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Winter Greenhouse Enterprise Analysis

A STUDY OF THE COSTS AND BENEFITS OF OPERATING DEEP WINTER GREENHOUSES IN THE UPPER MIDWEST

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Photo by Dan Handeen

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A special thanks to all growers who participated in this research and shared information about their operations.

We hope this research helps existing growers improve their operations and assists prospective operators in planning reasonable winter greenhouse projects.

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EXECUTIVE SUMMARY

A University of Minnesota Extension analysis of eight deep winter greenhouse enterprises found that all are operating profitably, and growers are seeing a positive return on investment.

In this study, deep winter greenhouses cost an average of $18,583 to construct, or an average of approximately $33 per square foot of space. Although start-up costs are significant, study participants realized an overall return on investment (ROI) of 7.3 percent, ranging from -3.7 percent to 30.8 percent. Overall payback time was 8.6 years. In terms of annual expenses and returns, variable costs such as propane, seeds, and soil mix ranged from $35 to $2,148 to produce a crop, or an average of $906. This translated into operating revenue of $2.52 per square foot of growing space.

Extension conducted an enterprise analysis of seven greenhouse operators in 2015, four of which also participated in this study. Those that participated in both analyses have decreased labor inputs by 30 percent. Each has also found ways to make his or her greenhouse more profitable from increasing growing space, adding wood heat, or decreasing propane costs. Comparing the 2015 and 2018 studies, the average cost of greenhouse construction decreased while average variable costs remained much the same. These and other differences, such as an increased return on investment (ROI) between 2015 and 2018, is primarily due to sample size and which greenhouse operators participated in the studies. With results from only seven and eight participants respectively, findings are not statistically significant. They are instead observations from growers trying to make winter greenhouse production commercially profitable.

Study findings suggest success factors regarding marketing product and greenhouse costs are similar to those of the 2015 study. Prospective and current operators should consider the following recommendations:

#1: Explore kit construction

The most profitable greenhouse operator in this study retrofitted a high tunnel kit with deep winter greenhouse elements (including a heat sink and highly insulated back wall). This gave him a large growing area at a low cost per square foot. The operator also forewent the cost of stick construction and polycarbonate panels to invest a minimal $8 per square foot of growing space. During the 2017 season, he had nearly $9,000 in winter sales from his sizable 3,000 square foot greenhouse. Surprisingly, with just a double layer of plastic, propane costs were no greater than for smaller greenhouses made with polycarbonate. If pursuing stick construction of a deep winter greenhouse, however, the do-it-yourself approach can significantly lower building costs compared to professional construction (Wika, S., Prieve, T., Schweser, G., & Draeger, K., 2018).

#2: Pursue outlets to sell off production and maximize space

All successful winter greenhouse operators had a ready market in which to sell their full production. Whether through a winter Community Supported Agriculture (CSA) arrangement or sales to institutions willing to purchase large quantities, profitable operators used as much of their greenhouse as possible for growing and selling product. Since a winter greenhouse is a relatively expensive growing space, operators need to use all available space to be most profitable.

#3: Consider ways to lower annual operating costs

Though it may seem surprising, soil mix had a higher annual operating cost than propane in our sample. Three operators had profitable greenhouses (gross margins of 80 percent or higher) in large part due to very low operating costs. These low costs resulted from heating alternatives, such as wood stoves and boilers, and inexpensive seed and soil mix.

METHODOLOGY

Detailed information was collected about start-up and operating costs, greenhouse dimensions, and labor inputs from eight winter greenhouse operators in the Upper Midwest. The study's scope was limited to operations selling food produced in the greenhouse and using the Garden Goddess deep winter greenhouse design principles, as outlined in *The Northlands Winter Greenhouse Manual*. Since its publication in 2009, *The Northlands Winter Greenhouse Manual* has inspired many people to build winter greenhouses. Twenty-one were found to be operating in the Upper Midwest (North and South Dakota, Minnesota, and Wisconsin) after investigating both online and through interviews with winter greenhouse operators. Of the 21 winter greenhouses, only 14 were deemed commercial in nature (others were at educational institutions or for personal use only). Eight of the 14 elected to participate in this study. Half were relatively new winter greenhouse operators and half had built and started operating their greenhouses between five and 20 years ago.

Data Collection Procedure

During winter 2017-2018, participants were recruited through phone calls, email, and a mailing. They received data collection spreadsheets to fill out regarding start-up and annual variable costs, as well as labor inputs. Individual financial records were used to complete the spreadsheets. While many respondents had very accurate and precise records, they estimated figures at times based on past production experience. Consequently, these assumptions may affect the precision of study findings.

Calculations and Comparisons

Since the primary questions about deep winter greenhouse operations concern financial returns and payback, Extension's analysis focused on annual return to operations and labor, with a specific emphasis on return on investment and payback time. Operational costs and returns varied significantly among operators, with only one not experiencing a positive net revenue.

DEEP WINTER GREENHOUSE ENTERPRISE FINDINGS

As mentioned previously, annual operating costs and returns, as well as start-up costs, varied significantly among study participants.

About Deep Winter Greenhouse Structures and Operations

Study participants built a range of deep winter greenhouse structures. Based on the original design outlined in *The Northlands Winter Greenhouse Manual* (http://www.gardengoddessenterprises.com/), sizes ranged from 288 square feet (12 x 24 feet) to 3,264 square feet (34 x 96 feet) and included the design features below:

- One greenhouse incorporated thermal solar panels and in-ground floor heat, in addition to a rock heat sink.
- Three greenhouses used heat generated by wood boilers.
- Four greenhouses were free-standing structures and four were attached to pre-existing buildings.
- One greenhouse was built from a greenhouse kit with a double layer of plastic, although it still had a heat sink and heavy insulation elements (which used stick construction and polycarbonate panels).

Each of the above design features affect construction cost and potentially the performance of the structures themselves. (There is no specific data to discern how individual design features have influenced heating costs or production, as each greenhouse faces distinct climatological conditions).

Almost all deep winter greenhouse operations were relatively new. The oldest facility was built in 1998 and the newest was built in December 2017. Each greenhouse had a single person who handled nearly all of the daily chores of planting, watering, and harvesting with assistance from a spouse or other family member. All greenhouses were also commercial in nature.

In terms of production, all greenhouse operators raised winter greens such as arugula, lettuces, and Asian greens, as well as select roots crops like turnips and radishes. For greens production, operators took multiple cuttings of each planting. No study participants used chemical herbicides or pesticides, and all generally used only organic inputs for soil mix, such as blood and bone meal (although a few exclusively sourced organic seed).

A challenge of this study was determining an apples-to-apples comparison between the greenhouses since sales were so diverse. All greenhouse operators used their structures for ancillary revenue-generating activities, such as growing transplants, food for home use, value-added products, and tours. Revenue sources were also mixed with products grown outside the greenhouse. For example, attributing the total revenue from a winter CSA that combined winter greens with storage crops would overestimate the value of production from the greenhouse operations. On the other hand, a winter CSA would not have been possible were it not for the greens grown in the winter greenhouse. To best represent these complexities, this analysis only used the value of the products grown within the greenhouses during a consistent winter season, generally November through February.

Start-up Costs

Investment in a deep winter greenhouse is significant. The average start-up cost among participants was $18,583. Two of the eight cost less than $6,000, and four cost more than $20,000.

Start-up costs include building the greenhouse and preparing it for its first season. Individual expenses include lumber, polycarbonate sheets, and hardware, as well as excavation and foundation work. Additional costs include ground inputs for a heat sink (e.g., rock and sand), heating improvements (including a backup heat source or upgrades to heating systems), construction labor, and initial growing supplies (for example, seeding equipment, trays, and lumber to build raised beds). For operators who built their own greenhouses, the value of their labor was not included. Construction labor only included cash expenses.

A helpful way to consider start-up costs is on a square foot basis. For this study, the total square footage of each greenhouse and growing space (total amount of space in hangers plus area planted on the ground) was collected (Table 1).

The average cost per square foot of greenhouse space was $61, ranging from $20 per square foot to $133 per square foot. As a point of comparison, a 14 x 24 foot twin-wall polycarbonate greenhouse kit (not installed and without the passive solar heat sink) from Farmtek costs $14,705, or $44 per square foot.

Table 1: Start-up costs per greenhouse and per square foot of space and growing space

	Grnhse1	*Grnhse2*	*Grnhse3*	*Grnhse4*	*Grnhse5*	*Grnhse6*	*Grnhse7*	*Grnhse8*	***Average***
Start-up cost	$17,850	$5,797	$38,370	$24,042	$12,000	$20,578	$24,226	$5,800	$18,583
Cost per sq. ft.	$34	$20	$83	$47	$28	$27	$7	$17	$33
Cost per sq. ft. of growing space	$38	$40	$111	$94	$56	$74	$8	$141	$70

It cost an average of $33 per square foot to build the greenhouse structures (including the growing area and all ancillary packing space) and $70 per square foot of growing space. The difference between these two measurements gives a sense of space utilization. Operators with a small difference used their space quite intensively while those with large differences did not. Growing space returned an average of nearly $3 per square foot of operating revenue annually, calculated as gross sales minus variable expense (Table 2).

Product Marketing

All deep winter greenhouse operators grew and marketed similar products, primarily winter greens and lettuces that do well in a cool environment. Most also grew cole crops, Swiss chard, and root crops, such as radishes and turnips. (One operator, however, only grew herbs.)

Gross revenue, or sales, for the greenhouses ranged from $207 to $8,786. Removing variable costs needed to grow a crop (e.g., seed, soil mix, fuel), it was found that all greenhouses had positive operating revenue (gross revenue minus variable costs). Each had quite a variation, however, due to greenhouse size and intensity of production. Converting revenue per greenhouse to operating revenue per square foot of space, participants took in an average of nearly $3 per square foot, ranging from $0.24 to $6.94 (Table 2).

A common way of presenting operating revenue is through a measure of gross margin. Calculated as operating revenue divided by gross revenue, gross margin is a percentage of gross sales an operator retains after taking out direct expenses to produce a crop. For example, one greenhouse kept 76 cents of every dollar it sold and therefore had a gross margin of 76 percent. Study participants had a range of gross margins from 54 percent to 83 percent, with an average of 69 percent (Table 2).

Table 2: Gross revenue and operating revenue

	Grnhse1	*Grnhse2*	*Grnhse3*	*Grnhse4*	*Grnhse5*	*Grnhse6*	*Grnhse7*	*Grnhse8*	*Average*
Gross revenue	$3,150	$2,500	$4,800	$2,900	$207	$349	$8,786	$480	$2,897
Operating revenue	$1,817	$2,000	$3,118	$1,608	$172	$187	$6,638	$382	$1,990
Operating revenue per sq. ft. of growing space	$3.44	$6.94	$6.78	$3.14	$0.40	$0.24	$2.03	$1.14	$3.01
Gross margin	58%	80%	65%	55%	83%	54%	76%	80%	69%

Operating Costs and Returns

All greenhouse operators experienced positive operating revenue (defined as gross revenue minus variable expenses, such as fuel, soil mix, and seeds). Setting aside the capital costs associated with building a greenhouse, operators had an average gross margin of 69 percent, meaning they kept 69 cents of profit for each dollar of revenue. Gross margins ranged from 54 percent to 83 percent. This variation is explained primarily through the difference in revenue, as variable costs were fairly consistent for most of the greenhouses (approximately $1,000), with an average annual variable cost of $892. Those operating winter CSAs had three of the four highest gross margins, ranging between 54 percent and 83 percent. This difference in how product was marketed also translated to significant differences in profitability.

Table 3: Operating expenses*

	Grnhse1	Grnhse2	Grnhse3	Grnhse4	Grnhse5	Grnhse6	Grnhse7	*Grnhse8*	**Average**
Annual variable expenses*	$1,333	$500	$1,682	$1,292	$35	$162	$2,148	$98	$906
Seeds	$250	$75	$145	$235	$10	$12	$192	$29	$119
Propane	$525			$317		$32	$586		$183
Soil mix	$350	$220	$554	$285		$43	$32	$49	$219
Marketing costs	$88	$25	$91	$173		$65			$74
Utilities	$120	$150		$100		$10	$601	$20	$143
Other		$30	$350	$182	$25		$737		$221

*Average for all winter seasons in operation

The largest variable expense was “other” (mainly due to greenhouse 7, which had a high supply expense), followed by soil mix, propane, utilities, and seed costs (Table 3). Marketing costs—those incurred once a crop is raised—involves delivery and packaging expenses. Some growers chose to present products in containers, such as clamshells, and use waxed boxes for packing finished products. Another marketing cost was mileage for operators who delivered their product to buyers. Considering the greenhouses generally operated October through March, fuel costs were relatively

low at $199 annually. Three operators reported no propane costs during the 2017-18 season, using heat exclusively from wood boilers, electric, or home heat.

Financial Performance

The primary measure of financial performance for any enterprise is net revenue, calculated as gross revenue minus capital and operating (variable) expenses. In this instance, the annual depreciation expense (capital costs) and annual operating expenses were subtracted, such as seed and propane (operating costs), from gross (Table 4). Extension calculated depreciation using straight line depreciation over 20 years, minus a salvage value of $1,500. Greenhouse 5 did not have a depreciation cost since it is 20 years old.

Greenhouse 7 had the highest net revenue by far. This is explained by the size of the greenhouse, which is fully utilized to garner almost $9,000 in gross sales. Its capital costs and operating costs are the highest, but at over 3,000 square feet, even modest sales per square foot would provide significant sales.

Table 4: Net revenue, capital costs (depreciation expenses), and operating costs (variable expenses)

	Grnhse1	Grnhse2	Grnhse3	Grnhse4	Grnhse5	Grnhse6	Grnhse7	Grnhse8	**Average**	**Median**
Net revenue	$976	$1,785	$1,275	$468	$172	$(767)	$5,502	$167	$722	$1,197
Capital costs (depreciation)	$841	$215	$1,844	$1,140	$-	$954	$1,136	$215	$898	$793
Operating costs	$1,333	$500	$1,682	$1,292	$35	$162	$2,148	$98	$896	$906

Payback and Return on Investment

One of the most common questions from prospective winter greenhouse operators concerns the return on investment (or payback time).

Calculated as net revenue divided by start-up costs, return on investment (ROI) ranged from 30.8 percent down to -3.7 percent, with an overall ROI for all eight greenhouses of 7.3 percent (Table 5). Rather than an average, an overall ROI was calculated by dividing total net revenue by total start-up costs for all greenhouses.

In comparison, payback time does not account for capital costs or depreciation but is calculated as start-up costs divided by operating revenue. Calculated this way, payback time ranges from as few as three years to as many as 110 years, with an overall payback time of 8.6 years (calculated as total start-up costs divided by total revenue, minus total variable costs for all greenhouses).

Table 5: Return on investment and payback time

	Grnhse1	Grnhse2	Grnhse3	Grnhse4	Grnhse5	Grnhse6	Grnhse7	Grnhse8	**Overall Average**
ROI	5.5%	30.8%	3.3%	1.9%	1.4%	-3.7%	22.7%	2.9%	7.3%
Payback time (in years)	9.8	2.9	12.3	15.0	69.8	110.0	3.6	15.2	8.6

Labor Inputs and Returns

Each greenhouse operator was asked how much time they spent planting, watering, harvesting, and marketing crops for the foods they sold throughout the winter. Each study participant estimated their time for each month of the year and then tracked one month with a daily chore log to inform their estimates.

All study participants operated their greenhouses on a part-time basis with assistance, at times, from a spouse or other family member. The greenhouse operator who spent the most time invested a total of 394 hours during the winter season. On average, growers spent 139 hours to produce, market, and deliver winter crops, which breaks down to five hours per week on average. Hours spent on growing summer transplants in the greenhouse or other ancillary revenue-generators were not included. Presented as an hourly wage, operators made between $4.61 and $54.08 when calculated as operating revenue divided by total time spent working in the greenhouse (Table 6).

Table 6: Labor invested for winter production and time expressed as hourly wage (operating revenue/total hours worked)

	Grnhse 1	Grnhse 2	Grnhse 3	Grnhse 4	Grnhse 5	Grnhse 6	Grnhse 7	Grnhse 8	Ave.	Median
Total hours worked	394	84	308	141	5.9	33	123	27	103	139
Hours per week	14	3.5	11	5.9	0.4	1.7	5.1	1.7	5.4	4.3
Hourly wage	$4.61	$23.86	$10.12	$11.40	$29.40	$5.67	$54.08	$14.15	$12.77	$19.16

Other Benefits of Deep Winter Greenhouse Production

All survey participants experienced other benefits—some economic and some not—that are difficult to incorporate into a standard financial analysis, but they are no less important to many of the participants.

The ability to grow crops for family consumption was a primary motivator for many greenhouse operators. One participant estimated his family consumed the equivalent of four to five bags of salad mix per week, or a value of $400 throughout five winter months ($20/week for 20 weeks). Other participants shared similar estimates and stories.

Likewise, all study participants shared how they used their winter greenhouse to start summer transplants or for value-added products, like dried herbs or sun-dried tomatoes. One participant estimated saving nearly $600 in annual heating costs because he no longer needed to use his old hoop-style greenhouse, which had been in operation for more than a decade.

FUTURE RESEARCH

Future financial and marketing research related to deep winter greenhouse enterprises should consider the following:

- The cost and revenue of each planting in the growing space and the number of plantings per season to best estimate return per crop or tray.
- The value of ancillary enterprises enabled by deep winter greenhouses and their impact on whole farm and household costs, such as heating.
- Potential for cost savings in initial building of deep winter greenhouses.

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