PURDUE EXTENSION

FNR-546-W

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COSTS AND RETURNS OF PRODUCING HOPS IN ESTABLISHED TREE PLANTATIONS

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PURDUE UNIVERSITY
1913 - 2013
FORESTRY AND NATURAL RESOURCES
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Introduction

This article is the first of two publications that analyzes economic opportunities in forest farming for Indiana forest plantation owners. This study explores growing hops along the fence lines of newly established forest stands, while the second study investigates producing American ginseng in older (20- to 30-year-old) forests. The economic analysis presented in this article is developed for two hops varieties, 'Cascade' and 'Comet', based on marketability and presumed adaption to low sunlight, respectively.

The following economic analysis is presented in two parts:

a) estimates of the typical investment and operating costs of producing hops in Indiana on deer fence used as a trellis; and

b) profitability analysis using net present valuation methods over a range of yields and market prices.

This cost study can be used as a guide in preparing budgets and estimating market returns; however, actual results are expected to vary from operation to operation, due to differences in management and cultural practices, soil and weather conditions, and input and output prices. It should be noted that growing hops in a forest setting is very different from growing hops on a traditional, tall-trellis system. As such, this analysis is best used for hops produced in a forest ecosystem.

Assumptions

The assumptions underlying the enterprise budget are explained below.

Farm specification. The representative farm is a quarter-acre hardwood tree plantation that has been recently established. A young forest stand is recommended to minimize canopy shade as hops require high levels of sunlight to maximize yields. The cost estimates listed below are based on hops grown along the perimeter fence of a quarter-acre forest plot (approximately 540 linear feet), assuming that the fence is installed 15 feet from the edge of the planted tree rows (see Figure 2). Regarding site selection, since properly caring for hop plants is highly labor-intensive, it is recommended that the farm site be conveniently located to allow for multiple visits each week during the growing season.

Figure 1. Deer-fencing trellis without modifications. Photo: Judith Martin

Trellis system. Hop plants produce above-ground shoots (called bines) each spring that are grown on a trellis structure to maximize yields. There are numerous types of trellis systems. Given that the representative farm is a tree plantation, this study explores the possibility of using existing infrastructure common to forest farms, such as deer-fencing modified for hops production. Typical deer-fencing found on forest plots (see Figure 1) has a useful life of 5 to 7 years, which is shorter than the 10-year expected useful life of the hops operation in this analysis. In addition, typical deer-fencing is not designed to support the heavy load of mature hops plants year after year. As a result, the deer-fencing trellis structure described in this analysis has been modified to extend its useful life and better support heavy loads.

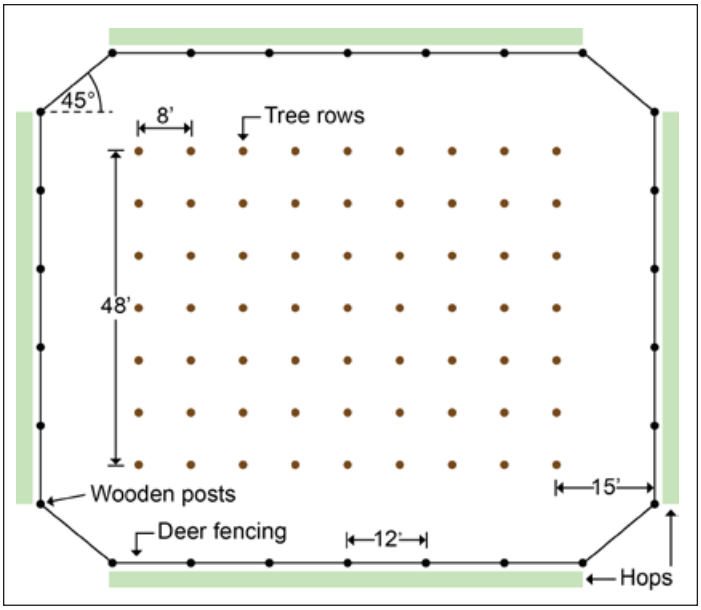

Figure 2. Diagram of plot layout for forest hops grown on deer-fencing (not to scale)

The modified deer-fencing uses 52 wooden, 6"x12' posts ($520) that are planted 12 feet apart and positioned 4 feet in the ground. Corners are arranged at 45-degree angles (see Figure 2) to increase strength and can be further reinforced with an H-post formation. To install the posts, a 6-inch auger implement and skid-steer loader can be rented for one day for $207. Monoline is then strung along the top, middle, and bottom of the posts to reinforce the mesh ($158). The monoline is tensioned using five gripples ($8) and a gripple-tightening tool ($75). Heavy-duty mesh is then attached to the posts (540 feet estimated at $859) using five U-shaped fencing staples per post ($9 for three packs). The mesh netting is then attached to the monoline using hog rings ($16 for one box) and a hog-ring plier ($55). J-shaped, 12-inch rebar stakes are used to stake the mesh to the ground between each post (48 stakes for $96). One T-post between each set of wooden posts can be used to further reinforce the mesh (48 posts for $199). Flagging tape is added to increase the visibility of the fencing and deter deer collisions ($2 for one roll). Skilled labor is estimated at $810. Total deer-fencing trellis costs are estimated at $3,013.

Land preparation. Soil testing is necessary to determine nutrient needs. One soil test ($15) is sufficient for up to a half-acre field[1]. Although soil test results may call for pH adjustments, such costs were not included in this analysis as they are heavily site-dependent. Herbicide ($4) was applied using a backpack sprayer ($90). Disking and plowing for roughly an acre of land are estimated at $29,

[1] Sites with significant soil variation may require more than one test.

based on 2013 Indiana Farm Custom Rates, which include fuel, operator labor, and machinery ownership costs. Land preparation costs total to approximately $137.

Planting. Under a deer-fencing trellis system, hop transplants are planted along the outside perimeter of the fencing and two feet apart[2] (see Figure 2) for a total cost of $796 (240 plants at $3.31 per unit). Although hop rhizomes can be used, transplants were used on Purdue's experiment plots to ensure higher survival rates and minimize the chance of getting infected hops.[3] Granular fertilizer (nitrogen, phosphorus, and potassium) can also be applied during planting (approximately 136 pounds totaling $209). An estimated 32 labor hours are needed at an hourly rate of $11.40 for a total of $364. Total initial planting costs amount to $1,160. In Year 2, it may be necessary to replant hop plants that did not survive. Based on experiment plot results, a replanting rate of 14%[4] was used. It is estimated that 34 hop transplants ($113) would need to be replanted, requiring 4.5 labor hours ($52). Total replanting costs are $166.

Irrigation. Hops are typically produced under irrigation; however, the production system described in this analysis does not use irrigation, because the majority of Indiana forest plantations are located in remote areas without already established well access.[5] Establishing an irrigation well would add an estimated $10,000 to investment costs, plus the costs of the irrigation system (i.e., tubing, tensiometer, emitters, labor, etc.) and subsequent maintenance. Nonetheless, hop plants need water and neglecting to satisfy these needs will reduce yields. Depending on the amount of precipitation in a given growing season, yield impacts due to lack of irrigation can vary widely. To account for the lack of irrigation, this analysis decreased yields by nine percentage points.[6]

Fertility management. Soil should be tested annually ($15 per year) to determine nutrient needs. It is estimated that 75 pounds of fertilizer (containing a mixture of nitrogen, phosphorus, and potassium) will be needed annually ($111). In years 2 to 10, liquid fertilizer can be applied using a backpack sprayer. Approximately 1 labor hour is needed for a total of $12. Annual fertility costs are estimated at $123.

Pest management. Total annual pest management costs are estimated at $415 annually, as described below. For detailed information on pests and products, refer to Purdue Extension publication ID-462-W, *Integrated Pest Management Guide for Hops in Indiana 2015.*

- *Weed management.* To manage weeds effectively, both pre-emergent and post-emergent herbicides ($21) should be used. Herbicide application labor is estimated at 1 hour per year ($12). Additional hand weeding may be necessary given conditions at individual sites. Since the amount of hand weeding will vary dramatically given the weed pressure at a particular site, the cost of labor was not included in this analysis.

- *Insect management*. Common hop yard pests include hop aphids and spider mites; however, in Indiana, Japanese beetles have been the most problematic and the only pests that have reached economic thresholds in Purdue's experimental hop yards[7]. Weekly scouting is necessary to minimize damage from insects and disease (8 labor hours totaling $91). Pesticide use should be minimized and should only be applied when certain thresholds are reached. It is estimated that $56 of insecticides will be applied annually.

- *Disease management*. The most prevalent diseases growers will have to contend with are downy mildew and powdery mildew. Fungicides are applied approximately every 10 days (or more often, depending on disease pressure[8]) during the growing season, which will require 12 labor hours ($133). It is estimated that $63 of fungicides will be applied annually. In addition, lower foliage can be pruned or stripped to increase airflow and minimize disease. On the experiment plots, lower foliage was stripped using herbicide application ($10 for materials and $12 for labor).

Other cultural practices. The deer-fencing trellis system described in this analysis is best suited for dwarf hop plant varieties. In the United States, dwarf varieties are not yet publicly available; however, certain varieties of conventional hop plants can be tricked into growing like dwarf varieties by cutting off the apical meristem to slow stem elongation while stimulating lateral branch growth

[2] Most hop varieties grown in a conventional, tall system are typically spaced three to three and a half feet apart to minimize disease pressure. The hops in this analysis were spaced two feet apart to distribute weight towards the fence posts.

[3] Major diseases, such as downy mildew, powdery mildew, and Verticillium wilt, affect hops. It is important to start with a disease-free plant stock.

[4] The replanting rate of 14% is based on experiment plot results for Purdue's dwarf trellis hop yard, not its deer-fencing plots. At the time of this analysis, the deer-fencing plots had not yet reached the second growing season, so no replanting data was available. Anecdotal evidence suggests 14% may be higher than normal.

[5] Beheler, B. Personal communication, 8/6/2015.

[6] The estimated yield decline of nine percentage points is likely optimistic. For example, in Germany, where only 18% of hop acreage is irrigated, the 2015 German hop yields were down by approximately 50% due to a drought.

[7] Hoagland, L. Personal communication 3/29/2017.

[8] Disease pressure is expected to be higher in areas with less sunlight.

Figure 3. Hop bine stem and lateral shoots climbing trellis. Photo: Judith Martin

and flower formation[9] (see Figure 3). In addition, removing early season "bull shoots" can also be very helpful as these produce bines with longer internodes than later shoots that emerge. It is estimated that eight labor hours are needed to clip the hops plants ($91).

Fencing management. The deer-fencing trellis structure will be subject to wear and tear due to heavy plant loads, wind loads, as well as deer pressure. Regular maintenance is necessary to maintain the integrity of the structure. It is estimated that $12 of materials and $46 of labor will be needed to maintain the fencing ($58 annually).

Yield. Given the forest setting depicted in this analysis, it is expected that it will take 4 to 5 years for a hop plant to reach full production.[10] Yields in the first, second, third, and fourth years are estimated at 20%, 40%, 60%, and 80% of mature yields, respectively. As the Indiana hops industry is still in its early stages of development, there is very little data on mature hop yields in Indiana. Hops grown on a conventional tall-trellis system in Indiana are projected to have mature yields of roughly 1,000 to 1,200 dried lbs an acre.[11] This analysis assumes 1,000 dried lbs an acre or 1.18 dried lbs per plant, assuming 850 plants per acre. However, conventional hops grown on low-trellis systems will see reduced yields, with losses ranging from 26% to 80%, depending on the variety and growing environment.[12] The yield loss for 'Cascade' is estimated at 26%. Assuming total reduced yields of 35%—due to the dwarf system, forest ecosystem, and lack of irrigation—it is approximated that the hop system described in this study will produce a mature yield of 184 dried lbs per quarter acre or 0.76 dried lbs per plant, which will be used as the base analysis for this study.

Harvesting. In Indiana, harvest occurs in August to early September with each hop variety having a discrete harvest window that typically lasts 4 to 5 days, or longer depending on the variety.[13] The hop system described in this analysis uses manual harvest labor where the bines remain on the fencing and the hop cones (see cover photo) are hand picked. While mechanical dwarf hop harvesters exist and would be appropriate for such a system, the small scale of a forest hop operation probably does not merit the high cost of a mechanical harvester. It is estimated that it will take approximately 45 minutes to harvest a mature forest dwarf hop plant by hand. Totaled across 240 plants, harvesting will require 180 labor hours annually ($2,052) in years 5 to 10. Practically speaking, in order to manually harvest a quarter acre within the optimal harvest window, it would be necessary to have at least four people working 9-hour days for 5 days in a row. Due to the short harvest window and labor intensiveness of manual picking, it is recommended that operations exceeding one acre use a mechanized harvester.

Post harvest handling. Hops can be sold fresh, as dried whole cones, or pelletized. The vast majority of commercial brewers prefer pelletized hops, because their brewing systems are not set up for fresh or dried whole-cone hops, which can clog their systems. Nonetheless, due to the small scale of the local industry, approximately 90% of Indiana hops are sold fresh.[14] However, fresh or wet hops are in limited demand compared to pelletized hops, as they have an extremely short shelf life (less than one day) and can only be used for brewing seasonal beers. As a result, there is growing pressure for Indiana hops producers to further add value to their hops to extend the life of their product. This analysis includes post-harvest handling costs relevant to producing fresh and dried whole-cone hops and assumes that 50% of crops are sold in each form. While pelletized hops are preferred in the market, the high cost of pelletizing equipment is not practical for the small scale of a forest hop operation. In other growing regions, it is common for small-scale producers to send their hops to a pelletizing and packing facility[15]; however, there are currently no third-party hops pelletizers in Indiana, as the local industry is still in development. The following post-harvest handling costs are applied to dried whole-cone hops only.

[9] Henning, J. 2011. High Quality Hop Production, Low-Trellis Systems.

[10] Hop plants grown in traditional hop yards under optimal conditions typically achieve full maturity in year 3

[11] Gray, S. Personal communication, 3/3/2016; Howe, S. Personal communication 3/15/2017

[12] Henning, J. 2011. High Quality Hop Production, Low-Trellis Systems.

[13] Howe, S. Personal communication, 3/30/2016.

[14] Gray, S. Personal communication, 9/24/2015.

[15] Processing facilities include other growers offering custom processing services as well as brokers with processing equipment.

- *Drying.* Fresh hops contain 75% to 80% moisture and are dried to 8% to 10% moisture using an oast. Many small-scale hop producers construct a homemade oast, which costs approximately $1,312, based on estimates from the University of Vermont. Electricity costs are estimated at $10 annually. The dryer should be located within 30 to 45 minutes of the growing site, as the quality of the hops will deteriorate rapidly once picked. Labor costs for drying hops are estimated at $23 per year in years 5 to 10. Costs associated with transporting the picked hops to the dryer are not included in this analysis; however, these costs can be substantial.

- *Packaging.* To limit oxidation and extend shelf life, hops are vacuum-packed in mylar bags. A vacuum sealer costs about $150 and mylar bags are estimated at $0.50 per pound ($46 in years 5 to 10).[16] Labor costs for packaging hops are estimated at $87 annually in years 5 to 10.

- *Cold storage.* Once dried and packaged, hops are stored in cold storage at 29 to 32 degrees F[17] to slow the rate of deterioration. A commercial cooler and the electricity needed to operate it is estimated at $1,500 for the unit and $124 in annual electricity costs.

Total post-harvest handling costs amount to approximately $3,155 in the first year in which post-harvest handling takes place (year 1 or 2) with the acquisition of equipment, and $289 in mature years (year 5 to 10).

Labor rates. Unskilled labor rates are estimated at $11.40 per hour, based on the 2014 Bureau of Labor Statistics' occupational employment statistics for farm laborers in Indiana. Skilled labor, which is necessary for trellis construction, is estimated at $20 per hour.

Table 1: Estimation of salvage values

	Cost	Year purchased	Salvage Value	
			% of cost	Value
Trellis	$3,013	0	25%	$753
Backpack sprayer	90	0	10%	9
Dryer	1,312	1	25%	328
Vacuum sealer	150	1	15%	23
Cold storage	1,500	1	15%	225

[16] This estimate does not account for the cost of Nitrogen-flushing (N-flushing) the mylar bags to reduce oxidation. While N-flushing is commonly practiced, some small-scale producers have managed to work around this need.

[17] Perrault, J. Presentation, 3/3/2016.

Salvage value. Salvage value is the estimated resale value of an asset at the end of the investment horizon, which in this case is year 10. To determine salvage value, a percentage of cost was estimated, based on approximate age and usage at the end of the investment period (see Table 1). Salvage values were calculated for assets that offered a potential resale value.

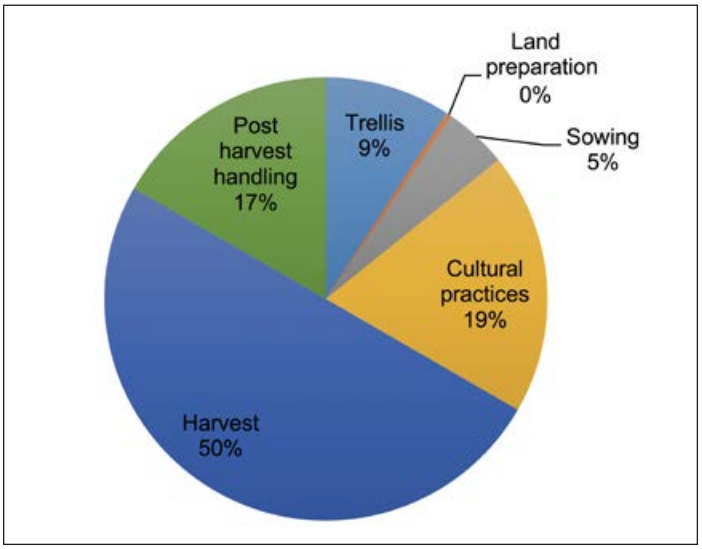

Figure 4. Proportion of hop costs by production stage

Returns. Farmers can sell their hops to brokers or directly to brewers. This analysis assumes that farmers will sell hops to brewers in fresh or dried whole-cone form. Selling prices for fresh or dried whole-cone hops vary from year to year. Even within a given year, prices can range anywhere from $5 to $15, depending on the farm, quantity, and the time purchased. While there is a current premium in the market for Indiana hops, conversations with brewers suggest that a price of $4 to $7 per pound is more sustainable in the long run.[18]

Other costs. Land rent is not included in this analysis because the target audience is assumed to already have established tree plantations; thus, any associated land rents for the added hops operation are a sunk cost of their forest operation. Insurance is not included, as specialty crops are not generally covered. In some instances, it may be possible to insure a traditional trellis structure; however, it is not likely that the deer-fencing trellis structure described in this analysis would be covered. In addition, transportation costs to and from the field are not included as they are dependent on distance, which can vary for each operation.

[18] Howe, S. Personal communication, 3/30/2016.

Summary of costs. The total costs of producing hops in an agroforestry ecosystem are $32,847 for a quarter-acre field. The timing of these costs is outlined in Table 2. Figure 4 illustrates the proportion of costs across the various production stages. Investment costs, which include trellis construction, land preparation, and sowing, amount to $4,666, representing 14% of total costs, whereas operating costs (cultural practices, harvesting, and post-harvest handling) amount to $28,181 or 86% of total costs. As can be seen, harvesting represents the largest proportion of costs (50%), followed by cultural practices, post-harvest handling, and trellis construction. Figure 5 shows the breakdown of material and labor costs. Material costs represent the large majority (74%) of investment-related costs, whereas labor is the main driver of operating costs (74%).

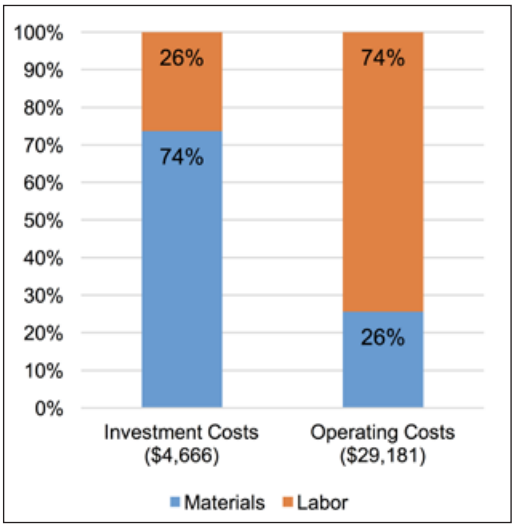

Figure 5. Breakdown of material and labor costs

Table 2: Timing and breakdown of costs to produce a quarter acre of hops grown in forest ecosystem

	Unit	Quantity	$/Unit	Year				
				1	2	3	4	5-10
Investment Costs								
Trellis								
Posts	post	52	$10	$520				
Heavy duty mesh	feet	540	2	859				
Monoline	feet	1,620	0.10	158				
U-shaped staple	pack	3	3	9				
Gripple	gripple	5	2	8				
Gripple tightening tool	tool	1	75	75				
Hog rings	rings	1	16	16				
Hog ring pliers	plier	1	55	55				
Rebar stakes	stake	48	2	96				
Flagging tape	roll	1	2	2				
T-post	post	48	4	199				
Auger implement rental	1 day rental	1	28	28				
Skid-steer loader rental	1 day rental	1	179	179				
Skilled Labor	hours	41	20	810				
Land Preparation								
Lab fees (for soil testing)	test	1	15	15				
Discing (custom hire)	acre	1	16	16				
Plowing (custom hire)	acre	1	13	13				
Herbicide	oz	22	0	3				
Backpack sprayer	backpack	1	90	90				
Sowing								
Transplants	plant	240	3	796	114			
Fertilizer	lbs	123	2	190				
Labor	hour	32	11	364	52			
Subtotal, Materials				3,326	114			
Subtotal, Labor				1,174	52			
Operating Costs								
Fertility								
Soil test	test	1	15		15	15	15	15
Fertilizers	lbs	133	1		111	111	111	111
Labor	hours	1	11		12	12	12	12
Pest management								
Herbicide		1	31	31	31	31	31	31
Pesticide		1	56		56	56	56	56
Fungicide		1	63		63	63	63	63
Labor	hours	22	11	103	248	248	248	248
Other cultural practices								
Clipping	hours	8.00	11		91	91	91	91
Fencing management								
Materials		1	12		12	12	12	12
Labor	hours	4	11		46	46	46	46
Harvest labor	hours	180	11	410	821	1,231	1,642	2,052
Post harvest handling								
Oast dryer	dryer	1	1,312		1,312			
Vacuum sealer	sealer	1	150		150			
Cold storage	refrigerator	1	1,500		1,500			
Mylar bags	bags	121	0.50		18	28	37	61
Labor	hours	10	11		47	76	93	110
Electricity	kwh	3.9	0		129	134	134	134
Subtotal, Materials				31	3,396	448	457	481
Subtotal, Labor				513	1,264	1,703	2,131	2,558
Salvage Value								1,315

Profitability Analysis

Hop production is a multi-year endeavor with various inflows and outflows occurring each year. As such, profitability analysis was conducted using a discounted cash flow valuation method to reflect the time value of money. *Time value of money* is the economic principle that money available today is worth more than the same amount tomorrow due to its potential earning capacity. The annual cash flows presented in this study were discounted at an annual rate of 4% to estimate their present value.

The break-even price, given our assumption of 240 plants across 540 linear feet and baseline yield of 182 pounds per quarter acre, is $22.82 per pound of hops. This break-even price is higher than the estimated selling price of $5 to $15. Hop yields and prices can vary significantly from operation to operation, based on numerous farm-management, agronomic, and market factors. Table 3 provides analysis, including total costs, break-even price, and net returns, at various yield and price combinations so that growers can approximate their hop operation's profitability using the price and yield combination that most closely reflects their own.

The baseline analysis described in the sections above most closely resembles the scenario presented in column c of Table 3. Columns a and b depict scenarios resulting in lower yields, which could be due to droughts and significant disease pressure, among other reasons. Columns d, e, and f represent scenarios in which the yields are higher than the baseline scenario. As can be seen from Table 3, the baseline scenario is not viable under any of the given market scenarios. In order to be profitable, a producer would need to achieve yields of at least 230 dried pounds per quarter acre and market prices of $20 per pound. Such high market prices are uncommon and are likely to be unsustainable in the long run, unless Indiana brewers and/or consumers are willing to pay a premium for local hops. Economic research is currently ongoing to analyze this premium. If market prices are not likely to increase, then focus should be given to improving yields, such as better farm-management practices or developing hop breeds that produce higher yields. Although the forest hops system used in this analysis does not appear to be a viable commercial operation, some producers may consider it for a hobby operation. Areas for future economic analysis could explore the acreage threshold at which a forest hops system would be more likely to be profitable.

Table 3: Costs and returns per quarter acre across various yield and price combinations

	a	b	c	d	e	f
	Mature Yield					
Pounds per plant (average)	**0.36**	**0.56**	**0.76**	**0.96**	**1.16**	**1.36**
Pounds per quarter acre	**86**	**134**	**182**	**230**	**278**	**326**
Present value of cash flows at varying yields						
Trellis	$3,013	$3,013	$3,013	$3,013	$3,013	$3,013
Land preparation	137	137	137	137	137	137
Sowing	1,509	1,509	1,509	1,509	1,509	1,509
Cultural practies	5,214	5,214	5,214	5,214	5,214	5,214
Harvest	11,602	12,481	13,360	14,239	15,118	15,997
Post harvest handling	4,471	4,725	4,906	5,145	5,337	5,577
Salvage value	(924)	(924)	(924)	(924)	(924)	(924)
Total	25,023	26,155	27,215	28,333	29,405	30,523
Break-even price	44.92	30.03	22.82	18.85	16.15	14.25
Present value of net returns						
$/pound						
5	(21,766)	(21,233)	(20,643)	(20,141)	(19,590)	(19,052)
8	(20,131)	(18,689)	(17,168)	(15,779)	(14,319)	(12,873)
11	(18,495)	(16,144)	(13,694)	(11,417)	(9,048)	(6,693)
14	(16,859)	(13,600)	(10,219)	(7,055)	(3,777)	(514)
17	(15,223)	(11,055)	(6,744)	(2,693)	1,493	5,666
20	(13,588)	(8,511)	(3,270)	1,669	6,764	11,845

Note: All figures are expressed in present value

Disclaimer

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Acknowledgements

We would like to acknowledge Judith Martin and Brian Beheler who were instrumental in carrying out Purdue's forest hop yard trials. In addition, we would like to acknowledge Steve Howe, Howe Farms, and Rob Sirrine, Michigan State University Extension, for reviewing this publication.

This work was funded by Agricultural Science and Extension for Economic Development (AgSEED) funding from the Purdue College of Agriculture.

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Jun 2017