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Assessing Profitability of Selected Specialty Crops Grown in High Tunnels

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Increased interest in farming and small farms, leads to the question of their potential profitability. Small farms are using high tunnels to expand production opportunities and increase sustainability and profitability. High tunnels are season extension production systems that allow earlier planting and harvest before outdoor grown produce depresses prices. The profitability of high tunnels and their effect on land values and market size were determined using production records and budgets for strawberries, tomatoes and squash. The analysis shows that even when land values are high, tunnel production units are profitable, provided the produce is out-of-season and sold at farmers' markets.

Key words: direct marketing, farmers' markets, high tunnels, intensive agriculture, small farm profitability

The interest in small farms has been increasing over the last several years. This interest can be seen in the requests for grant proposals, popular media and through popular online farming games like Farmville (http://www.farmville.com/) and John Deere American Farmer (http://www.universalfarmer.com/). These suggest a renewed interest and desire for people to have their own small farms. Federal programs like the 'Beginning Farmer and Rancher Grant' and 'Know Your Farmer, Know Your Food' have focused more attention on local foods and small farm systems. Extension programming in many states is addressing these issues by holding small farms conferences and other programs.

The increased interest due to these programs and others can also be seen in the increase in the number of very small farms, and the decrease in the overall average farm acreage. This means that most of the growth in the number of farms is from increases in the numbers of very small farms. The USDA defines small farms as farms with $250,000 or less in sales of agricultural commodities (USDA-NASS, 1997). In the United States from 1998 to 2009 there was a loss of 32.2 million acres in farms, but the number of

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farms went up slightly by 7,680. During this same period farms with sales of less than $10,000 increased by over 37,000. Utah saw an overall decrease in farm acreage of 500,000 acres while increasing the number of farms by 1,100. Over this period, the number of farms in Utah with sales of less than $10,000 increased by 1,200 (USDA-NASS, 2011).

However, though urbanization and industrial development and construction have slowed in the past few years, there is still continued pressure to convert farm land for other uses, causing an increase in agriculture land prices (Biermacher et al., 2007). While Beirmacher et al. was referring to Oklahoma, it is applicable to other Western States like Utah which similar to Oklahoma have a few large urban centers, with very large rural areas. Long term sustainability in agricultural land use and the opportunity cost of holding land for an agricultural use must be considered. Since farm real estate constitutes roughly 75% of total farm assets, it is an extremely important consideration for farmers' profitability (USDA ERS, 1994). While there are many other factors that affect the profitability of small farms, including the operator's age, soil productivity, insurance, etc. (Mishra, El-Osta, and Steele, 1999), specialty crops provide one way for small farms to achieve large profits from a limited number of acres.

Over the past 10 years, interest in locally grown produce has increased among American consumers. This shift in consumer preference represents an opportunity for small rural farmers and those located at the urban interface. The USDA, with its 'Know Your Farmer, Know Your Food' program, has promoted this paradigm shift and is supporting the development of rural farms through multiple grant, loan, and support programs (USDA, 2011). The reconnection of the public to farmers and farms can be seen in the rapid increase in farmers' markets and community supported agriculture (CSA) programs. Since 2000, the number of farmers' markets in the United States has increased by 249% (2,863 to 7,175) while CSAs increased by more than 1250% (1,019 to 12,549). Similar trends have occurred in Utah. At present, there are 31 farmers' markets and 37 functioning CSAs in Utah with a fruit and vegetable industry having combined annual sales in excess of $42.2 million (UDAF, 2011b).

The increased demand for local fruits and vegetables provides a unique opportunity for farmers working with smaller acreage to capture a portion of the market. Consumer tastes and preferences drive the purchasing patterns for specialty crops (Brumfield, Adelaja, and Lininger, 1993). Over time, with improvements in transportation, economies of scale, costly land, labor and production inputs, and the availability of year around supply, local production of specialty crops declined in many areas of the country. To recapture local consumers, small farmers need to innovate as well as supply produce in the local market for longer periods of time each year. Studies have shown that consumers buy local produce because of its freshness, high quality, and cost, as well as allowing

them to develop a relationship with the farmer producing those crops (Brown, 2003; Yue and Tong, 2009).

High tunnels are walk-in, plastic covered, environment altering structures which allow early and late season production of high quality fruits, vegetables and flowers (Carey et al., 2009). High tunnels are inexpensive single- or multi-span structures which lengthen the growing season for agricultural crops (Hightunnels.org, 2011). Though they have been used successfully for quite some time in other areas of the country, they are relatively new to the Intermountain West (Carey et al., 2009; and Heidenreich et al., 2009). In Utah there were only about 10 high tunnels in 2005, today there are over 100 growing a variety of fruits and vegetables.

Not only do high tunnels extend the growing season, they also increase farm profitability (Donnell, Biermacher, and Upson, 2011). Rowley et. al. (2010b) found that use of high tunnels allowed strawberry production to extend from four weeks with a conventional outdoor production system to almost nine weeks with high tunnels. This was because berries grown and sold during the off-season command a premium price, which may be up to two or three times higher than the peak seasonal price of a given crop (Heidenreich et al., 2009). The benefits of local high tunnel use is two-fold; first, high tunnels increase the productivity of the land, thus offsetting some of the cost of the land, and second, it positions the small farm operator to more aggressively capture a larger market share of locally produced fruits and vegetables.

This paper will focus on the sustainability of very small farms with the use of high tunnels. It will first examine if, by using high tunnels, these farms can be profitable. It will then examine the number of small farms that could be absorbed into local produce markets. Finally, to consider long-term sustainability, the effect of higher land prices on profitability will be examined. For those who currently own land, including the opportunity cost of the land and for new farmers assessing land costs associated with establishing a small farm are needed to assess long-term sustainability of a high tunnel based agricultural enterprise.

Data and Methodology

There are three questions examined in this paper. First, can a small farm integrating high tunnel production of specialty fruits and vegetables be profitable? Next, if so, how many small farms would local demand support? Finally, could this be sustained over time as land values increase? The data and methodology relating to each question is explained below.

Profitability of One Acre

It is generally assumed that one or two acres will not be able to provide enough profit to be sustainable using traditional agriculture production approaches, such as a cow-calf operation or a small grains production system. A more intensive system, producing higher value products and engaging in direct marketing are more likely to generate sufficient income to make a farm profitable. In Utah, with cold snowy winters and short growing seasons (Moller and Gilles, 2008), the number of options is reduced. However, high tunnel cropping systems have been shown to extend the growing season and even to allow for double cropping in one production year (Lamont, 2005). We will use this system, which has the most profit potential in Utah, to examine the profitability of a small farm. While there are many small fruits and vegetables that might be grown in high tunnels and direct marketed, we will evaluate June-bearing strawberries, and early and late season tomatoes and squash. Strawberries require a one-year production cycle as they are planted in late summer and harvested during the following spring and early summer. Tomatoes and squash could be double cropped, with early tomatoes followed by late squash, or vice versa and could be scheduled so that half the houses are in one crop or the other for the full season. These crops were selected as detailed production and sales records were available and these crops are widely grown in local high tunnels (Carey et al., 2009).

Research in Utah has demonstrated that these three crops can be grown and that they are profitable (Hunter, Drost, and Ward, 2011; Drost and Ward, 2011; and Rowley, Black, and Feuz, 2010a) based on the associated budgets. The profit was based upon a single crop grown in a 14-foot by 96-foot low-cost high tunnel and all crops are adapted to production in these structures. While multiple crops may be grown simultaneously in a high tunnel, only a single crop would be grown in an individual high tunnel at the same time. Experience has shown that tunnels cannot be managed optimally (watered, fertilized, temperature controlled) when more than one crop at a time is grown due to differences in the individual crops' environmental requirements (Black and Drost, 2010). Crops are grown in the soil, and the environment managed by raising and lowering the sides and opening and closing the doors to ensure appropriate temperature control. Since high tunnels are not greenhouses, they require no expensive heating and cooling systems, but do capture and trap radiant energy which improves early and late season environmental conditions.

Conner et al. (2010) noted that budgets focusing on a single crop or tunnel fail to capture the decision making process used by direct market vendors and regularly fail to account for sales of produce in the actual marketplace. The budgets developed for each system used in our analysis were generated from sales at the local farmers' market but did not include the costs of land, equipment, etc., because they only examine the

profitability of one tunnel while assessing returns based on the space of the tunnel alone. The profit potential shown, however, raises the question of the possibility of making a sustainable profit with multiple tunnels on small parcels of ground. This is important because those considering purchasing land to start a high tunnel operation or expand an existing operation need to consider the full cost of production. Those who already own land, need to consider the full cost (include the opportunity cost) to examine the long-run sustainability of the system. Even though land may be a "sunk" cost for existing operations, in the long-run farmers face choices for their land use. As they consider generational transfer, this is especially important as the next generation needs an operation that will cover the full cost of production. Each single span tunnel (14 x 96 ft) would require approximately 2,200 sq ft of area to ensure minimal tunnel-to-tunnel shading and sufficient access for equipment. Therefore, 20 tunnels could be put on one acre, which would cover 61.7% of the land area.

Information on the costs of building the tunnels and costs and returns of using them for strawberries, tomatoes and squash are from budgets from 2010 and 2011 (Hunter, Drost and Ward, 2011; Drost and Ward, 2011; and Rowley, Black, and Feuz, 2010a). For this analysis, a low-cost high tunnel with a much smaller investment cost and setup time was evaluated rather than assessing the economics of larger, steel framed, expensive high tunnels that are commercially available.

To set up this operation, we assumed land costs to be $30,000 per acre. Construction costs for each tunnel was $1,628 (Hunter, Drost and Ward, 2011), and just over $3,000 is needed to develop the irrigation system for the tunnels. In addition, used equipment including a truck ($8,000), small tractor ($6,000), trailer ($1,500), tiller ($1,500), and plastic layer ($2,000) are needed as start-up costs, for a total cost for one acre of $87,370. These costs were developed through a combination of experience and costs from local equipment dealers. It was assumed that half was paid initially and the remainder financed over 10 years at 8% interest. At the end of the 10-year period the land would have a terminal value of $30,000.

Other annual costs and returns were taken from the respective crop budgets, adjusted for labor and those items used for more than one year. The owner's labor was split out from hired labor and was assumed to cost $24,000. Additional labor was included for a cost of $10 per hour. The initial returns were assumed to grow at 1% each year while expenses grew 2% each year since prices charged often do not increase as fast as the input prices. Having expenses increase slightly faster than returns makes the analysis slightly more conservative. The start-up equipment was depreciated over appropriate years and a 20% rate for income tax was used. In addition to the direct costs for each crop, additional overhead costs were incorporated which included gas, repairs, farmers' market booth rental, supplies, insurance, etc. This totaled $4,666 per year.

The information above was used to create a capital budget over 10 years for each option (strawberries and tomatoes/squash). Annual net cash flows were discounted at 10% to find the net present value (NPV). Since the owner's labor was included in the cost, a positive NPV shows the amount of return above the 10% return on investment.

The results are sensitive to the commodity prices received and the amount of labor cost for the owner. To examine this and the sensitivity of the results for various levels of owner labor invested, the net present values were obtained over a range of prices and owner labor costs. The prices received for strawberries, tomatoes and squash vary depending on the market outlet. For strawberries in high tunnels, most of the production is four to six weeks earlier than outdoor local production, so demand is present and the price is fairly stable. For tomatoes/squash, the analysis was done using a low price scenario where all produce was sold at wholesale prices, a mid-level pricing scenario at smaller or more rural farmers' markets, and a high price scenario for prices received at certain high-end farmers' markets found in resort communities around Salt Lake City (i.e. Park City, Utah). Pricing scenarios are from numbers gathered from growers who use these market outlets.

Potential Market Size

USDA-Economic Research Service publishes annual food availability per capita for many fruits and vegetables. These numbers can be used as proxies for per capita consumption. For 2008 (the latest year available), the per capita consumption for fresh strawberries was 6.45 pounds. For squash it was 4.17 pounds and for tomatoes it was 18.53 pounds (USDA ERS, 2011). According to the 2010 Census, Utah's population is 2.76 million (USCB, 2010).

In Utah, June-bearing strawberries normally have a four-week harvest season starting in early to mid-June; with high tunnels, strawberry harvest begins four to six weeks early with yields more than double outdoor production (Rowley et al., 2010b). Field grown tomatoes normally have a 9-10 week harvest period beginning in late July and extending to mid-to-late September. With high tunnel tomatoes, harvest begins four weeks earlier and can continue for an additional four weeks at the end of the season, resulting in 17 potential weeks of production. For outdoor squash, the normal harvest season is 12 weeks but can be extended to 21 weeks in high tunnels. Season extension using high tunnels offers the small farm the potential for increased yield, increased access to markets, and the potential for greater farm income.

Per capita availability was multiplied by the population and divided by 52 to estimate the weekly demand for these commodities. The weekly demand multiplied by the number of weeks in the harvest season estimates the total amount of each fruit or vegetable that would be consumed in Utah during the harvest period. These values were compared to

published high tunnel yields for one acre of strawberries and/or one acre of squash/tomatoes as used in the analysis to estimate potential profit from the high tunnel cropping systems. From these data, an estimated number of acres of each crop that would be needed to replace various percentages of the total market was determined. McFadden, Thomas, and Onozaka (2009) estimate that usually less than 10% of the market is captured in farmers' markets. Since most produce is imported into Utah, examining potential market size can help growers assess the market share that needs to be captured. Without using high tunnel technology, the only source for out-of-season produce in Utah is imported produce. While high tunnel strawberries produced in Utah directly compete with conventional field-grown strawberries from California, local berries are of higher quality and are more flavorful.

It should be recognized for this exercise, a low estimate of the potential demand for the produce is expected since the year's demand is spread equally over the entire year. Generally, consumption of fresh fruits and vegetables is higher during harvest seasons as local produce becomes available in the marketplace (Yue and Tong, 2009). As it is unclear, however, how much higher in-season consumption would be, thus spreading consumption evenly over the year provides a minimum estimate of the potential demand. This will also allow some estimate of how replicable small farms with high tunnels could be.

Similar techniques were used to examine how many acres of production would be needed for various numbers of customers expected at selected market outlets. This will be used to examine if small rural farmers' markets can attract sufficient customers to support a high tunnel enterprise. While rural communities have less competition (access to fresh fruits and vegetables), growers there may be able to capture a larger market share. In general, costs would also be potentially lower (land, labor, etc); however, their customers may also be more price conscious.

Land Values

Results for the potential profits from a single acre of high tunnels growing a variety of fruits and vegetable will be used to evaluate the net present value (NPV) over a range of land values for the various crop prices. This will show those combinations of high tunnel production for which the prices received and land values result in a positive NPV, establishing that it makes economic sense to produce those commodities.

Results

Profitability of One Acre

The annual cash flow for the tomato/squash production system are found in Table 1 and indicate that one acre of high tunnels that produce a double crop of tomatoes and squash can be profitable. The NPV was $6,294, showing a positive return above the $24,000 allocated to owner labor. The internal rate of return (IRR) was 13.24% and the modified internal rate of return (MIRR) 11.49%. The MIRR while similar to IRR makes different estimates on the reinvestment rate and is often a more accurate reflection of profitability. This suggests that direct marketing both tomatoes and squash for $2 per pound at a farmers' market will provide a positive return with a payback period of six years. In Utah, early season high-tunnel tomato prices range from $2-$5 per pound depending on the location of the farmers' market. While yields for individual years will vary from year-to year, we used a conservative average yield which should be fairly stable over the 10 year planning horizon. Since it was assumed that the owner would provide 50% of the investment, the feasibility would be dependent on the owner having about $44,000 to invest in the project. With land valued at $30,000/acre, this scenario would be realistic for land owners that already have large urban lots of an acre or more. Labor is by far the highest expense of these high tunnel operations. In addition to the $24,000 of owner labor, additional labor expense of over $27,000 is incurred each year. If the owner did more of the work personally, profits could be higher. Since the NPV is positive but not large, high tunnel production systems do not look promising without selling at a farmers' market or through other forms of direct marketing where returns are potentially greater than in wholesale markets. Table 2 shows that early June-bearing strawberries are also profitable. While the NPV is slightly lower ($2,505) than for tomatoes and squash with an IRR of 11.31% (MIRR 10.62%) the investment is still profitable. Growing just strawberries would take 7 years to recoup the original investment. Labor is the largest expense and the project is only feasible with significant owner investment ($44,000). While the investment may be profitable with more money borrowed, it appears unrealistic for the producer to be able to borrow a larger portion of the investment.

These results suggest that a one-acre farm can be profitable with intensive production systems and various marketing outlets. The sensitivity of the results to prices received for tomatoes and squash and the value of the owner labor provided was also tested.

Table 1. Cash Flow ($) for One Acre of Double-Cropped Tomatoes and Squash Using High Tunnels [a]

Year	0	1	2	3	4	5	6	7	8	9	10
Receipts ($)											
Tomatoes		68,000	68,680	69,367	70,060	70,761	71,469	72,183	72,905	73,634	74,371
Squash		20,000	20,200	20,402	20,606	20,812	21,020	21,230	21,443	21,657	21,874
Terminal Value											30,000
Cash Inflow		88,000	88,880	89,769	90,666	91,573	92,489	93,414	94,348	95,291	126,244
Expenses and Cash Outflow ($)											
Down	43,685										
Supplies		9,904	10,102	10,304	10,510	10,721	10,935	11,154	11,377	11,604	11,836
Labor Hired		27,140	27,683	28,236	28,801	29,377	29,965	30,564	31,175	31,799	32,435
Owner Labor [b]		24,000	24,480	24,970	25,469	25,978	26,498	27,028	27,568	28,120	28,682
Operating		4,667	4,760	4,855	4,952	5,051	5,152	5,255	5,361	5,468	5,577
Depreciation		11,295	17,596	12,216	7,118	2,613	2,613	2,613	1,307	0	0
Interest		3,495	3,254	2,993	2,712	2,408	2,080	1,725	1,342	929	482
Principal		3,016	3,257	3,517	3,799	4,103	4,431	4,785	5,168	5,582	6,028
Taxable Income		31,500	25,486	31,164	36,573	41,404	41,745	42,103	43,786	45,492	75,914
Income Taxes		6,300	5,097	6,233	7,315	8,281	8,349	8,421	8,757	9,098	15,183
Cash Outflow	43,685	78,521	78,632	81,109	83,558	85,919	87,409	88,932	90,749	92,599	100,224
Net Cash Flow	(43,685)	9,479	10,248	8,660	7,109	5,655	5,080	4,482	3,599	2,692	26,021

[a] Returns are based on 20 high tunnels per acre which utilize 61.7% of the space, leaving the remainder for spacing and roads. The returns represent either early tomatoes followed by late squash, or early squash followed by late tomatoes.

b Owner labor is listed separately to represent a return for the owner's time. It is not deducted to determine taxable income.

Table 2. Cash Flow ($) for One Acre of Strawberries Using High Tunnels[a]

Year	0	1	2	3	4	5	6	7	8	9	10
Receipts ($)											
Strawberries		87,090	87,961	88,841	89,729	90,626	91,532	92,448	93,372	94,306	95,249
Terminal Value											30,000
Cash Inflow		87,090	87,961	88,841	89,729	90,626	91,532	92,448	93,372	94,306	125,249
Expenses and Cash Outflow ($)											
Down	43,685										
Supplies		10,473	10,682	10,896	11,114	11,336	11,563	11,794	12,030	12,271	12,516
Labor Hired		26,410	26,938	27,477	28,027	28,587	29,159	29,742	30,337	30,944	31,562
Owner Labor[b]		24,000	24,480	24,970	25,469	25,978	26,498	27,028	27,568	28,120	28,682
Operating		4,667	4,760	4,855	4,952	5,051	5,152	5,255	5,361	5,468	5,577
Depreciation		11,295	17,596	12,216	7,118	2,613	2,613	2,613	1,307	0	0
Interest		3,495	3,254	2,993	2,712	2,408	2,080	1,725	1,342	929	482
Principal		3,016	3,257	3,517	3,799	4,103	4,431	4,785	5,168	5,582	6,028
Taxable Income		30,751	24,731	30,403	35,807	40,631	40,966	41,319	42,995	44,695	75,111
Income Taxes		6,150	4,946	6,081	7,161	8,126	8,193	8,264	8,599	8,939	15,022
Cash Outflow	43,685	78,210	78,317	80,789	83,233	85,589	87,075	88,593	90,405	92,251	99,870
Net Cash Flow	-43,685	8,880	9,644	8,052	6,496	5,037	4,457	3,854	2,967	2,055	25,379

[a] Returns are based on 20 high tunnels per acre which utilize 61.7% of the space, leaving the remainder for spacing and roads. The returns represent "June-bearing" strawberries, which can be produced for eight weeks.
[b] Owner labor is listed separately to represent a return for the owner's time. It is not deducted to determine taxable income.

Table 3. NPV ($) of One Acre of High Tunnel Tomatoes, Squash, and Strawberries [a]

	Value of Owner Labor ($)						
Price	-	12,000	18,000	24,000	36,000	48,000	60,000
Tomatoes and Squash for Various Prices [b]							
$0.75 tomato, $0.62 squash	(122,014)	(201,517)	(241,269)	(281,021)	(360,525)	(440,029)	(519,532)
$2 tomato, $2 squash	165, 302	85,798	46,046	6,294	(73,209)	(152,713)	(232,217)
$5 tomato, $3 squash	736,870	657,367	617,615	577,863	498,359	418,856	339,352
Straw-berries	161,513	82,009	42,257	2,505	(76,998)	(156,502)	(236,006)

[a] Returns are based on 20 high tunnels per acre which utilize 61.7% of the space, leaving the remainder for spacing and roads. The returns represent either early tomatoes followed by late squash or early squash followed by late tomatoes.

[b] Tomato and squash prices are based on a low wholesale pricing scenario (typical of outdoor field production), a mid-level farmers' market scenario (smaller rural setting) and a high-end farmers' market (typical of a more affluent or resort community). Strawberries are mostly produced out of season and command a higher more fixed price.

Table 3 shows the NPVs over a range of prices and values of owner labor. When changing the values of owner labor, the amount of hired labor was not changed. The results assess the amount the owner could be paid while maintaining profitability in the business. Even with owner labor valued at $0, high tunnel operations selling at wholesale prices are not profitable. This is consistent with the finding of Donnel, Biermacher and Upson (2011). This indicates that direct markets, and the higher prices they command, are needed to make a small one-acre high tunnel farm cost-effective. Since wholesale prices do not cover out-of-pocket direct expenses, additional market outlets need to be identified. These could include CSAs, restaurants, direct farm sales, and farmers' markets. This is reasonable as the high tunnel system is designed to be more intensive and provide produce out of season, when demand and prices are generally higher.

At a mid-level pricing structure, owner labor at $24,000 can be profitable (NPV=$6,294). There are 36 farmers' market outlets throughout Utah (UDAF, 2011b), and prices for produce vary with attendance and location. For example, Park City, Utah, has higher prices than Logan, Utah, because of its status as a resort community. With higher market prices ($5 and $3 per pound for tomatoes and squash, respectively), even $60,000 owner labor value has a very high NPV ($339,352). This demonstrates that the findings are very sensitive to markets and prices. Yue and Tong (2009) found that while 83% of survey recipients want "fresh, safe locally grown produce", 65% thought lower

prices to be "somewhat" or "very" important when making their purchases. Therefore, to make a profit, small farmers need to assess farmers' markets, local pricing and competition. If high-end farmers' market prices can be obtained, the return on investment from a single acre farm can be quite large. However, growers need to promote their products in ways that emphasize it as local, fresh, and safe if they expect to get the "price premiums" needed to support high tunnel operations (Yue and Tong, 2009).

Since June-bearing strawberries in a high tunnel are harvested four to six weeks earlier than outdoor produced strawberries, only one set of off-season prices was used. Strawberries were valued at $4.50 per pound out-of-season and $3 per pound when field-grown outdoor berries are available. We assumed that 81% of the strawberries would be sold out-of-season (Rowley, et al., 2010a). Strawberries priced at these levels were profitable at an owner labor value of $24,000, but not at higher owner labor values.

Potential Market Size

While the profitability of small high tunnel operations appears promising, it is dependent on being able to sell at farmers' markets or other direct marketing channels. Using these findings, we considered the actual size of the marketing channels and how much room there would be for higher production levels. Multiplying Utah's population by the per capita availability of this produce shows that Utah annually consumes 51.2 million pounds of fresh tomatoes, 11.5 million pounds of squash and 17.8 million pounds of strawberries (USDA ERS, 2011). Therefore, weekly consumption would be approximately 985,000; 222,000; and 343,000 pounds of tomatoes, squash and strawberries, respectively. Using the described high tunnel production system and having 20 tunnels per acre would produce 34,000 pounds of tomatoes, 10,000 pounds of squash and 20,660 pounds of strawberries. If weekly consumption is multiplied by weeks in the market and then divided by the yield per acre, the number of acres of high tunnels needed to meet various levels of demand can be determined (Table 4).

Table 4. Acres of High Tunnel Production Required for Market Share[a b c]

Percent of Market	Strawberries		Tomatoes		Squash		All Three	
	4 wks	8 wks	9 wks	17 wks	13 wks	21 wks	outdoor	with tunnel
0.25%	0.2	0.3	0.7	1.2	0.7	1.2	1.5	2.7
0.33%	0.2	0.4	0.9	1.6	1.0	1.5	2.0	3.6
0.50%	0.3	0.7	1.3	2.5	1.4	2.3	3.1	5.5
1%	0.7	1.3	2.6	4.9	2.9	4.7	6.2	10.9
5%	3.3	6.6	13	24.6	14.4	23.3	30.8	54.5
10%	6.6	13.3	26.1	49.2	28.8	46.6	61.5	109.1
20%	13.3	26.6	52.1	98.5	57.6	93.1	123	218.1
40%	26.6	53.1	104.3	196.9	115.3	186.2	246.1	436.3
60%	39.8	79.7	156.4	295.4	172.9	279.3	369.1	654.4
80%	53.1	106.2	208.5	393.9	230.6	372.4	492.2	872.6
90%	59.8	119.5	234.6	443.1	259.4	419	553.7	981.6
100%	66.4	132.8	260.6	492.3	288.2	465.6	615.2	1090.7

[a] Production periods (weeks) for outdoor harvest intervals and extended harvest periods utilizing high tunnels.

[b] The number of acre estimates are based on production on high tunnels on 0.62 of an acre- the rest of the acre is for spacing between and around tunnels.

[c] Calculations are based upon USDA-ERS information for U.S. per capita food availability and Utah's estimated population from U.S. Census 2010.

Weeks in production for two marketing periods are presented. The smaller number is the normal harvest season for outdoor production and the larger value indicates the extended growing season using high tunnels. If 100% of the market was captured for all three crops, less than 1,100 acres of high tunnel production would be needed. If only 1% of the market was captured, just 11 acres with high tunnels would be needed. At present, it is estimated that there may be 2-3 acres of high tunnels in production in Utah. Usually less than 10% of the market is captured at farmers' markets (McFadden, Thomas, and Onozaka, 2009). This suggests that there is potential for significant expansion of the high tunnel production system in Utah to take advantage of market opportunities.

Table 4 shows that for the crops considered, at 10% of the market share, 109 acres of high tunnel production are needed. Yue and Tong (2009) reported in a consumer preference survey on tomato purchases that 27% of survey participants attended roadside stands or farmers' markets and that, when available, 54% "always" or "most times"

purchased locally grown produce. According to the 2010 Census Utah's population is 2.76 million. If 10% of the market were captured, this would mean 270,000 customers. While attendance numbers at Utah's farmers' markets are not available, most communities across the state have existing markets which offer outlets for locally grown fruits and vegetables. With the production of additional crops (lettuce, peppers, flowers, cucumbers, etc.) beyond those examined here, a small viable high tunnel industry could develop to support additional high tunnel enterprise. However, it should be noted that these agriculture enterprises would not be a major economic driver for the local economy nor would they provide a substantial number of jobs. However, they offer farm diversification opportunities and alternative employment options for farm families.

Another way to examine these numbers is in the context of alternative crop production options for rural areas of Utah. Although the population is quite small in rural areas, many of these communities have farmers' markets and therefore have direct marketing options to capture a fairly high percentage of the local population (Farmer's Market Online, 2011).

Table 5. Acres Needed for Various Numbers of Customers with Normal and Extended Harvest Periods[a] [b]

Number of Customers	Strawberries		Tomatoes		Squash		All Three	
	4 wks	8 wks	9 wks	17 wks	13 wks	21 wks	outdoor	with tunnel
1,000	0.02	0.05	0.09	0.18	0.1	0.17	0.2	0.4
1,500	0.04	0.07	0.14	0.27	0.16	0.25	0.3	0.6
2,000	0.05	0.1	0.19	0.36	0.21	0.34	0.4	0.8
2,500	0.06	0.12	0.24	0.45	0.26	0.42	0.6	1.0
3,000	0.07	0.14	0.28	0.53	0.31	0.51	0.7	1.2
3,500	0.08	0.17	0.33	0.62	0.36	0.59	0.8	1.4
4,000	0.10	0.19	0.38	0.71	0.42	0.67	0.9	1.6
4,500	0.11	0.22	0.42	0.8	0.47	0.76	1.0	1.8
5,000	0.12	0.24	0.47	0.89	0.52	0.84	1.1	2.0
5,500	0.13	0.26	0.52	0.98	0.57	0.93	1.2	2.2
6,000	0.14	0.29	0.57	1.07	0.63	1.01	1.3	2.4
6,500	0.16	0.31	0.61	1.16	0.68	1.09	1.4	2.6

[a] The number of acre estimates are based on production on high tunnels on 0.62 of an acre- the rest of the acre is for spacing between and around tunnels.

[b] Calculations are based upon USDA-ERS information for U.S. per capita food availability and Utah's estimated population from U.S. Census 2010.

Table 5 indicates that for a small farm growing all three crops on a single acre, 2,500 customers would be needed to make the farm profitable. Given that people generally consume more produce in-season when it is locally available (Brumfield, Adelaja, and Lininger, 1993), the number of customers needed may be even lower. This suggests that a single producer could develop a niche market in a rural area with a low population where you may not see a farmers' market with many vendors. While rural populations are smaller, a producer there may have more visibility and could attract a larger percentage of the population.

Land Values

The long-term trend has been for agricultural land to go out of production and be developed for residential or other commercial improvements. In Utah, it has been estimated that over the last decade more than 500,000 acres of farm land has been lost in this way (UDAF, 2011a), resulting in increased land values. While the recent economic downturn has slowed this trend, there is still pressure over the long term for additional farm land losses to continue. We examined how high land values may go before it no longer makes economic sense to keep them in agriculture production. For this analysis, $30,000 per acre was used as a conservative estimate of land cost in fairly urban areas. When the land value was varied, even very low land values were not enough to make wholesale production of high tunnel tomatoes and squash profitable. For mid-level pricing structures noted at smaller or more rural farmer's markets, when the cost of land falls between $30,000 and $50,000, it becomes too costly to organize and manage a high tunnel production operation. However, for high-price markets, even at $100,000 per acre, it may make sense to stay in agriculture production. For strawberries only one pricing structure was used which is a mid-level pricing that provides a premium since strawberries are local and out-of-season. When the cost of land rises to somewhere between $30,000 and $50,000, production of strawberries using high tunnels is not cost effective. This suggests that a few niche market businesses who receive very high prices could remain in production even as land values get very high. However, with competition, there would not be room in these marketplaces to sustain many high tunnel enterprises.

Conclusion

Our analysis suggests that there is the potential for additional producers to run high tunnel operations and make reasonable profits on a single acre. Growers will need to be able to do some type of direct marketing, may have to explore other market outlets and have the necessary related production skill to manage high tunnels. If they are able to get premium prices, the profits are considerably higher for greater levels of grower labor utilized. However, these operations will never be a large driver of the local economy. Overall, the number of acres needed to meet market demand is too small and roughly 20-50 producers could theoretically capture 5-10% of the market. High tunnels also provide diversification opportunities for growers to produce and sell in fairly rural areas, if a large portion of the local population can be attracted as customers.

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