013**		**1,844,351**	

Key Notes

1 Public lands in the windward O'ahu watershed areas already identified as candidate for restoration. Mod increases reflect increasing acceptance of vetiver.

2 75% > 5% grade, Rehab 5000 acres/yr, vetiver of limited use for range as too tall and seeding method not ideal. Mod reflects low but increasing acceptance.

3 Not currently managing lands like ITAM, but interested. Mod reflects slow start, increasing acceptance.

4 Mostly shipyard thus low likelihood. Mod reflects low and slow acceptance.

5 Managed like ITAM but relatively small acreage. Wetter and more sloped.

6 2700 acres now, but expect 3-4x that two years so used 3.5x current. Tenants are required to implement conservation plan in 1 year. Mod reflects growing acreage and tenancy.

7 Planned vetiver pilot project. Mod reflects increasing acceptance.

8 No feedback on acre volumes but have data from planned vetiver project. Mod reflects successful vetiver pilot.

Large Private Landowner Demand

Vetiver Demand on O'ahu, Large Private			A	B	C	B	C	B	C	B	C	B	C	
Key	Customers with identified acreage	Acres	Formula Linear feet	Yr 1 Mod	Yr 1 candidate plants	Yr 2 Mod	Yr 2 candidate plants	Yr 3 Mod	Yr 3 candidate plants	Yr 4 Mod	Yr 4 candidate plants	Yr 5 Mod	Yr 5 candidate plants	Total 5 year
1	Campbell Estate	36200	7565800	0%	0	0.2%	60526	0.5%	151316	0.5%	151316	0.5%	151316	1.7%
2	Kamehameha Schools	50577	10570593	0%	0	0.2%	84565	0.5%	211412	0.5%	211412	0.5%	211412	1.7%
3	Castle & Cooke, Inc.	30648	6405432	0%	0	0.1%	25622	0.1%	25622	0.1%	25622	0.1%	25622	0.4%
4	James Campbell Company	14413	3012317	0%	0	0.1%	12049	0.1%	12049	0.1%	12049	0.1%	12049	0.4%
					-		**182,762**		**400,399**		**400,399**		**400,399**	

Key Notes

1 In Kunia, 8,300 ag and 5,000 conservation acres. In Kahuku, 1000 ag acres. Mod reflects increasing acceptance of vetiver.

2 Large ag and conservation landholdings. Mod reflects increasing acceptance of vetiver.

3 Actions primarily to comply with NPDES standards and C&C Planning & Permitting.

4 Primarily industrial/commercial, Kapolei, not all developed.

Farms Demand

Vetiver Demand on O'ahu, Farms

Key	Customers with identified acreage	Acres	Formula Linear feet	Yr 1 Mod	Yr 1 candidate plants	Yr 2 Mod	Yr 2 candidate plants	Yr 3 Mod	Yr 3 candidate plants	Yr 4 Mod	Yr 4 candidate plants	Yr 5 Mod	Yr 5 candidate plants	Total 5 year
1	All O'ahu Farms, USDA 2002 Census	70,705	14,777,345	0.4%	236,438	0.5%	295,547	0.6%	354,656	0.6%	413,766	0.6%	472,875	2.7%
					236,438		**295,547**		**354,656**		**413,766**		**472,875**	

Key Notes

1 Mod based on historical recommended linear feet, expected to grow with increased awareness and conservation planner capacity.

Note that the acreage used in the demand calculation only includes that which was determined to be farm land, as opposed to simply agriculturally zoned (3-4x the farm land number). Using agricultural zoned acreage would, in effect, double-count a significant number of acres already considered for the Large Private Landowner market.

It is generally assumed that this market will utilize vetiver based on conservation plan fulfillment and include those plans generally eligible for cost share, estimated to fall into two classes of vetiver need:

- Small Cooperator: 200-400 feet
- Large Cooperator: 2,000 feet

Historical vetiver recommendations and implementation from NRCS O'ahu

Note that implementation typically lags recommendation and thus the ratio of implementation to recommendation cannot be meaningfully calculated. Note also the limited number of years that vetiver has been recommended and the high rate of growth in recommendation.

Conservation Plan Project Year	Linear feet recommended by conservation plans (O'ahu)	Conservation plan Linear feet implemented (O'ahu)
2007	1,500	500
2008	5,150	1,150
2009	22,000	TBD
Total	**28,650**	**1,650**

Installation Demand – All Markets

O'ahu Installation Demand Estimates

Key	Market	Mod	Year 1 feet	Year 2 feet	Year 3 feet	Year 4 feet	Year 5 feet	Totals
1	Government	85%	43,705	153,132	256,287	372,515	391,924	**1,217,564**
2	Large Private Landowner	95%	-	43,406	95,095	95,095	95,095	**328,091**
3	Farms	10%	5,911	7,389	8,866	10,344	11,822	**44,332**
	Totals		**49,616**	**203,927**	**360,248**	**477,954**	**498,841**	

Key Notes

1 Mod impacted by proclivity to contract services but slightly ameliorated by existence of some capacity to do this themselves.

2 Mod impacted by proclivity to contract services and low capacity to do this themselves.

3 Mod impacted by capacity for implementing vegetative material and generally low financial resources.

Research Sources

Publications

All photo images obtained with permission from the Vetiver Network International (www.vetiver.org).

Hawaii Business Magazine, November 2007. *Top 20 Wealthiest Landowners.*

Hawaii Natural Resource Information System v2.0, College of Tropical Agriculture and Human Resources, University of Hawaii.

Joy, Robert J. 2009. *Plant Guide: 'Sunshine' Vetiver Grass.* United States Department of Agriculture, Natural Resources Conservation Service (http://plants.usda.gov/).

Kinoshita, Charles, et al. 2006. *Potential for Ethanol Production in Hawaii.* Department of Business, Economic Development and Tourism, State of Hawaii.

Lavelle, Neoma. 2007. *Improving Hawaii's Water Quality: Selecting Sites for Riparian Restoration in a GIS*. Nicholas School of the Environment and Earth Sciences, Duke University.

O'ahu Soil and Water Conservation Districts. June 2007. *The O'ahu Outlook*

The Vetiver Network International website. Articles and other reference materials found at www.vetiver.com

The Vetiver System: A proven solution. Brochure written and published by The Vetiver Network International.

Truong, Paul, Tran Tan Van, and, Elise Pinners. 2008. *Vetiver System Applications Technical Reference Manual*. The Vetiver Network International.

Urban Groundwater Database, 1999

United States Department of Agriculture 2007 Census of Agriculture

Vetiver Grass: A thin green line against erosion. Written by the National Research Council. Published in 1993 by the National Academy Press, Washington, D.C.

Subject Matter Experts

Brokish, Jean, Project Manager, O'ahu Resource Conservation and Development

Char, Marvin, Civil Engineering Branch, Site Development Division, Department of Planning and Permitting, City and County of Honolulu

Dacus, Chris, Landscape Architect, Department of Transportation Services, City and County of Honolulu

Howland, Mark, Integrated Training Areas Management (ITAM)/Improved Repairable Asset Management (IRAM), General Dynamics for United States Army

Inouye, Wayne, Permit Issuance Branch, Department of Planning and Permitting, City and County of Honolulu

Joy, Robert, Plant Materials Specialist, Natural Resources Conservation Service, United States Department of Agriculture

Kacir, Richard, District Conservationist, Natural Resources Conservation Service, United States Department of Agriculture

Leong, Russell, Army Corp of Engineers, United States Army

Matsunami, Garret, Engineering and Site Construction, Castle & Cooke

Miller, Kim, Land Ownership Specialist, Hawaii Housing Finance and Development Corporation, State of Hawaii

Morton, Mawae, Strategic Resources Manager, Land Assets Division, Endowment Group, Kamehameha Schools

Nakata, Ryan, Department of Transportation Services, City and County of Honolulu

Rice, James, Wastewater Program Manager, United States Army Garrison Hawaii

Sakamoto, Glenn (and staff David Duvauchelle, Keni Reyes, Andres Juario), Manager, Hoolehua Plant Materials Center, Natural Resources Conservation Service, United States Department of Agriculture

Santo, Lance, Agronomist/Field Coordinator, Hawaii Agricultural Research Center

Slay, Hudson, Clean Water Branch, Department of Health, State of Hawaii

Smith, Craig, Agronomist, USDA-NRCS Pacific Islands West.

Takayesu, Gerald, Department of Environmental Services, City and County of Honolulu

Teruya, Randall, Agricultural Asset Manager, Agricultural Resource Management Division, Hawaii Department of Agriculture, State of Hawaii

Turnbull, Steve, Environmental Branch, Army Corp of Engineers, United States Army

Woll, Jason, Department of Parks and Recreation, City and County of Honolulu

Subject Matter Experts - Unresponsive

The following were contacted for information but did not provide feedback in time for the publication of this report. These contacts are listed for the purpose of further illuminating the scope of the research as well as providing potential sources of further research.

Army Family Housing, United States Army

Bureau of Land Management, United States Department of the Interior

Constantinides, Michael, Forestry and Wildlife Division, Department of Land and Natural Resources, State of Hawaii

Fish and Wildlife Service, United States Department of the Interior

Forest Service, United States Department of Agriculture

Hirano, Eric, Chief Engineer, Engineering Division, Department of Land and Natural Resources, State of Hawaii

James Campbell Company, Hawaii

Land Division, Department of Planning and Permitting, City and County of Honolulu

Land Management Division, Land Management Branch, Department of Hawaiian Homelands, State of Hawaii

Mansker, Michelle, Department of Public Works, United States Army

National Park Service, United States Department of the Interior

Penn, David, Total Maximum Daily Load (TMDL) Coordinator, Environmental Planning Office, State of Hawaii

Road Maintenance Division, Department of Transportation Services, City and County of Honolulu (indicated not applicable)

Urban Forestry, Department of Parks and Recreation, City and County of Honolulu

Watts, Kimberly, Director, Sustainable Ranges Program, United States Army Environmental Command