

SUPPLEMENTAL METHODS

Cost Analysis

Methods for Estimating Baseline Costs for the 0.13 ha Experimental Field Trial

The entire 0.13 ha experimental study site was cleared, fenced, and treated with herbicide the first year. Twenty test plots (four blocks consisting of five 9 m² test plots) were established and maintained as described in the printed version of the article. Twelve of the 9 m² test plots (three test plots per block; 108 m² total) were planted with 25 native species each, and those plants that died in the first month were replaced. During the second year, herbicide maintenance was performed on all 12 test plots and along corridors, and herbicide was applied to the four herbicide control plots; untreated control plots did not receive maintenance. In the third year, only herbicide maintenance was done on all plots except the untreated control plots. Surveys to ensure the integrity of the perimeter fence were performed in the second and third years. The experimental restoration site was enclosed with a 0.13 ha rectangular fence (62 m long and 21 m wide) to exclude invasive ungulates from the project site. The fence was constructed by a contractor (Pono Pacific) and completed by four people (project manager estimated hourly wage, \$25/hr; crew leader, \$15/hr; and two crew, \$13/hr). Based on interviews, we estimated that this fence contracting team could build the fence at a rate of 2.7 m/hr; thus the 166 m long fence required 61.5 hr. Using the unit costs at the experimental site, we estimated an overall rate of \$43/m for fencing materials. Fence maintenance was assumed to take place twice per year during the second and third years to ensure the integrity of the fence, a key consideration in areas with ungulates where ingress can rapidly degrade ecosystems. Fence maintenance was assumed to be completed by one person (contractor rate of \$35/hr) at a rate of 100 m/hr. Table S1 summarizes the baseline parameters for the 0.13 ha experimental site within the Wai‘anae Kai Forest Reserve, and Table S3 shows the calculated establishment and

maintenance costs when applying the baseline parameters.

Although in actuality many restoration activities were performed by University of Hawai‘i graduate students, we estimated their labor time and rates based on contractor rates. Initial invasive vegetation clearing was estimated at a rate of 120 hr/ha, and maintenance clearing was estimated at a rate of 10 hr/ha/person; herbicide maintenance was estimated at 52.5 hr/ha/person (year 1), 11.5 hr/ha/person (year 2), and 7 hr/ha/person (year 3); planting at a rate of 20 plants/hr/person; and water delivery at a rate of 132 liters/hr (watering each plant four times with 1 liter each time; assumes first watering at initial planting, followed by watering once per week for three subsequent weeks, then discontinuing thereafter). Using these rates, we estimated the cost of performing the restoration activities by applying the following contractor labor rates: \$16.50/hr/person for herbicide application, watering, and planting; and \$20/hr/person for clearing and clearing maintenance (clearing maintenance includes clearing of invasive trees and application of herbicide to cut stumps) (Table S1). Unit costs were applied for materials (i.e., herbicide, water, plants) and equipment (i.e., chain saw, weed-wacker, backpack sprayer, planting bar, and planting bag) (Table S3).

Methods for Identifying Costs of Scaling up to Full 0.13, 1, and 10 ha Management Units

Costs were evaluated to scale up the restoration experiment, assuming that the entire 0.13 ha (1,300 m²) experimental site within the Wai‘anae Kai Forest Reserve would be restored (rather than just the area within the smaller experimental plots). We assumed the establishment costs calculated for fencing, initial herbicide treatment, and clearing of the experimental site would not change because they covered the entire 0.13 ha site and accounted for additional herbicide and clearing costs for the four 9 m² control sites (untreated and herbicide-only controls) over years 2 and 3 (Table S4 and Table S5). We then used these same costs to scale up to 1 ha and 10 ha management units (Table S6 and Table S7).

Assumptions common to all sites were outplant composition (modeled after the experimental test plots), density (modeled after the experimental test plots plant density), and cost (\$2/plant); outplanting mortality rates [21% overall mortality (replaced only if within 1 month after outplanting)]; amount of water applied (1 liter/plant each week for first 4 weeks to improve survival and establishment), cost (\$0.0005/liter), and method (backpack sprayers) of application; method (backpack sprayers) of herbicide application (see Table S2 for an example of the calculated herbicide amounts for the 1 ha site); labor rates based on contractors used (\$16.50/hr/person for herbicide application, watering, and planting; project manager \$25/hr, crew leader \$15/hr, and two crew \$13/hr for fence construction; \$20.00/hr/person for clearing maintenance; and \$35/hr/person for fence maintenance); cost of equipment used for clearing, watering, and outplanting; cost of herbicides, frequency, and rate (averaged 0.15 to 1 liter/min); and fence maintenance frequency (twice per year) (Table S1).

Methods for Long-Term Cost Analysis

As land managers move toward scaled-up, long-term restoration, information on the associated costs can improve budgeting and planning. Therefore, we projected long-term costs (30 yr) for 1 ha and 10 ha hypothetical sites to illustrate the costs of longer-term restoration efforts. The 30 yr time period for the long-term restoration cost analysis was selected to reflect a reasonable project time horizon. Based on interviews with experts, a number of variables were adapted to account for the longer time horizon: clearing maintenance frequency (once every other year); replacement period for fencing (20 yr); and time period and frequency for herbicide application (Table S2), clearing, and fence maintenance (30 yr).

Methods for Cost-Reduction Strategies Cost Analysis

To better understand the impact on overall cost through the use of cost-reduction strate-

gies, we modeled costs under: (1) reduced labor costs to account for use of volunteer labor (assumed a labor rate of \$25/hr for one person to supervise 10 volunteers during planting, replanting, and watering activities), though planting activities are estimated to take 1.5 times longer (i.e., 13 plants/hr/person) when employing volunteer labor versus trained land managers, and watering would be completed at the same speed (132 liters/hr); (2) reduced plant costs (50% cost reduction) to account for application of more cost-effective production of seedlings [e.g., on-site propagation and seed banks (Table S8)]; (3) doubled planting speed to account for better and more expensive equipment; (4) installation of irrigation system infrastructure (at a cost of \$27,000 ha⁻¹); and (5) discontinuing herbicide application and clearing after 5 and 10 yr for the longer 30 yr time frame.

Methods for Distinguishing Labor and Material Needs

The experimental site within the Wai‘anae Kai Forest Reserve is considered to be on the easy end of the spectrum compared to more remote sites with more arduous restoration conditions, thus the estimates of labor and material needs may be too optimistic for all conditions. To better understand the costs for more arduous restoration scenarios we compared costs for a 1 ha “Easy” site (modeled after our Wai‘anae Kai Forest Reserve study site) to two 1 ha hypothetical sites that would have more labor and material needs (i.e., “Moderate” and “Difficult” sites). The “Easy” site is fully accessible by road, ~10 m elevation gradient, fairly rough and rocky terrain, dominated by an invasive grass with few scattered invasive trees, and requires exclusion of ungulates via fence construction. To estimate cost for more arduous restoration sites we assumed a “Moderate” scenario [more arduous restoration conditions (e.g., located ~0.8 km from nearest road, ~20 m elevation gradient, moderate rough and rocky terrain, dominated by dense populations of invasive grass and trees, and requiring exclusion of ungulates)]; and a “Difficult” scenario [more arduous restoration conditions (e.g., located ~3.2 km from

nearest road; ~20 m elevation gradient; rough, rocky, and uneven terrain; dominated by dense populations of invasive grass and trees; and requiring exclusion of ungulates). These differences mainly affected (1) labor inputs [hours required for fence construction, invasive removal (clearing and herbicide application), outplanting, water delivery, maintenance (clearing, herbicide application, and fence maintenance)]; and (2) fencing material costs (from \$43/m for Easy and Moderate sites to \$49/m for Difficult sites, with higher probability of uneven terrain requiring additional materials to accommodate the contour of a particular site and secure ground pinning to reduce the potential for disturbance by ungulates). Labor inputs were themselves a function of (1) planting rate (20 plants/hr/person in Easy, 15 plants/hr/person in Moderate, and 7 plants/hr/person in Difficult); (2) water delivery rate (132 liters/hr/person in

Easy, 88 liters/hr/person in Moderate, and 44 liters/hr/person in Difficult); (3) initial invasive vegetation clearing rate (120 hr/ha/person in Easy and 240 hr/ha/person for Moderate and Difficult) and maintenance clearing rate (10 hr/ha/person in Easy and 20 hr/ha/person for Moderate and Difficult); (4) herbicide application rate [52.5 hr/ha/person (year 1), 11.5 hr/ha/person (year 2), and 7 hr/ha/person (year 3) in Easy; 79 hr/ha/person (year 1), 17.5 hr/ha/person (year 2), and 10 hr/ha/person (year 3) in Moderate; 157.5 hr/ha/person (year 1), 34.5 hr/ha/person (year 2), and 20 hr/ha/person (year 3) in Difficult]; (5) fence construction rate (2.7 m/hr/4-person crew for Easy, 2 m/hr/4-person crew for Moderate, and 1.7 m/hr/4-person crew for Difficult); and (6) fence maintenance rate (100 m/hr/person for Easy, 75 m/hr/person for Moderate, and 50 m/hr/person for Difficult) (Table S1).

SUPPLEMENTAL TABLE S1

Summary of Site Baseline Parameters for the 0.13 ha Experimental Site within the Wa'anae Kai Forest Reserve, O'ahu, Hawai'i, and for Three Classes of 1 ha Sites (Easy, Moderate, Difficult) and a 10 ha Easy Site in an Invasive Grass-Dominated Lowland Ecosystem on O'ahu, Hawai'i

Sites	Experiment and Full 0.13 ha Easy	1 ha Easy	1 ha Moderate	1 ha Difficult	10 ha Easy
Location and Accessibility	Fully accessible by road (~2–15 m or <2 min)	Fully accessible by road (~2–15 m or <2 min)	Fairly accessible by road (~0.8 km or ~15 min)	Not accessible by road (~3.2 km or ~1 hr)	Fully accessible by road (~2–15 m or <2 min)
Area	0.13 ha	1 ha	1 ha	1 ha	10 ha
Perimeter	166 m	400 m	400 m	400 m	1,265 m
Fencing Material Cost	\$43/m	\$43/m	\$43/m	\$49/m	\$43/m
Fence Construction Rate	2.7 m/hr/4-person crew	2.7 m/hr/4-person crew	2.0 m/hr/4-person crew*	1.7 m/hr/4-person crew*	2.7 m/hr/4-person crew
Fence Maintenance Rate	100 m/hr/person	100 m/hr/person	75 m/hr/person*	50 m/hr/person*	100 m/hr/person
Elevation Gradient	~10 m elevation gradient	~10 m elevation gradient	~20 m elevation gradient	~20 m elevation gradient	~10 m elevation gradient
Invasive Vegetation	Moderate amount of small trees and cacti, but mainly grass	Moderate amount of small trees and cacti, but mainly grass	Densely vegetated with invasive tree species (2x Easy) and grass	Densely vegetated with invasive tree species (2x Easy) and grass	Moderate amount of small trees and cacti, but mainly grass
Initial Site Clearing	120 hr/ha/person	120 hr/ha/person	240 hr/ha/person*	240 hr/ha/person*	120 hr/ha/person
Maintenance	10 hr/ha/person	10 hr/ha/person	20 hr/ha/person*	20 hr/ha/person*	10 hr/ha/person
Herbicide Application	52.5 hr/ha/person (year 1); 11.5 hr/ha/person (year 2); and 7 hr/ha/person (year 3)	52.5 hr/ha/person (year 1); 11.5 hr/ha/person (year 2); and 7 hr/ha/person (year 3)	79 hr/ha/person (year 1); 17.5 hr/ha/person (even years); 10 hr/ha/person (odd years)*	157.5 hr/ha/person (year 1); 34.5 hr/ha/person (even years); 20 hr/ha/person (odd years)*	52.5 hr/ha/person (year 1); 11.5 hr/ha/person (year 2); and 7 hr/ha/person (year 3)
Original Outplanting Mix	144 Experiment/1,296 Full 0.13 ha— <i>D. viscosa</i>	10,000 <i>D. viscosa</i> 13,333 <i>P. zeylanica</i>	10,000 <i>D. viscosa</i> 13,333 <i>P. zeylanica</i>	10,000 <i>D. viscosa</i> 13,333 <i>P. zeylanica</i>	100,000 <i>D. viscosa</i> 13,333 <i>P. zeylanica</i>
	108 Experiment/1,728 Full 0.13 ha— <i>P. zeylanica</i>	1,481 <i>T. populnea</i> 1,481 <i>M. sandwicense</i>	1,481 <i>T. populnea</i> 1,481 <i>M. sandwicense</i>	1,481 <i>T. populnea</i> 1,481 <i>M. sandwicense</i>	14,815 <i>T. populnea</i> 14,815 <i>M. sandwicense</i>
	16 Experiment/192 Full 0.13 ha— <i>T. populnea</i>	1,481 <i>C. subcordata</i>	1,481 <i>C. subcordata</i>	1,481 <i>C. subcordata</i>	14,815 <i>C. subcordata</i>
	16 Experiment/192 Full 0.13 ha— <i>M. sandwicense</i>				
	16 Experiment/192 Full 0.13 ha— <i>C. subcordata</i>				

Mortality/Replanting Rates for Plants that Died during First Month after Outplanting	29% <i>D. viscosa</i> 15% <i>P. zeylanica</i> 13% <i>T. populnea</i> 6% <i>M. sandwicensis</i> 38% <i>C. subcordata</i> \$2/plant	29% <i>D. viscosa</i> 15% <i>P. zeylanica</i> 13% <i>T. populnea</i> 6% <i>M. sandwicensis</i> 38% <i>C. subcordata</i> \$2/plant	29% <i>D. viscosa</i> 15% <i>P. zeylanica</i> 13% <i>T. populnea</i> 6% <i>M. sandwicensis</i> 38% <i>C. subcordata</i> \$2/plant	29% <i>D. viscosa</i> 15% <i>P. zeylanica</i> 13% <i>T. populnea</i> 6% <i>M. sandwicensis</i> 38% <i>C. subcordata</i> \$2/plant	29% <i>D. viscosa</i> 15% <i>P. zeylanica</i> 13% <i>T. populnea</i> 6% <i>M. sandwicensis</i> 38% <i>C. subcordata</i> \$2/plant
Planting Speed	20 plants/hr/person	20 plants/hr/person*	15 plants/hr/person*	7 plants/hr/person*	20 plants/hr/person
Planting Tools	Planting Bar and Bag	Planting Bar and Bag	Planting Bar and Bag	Planting Bar and Bag	Planting Bar and Bag
Water Delivery System	Backpack sprayer	Backpack sprayer	Backpack sprayer	Backpack sprayer	Backpack sprayer
Water Delivery Rate	132 liters/hr/person	132 liters/hr/person	88 liters/hr/person*	44 liters/hr/person*	132 liters/hr/person
Labor Rates	\$20/hr/person—Clearing \$16.50/hr/person for Herbicide Application \$66/hr/4-person crew for Fence Construction \$16.50/hr/person for Watering \$16.50/hr/person for Planting \$20/hr/person Clearing Maintenance \$35/hr/person Fence Maintenance	\$20/hr/person—Clearing \$16.50/hr/person for Herbicide Application \$66/hr/4-person crew for Fence Construction \$16.50/hr/person for Watering \$16.50/hr/person for Planting \$20/hr/person Clearing Maintenance \$35/hr/person Fence Maintenance	\$20/hr/person for Clearing \$16.50/hr/person for Herbicide Application \$66/hr/4-person crew for Fence Construction \$16.50/hr/person for Watering \$16.50/hr/person for Planting \$20/hr/person Clearing Maintenance \$35/hr/person Fence Maintenance	\$20/hr/person for Clearing \$16.50/hr/person for Herbicide Application \$66/hr/4-person crew for Fence Construction \$16.50/hr/person for Watering \$16.50/hr/person for Planting \$20/hr/person Clearing Maintenance \$35/hr/person Fence Maintenance	\$20/hr/person for Clearing \$16.50/hr/person for Herbicide Application \$66/hr/4-person crew for Fence Construction \$16.50/hr/person for Watering \$16.50/hr/person for Planting \$20/hr/person Clearing Maintenance \$35/hr/person Fence Maintenance

* Represents changes in labor inputs from baseline Easy site due to differences in site characteristics (accessibility, elevation gradient, invasive vegetation, rockiness of terrain).

SUPPLEMENTAL TABLE S2A

Herbicide Application Quantities for a 3 Year Period and Beyond Scaled Up to a 1 ha Management Unit and Modeled after a 0.13 ha Experimental Site within the Wai'anae Kai Forest Reserve, O'ahu, Hawai'i

Herbicide Year and Mix	Materials	Quantity
Herbicides—Year 1		
mix 1	1. glyphosate (KleenUp)	25 ml/liter
	2. imazapyr (Habitat)	25 ml/liter
	3. phase (Surfactant)	5.3 ml/liter
	Quantity mix 1 per ha	284 liters/ha
mix 2	Labor speed mix 1	0.3 liter/min
	1. triclopyr (Pathfinder II)	83.3 liters/ha
mix 3	Labor speed mix 2	0.15 liters/min
	1. glyphosate (KleenUp)	50.2 ml/liter
	2. phase (Surfactant)	10.6 ml/liter
	Quantity mix 3 per ha	94.6 liters/ha
mix 4	Labor speed mix 3	0.3 liter/min
	1. glyphosate (KleenUp)	50.2 ml/liter
	2. phase (Surfactant)	10.6 ml/liter
mix 5	Quantity mix 4 per ha	284 liters/ha
	Labor speed mix 4	0.3 liter/min
	1. fluazifop p-butyl (Fusilade DX)	5.8 ml/liter
	2. phase (Surfactant)	7.9 ml/liter
Herbicides—Year 2	Quantity mix 5 per ha	428 liters/ha
	Labor speed mix 5	1 liter/min
	1. fluazifop p-butyl (Fusilade DX)	5.8 ml/liter
mix 6	2. phase (Surfactant)	7.9 ml/liter
	Quantity mix 6 per ha	428 liters/ha
	Labor speed mix 6	1 liter/min
mix 7	1. triclopyr (Pathfinder II)	41.6 liters/ha
	Labor speed mix 7	0.15 liter/min
Herbicides—Year 3 and every year on		
mix 8	1. fluazifop p-butyl (Fusilade DX)	5.8 ml/liter
	2. phase (Surfactant)	7.9 ml/liter
	Quantity mix 8 per ha	284 liters/ha
	Labor speed mix 8	1 liter/min
mix 9	1. glyphosate (KleenUp)	25 ml/liter
	Quantity mix 9 per ha	37.9 liters/ha
	Labor speed mix 9	0.3 liter/min
Herbicides—Year 3 and every other year on		
mix 10	1. triclopyr (Pathfinder II)	41.6 liters/ha
	Labor speed mix 10	0.15 liter/min

SUPPLEMENTAL TABLE S2B

Herbicide Unit Costs for Management of 0.13 ha Experimental Site in an Invasive Grass-Dominated Lowland Ecosystem within the Wai'anae Kai Forest Reserve, O'ahu, Hawai'i

Herbicide	Units	Unit Costs (2015 US\$)
Materials—Glyphosate (KleenUp, Loveland Products, Inc., Greeley, Colorado, US, EPA reg. no. 34704-890)	ml	\$0.01
Materials—Imazapyr (Habitat, BASF Corporation, Research Triangle Park, North Carolina, US, EPA reg. no. 241-426)	ml	\$0.04
Materials—Phase (surfactant)	ml	\$0.02
Materials—Triclopyr (Pathfinder II, Dow AgroSciences, Indianapolis, Indiana, US, EPA reg. no. 62719-176)	liters	\$18.14
Materials—Fluaxifop p-butyl (Fusilade DX, Syngenta Crop Protection, Inc., Greensboro, North Carolina, US, EPA reg. no. 100-1070)	ml	\$0.05

Herbicide (Labor + Material) (*multiple treatments—see SUPPLEMENTAL TABLES S2 and S3)

Labor ^d Material	10.5 hrs	\$16.50	\$173	1.5 hrs	\$16.50	1	hrs	\$16.50	\$17
Herbicide Glyphosate (KleenUp, Loveland Products, Inc., Greeley, Colorado, US, EPA reg. no. 34704-890)	3,301	ml	\$0.01	—	—	366	ml	\$0.01	\$4
Imazapyr (Habitat, BASF Corporation, Research Triangle Park, North Carolina, US, EPA reg. no. 241-426)	900	ml	\$0.04	—	—	—	—	—	—
Phase (surfactant) Triclopyr (Pathfinder II, Dow AgroSciences, Indianapolis, Indiana, US, EPA reg. no. 62719-176)	1,123 11	ml L	\$0.02 \$18.14	428 5	ml L	284 —	ml —	\$0.02 —	\$6 —
Fluaxifop p-butyl (Fusilade DX, Syngenta Crop Protection, Inc. Greensboro, North Carolina, US, EPA reg. no. 100-1070)	314	ml	\$0.05	314	ml	208	ml	\$0.05	\$10
Backpack Sprayer <i>Subtotal Herbicide</i>	2	each	\$65.00	—	—	—	—	—	—
			\$130						\$36
			\$611						(0.3%)*
			(4.3%)*						
			\$144						\$144
			(1.0%)*						(0.3%)*

SUPPLEMENTAL TABLE S3 (continued)

Establishment and Maintenance Activities	Year 1			Year 2			Year 3			
	Quantity (Rounded)	Units	Unit Cost (2015 US\$)	Quantity (Rounded)	Units	Unit Cost (2015 US\$)	Quantity (Rounded)	Units	Unit Cost (2015 US\$)	
Outplanting 9 m ² Test Plots (Labor + Equipment)										
Labor										
Contractor—Manual Planting (20 plants/hr) ^e	15	hrs	\$16.50	—	—	\$248	—	—	—	—
Contractor—Manual Watering (132 liters/hr)—1 liter when planted, then 1 liter once a week for following 3 weeks ^f	6.8	hrs	\$16.50	—	—	\$112	—	—	—	—
Equipment										
Planting Bar and Bag	2	each	\$45.00	—	—	\$90	—	—	—	—
Backpack Sprayer	2	each	\$65.00	—	—	\$130	—	—	—	—
Water	1,200	L	\$0.0005	—	—	\$1	—	—	—	—
Plants										
<i>Dodonaea viscosa</i> ('a'alt'i)	144	each	\$2.00	—	—	\$288	—	—	—	—
<i>Plumbago zeylanica</i> ('ilie'e)	108	each	\$2.00	—	—	\$216	—	—	—	—
<i>Thespesia populnea</i> (milo)	16	each	\$2.00	—	—	\$32	—	—	—	—
<i>Myoporum sandwicense</i> (naio)	16	each	\$2.00	—	—	\$32	—	—	—	—
<i>Cordia subcordata</i> (kou)	16	each	\$2.00	—	—	\$32	—	—	—	—
Subtotal Outplanting						\$1,180				
						(8.3%)*				

Mortality/Replanting Costs 9 m² Test Plots (Plants that died within 1 month of outplanting were replaced) (Labor + Equipment)

Labor								
Contractor—Manual Planting (20 plants/hr)	3.4	hrs	\$16.50	\$55	—	—	—	—
Contractor—Manual Watering (132 liters/hr) —1 liter when planted, then 1 liter once a week for following 3 weeks	2	hrs	\$16.50	\$33	—	—	—	—
Plants								
<i>Dodonaea viscosa</i> ('ā'ali'i)	42	each	\$2.00	\$84	—	—	—	—
<i>Phombago zeylanica</i> ('iile'e)	16	each	\$2.00	\$32	—	—	—	—
<i>Thespesia populnea</i> (milo)	2	each	\$2.00	\$4	—	—	—	—
<i>Myoporum sandwicense</i> (maio)	1	each	\$2.00	\$2	—	—	—	—
<i>Cordia subcordata</i> (kou)	6	each	\$2.00	\$12	—	—	—	—
Water	254	L	\$0.0005	\$0.13	—	—	—	—
Subtotal Mortality/Replanting				\$222	—	—	—	—
				(1.6%)*				

Yearly Net Cash Flow	Year 1: \$13,962 (97.6%)*	Year 2: \$239 (1.7%)*	Year 3: \$106 (0.7%)*
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Total Net Cash Flow	\$14,309
Present Value (2% discount rate)	\$14,299
Cost per hectare	\$109,993 ha ⁻¹

* Subtotal percentage of total 3-year cost.

^a At test site, clearing completed by UH graduate students. For cost analysis, time and cost based on completion by contractor.

^b At test site, fence constructed by contractor (i.e., Pono Pacific). For cost analysis, time and costs based on actual construction of fence at site.

^c Fence encloses 0.13 ha rectangular (62 m long and 21 m wide) test site.

^d At test site, herbicide applied by UH graduate students. For cost analysis, time and cost based on completion by contractor. Assumes sprayers calibrated to spray at rate of 8 ml/sec on average.

^e At test site, outplanting completed by 8 UH graduate students. For cost analysis, time and cost based on completion by contractor; assumes planting 20 plants/hr.

^f At test site, watering completed by UH graduate students. For cost analysis, time and cost based on completion by contractor; assumes water 132 plants/hr (water 4 times with 1 liter each time, assumes first watering included in planting time for each plant).

Herbicide (Labor + Material) (*multiple treatments—see SUPPLEMENTAL TABLES S2 and S3)

Labor ^d Material	10.5 hrs	\$16.50	\$173	1.5 hrs	\$16.50	\$25	1	hrs	\$16.50	\$17
Herbicide Glyphosate (KleenUp, Loveland Products, Inc., Greeley, Colorado, US, EPA reg. no. 34704-890)	3,396	\$0.01	\$34	—	—	—	377	ml	\$0.01	\$4
Imazapyr (Habitat, BASF Corporation, Research Triangle Park, North Carolina, US, EPA reg. no. 241-426)	926	ml	\$0.04	\$37	—	—	—	—	—	—
Phase (surfactant) Triclopyr (Pathfinder II, Dow AgroSciences, Indianapolis, Indiana, US, EPA reg. no. 62719-176) ^e	1,156 11	ml L	\$0.02 \$18.14	\$23 \$206	441 5	ml L	293 —	ml —	\$0.02 —	\$6 —
Fluaxifop p-butyl (Fusilade DX, Syngenta Crop Protection, Inc. Greensboro, North Carolina, US, EPA reg. no. 100-1070)	323	ml	\$0.05	\$16	323	ml	215	ml	\$0.05	\$11
Backpack Sprayer <i>Subtotal Herbicide</i>	2	each	\$65.00	\$130	—	—	—	—	—	—
				(2.3%)*						
				\$148						\$37
				(0.5%)*						(0.1%)*

SUPPLEMENTAL TABLE S4 (continued)

Establishment and Maintenance Activities	Year 1			Year 2			Year 3			
	Quantity (Rounded)	Units	Unit Cost (2015 US\$)	Quantity (Rounded)	Units	Unit Cost (2015 US\$)	Quantity (Rounded)	Units	Unit Cost (2015 US\$)	
Outplanting 9 m ² Test Plots (Labor + Equipment)										
Labor										
Contractor—Manual Planting (20 plants/hr) ^f	180	hrs	\$16.50	—	—	\$2,970	—	—	—	—
Contractor—Manual Watering (132 liters/hr)—1 liter when planted, then 1 liter once a week for following 3 weeks ^g	81.6	hrs	\$16.50	—	—	\$1,346	—	—	—	—
Equipment										
Planting Bar and Bag	2	each	\$45.00	—	—	\$90	—	—	—	—
Backpack Sprayer	2	each	\$65.00	—	—	\$130	—	—	—	—
Water	14,400	L	\$0.00005	—	—	\$7	—	—	—	—
Plants										
<i>Dodonaea viscosa</i> ('a'alt'i)	1,296	each	\$2.00	—	—	\$2,592	—	—	—	—
<i>Plumbago zeylanica</i> ('ilie'e)	1,728	each	\$2.00	—	—	\$3,456	—	—	—	—
<i>Thespesia populnea</i> (milo)	192	each	\$2.00	—	—	\$384	—	—	—	—
<i>Myoporum sandwicense</i> (naio)	192	each	\$2.00	—	—	\$384	—	—	—	—
<i>Cordia subcordata</i> (kou)	192	each	\$2.00	—	—	\$384	—	—	—	—
Subtotal Outplanting						\$11,744				
						(43.2%)*				

SUPPLEMENTAL TABLE S5

Establishment and Maintenance Costs for a 0.13 ha Square Restoration Site Modeled after the Experimental Test Plot Site within the Waialeale Kai Forest Reserve over 3 Years in an Invasive Grass-Dominated Lowland Ecosystem on O'ahu, Hawaii¹

Establishment and Maintenance Activities	Year 1			Year 2			Year 3			
	Quantity (Rounded)	Units	Unit Cost (2015 US\$)	Quantity (Rounded)	Units	Unit Cost (2015 US\$)	Quantity (Rounded)	Units	Unit Cost (2015 US\$)	Total (2015 US\$, Rounded)
Clearing (Labor + Equipment)										
Labor—Contractor (speed of 120 hr/ha/person—initial year 1 and 10 hr/ha/person—maintenance) ^a	15.6	hrs	\$20.00	1.3	hrs	\$20.00	—	—	—	\$26
Equipment—Chain saw	1	each	\$200.00	—	—	—	—	—	—	—
Equipment—Weedwacker	2	each	\$120.00	—	—	—	—	—	—	—
<i>Subtotal Clearing</i>										\$26 (0.1%)*
			\$312							
Fence (Labor + Material)										
Fence Construction Labor (2.7 m/hr) ^b										
Project Manager	53.4	hrs	\$25.00	—	—	—	—	—	—	\$1,335
Crew Leader	53.4	hrs	\$15.00	—	—	—	—	—	—	\$801
Crew 1	53.4	hrs	\$13.00	—	—	—	—	—	—	\$694
Crew 2	53.4	hrs	\$13.00	—	—	—	—	—	—	\$694
Fence (144.2 m long) Material ^c	144.2	m	\$43.00	—	—	—	—	—	—	\$6,201
Fence Maintenance (after year 1)—Contractor (once per year, 100 m/hr)	—	—	—	1.6	hrs	\$35.00	1.6	hrs	\$35.00	\$56
<i>Subtotal Fence</i>										\$56 (0.2%)*
			\$9,725							\$9,725 (37.9%)*
										\$56 (0.2%)*

Herbicide (Labor + Material) (*multiple treatments—see SUPPLEMENTAL TABLES S2 and S3)

Labor ^d Material	10.5 hrs	\$16.50	\$173	1.5 hrs	\$16.50	\$25	1	hrs	\$16.50	\$17
Herbicide Glyphosate (KleenUp, Loveland Products, Inc., Greeley, Colorado, US, EPA reg. no. 34704-890)	3,396	\$0.01	\$34	—	—	—	377	ml	\$0.01	\$4
Imazapyr (Habitat, BASF Corporation, Research Triangle Park, North Carolina, US, EPA reg. no. 241-426)	926	\$0.04	\$37	—	—	—	—	—	—	—
Phase (surfactant) Triclopyr (Pathfinder II, Dow AgroSciences, Indianapolis, Indiana, US, EPA reg. no. 62719-176)	1,156 11	\$0.02 \$18.14	\$23 \$206	441 5	ml L	\$9 \$98	293 —	ml —	\$0.02 —	\$6 —
Fluaxifop p-butyl (Fusilade DX, Syngenta Crop Protection, Inc. Greensboro, North Carolina, US, EPA reg. no. 100-1070)	323	\$0.05	\$16	323	ml	\$16	215	ml	\$0.05	\$11
Backpack Sprayer	2	\$65.00	\$130	—	—	—	—	—	—	—
<i>Subtotal Herbicide</i>			<i>\$620</i> <i>(2.4%)*</i>			<i>\$148</i> <i>(0.6%)*</i>				<i>\$37</i> <i>(0.1%)*</i>

SUPPLEMENTAL TABLE S6

Establishment and Maintenance Costs for a 1 ha Restoration Site Modeled after the Experimental Test Plot Site within the Waiʻanae Kai Forest Reserve over 3 Years in an Invasive Grass-Dominated Lowland Ecosystem on Oʻahu, Hawaiʻi

Establishment and Maintenance Activities	Year 1			Year 2			Year 3			
	Quantity (Rounded)	Units	Unit Cost (2015 US\$)	Quantity (Rounded)	Units	Unit Cost (2015 US\$)	Quantity (Rounded)	Units	Unit Cost (2015 US\$)	Total (2015 US\$, Rounded)
Clearing (Labor + Equipment)										
Labor—Contractor (speed of 120 hr/ha/person—initial year 1 and 10 hr/ha/person—maintenance) ^a	120	hrs	\$20.00	10	hrs	\$20.00	—	—	—	—
Equipment—Chain saw	1	each	\$200.00	—	—	—	—	—	—	—
Equipment—Weedwacker	2	each	\$120.00	—	—	—	—	—	—	—
<i>Subtotal Clearing</i>										
			\$2,400			\$200				\$200
			\$200			—				—
			\$240			—				—
			\$2,840			\$200				\$200
			(1.9%)*			(0.1%)*				(0.1%)*
Fence (Labor + Material)										
Fence Construction Labor (2.7 m/hr) ^b										
Project Manager	145.5	hrs	\$25.00	—	—	—	—	—	—	—
Crew Leader	145.5	hrs	\$15.00	—	—	—	—	—	—	—
Crew 1	145.5	hrs	\$13.00	—	—	—	—	—	—	—
Crew 2	145.5	hrs	\$13.00	—	—	—	—	—	—	—
Fence (400 m long) Material ^c	400	m	\$43.00	—	—	—	—	—	—	—
Fence Maintenance (after year 1)—Contractor (once per year, 100 m/hr)	—	—	—	4	hrs	\$35.00	4	hrs	\$35.00	\$140
<i>Subtotal Fence</i>										
			\$26,803			\$140				\$140
			(17.9%)*			(0.1%)*				(0.1%)*

Herbicide (Labor + Material) (*multiple treatments—see SUPPLEMENTAL TABLES S2 and S3)

Labor ^d Material	52.5 hrs	\$16.50	\$866	11.5 hrs	\$16.50	\$190	7	hrs	\$16.50	\$116
Herbicide Glyphosate (KleenUp, Loveland Products, Inc., Greeley, Colorado, US, EPA reg. no. 34704-890)	26,125	ml	\$0.01	\$261	—	—	907	ml	\$0.01	\$9
Imazapyr (Habitat, BASF Corporation, Research Triangle Park, North Carolina, US, EPA reg. no. 241-426)	7,125	ml	\$0.04	\$285	—	—	—	—	—	—
Phase (surfactant)	8,875	ml	\$0.02	\$178	3,375	\$68	2,250	ml	\$0.02	\$45
Triclopyr (Pathfinder II, Dow AgroSciences, Indianapolis, Indiana, US, EPA reg. no. 62719-176)	83	L	\$18.14	\$1,502	42	\$755	—	—	—	—
Fluaxifop p-butyl (Fusilade DX, Syngenta Crop Protection, Inc. Greensboro, North Carolina, US, EPA reg. no. 100-1070)	2,475	ml	\$0.05	\$124	2,775	\$139	1,650	ml	\$0.05	\$83
Backpack Sprayer	2	each	\$65.00	\$130	—	—	—	—	—	—
<i>Subtotal Herbicide</i>			\$3,346 (2.2%)*			\$1,151 (0.8%)*				\$252 (0.2%)*

SUPPLEMENTAL TABLE S6 (continued)

Establishment and Maintenance Activities	Year 1			Year 2			Year 3			
	Quantity (Rounded)	Units	Unit Cost (2015 US\$)	Quantity (Rounded)	Units	Unit Cost (2015 US\$)	Quantity (Rounded)	Units	Unit Cost (2015 US\$)	
Outplanting 9 m ² Test Plots (Labor + Equipment)										
Labor										
Contractor—Manual Planting (20 plants/hr) ^e	1,389	hrs	\$16.50	—	—	\$22,915	—	—	—	—
Contractor—Manual Watering (132 liters/hr)—1 liter when planted, then 1 liter once a week for following 3 weeks ^f	631	hrs	\$16.50	—	—	\$10,412	—	—	—	—
Equipment										
Planting Bar and Bag Backpack Sprayer	6	each	\$45.00	—	—	\$270	—	—	—	—
Water Truck Rental	6	each	\$65.00	—	—	\$390	—	—	—	—
Water	1	month	\$3,500.00	—	—	3,550	—	—	—	—
Plants	105,151	L	\$0.0005	—	—	\$53	—	—	—	—
<i>Dodonaea viscosa</i> ('a ali'i)	10,000	each	\$2.00	—	—	\$20,000	—	—	—	—
<i>Plumbago zeylanica</i> ('ilie'e)	13,333	each	\$2.00	—	—	\$26,666	—	—	—	—
<i>Thepesia popalinea</i> (miilo)	1,481	each	\$2.00	—	—	\$2,962	—	—	—	—
<i>Myoporum sandwicense</i> (naio)	1,481	each	\$2.00	—	—	\$2,962	—	—	—	—
<i>Cordia subcordata</i> (kou)	1,481	each	\$2.00	—	—	\$2,962	—	—	—	—
Subtotal Outplanting						\$93,141				
						(62.1%)*				

Mortality/Replanting Costs 9 m² Test Plots (Plants that died within 1 month of outplanting were replaced) (Labor + Equipment)

Labor								
Contractor—Manual Planting (20 plants/hr)	287	hrs	\$16.50	\$4,739	—	—	—	—
Contractor—Manual Watering (132 liters/hr) —1 liter when planted, then 1 liter once a week for following 3 weeks	131	hrs	\$16.50	\$2,162	—	—	—	—
Plants								
<i>Dodonaea viscosa</i> ('a'ali'i)	2,900	each	\$2.00	\$5,800	—	—	—	—
<i>Plumbago zeylanica</i> ('ilic'e)	2,000	each	\$2.00	\$4,000	—	—	—	—
<i>Thespesia populnea</i> (milo)	193	each	\$2.00	\$385	—	—	—	—
<i>Myoporum sandwicense</i> (naio)	89	each	\$2.00	\$178	—	—	—	—
<i>Cordia subcordata</i> (kou)	563	each	\$2.00	\$1,126	—	—	—	—
Water	21,743	L	\$0.0005	\$11	—	—	—	—
Water Truck Rental	1	month	\$3,550.00	3,550	—	—	—	—
Subtotal Mortality/Replanting				\$21,950				
				(14.6%)*				

Yearly Net Cash Flow	Year 1: \$148,080 (98.8%)*	Year 2: \$1,491 (1.2%)*	Year 3: \$392 (0.3%)*
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Total Net Cash Flow	\$149,964
Present Value (2% discount rate)	\$149,918
Cost per hectare	\$149,918 ha ⁻¹

* Subtotal percentage of total 3-year cost.

^a At test site, clearing completed by UH graduate students. For cost analysis, time and cost based on completion by contractor.

^b At test site, fence constructed by contractor (i.e., Pono Pacific). For cost analysis, time and costs based on actual construction of fence at site.

^c Fence encloses 1 ha square site (approximately 100 m long and 100 m wide).

^d At test site, herbicide applied by UH graduate students. For cost analysis, time and cost based on completion by contractor. Assumes sprayers calibrated to spray at rate of 8 ml/sec on average.

^e At test site, outplanting completed by 8 UH graduate students. For cost analysis, time and cost based on completion by contractor; assumes planting 20 plants/hr.

^f At test site, watering completed by UH graduate students. For cost analysis, time and cost based on completion by contractor; assumes water 132 plants/hr (water 4 times with 1 liter each time, assumes first watering included in planting time for each plant).

SUPPLEMENTAL TABLE S7

Establishment and Maintenance Costs for a 10 ha Restoration Site Modeled after the Experimental Test Plot Site within the Wai'anae Kai Forest Reserve over 3 Years in an Invasive Grass-Dominated Lowland Ecosystem on O'ahu, Hawai'i

Establishment and Maintenance Activities	Year 1			Year 2			Year 3			
	Quantity (Rounded)	Units	Unit Cost (2015 US\$)	Quantity (Rounded)	Units	Unit Cost (2015 US\$)	Quantity (Rounded)	Units	Unit Cost (2015 US\$)	Total (2015 US\$, Rounded)
Clearing (Labor + Equipment)										
Labor—Contractor (speed of 120 hr/ha/person—initial year 1 and 10 hr/ha/person—maintenance) ^a	1,200	hrs	\$20.00	100	hrs	\$20.00	—	—	—	\$2,000
Equipment—Chain saw	2	each	\$200.00	—	—	—	—	—	—	—
Equipment—Weedwacker	4	each	\$120.00	—	—	—	—	—	—	—
<i>Subtotal Clearing</i>										\$2,480 (2.0%)*
Fence (Labor + Material)										
Fence Construction Labor (2.7 m/hr) ^b	468.5	hrs	\$25.00	—	—	—	—	—	—	—
Project Manager	468.5	hrs	\$15.00	—	—	—	—	—	—	—
Crew Leader	468.5	hrs	\$13.00	—	—	—	—	—	—	—
Crew 1	468.5	hrs	\$13.00	—	—	—	—	—	—	—
Crew 2	468.5	hrs	\$13.00	—	—	—	—	—	—	—
Fence (1,265 m long) Material ^c	1,265	m	\$43.00	—	—	—	—	—	—	—
Fence Maintenance (after year 1)—Contractor (once per year, 100 m/hr)	—	—	—	13.8	hrs	\$35.00	13.8	hrs	\$35.00	\$484
<i>Subtotal Fence</i>										\$484 (0.04%)*
										\$484 (0.04%)*

Herbicide (Labor + Material) (*multiple treatments—see SUPPLEMENTAL TABLES S2 and S3)

Labor ^d Material	525 hrs	\$16.50	88,665	115 hrs	\$16.50	66	hrs	\$16.50	\$1,898	\$1,089
Herbicide Glyphosate (KleenUp, Loveland Products, Inc., Greeley, Colorado, US, EPA reg. no. 34704-890)	261,250	ml	\$0.01	—	—	2,867	ml	\$0.01	—	\$29
Imazapyr (Habitat, BASF Corporation, Research Triangle Park, North Carolina, US, EPA reg. no. 241-426)	71,250	ml	\$0.04	—	—	—	—	—	—	—
Phase (surfactant)	88,750	ml	\$0.02	33,750	ml	22,500	ml	\$0.02	\$675	\$450
Triclopyr (Pathfinder II, Dow AgroSciences, Indianapolis, Indiana, US, EPA reg. no. 62719-176)	829	L	\$18.14	413	L	—	—	\$18.14	\$7,485	—
Fluaxifop p-butyl (Fusilade DX, Syngenta Crop Protection, Inc. Greensboro, North Carolina, US, EPA reg. no. 100-1070)	24,750	ml	\$0.05	24,750	ml	16,500	ml	\$0.05	\$1,238	\$825
Backpack Sprayer	6	each	\$65.00	—	—	—	—	—	—	—
<i>Subtotal Herbicide</i>			\$390 \$32,568 (2.6%)*						\$11,295 (0.9%)*	\$2,393 (0.2%)*

SUPPLEMENTAL TABLE S7 (continued)

Establishment and Maintenance Activities	Year 1			Year 2			Year 3			
	Quantity (Rounded)	Units	Unit Cost (2015 US\$)	Quantity (Rounded)	Units	Unit Cost (2015 US\$)	Quantity (Rounded)	Units	Unit Cost (2015 US\$)	
Outplanting 9 m ² Test Plots (Labor + Equipment)										
Labor										
Contractor—Manual Planting (20 plants/hr) ^e	13,889	hrs	\$16.50	—	—	\$229,167	—	—	—	—
Contractor—Manual Watering (132 liters/hr)—1 liter when planted, then 1 liter once a week for following 3 weeks ^f	6,313	hrs	\$16.50	—	—	\$104,165	—	—	—	—
Equipment										
Planting Bar and Bag Backpack Sprayer	25	each	\$45.00	—	—	\$1,125	—	—	—	—
Water Truck Rental	12	each	\$65.00	—	—	\$780	—	—	—	—
Water	1	month	\$3,550.00	—	—	3,550	—	—	—	—
Plants	1,051,504	L	\$0.0005	—	—	\$526	—	—	—	—
<i>Dodonaea viscosa</i> ('a'ali'i)	100,000	each	\$2.00	—	—	\$200,000	—	—	—	—
<i>Plumbago zeylanica</i> ('ilie'e)	133,333	each	\$2.00	—	—	\$266,666	—	—	—	—
<i>Thepesia popalinea</i> (miilo)	14,815	each	\$2.00	—	—	\$29,630	—	—	—	—
<i>Myoporum sandwicense</i> (nato)	14,815	each	\$2.00	—	—	\$29,630	—	—	—	—
<i>Cordia subcordata</i> (kou)	14,815	each	\$2.00	—	—	\$29,630	—	—	—	—
Subtotal Outplanting						\$894,868				
						(72.1%)*				

Mortality/Replanting Costs 9 m² Test Plots (Plants that died within 1 month of outplanting were replaced) (Labor + Equipment)

Labor									
Contractor—Manual Planting (20 plants/hr)	2,872	hrs	\$16.50	\$47,392	—	—	—	—	—
Contractor—Manual Watering (132 liters/hr) —1 liter when planted, then 1 liter once a week for following 3 weeks	1,306	hrs	\$16.50	\$21,549	—	—	—	—	—
Plants									
<i>Dodonaea viscosa</i> ('a'ali'i)	29,000	each	\$2.00	\$58,000	—	—	—	—	—
<i>Plumbago zeylanica</i> ('ilie'e)	20,000	each	\$2.00	\$40,000	—	—	—	—	—
<i>Thespesia populnea</i> (milo)	1,926	each	\$2.00	\$3,852	—	—	—	—	—
<i>Myoporum sandwicense</i> (naio)	889	each	\$2.00	\$1,778	—	—	—	—	—
<i>Cordia subcordata</i> (kou)	5,630	each	\$2.00	\$11,259	—	—	—	—	—
Water	217,449	L	\$0.0005	\$109	—	—	—	—	—
Water Truck Rental	1	month	\$3,550.00	3,550	—	—	—	—	—
<i>Subtotal Mortality/Replanting</i>				\$187,488					
				(15.1%)*					

<i>Yearly Net Cash Flow</i>	<i>Year 1: \$1,225,121</i>	<i>Year 2: \$13,779</i>	<i>Year 3: \$2,877</i>
	(98.7%)*	(1.1%)*	(0.2%)*

Total Net Cash Flow \$1,241,777

Present Value (2% discount rate) \$1,241,395

Cost per hectare \$124,139 ha⁻¹

* Subtotal percentage of total 3-year cost.

^a At test site, clearing completed by UH graduate students. For cost analysis, time and cost based on completion by contractor.

^b At test site, fence constructed by contractor (i.e., Pono Pacific). For cost analysis, time and costs based on actual construction of fence at site.

^c Fence encloses 10 ha square site (approximately 316.23 m long and 316.23 m wide).

^d At test site, herbicide applied by UH graduate students. For cost analysis, time and cost based on completion by contractor. Assumes sprayers calibrated to spray at rate of 8 ml/sec on average.

^e At test site, outplanting completed by 8 UH graduate students. For cost analysis, time and cost based on completion by contractor; assumes planting 20 plants/hr.

^f At test site, watering completed by UH graduate students. For cost analysis, time and cost based on completion by contractor; assumes water 132 plants/hr (water 4 times with 1 liter each time, assumes first watering included in planting time for each plant).

SUPPLEMENTAL TABLE S8

Example Seedling Propagation Costs Per Plant for a 1 ha Restoration Site Modeled after the Experimental Test Plot Site within the Wai'anae Kai Forest Reserve in an Invasive Grass-Dominated Lowland Ecosystem on O'ahu, Hawai'i Under the Reduced Plant Costs Model

Seedling Propagation Activities and Equipment (Incurred During Year 1)	Quantity (Rounded)	Units	Unit Cost (2015 US\$)	Total (2015 US\$, Rounded)
Plant Propagation (Labor + Equipment)				
Labor				
General Labor, Propagation (35 plants/hr)	794	hr	\$16.50	\$13,094
Equipment				
Hand Tools	35	each	\$10.00	\$350
Fertilizer and Soil (50 lbs per 1,500 plants)	925.9	lbs	\$1.50	\$1,389
<i>Dodonaea viscosa</i> ('a'ali'i)	10,000	each	\$0.50	\$5,000
<i>Plumbago zeylanica</i> ('ilie'e)	13,333	each	\$0.50	\$6,667
<i>Thespesia populnea</i> (milo)	1,481	each	\$0.50	\$741
<i>Myoporum sandwicense</i> (naio)	1,481	each	\$0.50	\$741
<i>Cordia subcordata</i> (kou)	1,481	each	\$0.50	\$741
Water	105,151	liters	\$0.0005	\$53
Subtotal Plant Propagation				
<i>Cost for 27,776 plants</i>	\$28,774			
<i>Cost per plant with onsite propagation</i>	$27,776 \div$	$\$28,773$	$=$	$\sim \$1.00$
	<i>plants</i>	<i>total cost</i>		<i>per plant</i>