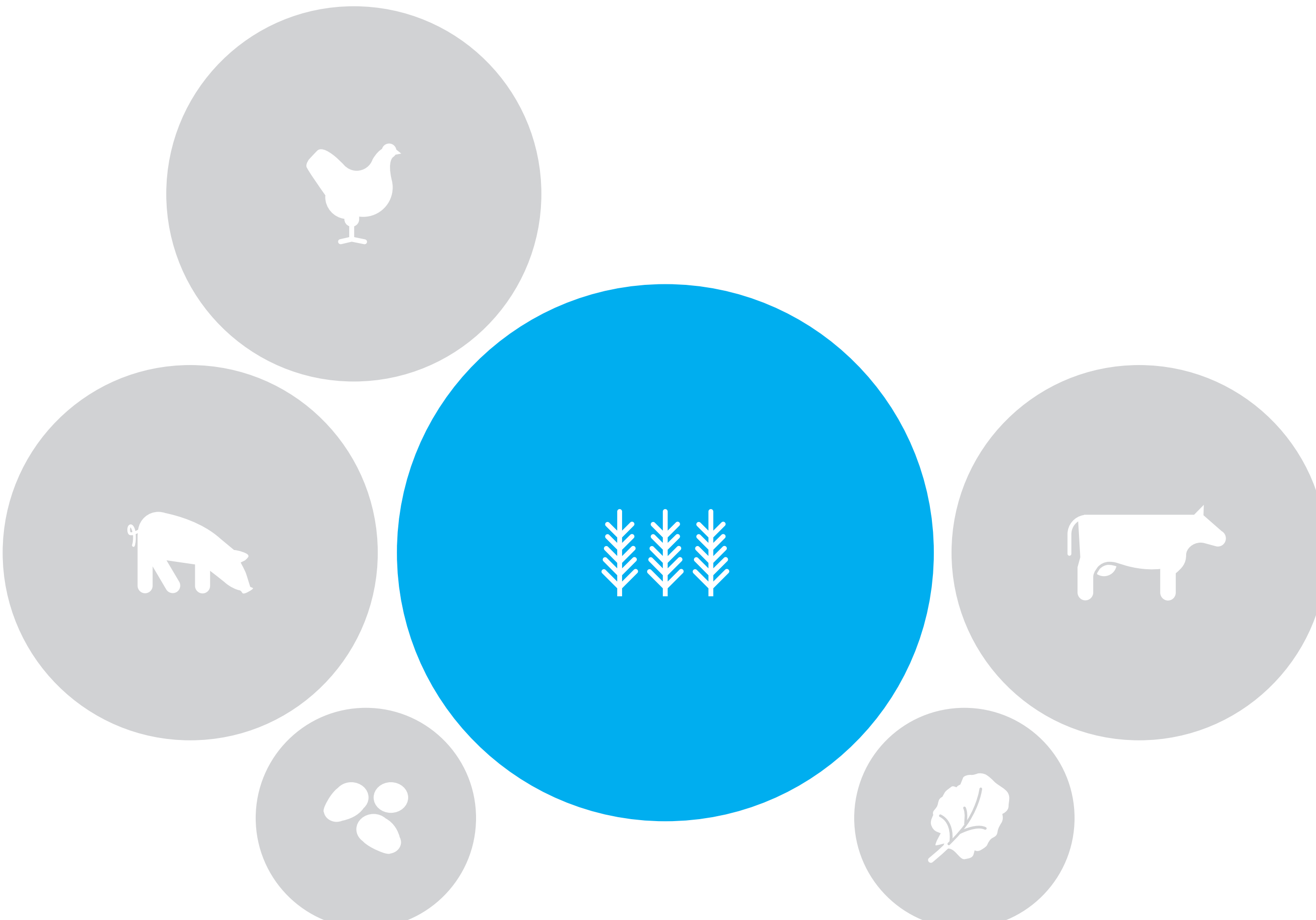

Differentiated Cost of Production in the Northwest:

An Analysis of Six Food Categories

WHEAT & SMALL GRAINS / June 2016

ecotrust

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Cascadia Foodshed Financing Project

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Project Background

Consumers have demonstrated a willingness to pay a premium for food attributes such as "freerange," "antibiotic-free," "organic," and "local." However, when production systems designed to yield those attributes are authentically implemented on the ground, such methods also tend to bear higher production and processing costs in comparison to conventional production methods. As a result, higher retail prices do not always ensure a sufficient income to the producer, nor constitute a viable supply chain.

Further, institutions such as schools, hospitals, colleges, and jails are noticeably slower as a buyer segment (versus restaurants, retailers, and manufacturers) to respond to customer interest in differentiated products for a variety of reasons, including high price sensitivity. Such buyers are vital players in the quest to get fresh, nutrient-dense food to vulnerable populations, however, so creating frameworks that allow them to access minimally processed, regionally produced food at reasonable prices would serve farmer and eater alike.

Understanding the costs of differentiated production systems in comparison to conventional approaches is vital to identifying opportunities where efficiencies may be gleaned or market value harvested to support a viable regional food ecosystem.

Ecotrust is conducting cost of production analysis in six distinct food product categories, including this one on wheat and small grains. In each category we define an "ag of the middle" scale and a "differentiated production system" for analysis purposes, meaning: a specific alternative production system (one that spawns product attributes about which consumers care, such as organic, pastured, or grass-fed) will be defined at a particular scale of operation (big enough to participate meaningfully in an institutional supply chain), and be assessed relative to the conventional/commodity/industrial model of production for that category.

While there are certainly many variations of both production systems and scales of operation possible in a thriving regional food system, singling out a specific system allows us to create an economic model that facilitates sensitivity analyses and high level conclusions regarding which regional food sectors could make efficient and effective use of investment.

Note, this project builds on the foundation laid by the Oregon Food Infrastructure Gap Analysis report, released in May 2015. The full report and executive summary can be accessed here: http://www.ecotrust.org/publication/regional-food-infrastructure/, or a quick digital summary of highlights is available at http://food-hub.org/intrepid. The wheat chapter from that report is included with this model/report as an addendum.

Executive Summary / Introduction

Small grains are an important part of Pacific Northwest agriculture and food systems. This study documents important, emerging trends in alternative production systems for the small grains sector in the U.S. Pacific Northwest. The principal finding is that the two most economically and ecologically important, emerging trends in this sector are the rise of no-till farming and related practices of conservation tillage; and the increasing diversity and complexity of crop rotations. These two interrelated sets of farming practices make up a range of alternative small grain production systems that vary widely within the region, based on local differences in temperature and precipitation.

No-till (also called direct seeding) refers to the farming practice of inserting or drilling seeds directly into the soil following the previous crop, leaving the bulk of the residue from the previous crop in the field. Related practices include conservation tillage, which reduces but does not eliminate tilling. These practices are dramatically different from conventional grain agriculture, which tills (turns over) the soil before each planting, eliminating weeds but also releasing soil carbon into the atmosphere and creating the conditions for erosion. No-till and conservation tillage comprise arguably the most important environmental trend in Pacific Northwest small grain agriculture today: they build soil health, reduce erosion and nutrient runoff, and sequester soil organic carbon. Though organic small grains also hold some potential for market growth, no-till grains are currently much more economically and ecologically significant than organics (see Appendix for details).

Wheat is by far the most important small grain crop in the Pacific Northwest, with over 3 million acres harvested across Oregon and Washington (NASS 2015). Accompanying the cultivation of no-till or conservation tillage wheat are a group of differentiated, high-value varieties of small grains, oilseeds, and legumes, which are grown as rotation crops. Currently, the most common rotation crops are barley, oats, and chickpeas. Rotation crops in a no-till system are planted (drilled) directly into the post-harvest soil and residue from the previous crop. Crop rotations reduce disease and weed pressure, improve soil moisture holding capacity and increase soil organic matter content (Smith 2009). A sample of these crops includes:

- Small Grains: amaranth, sorghum, and millet
- Oilseeds: canola, safflower, and sunflower
- Legumes: chickpeas, peas, and lentils.

The drivers of supply for no-till wheat and rotation crops are as follows:

1. Production costs: no-till can be cost competitive for wheat and most rotation crops, depending on the geographic production zone
2. Markets for rotation crops: these markets are at different stages of development; most are growing
3. Pricing systems: cost-plus pricing by farmer-owned companies offers greater economic stability than commodity markets
4. Scale and machinery: expensive no-till machinery has led to rising land rents and increasing farm size
5. Processing infrastructure: for crops other than wheat, regional processing infrastructure has been scarce.

The drivers of demand for no-till wheat and rotation crops are as follows:

1. Transparency: large buyers and consumers are seeking transparent supply chains
2. Crop Diversity: demand for grain, oilseed and legume crops is diversifying
3. Nutrition: consumers are seeking crops with high nutritional content
4. Environmental Values: consumers may be willing to pay a premium for an environmental attribute such as no-till.

Diverse, no-till / conservation tillage grain growing brings multiple ecological and economic benefits. The principal benefits of this system are:

1. Climate Benefits. No-till / conservation tillage farming sequesters carbon in the soil, reversing climate change if done at sufficient scale.
2. Local Environmental Benefits. No-till / conservation tillage farming has two main local environmental benefits:
   a. It builds soil health and fertility by fostering a diverse microbial life in the soil.
   b. It reduces soil erosion and nutrient runoff from farmland into waterways, protecting topsoil and restoring water quality.
3. Local and Regional Crop Diversity. The crop diversity that complements no-till or conservation tillage has three interrelated benefits:
   a. It promotes economic diversity and resilience in farming communities, by boosting yields and creating multiple revenue streams.
   b. It creates ecological diversity and resilience in the field, by creating natural control mechanisms for weeds, pests, and diseases.
   c. It promotes nutritional diversity for eaters.

Diverse, no-till grain farming is also growing in the Pacific Northwest, giving rise to market opportunities. Three important opportunities to keep track of are:

1. Investment in emerging processing infrastructure for diverse grain, oilseed, and legume crops.
2. Investment in commercialization of rotational crops with potentially high nutritional and commercial value.
3. Funding of marketing and storytelling efforts around the benefits of no-till crops for ecology, economics, and nutrition.
4. Transition financing to assist farmers in acquiring specialized equipment for no-till agriculture.

The sections that follow summarize key economic findings about the growth and profitability of small grain, oilseed, and legume farming in the Pacific Northwest, using crop rotations and no-till or conservation tillage.

Defining Small Grain Agriculture of the Middle in the Pacific Northwest

Alternative Production System: No-Till Wheat with Crop Rotation

No-till (also called direct seeding) refers to the farming practice of inserting or drilling seeds directly into the soil following the previous crop, leaving the bulk of the residue from the previous crop in the field. Related practices include conservation tillage, which reduces but does not eliminate tilling[2]. Both of these practices simultaneously build soil health, reduce erosion and nutrient runoff, and sequester soil organic carbon. These practices are dramatically different from conventional grain agriculture, which tills (turns over) the soil before each planting. Tilling eliminates weeds but also releases soil carbon into the atmosphere and increases the potential for erosion. No-till or conservation tillage practices often work in tandem with crop rotations, in which the main crop (usually wheat) is rotated with a diverse array of small grains, oilseeds, and legumes.

No-till / conservation tillage and crop rotation practices comprise arguably the most important environmental trend in Pacific Northwest small grain agriculture today. As Chad Kruger, director of the Center for Sustaining Agriculture and Natural Resources (CSANR) at Washington State University says: “Without question, no-till agriculture is the most well-established alternative production system for grain crops in the Pacific Northwest, based on the sheer volume of acres, number of producers, output, and level of development of the system” (C. E. Kruger 2015). Farmers are increasingly seeing the benefits of no-till production in the health of their farms. David Dobbins, a no-till wheat grower in eastern Washington, cites management and labor efficiencies, good soil replenishment, and reduced soil erosion as three primary benefits from no-till practices (Dobbins 2015).

Bryan Dobbins (far right) and his wife Carolyn converted to no-till wheat farming in the 1980s, and raised son David (far left) in the practice, which he now carries on with his wife Margaret.

According to a 2008 article in Scientific American, "Tillage is a root cause of agricultural land degradation—one of the most serious environmental problems worldwide." (Huggins and Reganold 2008) No-till and conservation tillage farming have had major impacts on soil erosion in U.S. agriculture: according to the USDA's National Resources Inventory data, soil erosion from water and wind on U.S. cropland decreased 43 percent between 1982 and 2003, with much of this decline coming from the adoption of conservation tillage (Huggins and Reganold 2008).

No-till / conservation tillage farming and crop rotations work in tandem to produce a high-yield, diverse agriculture of small grains, oilseeds, and legumes. As Kruger says simply: "Crop rotations make no-till work." By contrast, conventional small grain production rarely involves crop rotation, focusing instead on cultivating a single wheat crop (such as winter wheat) year after year, punctuated by fallow periods where the land is given time to recover. This conventional practice reduces soil health and releases carbon dioxide into the atmosphere; it also leads to declining yields over time.

Accompanying the cultivation of no-till or conservation tillage wheat are a group of differentiated, high-value varieties of small grains, oilseeds, and legumes, which are grown as rotation crops. Examples of small grains grown as rotation crops are amaranth, sorghum, and millet; oilseeds include canola, safflower, and sunflower; and legumes include chickpeas, peas, and lentils. Rotating legumes, oilseeds, and other small grains with wheat allows the farmer to boost wheat yields and profitability by breaking pest and weed cycles, fixing nitrogen in soil, and enhancing overall soil health and microbial life. In eastern Washington, David Dobbins rotated flax, buckwheat, safflower, sunflowers, canola, and peas with five different types of wheat (Dobbins 2015).

The development of markets for the diverse set of rotation crops that accompany no-till wheat offers an important opportunity for fostering a diverse, regenerative, and climate-friendly grain agriculture in the Pacific Northwest. For several rotation crops including chickpea, lentils, and canola, markets are already well developed. For other rotation crops including amaranth, sorghum, and millet, markets are still relatively thin, but growing. The Washington flour and grain company Shepherd's Grain has identified up to thirty separate crops that can function in rotation with no-till or conservation tillage wheat in the Pacific Northwest, depending upon the temperature and precipitation (Kupers 2015). Most of these crops are in early stages of commercialization.

Changing the methods by which Pacific Northwest wheat is grown holds the potential to change the entire system of grain growing in the region. The rise of no-till, conservation tillage, and crop rotation agriculture is changing, in fundamental ways, the methods by which wheat and other small grains are grown in this region, fostering a resilient agriculture system that both mitigates and adapts to climate change, while delivering a more diverse range of grain, legume, and oilseed products for local and regional markets. For these reasons, it is an important market trend in terms of both economics and ecology.

1. Key Business Focus: Shepherd's Grain

The growth of no-till and conservation tillage agriculture in the Pacific Northwest has been spurred by the efforts of Shepherd's Grain, a group of about 60 mid-sized farmers in Washington, Oregon, Idaho, and western Canada. Shepherd's Grain markets flour from wheat growers practicing predominantly no-till techniques along with rotation of oilseeds, legumes, and small grains. It is a farmer-owned business that engages in joint marketing and branding of flour and related products, working with value-chain partners for storage, milling, and distribution; sales totaled $6.5 million in 2014 (Ecotrust 2015). Shepherd's Grain flour is certified by Food Alliance, a sustainability certification for agriculture products. The overarching goal of Shepherd's Grain, according to co-founder Karl Kupers, is "to extend and to create value from a production system of no till" (Shepherd's Grain 2015). Interviews with two key representatives of Shepherd's Grain, co-founder Karl Kupers and general manager Mike Moran, provided us with substantial material for this report.

Disclosure: Please note that Amanda Oborne, VP of Ecotrust Food & Farms program and collaborator on this report, serves on the Board of Directors for Shepherd's Grain. Amanda did not participate in the selection of no-till as the alternative production system of study, nor did she participate in the interviews with Shepherd's Grain staff.

2. A Note on Farming Practices: No-Till vs. Organic

No-till and conservation tillage farming practices differ from organic practices in some fundamental ways. While both are oriented towards conservation of soil and water, plant nutrition, and crop diversity, they approach these objectives from different angles. We have chosen to focus on no-till and conservation tillage practices in small grains because of the greater economic importance of these practices for this sector, in this region, compared to organics (see Appendix for details). This subsection briefly explains the differences in approach between the two systems.

Organic practices focus on the reduction or elimination of pesticides, herbicides, and other chemical inputs. Tillage is a necessary component of organic agriculture, in order to control weeds, pests, and diseases. By contrast, no-till/conservation tillage focuses on the reduction in soil erosion from reducing or eliminating tillage; pesticides and herbicides are thus important tools in the farmer's arsenal of combating weeds, pests, and diseases (C. E. Kruger 2015, Kupers 2015, Dobbins 2015). It is currently very difficult to perform no-till agricultural techniques without the use of these agrochemicals. New approaches to crop rotation promise the possibility of reducing chemical applications by breaking pest and disease cycles through careful selection of crops that do not fall prey to the same pests/diseases. David Dobbins, who farms no-till wheat in eastern Washington, reports a reduction in the use of herbicides, particularly the harsher chemicals, since adopting crop rotations (Dobbins 2015). In addition, since no-till operations significantly reduce erosion and water runoff, the threat of water pollution from herbicides, pesticides, and fertilizer runoff is reduced significantly.

3. The Growth of No-Till Wheat in The Pacific Northwest

a. Acreage

Table 1 below provides 2004 data from USDA Economic Research Service (Horowitz, Ebel and Ueda 2010) on wheat tillage practices in the Pacific Northwest and the country as a whole. As early as 2004, Oregon and Washington wheat farmers conducted almost two-thirds of their production, over 2.1 million acres, with some form of reduced tillage; 10.2% of all acreage (about 330,000 acres) was cultivated under no-till practices.

The data in the table below categorizes tillage practices by the percent of agricultural residues left in the field. Conventional tillage leaves less than 15% of agricultural residues in the field; reduced tillage practices leave 15% - 30%, conservation tillage over 30%, and no-till up to 100%. Leaving over 30% of crop residue in the field significantly reduces erosion compared to all levels below 30%; it is an important threshold for the environmental impacts of cropping.

Unfortunately, there is no publicly available, up-to-date data on acreage by tillage practices at the state or regional level.[1] The most recent study, conducted in 2012-2013, estimated that no-till practices encompass 30.2%, and conservation tillage practices encompass 39.4%, of all wheat acreage in the Pacific Northwest (REACCH 2015). These estimates are corroborated anecdotally by Shepherd's Grain founder Karl Kupers (Kupers 2015), who reports that non-conventional tillage practices have grown continuously in the Pacific Northwest since 1995.

1 The Conservation Technology Information Center collects and sells summary reports on tillage practices at the county, state, and regional level; publicly available data is provided for the national level only (Conservation Technology Information Center 2016).

Table 1. Wheat Production Acreage by Tillage Practice, U.S. Pacific Northwest (2004)

	# Acres	No tillage and residues >30%	Residues > 30 % (conservation tillage)	Residues 15% - 30% (reduced tillage)	Residues < 15% (conventional tillage)	Total Acreage, Non-Conventional Tillage
Oregon	999,845	20.9%	47.3%	16.4%	36.2%	636,901
Washington	2,330,045	5.6%	33.8%	31.0%	35.2%	1,509,869
Region	3,329,890	10.2%	37.9%	26.6%	35.5%	2,146,770
US Total	53,150,196	21.9%	47.4%	22.3%	30.4%	37,045,687

b. Market Size

We can use acreage data to estimate the size of the market for no-till wheat. In 2004, the average composite price for wheat in Oregon and Washington (not including subsidy payments to farmers) was $3.69 / bushel (NASS 2015). Average wheat yields in the Pacific Northwest were about 61 bushels per acre (NASS 2015). The average wheat farmer in the Pacific Northwest thus earned about $225 / acre in 2004. Given that 10.2% of total wheat acreage in the region was farmed using no-till techniques, the total number of acres farmed under no-till was 339,648. Multiplying revenue per acre by the number of acres under no-till, the total value of no-till wheat cultivated in the Pacific Northwest was about $76.4 million. 37.9% of wheat acres in the region were estimated to be cultivated using conservation tillage or no-till; the number of acres under conservation tillage was approximately 1,262,028. The total value of wheat grown using no-till or conservation tillage in the region was thus about $284 million. In comparison, the market size for conventional wheat for the region in 2004 was about $266 million. For the intermediate category of reduced tillage, which leaves between 15 – 30% of crop residue in the field, the market size was about $199 million. The total market size for Pacific Northwest grown wheat was thus about $749 million.

By the most recent expert estimates (REACCH 2015), no-till currently encompasses about 30.2% of total wheat acreage in the Pacific Northwest, and conservation tillage (not including no-till) encompasses 39.4% of all wheat acreage. Wheat yields in 2015 were lower on average than in 2004, about 49 bushels/acre, as was total acreage harvested (3.04 million acres). Wheat prices, however, were considerably higher, about $6.60/bushel on average. Given these rough, ballpark figures, we can estimate that the total market size for no-till wheat in the Pacific Northwest in 2015 was about $297 million, and the total market size for conservation tillage wheat (not including no-till) in the region was about $388 million. Total market size for conservation tillage and no-till combined was thus about $685 million. Conservation tillage practices in the Northwest have become, to some degree, big business.

Scale of Production for No-Till Agriculture of the Middle

Table 2 below provides the distribution of farms by acreage in Oregon and Washington over the period 1997-2012, collected from USDA (NASS 2015). Over the period, the number of farms in every category of acreage under 2,000 acres decreased, and the number of farms in categories between 2,000 and 4,999 acres increased. Pacific Northwest wheat farming appears to be becoming more concentrated by acreage.

From the perspective of small- to mid-sized farms, the picture is made more hopeful by the fact that between 2007 and 2012, the number of farms in six of the eight acreage categories under 1,000 acres increased, though the number of farms did not recover to 1997 levels. For instance, between 2007 and 2012 the number of farms between 100 and 249 acres increased from 287 to 350, while the number of very small-scale farms (under 15 acres) increased from 57 to 103. Though this may indicate a revival of small- to medium-scale grain production in the Pacific Northwest, it is too early to tell.

Table 2. Distribution of Wheat Farms by Area Harvested, Oregon and Washington, 1997-2012

	Year				
Area Harvested (ac)	1997	2002	2007	2012	% Change (1997-2012)
1 - 14.9	180	83	57	103	-43%
15 - 24.9	183	91	60	94	-49%
25 - 49.9	342	200	159	140	-59%
50 - 99.9	473	309	186	203	-57%
100 - 249	604	406	287	350	-42%
250 - 499	226	200	157	193	-15%
500 - 999	170	112	95	130	-24%
1,000 - 1,999	110	96	80	78	-29%
2,000 - 2,999	19	29	29	34	79%
3,000 - 4,999	10	22	17	18	80%
>= 5,000	13	8	11	11	-15%

Given that there is no precise scale definition of "Agriculture of the Middle" as applied to wheat, we use a rule of thumb based on income.2 McAdams (2015) defines Agriculture of the Middle producers as those who can support a family of four on at least twice the federal poverty level of $24,250/year; hence, producers who earn $48,500 in net income or more. In Oregon, the only state for which we (Ecotrust) currently have good data on farmers' net income, producers with sales between $250,000 and $499,999 are the first to show an average net income in excess of two times the 2015 federal poverty level, with $80,931 in net income to the operation and $79,848 in net income to the operator (McAdams 2015).

2 The website of the Agriculture of the Middle Initiative, a national initiative devoted to renewing mid-scale agriculture and related food systems, clearly states: "It is important to recognize that the definition of AOTM farms and ranches is scale related but not scale determined. Most farms are in the $50,000-$500,000 range of gross sales. But there may be farms with higher gross sales that meet the other criteria. The specific size that is too big for direct markets but too small for commodity markets varies with crops produced, geography and market" (Agriculture of the Middle 2012).

If we adopt the rule of thumb of $250,000 - $500,000 in gross sales, then we can arrive at a ballpark definition of Agriculture of the Middle for wheat. Consider the budgets provided by Painter (2009) explained below in Section III.A, in which both conventional and no-till wheat earn $347/ac of gross revenue in the high-precipitation zone. Agriculture of the Middle in this context is thus approximately 720 - 1,440 acres. In the low precipitation zone, in which wheat earns about $229/ac in gross revenue, Agriculture of the Middle is approximately 1,100 – 2,200 acres. As in the case of pork, Ag of the Middle farms are not small farms. Mike Moran, general manager of Shepherd's Grain, estimates that farmers who sell through the business cultivate between 2,500 – 5,000 acres on average (Moran 2015). Farmer David Dobbins produces no-till wheat on 4,000 acres, most of it leased (Dobbins 2015).

The large average size of no-till wheat and small grain producers confounds the definition of "Agriculture of the Middle". The original hypothesis of the Agriculture of the Middle initiative was that farmers operating at medium scale were more likely to be independent and family-owned and operated, engage in innovative and ecologically sustainable farming techniques, practice supply chain transparency and develop differentiated, high-quality agricultural and food products for local and regional markets (Kirschenmann, et al. 2013). In the case of no-till, it is the farmers at the upper end of the size distribution who exhibit these qualities.

Drivers of Supply

This section identifies five main drivers of the supply of small grains, legumes, and oilseeds coming from farms practicing crop rotation and no-till or conservation tillage. We identify production cost, the development of markets for rotation crops, cost-plus pricing systems, economies of scale, and processing infrastructure as the five main drivers of supply for grains produced under this important class of alternative systems.

Production Cost

Production cost is an important driver of supply for small grains grown under alternative systems such as no-till. This subsection briefly reviews the comparisons between no-till, reduced-till, and conventional tillage by crop and production zone, as summarized in recently compiled enterprise budgets for no-till crops in the Pacific Northwest, created and maintained by Kathleen Painter at University of Idaho, Moscow (Painter, Dryland Crops, Northwest Wheat and Range Region 2009).

The University of Idaho (UI) budgets (Painter, Dryland Crops, Northwest Wheat and Range Region 2009) show that in the high rainfall zone (over 18" precipitation annually), no-till outcompetes conventional tillage on cost of production for every relevant crop. Table 3 below demonstrates the higher economic returns that characterize no-till

Table 3. Returns to Total Cost per Acre by Tillage System, High Rainfall Zone, Washington State

Returns over TC/ac					
Crop	C- Conventional Tillage	R - Reduced Tillage	N - No-Till	Difference N-C	Difference R-C
Winter Wheat (WW)	$106.88	$83.72	$110.08	$3.20	$(23.16)
Spring Barley (SB)	$(58.06)	$(19.66)	$(13.27)	$44.79	$38.40
Soft White Spring Wheat (SWSW)	$(53.12)	$(47.10)	$(19.92)	$33.20	$6.03
Hard Red Spring Wheat (HRSW)	$(17.06)	$(15.28)	$14.89	$31.95	$1.78
Peas (P)	$86.93	$91.69	$92.65	$5.72	$4.76
Lentils (L)	$151.25	$153.08	$156.97	$5.72	$1.83
Garbanzos (G)	$34.33	$38.04	$40.05	$5.72	$3.70
Spring Canola (SC)	$(48.10)	$(26.87)	$(35.84)	$12.26	$21.23

Table 4. Production Costs by Tillage System, Soft White Winter Wheat High Precipitation Zone (over 18" annual)

	No-Till		Conventional		Reduced Tillage	
Item	$/Ac	% Total Cost	$/Ac	% Total Cost	$/Ac	% Total Cost
Gross Returns of 90 bushels/ac at $5.08/bu	$457.20	-	$457.20	-	$457.20	-
Variable Costs:						
Fertilizer	$78.87	22.7%	$77.72	22.2%	$88.05	23.6%
Pesticides	$48.33	13.9%	$27.58	7.9%	$35.48	9.5%
Machinery	$35.09	10.1%	$41.62	11.9%	$49.91	13.4%
Seed	$13.50	3.9%	$13.50	3.9%	$13.50	3.6%
All Other Variable Costs	$36.64	10.5%	$44.66	12.7%	$44.25	11.9%
Fixed Costs:						
Machinery Depreciation, Insurance, Taxes, Licenses, Housing	$29.20	8.4%	$32.52	9.3%	$35.59	10%
Land Cost and Taxes	$105.49	30.4%	$112.71	32.2%	$106.70	29%
Total Costs per Acre	$347.12		$350.32		$373.48	
Net Returns Above Total Costs	$110.08		$106.88		$83.72	

Source: Painter (2009).

farming techniques in every major crop category. In the budgets presented below, these advantages are greatest in the case of spring barley, soft white spring wheat, and hard red spring wheat. They are smallest in the case of winter wheat, peas, lentils, and garbanzos.[3]

The UI budgets assume that yields, output prices, input prices, and machinery fixed and variable unit costs are constant across tillage systems. The farmer interviews we conducted in eastern Washington confirm that yields from no-till are competitive with conventional yields (Dobbins 2015). The differences, then, lie in the mix of inputs and machines used in production of the crop.

How do these input mixes differ? Table 5 below provides a comparison of the total fixed and variable costs, and cost proportions per acre, across tillage systems for soft white winter wheat, the most commonly grown and abundant grain crop. This budget applies only to the high precipitation zones of the inland Pacific Northwest, which receive on average over 18” of rain annually.

Table 5 shows that no-till has the lowest total costs (highlighted in gold), and thus highest total returns, per acre, in comparison to both conventional and reduced tillage. Pesticide and fertilizer costs are higher for no-till, and machinery costs and all other variable costs (which include all rentals, overhead, consultant labor, and interest on working capital) are lower.4 No-till also has a clear advantage in comparison to reduced tillage. Land costs are nearly identical, but fertilizer, machinery, and all other variable costs are significantly lower, while pesticide costs are significantly higher. The higher pesticide costs do not offset the lower costs of the other inputs. David Dobbins, our eastern Washington farmer contact, confirms that no-till practices on his farm have led to savings on fuel, labor and equipment, once the upfront investment in the new equipment has been made (Dobbins 2015). For more detail on this upfront investment in equipment, please see Section III.D below.

Does the cost advantage described in Table 4 above persist across wheat varieties, rotation crops, and rainfall zones? Table 5 below shows the costs and returns to garbanzo beans (chickpeas) across tillage systems in the high rainfall zone (Painter, Dryland Crops, Northwest Wheat and Range Region 2009). No-till also comes out ahead in this budget, but the increased returns are driven primarily by lower machinery costs. Machinery variable and fixed costs for no-till are significantly lower for both conventional and reduced tillage. These lower machinery costs are partially offset by the higher cost of pesticides. Land costs are lower for no-till but the difference is much less. The budget for this crop assumes no fertilizers are used.

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3 These results are meant to be purely illustrative and should not be generalized: the relative cost advantages of no-till with respect to conventional or reduced tillage differ based on agro-climatic zones, management skill and experience, choice of crop rotation, chance weather patterns, and other factors.

4 Land costs are assumed to be based on a cost-share system; the lower costs of machinery and other variable costs are thus passed onto the tenant in the form of lower rents.

	No-Till		Conventional		Reduced Tillage	
Item	$ /Ac	% Total Cost	$/Ac	% Total Cost	$/Ac	% Total Cost
Gross Returns of 1200 lbs/ac at $0.27/lb	$318.00		$318.00		$318.00	
Variable Costs						
Seed	$66.30	23.9%	$66.30	23.4%	$58.50	20.9%
Pesticides	$36.83	13.2%	$24.47	8.6%	$27.50	9.8%
Fungicides1	$17.84	6.4%	$17.84	6.3%	$17.84	6.4%
Machinery	$33.96	12.2%	$45.86	16.2%	$45.14	16.1%
All Other Variable Costs	$29.37	10.6%	$26.61	9.4%	$28.85	10.3%
Fixed Costs						
Machinery Depreciation, Insurance, Taxes, Licenses, Housing	$28.95	10.4%	$34.80	12.3%	$35.10	12.5%
Land Cost and Taxes	$64.70	23.3%	$67.79	23.9%	$67.03	23.9%
Total Costs per Acre	$277.95		$283.67		$279.96	
Net Returns Above Total Costs	$40.05		$34.33		$38.04	

Table 5. Production Costs by Tillage System, Garbanzo (Chickpea), High Precipitation Zone (over 18" annual)

The relative costs of no-till and conventional tillage differ across agro-climatic zones.

Table 6 below shows cost comparisons between conventional and reduced tillage for the low precipitation zone of less than 15" annually. The budget shows that reduced tillage cannot compete with conventional tillage in the low precipitation zone. Though there is no corresponding no-till budget for this zone from the same source, a seminal study on this topic, conducted at Washington State (Schillinger, et al. 2008) indicates that in low precipitation zones, no-till winter wheat is not cost competitive with conventional tillage. The Washington State study compared no-till with the conventional rotation of winter wheat/summer fallow (WWSF) that has been dominant in the low-precipitation zone of the inland Pacific Northwest for over a century. In reality, there are farmers who practice no-till in low precipitation zones; however, the practice is considered best optimized for an intermediate level of rainfall, between 15" – 18" of annual precipitation. (Painter 2015).

Table 6. Production Costs by Tillage System, Soft White Winter Wheat, Low Precipitation Zone (under 15" annual)

	Conventional Tillage		Reduced Tillage	
Item	$/Ac	% Total Cost	$/Ac	% Total Cost
Gross Returns of 55 bushels/ac at $5.08/bu	$279.40	–	$279.40	–
Variable Costs				
Seed	$10.50	4.6%	$12.00	4.4%
Fertilizer	$0.00	0.0%	$40.44	15.0%
Pesticides	$7.54	3.3%	$9.14	3.4%
Machinery	$20.10	8.8%	$22.05	8.2%
All Other Variable Costs	$11.47	5.0%	$15.97	5.9%
Fixed Costs				
Machinery Depreciation, Insurance, Taxes, Licenses, Housing	$11.84	5.2%	$12.79	5%
Fallow Costs	$95.66	41.7%	$83.04	31%
Land Cost and Taxes	$72.43	31.6%	$74.36	28%
Total Costs per Acre	$229.54		$269.79	
Net Returns Above Total Costs	$49.86		$9.61	

This section has argued, using data from university extension enterprise budgets, that no-till can be competitive with conventional agriculture, depending on the crop and climatic zone. Further research on how to make no-till competitive with conventional tillage in low-precipitation zones is currently underway. As the practice becomes more common, and farmers build skills and know-how, the cost of production falls. As Karl Kupers of Shepherd's Grain, observes, "Farmer to farmer education, (backed up) by research, is the only way to sustainable change. No-till generally never flourishes around the first innovators. It's the second, third tier where it takes off" (Kupers 2015).

Rotation Crops

Rotation crops are an important aspect of no-till agriculture. Legumes, oilseeds, and other rotation crops nourish soil microbial life, and provide natural methods of weed, pest, and disease control, all of which boosts the yields of the predominant wheat crop and reduces the need for chemical herbicides (Dobbins 2015, C. E. Kruger 2015, Kupers 2015). The potential for expansion of acreage of these rotational crops depends on a wide variety of factors. Most rotation crops are highly sensitive to climate and soil types. Chad Kruger summarizes:

Usually what you're going to see in a rotation is: winter wheat, followed by a spring grain, either wheat or barley; then a legume; then back to winter wheat. But with dryland (non-irrigated) agriculture, every 5-10 miles the system changes. There's that much heterogeneity around soils and climate, precipitation, and temperature; so there's a west-east and north-south gradient, where west-east is precipitation and north-south is temperature. It's not linear though, it's weird shapes. It's very complicated! (C. E. Kruger 2015)

Research on the wide diversity of rotation crops that can grow in the Pacific Northwest has, historically, taken a back seat to a near-exclusive focus on wheat. Breeding of rotation crops that are adapted to the diverse agro-climatic zones in this region and can tolerate drought, pests and diseases, and a wide variety of weather conditions, has not been a priority of agricultural research. Processing and marketing infrastructure in this region has not historically been oriented towards rotation crops. Karl Kupers notes: “I didn’t realize until I started diversifying my own farm, how monoculture we were as an industry. The research is all about wheat; the infrastructure is built around bulk commodities, all wheat. Bringing in a crop that isn’t wheat, and getting it processed and prepared for sale, that’s an uphill battle” (Kupers 2015).

The potential for rotation crops becoming profitable in themselves is relatively recent; historically, the entire reason for growing legumes and oilseeds was to boost wheat yields. Chad Kruger notes, “Historically, canola and legumes have been money losers. The key is whether canola and the legume provides enough agronomic benefit so that the whole rotation is more profitable. That’s counterintuitive. You get to these points where disease and weed infestations become so severe that you start to lose yield; cost of control rises too high; or efficacy of control falls. What happens is that the rotation crops break even or lose, but wheat yields increase” (C. E. Kruger 2015).

This historical pattern is now changing, as rotation crops become profitable in themselves. Chickpeas are a particularly important illustrative case. The boom in chickpea production (evident in Figure 1 below) has been driven by demand for chickpea as a key ingredient in hummus, a highly nutritious snack food of Middle Eastern origin that has become increasingly popular in cities throughout the United States, especially in the Northeast. Chad Kruger says the following about chickpea:

It’s the best story ever. It’s driven by an East Coast demand for hummus, and it has exploded. Where is chickpea grown? In the inland Pacific Northwest. We have seen an explosion of acres of chickpea in response to demand for this highly nutritious snack food. We have a legume crop in the Palouse that’s making money by itself. Some farmers have told me that they’re even more profitable on chickpea than wheat. This is a very unique story that is market demand driven. Historically, chickpea has been an annual, relatively wet dryland crop. Now it’s pushing west in terms of who’s growing it, because the market demand is so strong; they’re pushing past where they’ve historically grown it. (C. E. Kruger 2015)

There lies a danger in focusing too heavily on chickpea, however: growers whose land is not best suited for chickpea may adopt the crop in response to market demand. If market demand then weakens, these growers may find themselves growing an unprofitable crop not optimized for soil health and pest control in their region. From the investor perspective, the best move is probably to look for the next profitable rotation crop. From the farmer perspective, the best choice of crop is the one that is best suited to existing climate and soils, and rotates well with the other crops.

In general, the market outlook for legumes, oilseeds, and other rotation crops appears bright. In the opinion of Karl Kupers, "the marketplace is probably more ready for (crop) diversity than even for (our company's) flour" (Kupers 2015). On a crop-by-crop basis, however, the outlook is more complex. Figures 1 through 9 below summarize market trends over the past decade for five important crops that rotate with no-till wheat: chickpea, canola, barley, oats, and sunflower.

Figures 1 and 2 (see next page) indicate the trends in acreage for chickpea in Oregon and Washington, respectively, using national price trends (state-level price data was not available). These trends indicate dramatic differences between the two states. Chickpea has not been a major crop in Oregon over this period, with only 3,500 acres cultivated in 2004 and a decline to less than 500 acres cultivated in 2009. In Washington, however, chickpea cultivation has risen dramatically, from less than 20,000 acres in 2003 to over 80,000 acres in 2014.

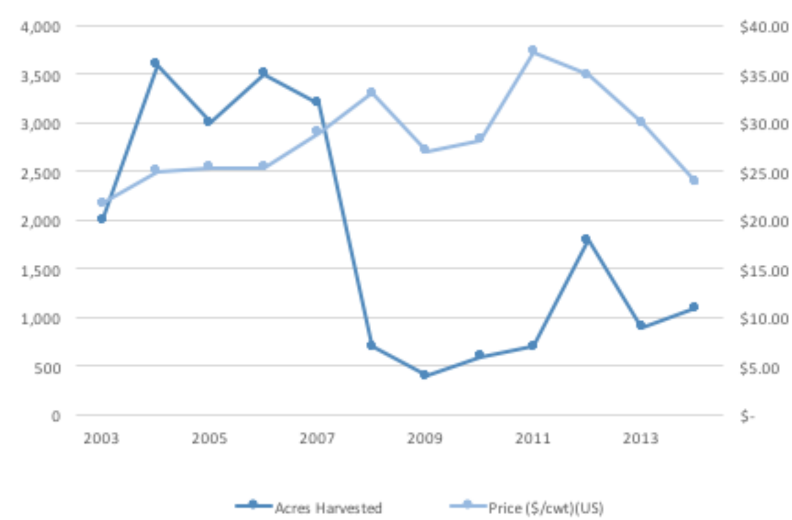

Figure 1. Chickpeas (Dry, Edible): Acres Harvested and Prices ($/cwt), OR, 2003–2014

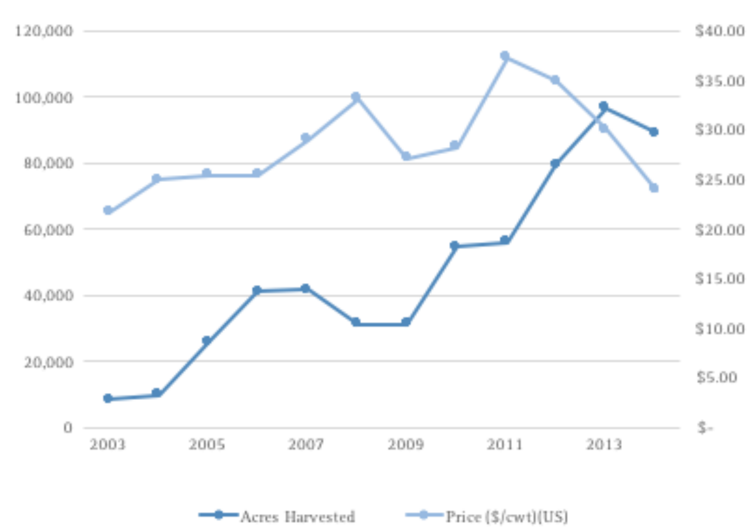

Figure 2. Chickpeas (Dry, Edible): Acres Harvested and Price Received, WA, 2003–2014

Figures 3 and 4 below present acreage and price data for canola from the annual Agricultural Survey. Though price series for individual states are available, annual state-level acreage data series do not start until 2009 for Oregon and 2011 for Washington. The five-year Census of Agriculture provides state-level data going back to 1997, which do not capture the dramatic upward trend in canola production, particularly in Washington, since 2011. Existing data reveal a significant increase in acreage planted in both states, though both the increase and the total acreage are far smaller in Oregon than in Washington.

Figure 3. Canola: Acreage Harvested and Price Received, OR, 2009–2014

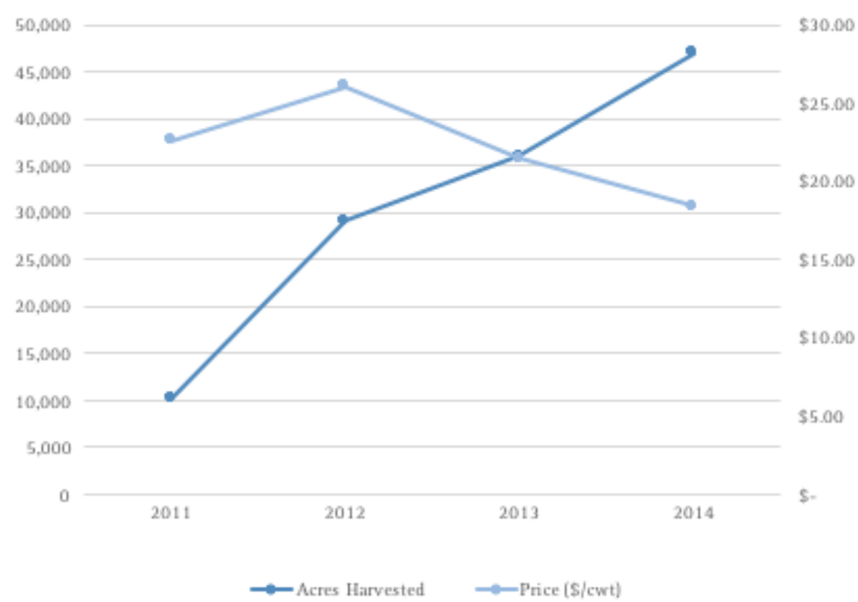

Figure 4. Canola: Acreage Harvested and Price Received, WA, 2011–2014

Not all rotation crops have experienced significant increases in acreage; some have experienced decreases. Barley is one crop commonly rotated with no-till wheat; total acreage planted in barley in the Pacific Northwest has decreased over the 2000s. Figures 5 and 6 below present data for barley acreage and prices for Oregon and Washington over the period 2003-2014. In both states, acreage planted in barley has decreased even as prices have showed an overall upward trend. Again, Washington is a much more significant producer of this grain than Oregon.

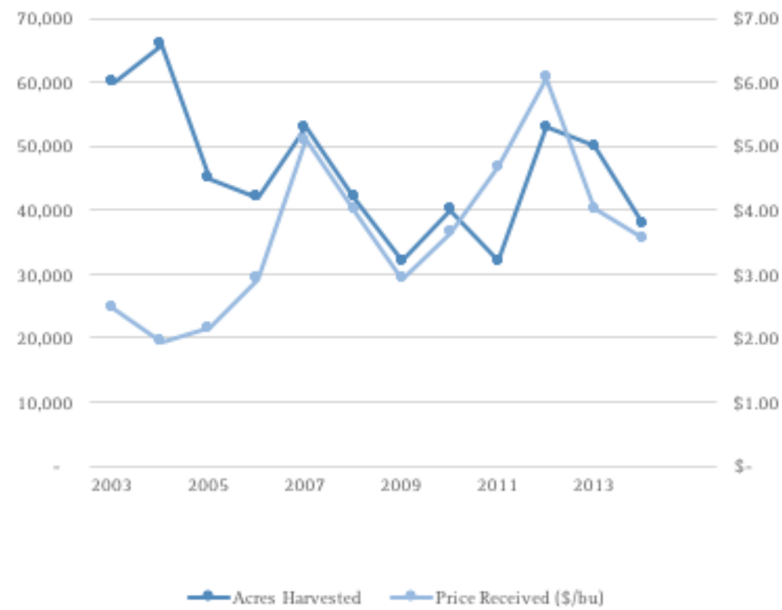

Figure 5. Barley: Acreage and Prices, OR, 2003-2014

Figure 6. Barley: Acreage and Prices, WA, 2003-2014

Figures 7 and 8 below demonstrate a similar trend in oats acreage and prices as that of barley. Even as oats prices have risen since 1995 in both Oregon and Washington, acreage planted has fallen in both states.5 In contrast to barley, the oats crop is more significant in Oregon than in Washington.

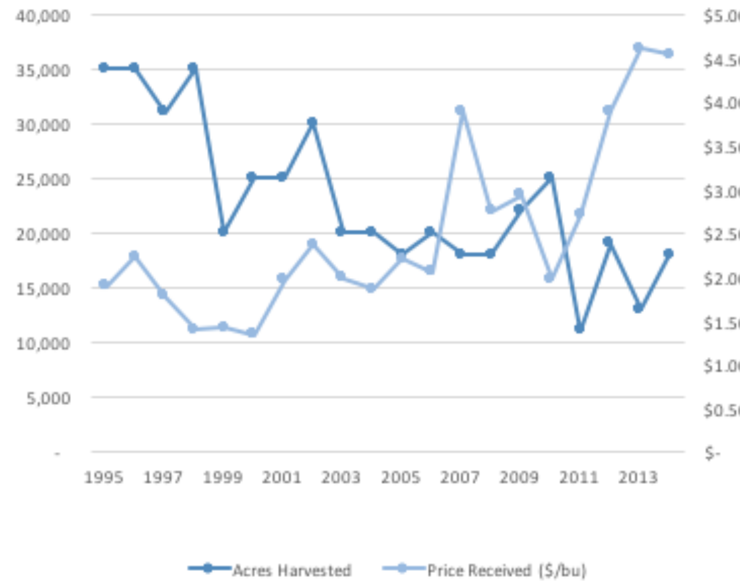

Figure 7. Oats Acreage and Prices, OR, 1995–2014

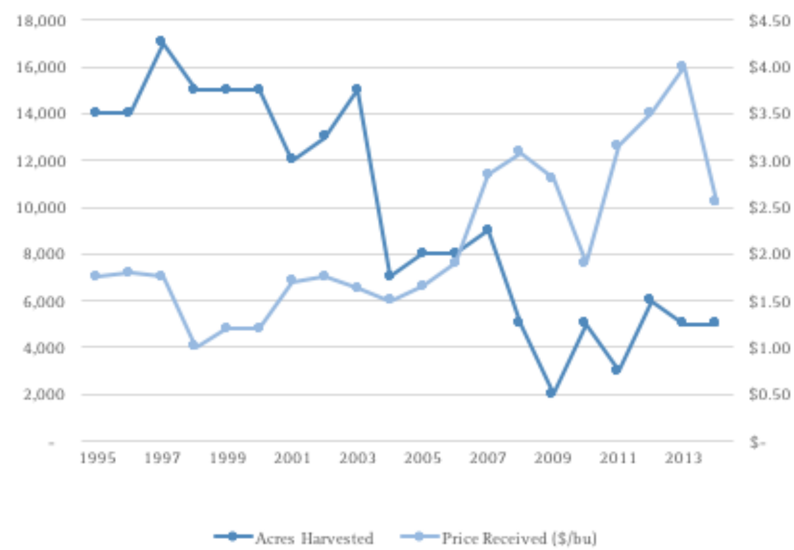

Figure 8. Oats Acreage and Prices, WA, 1995–2014

Publicly available state-level data on acreage and prices for additional rotation crops in the Pacific Northwest, particularly oilseeds, are scarce. Oilseeds currently considered as potential candidate crops for no-till wheat include safflower, sunflower, camelina, and flax seed. State-level price series for these crops over this period are not publicly available. Of these, the only crop for a single state for which multiple years exist, and for which a clear upward trend is evident, is sunflower in Oregon,

5 The longer timeframe given for barley and oats reflects the superior data quality and longer timeframe for regional data on these crops.

presented below in Figure 9.6 Nonetheless, there is significant optimism about the future of these oilseed crops in the Pacific Northwest, and an impact investor seeking to work in this space should keep an eye on their trajectory.

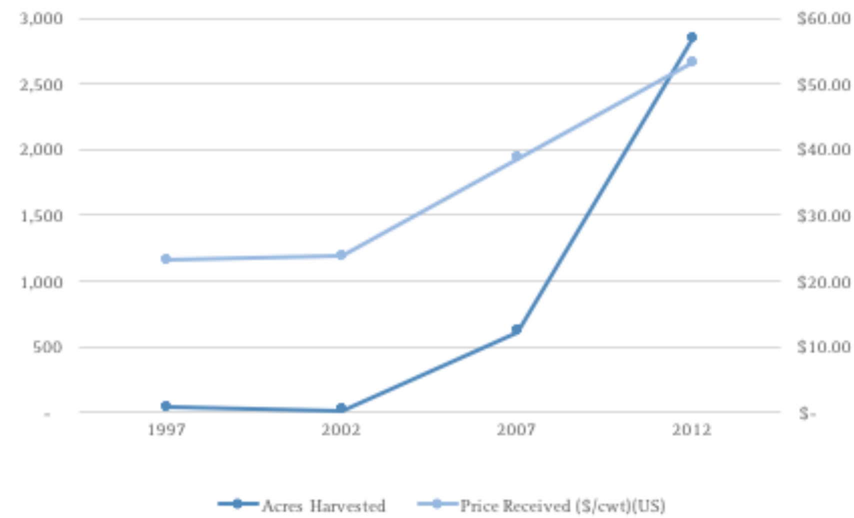

Figure 9. Sunflower: Acres Harvested and Price Received, OR, 1997-2012

The five crops presented in the graphs above are just the tip of the iceberg. Shepherd's Grain has identified about thirty crops with commercial potential in this region, all of which fit into a no-till wheat and small grain growing system. These crops include small grains such as amaranth, sorghum, and millet, and oilseeds such as flax, safflower, and camelina. Some of these crops have yet to be adapted to the current ecological conditions of the Pacific Northwest; plant breeding and related extension research will play an important role in this process in the years to come. Karl Kupers explains, "Finding those microclimates and the small ecological areas that are good for one crop and not another - that's the process that we're in the beginning stages of. I think it'll be about 50 years before we've gotten (these issues) hammered out" (Kupers 2015).

The graphs below indicate that for some rotation crops, regional production has increased at the same time that prices have increased nationally.7 It is possible that the increased production of oilseeds and legumes in the Pacific Northwest is driven by a producer supply response to increased national demand, as in the chickpea case above. The ecological benefits of crop rotation thus reinforce the economically driven supply response, by boosting wheat yields and reducing pest and disease problems while building soil health. The development of markets for rotation crops reinforces the entire no-till system. As David Dobbins relates: "Getting even slightly better prices for the rotation crops makes a big different in farm's bottom line!" (Dobbins 2015) Though the markets for rotation crops are subject to uncertainty as to whether growth will continue, they are certainly worth the attention of investors.

6 The longer time interval between data points for sunflower reflects the fact that regional data on this crop is only available through the five-year Census of Agriculture, rather than the annual Agriculture Survey.

7 Price data series are not available for all of the crops at the regional (Oregon and Washington) level. When price data for the Pacific Northwest is not available, we have used national-level data.

Pricing

An important and emerging trend in alternative grain agriculture in the Pacific Northwest is cost-plus pricing, in which businesses such as Shepherd's Grain pay farmers a fixed markup over farmers' production costs rather than the often-volatile commodity price. Shepherd's Grain calculated its farmers' production costs over a six-month period in collaboration with a researcher from Washington State University. The company determines prices and markups twice a year, February and August; the prices hold for six months each starting the following month, March and September (Lev and Stevenson 2013). This practice de-links Shepherd's Grain from the commodity markets and is one of the keys to the success of its business model. Karl Kupers notes: "In my thinking, (cost-plus pricing) has been the riskiest thing we've done as a business. But in reality, it's probably the safest! We've never had an argument with (buyers) about it. They might not like the pricing. But they never question how we arrived at that pricing - ever!" (Kupers 2015)

The cost-plus pricing model usually guarantees farmers a significant premium over the commodity price. Currently at the time of writing, Shepherd's Grain pays $7.85/bushel for hard winter wheat, versus a commodity price is $5.06/bushel (Moran 2015); the premium paid by Shepherd's Grain for hard winter wheat is over 55%. Nevertheless, Shepherd's Grain farmers remain free to sell grain on commodity markets to capitalize on temporary price spikes. As of 2007, Shepherd's Grain farmers were required to commit at least 10%, but no more than 50%, of their total production of each type of wheat to the business (Lev and Stevenson 2013).

Table 7 below presents a comparison of returns using the prices quoted for Shepherd's Grain and commodity grains above, and the budget information from the University of Idaho study (Painter 2009). The results clearly indicate the superior returns to no-till when cost-plus pricing is used, under the assumptions about production costs from the UI budgets. (Returns are given in bold.) Nevertheless, Shepherd's Grain farmers remain free to sell grain on commodity markets to capitalize on temporary price spikes. As of 2007, Shepherd's Grain farmers were required to commit at least 10%, but no more than 50%, of their total production of each type of wheat to the business (Lev and Stevenson 2013).

Table 7. Comparison of Returns, No-Till/Cost-Plus vs. Conventional/Commodity Pricing

	Conventional	No-Till
Yield (bu/ac)	90	90
Price / bu	$5.06	$7.85
Revenue / ac	$455.40	$706.50
Total Cost	$350.32	$347.12
Return over Total Cost	$105.08	$359.38
Variable Cost	$205.08	$212.43
Return over Variable Cost	$250.32	$494.07

Even as commodity prices have fallen, Shepherd's Grain has continued to grow. General manager Mike Moran estimates five-year average annual growth of over 8% per year, with a recent spurt approaching 15% annual growth (Moran 2015).

Given that U.S. consumers are accustomed to cheap grains, it is not clear how many businesses will be able to adopt cost-plus pricing. Shepherd's Grain is able to maintain the practice through strong branding, product differentiation, and relationships with buyers. On the other hand, cost-plus will always remain attractive to farmers, since commodity agriculture does not guarantee that farmers will be able to cover their production costs. As Chad Kruger notes: "Commodity agriculture means that half the producers are getting prices below costs of production" (C. E. Kruger 2015).

Scale

Scale is an important consideration for impact investors seeking to foster a robust Agriculture of the Middle in small grains. The expensive machinery required for a farmer to adopt no-till or conservation tillage practices means that these practices tend to be undertaken at large scale. The most important of these machines is the drill seeder, which can cost $250,000 (Dobbins 2015).

Dr. Kathleen Painter at University of Idaho is currently researching economies of scale in no-till and related farming practices. The scale effects of no-till farming, which encourage the cultivation of larger plots of land, are driven almost entirely by the need for farmers to invest in new, expensive machinery. Dr. Painter observes:

The cost and scale of machinery has driven (land) consolidation. The machinery is expensive - bells and whistles, high capacity. It's very efficient, it uses GPS and you can run it at night.8 But you can't afford to have that new machinery unless you're quite large. And it is very risky to not have your own machinery. The only way (the farmer) can pay for it is to have a bigger farm with more land. It bids up the price of land (Painter 2015).

The lower marginal cost of no-till agriculture is another factor driving land consolidation. No-till grain farmers must make fewer passes over the land during the cultivation process than their conventional counterparts: whereas conventional agriculture can require up to 12 passes over the land, no-till agriculture requires only 1-2 passes. The cost of cultivating an additional acre of land – the marginal cost of cultivation - is thus lower for the no-till producer than for the conventional (C. E. Kruger 2015). Given these lower marginal costs, a no-till farmer can bid up the lease price of land and thus outcompete the conventional farmers in the land leasing market. No-till farmers are thus able to aggregate large plots of land, more quickly, than their conventional counterparts.

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8 The high level of sophistication in no-till farm machinery is part of a larger trend of technological change in U.S. farming known as precision agriculture, which has attracted large amounts of capital investment, research funding, marketing, and news sources (PrecisionAg 2016).

Though the drill seeding machinery needed for no-till agriculture tends to incentivize production at large scale, smaller growers can still adopt reduced tillage or conservation tillage practices without having to invest in new machinery. The key to cost savings from reduced or conservation tillage is the fewer number of passes over the land, mentioned above, which saves the farmer on labor and fuel costs while reducing erosion. A skilled farm manager practicing conservation tillage can achieve high yields with only 3 passes over the land (Painter 2015).

In general, a farmer's decision to adopt no-till versus conservation tillage is often a financial one based on the condition and age of machinery and equipment, and the desired scale of operation. If machinery is sufficiently decrepit to require replacement, the farmer may choose to convert entirely to a no-till system; however, if the farmer seeks to retain the same machinery with minor modifications or retrofits, conservation tillage is often a more cost-effective option. If the farmer is seeking to scale up production (and is capable of doing so), investing in new machinery may be more cost-effective than retrofitting the old. In this case, no-till may be the more cost-effective option as well.

Management skill is critically important in making no-till and conservation tillage practices economically competitive with conventional. David Dobbins notes that proper management of crop residue is an important condition for the success of no-till. For example, the no-till drill machinery requires that the previous year's crop residue must be cut to the correct height. Otherwise, the seeds are not properly planted into the soil, but stay in the residue and fail to grow properly. The farmer must think one year ahead at the time of harvest, planning for the kind of residue necessary for the following year's crop: successful management requires that the residue hold snow and moisture during winter, but remain short enough to ensure successful planting in the spring (Dobbins 2015).

Providing transition financing for farmers to convert from conventional to no-till agriculture, including the purchase of expensive equipment and machinery, is one area in which impact investing may be able to fill gaps in capital markets. But this endeavor should be approached with caution, due to recent developments in U.S. agriculture. Between 2008 and 2014, during a time of high food and energy prices, the entire agriculture sector in the United States went through a period of intense investments in equipment and machinery. These years saw rapid adoption of no-till farming techniques, as farmers were able to afford the equipment and machinery necessary to make the shift; many of these purchases were self-financed. In the last two years, as energy and food prices have fallen, this investment has slowed. An impact investor seeking to provide below-market transition loans to farmers seeking to adopt no-till practices should assess carefully the farmer's financial solvency and management skill, inquiring carefully why the farmer did not make the transition during the recent boom times.

Processing Infrastructure

Table 8 below presents data from the County Business Patterns for the four-digit NAICS category 3112, Grain and Oilseed Milling, which covers oilseed crushing and pressing and milling of all grains, for Oregon and Washington, over the period 1998-2013 (U.S. Census Bureau 2015).

Table 8 below indicates an overall pattern of a shrinking number of small mills (less than 10 employees), and an increase in the number of mid-sized mills (10-49 employees), and no change in the number of larger mills (50-249 employees); the largest mill (over 250 employees) either has shrunk in size or no longer exists. These patterns could be caused by a number of factors including closure of small mills, consolidations/mergers increasing mill size, growth of small mills to mid-size, or start-up of mid-size mills.

Table 8. Grain and Oilseed Milling, Oregon and Washington, 1998-2013

	Year				
# Employees	1998	2003	2008	2013	% Change (1998-2013)
'1-4'	9	6	5	5	-44%
'5-9'	8	6	4	6	-25%
'10-19'	4	2	4	6	50%
'20-49'	6	5	6	8	33%
'50-99'	6	4	4	6	0%
'100-249'	4	3	3	4	0%
'250-499'	0	0	1	0	0%
'500-999'	0	0	0	0	0%
'1000 or more'	0	0	0	0	0%

Both the data and anecdotal evidence indicate a shortage of medium-sized to large-scale grain and flour mills in the Pacific Northwest. For instance, all of Shepherd's Grain's wheat flour is processed at the Archer Daniels Midland (ADM) mill in Spokane. ADM is the only significantly sized flour mill within reasonable distance of the Shepherd's Grain producers (Lev and Stevenson 2013).

Drivers of Demand

Transparency

Transparency – knowing where your food comes from – is an increasingly valuable attribute in agriculture and food markets. The local food movement can be seen as part of a broader movement among consumers to know and understand the process of food production, including the farmer's environmental stewardship, labor practices, food safety, and the product's nutritional and biological content, including the presence or absence of controversial crop attributes such as genetic modifications (GMOs). Certifications, such as Food Alliance, the family of organic certifiers, and the fair trade certification movement, all exemplify this trend as well.

Mike Moran, general manager of Shepherd's Grain, explains that his company's transparent sourcing and trading practices have worked to their advantage in the marketplace: "While local is a driver unto itself, at some level what people are looking for is transparency. The easiest way to build trust is a transparent, information-filled supply chain" (Moran 2015). The relatively transparent supply chain that Shepherd's Grain offers has attracted name brands that supply large retailers, such as J.M. Smucker and Beekman 1802 (which supply Target).

Crop Diversity

The increased diversity of grains, oilseeds, and legumes that accompany no-till grain growing lend themselves to a wider variety of products than in a conventional monoculture wheat growing system. As demand for food products in U.S. markets diversifies, an agricultural system that produces and markets multiple crops will find itself more economically robust. Figure 1 through Figure 9 indicate that markets for many of the key rotation crops in the no-till / conservation tillage toolkit are growing. Demand for foods high in nutritional content, such as chickpeas, sunflower seeds, and flaxseed, are probably an important driver for market growth in these crops.

As a side note, in addition to increased demand for rotation crops, demand for heritage grains such as emmer, spelt, and kamut, have also risen. Some of these grains are grown as part of a no-till or conservation tillage rotation, and some not. The heritage grains movement is currently a small-scale, through growing, market niche; heritage grains sell at premium prices and are highly sought-after by groups of health-conscious and novelty-seeking consumers. But it is not yet clear to what extent they'll become a mass market phenomenon.

Nutrition

It is possible that grain crops grown using no-till or conservation tillage have higher nutritional content than conventionally grown grains. As Dr. Jill Clapperton of agriculture consulting firm Rhizoterra writes, "Agricultural practices such as crop rotations and tillage affect the numbers, diversity, and functioning of the micro- and larger-organisms in the soil community, which in turn affects the establishment, growth, and nutrient content of the crops we grow" (Clapperton 2003). By re-establishing a dense and diverse soil microbial life, no-till and conservation tillage may increase the nutritional value of crops. Research in various areas of agriculture has borne out these findings. For example, a 2010 study by Dr. John Reganold of Washington State University has revealed a positive association between organic farming practices, which build soil microbial life, and the nutrition, taste profile, and shelf life of strawberries (Nameth 2010).

However, the findings of these studies are not uniform and the causal linkages not well specified. In the area of small grains, there are relatively few published studies that attempt to quantify the causal linkages between tillage practices and the nutritional content of food crops. As a result, there are relatively few companies that market crops grown under no-till or conservation tillage based on their nutritional content. This area could benefit from additional research, followed up by public engagement and storytelling if the findings support the hypothesis.

Environmental Values and Consumers' Willingness to Pay Premiums

The question of how to market no-till and related forms of agriculture to consumers remains open to debate. It is not clear whether the attribute of "no-till" or conservation tillage will catch on in the same way, or to the same degree, that the attribute of "organic." And there is a range of views among practitioners about whether it should.

Mike Moran, General Manager of Shepherd's Grain, favors a marketing approach based more on systems thinking. "No-till is only one component (of the management strategy)," he says. "I would like us to talk more about conservation and regenerative agriculture practices. The focus is on soil health; no-till is one contributor to soil health. What does the farmer do to support no-till? Diversity of rotations, et cetera. No-till fails when you adopt it into a monocultural system" (Moran 2015).

Karl Kupers, co-founder of Shepherd's Grain, advocates for no-till as a marketable attribute. "In any conversation (about sustainable agriculture) the dust settles back onto a system that is as closely living to nature as possible. It's easily understood: nature doesn't till. Nature has diversity. So what are we doing? We're providing a diverse, no-till production system" (Kupers 2015).

Currently no widely published studies measure consumer willingness to pay for no-till as a product attribute. However, the increasing publicity that no-till techniques have received in the popular literature on food systems suggest that the practices are becoming recognized as an important agricultural innovation to combat climate change (Ohlson 2014).

Conclusion and Recommendations

This brief study has identified the economic and ecological benefits of a diverse small grains agriculture with reduced or eliminated tillage. For investors, the task remains to identify market opportunities in this area. Currently, Shepherd's Grain has no direct competitors; it is the only company in the Pacific Northwest marketing differentiated small grains and rotation crops with reference to tillage practices and crop rotations (Moran 2015).

The processing of rotation crops is one area in which impact investment could make a difference. The historical focus of the Pacific Northwest's grain marketing system on wheat; the growing markets, profitability, and high prices of rotation crops; the low excess capacity in grain and oilseed milling in the region; and the current wave of farmers adopting no-till or conservation tillage with crop rotations, all suggest that investment in processing infrastructure for potentially profitable rotation crops, including safflower, sunflower, and canola, as well as sorghum, amaranth, and millet, may be a profitable channel for an impact investor to pursue.

The further development of regional markets for rotational crops is a second area in which impact investment could be catalytic. Existing data, while relatively scanty, indicate that markets for several rotation crops, including chickpea and sunflower, are in a period of growth. Existing no-till farming experts have identified a wide range of potential rotation crops.

The pursuit of marketing campaigns and storytelling to engage with the public on the myriad benefits of these new forms of agricultural practices – for example, on grounds of nutrition, environmental stewardship, and farmer well-being - could also prove a fruitful channel for philanthropic investment. Storytelling, images, branding, and data visualizations can all play a role in communicating these benefits to the public.

Transition financing is the fourth and final area in which there may exist opportunities for investors to play a catalytic role. There currently exist financial arrangements for farmers to undergo transition to conservation tillage or no-till, mostly through the conventional channels of agricultural lending for land and equipment purchase (Kupers 2015). However, it remains to be seen whether these financing options are sufficiently competitive to maximize the adoption of the new practices, or whether an impact-oriented investor could offer farmers superior lending rates and terms, catalyzing a more rapid transition to a regenerative agriculture. Importantly for investors, the farmer's skill level and financial solvency are important areas to consider when seeking to develop a transition financing product; farmers who did not invest in new equipment during the recent boom in agricultural investment may present higher than average risks.

Finally, it is worth remembering that the type of agriculture described in this document is still evolving. While an important attribute in its own right, "no-till" should not become a fixation or single-minded focus for impact investors or philanthropists. It is not a one-size-fits-all solution; rather it is an important alternative for farmers facing heterogeneous conditions of climate, landscape, soil type, and skill set. The focus of philanthropic intervention or impact investment in agriculture, rather, should be on the regenerative properties of the system that includes both no-till / conservation tillage and crop rotations. As a 2008 article in Scientific American puts it, "No-till is not a cure-all; such a thing does not exist in agriculture. Rather it is part of a larger, evolving vision of sustainable agriculture, in which a diversity of farming methods from no-till to organic—and combinations thereof—is considered healthy." (Huggins and Reganold 2008)

Appendix: Organic Wheat

This brief paper has focused almost entirely on the production system for no-till wheat. Why did we not choose organic wheat? The answer lies in the data: compared to the scale and scope of no-till, and to the size of the small grains sector as a whole, organic wheat is not an economically significant production system in this region.

Table 9 below provides a synopsis of organic wheat production in the U.S. Pacific Northwest (Oregon and Washington) in 2014. In 2014, there were 10,528 acres of certified organic wheat being grown in the Pacific Northwest, and 3,150,000 total acres of wheat (NASS 2015). Organic thus comprised 0.3% of all wheat grown in the region, with a total of 82 farms with organic sales. In 2004, about 330,000 acres of wheat in Oregon and Washington were produced using no-till techniques; using that figure as a (lower bound) benchmark, we can say that the scale of no-till wheat farming is at least 30 times that of organic.

While there undoubtedly exist a group of successful organic wheat farmers in the Pacific Northwest, organic production practices are simply not as important in this product category as no-till or conservation tillage. By contrast, in fruit and vegetable product categories, organic production practices represent an important, rapidly growing, and economically viable alternative which has begun to gain significant market share at the expense of conventional agriculture over the last two decades. For this reason, we chose to focus on the no-till / crop rotation systems in the context of Agriculture of the Middle, and intend to focus on organic production of greens and storage crops in the next two installments of this research.

Table 9.
Organic Wheat Production and Sales, Oregon and Washington (2014)

	2014
Acres Harvested	10,528
Number of Farms with Sales	82
Total Production in Bushels	622,370
Total Sales (all in organic markets)	$ 8,950,080

The trend in the production of organic wheat in the Pacific Northwest appears to be upward, but inconsistent.

Table 10 below provides data on the trajectory of organic wheat acreage in the U.S. Pacific Northwest, and the nation as a whole, over the period 2001-2011 (USDA ERS 2013). From 2001 to 2011, the acreage planted in certified organic wheat in the Pacific Northwest increased from 2,598 acres to 9,861 acres – nearly a fourfold increase. However, the reported acreage harvested in 2014, 10,528 acres (reported above), is less than the amount reported in 2010 (11,325 acres). It is not clear whether the long-term trend in organic wheat acreage in the region is consistently upward.

	2001	2002	2003	2004	2005	2006	2007	2008	2010	2011
U.S. total	194,640	217,611	234,221	214,244	277,487	224,782	329,688	415,902	348,041	335,829
Oregon	483	1,065	-	1,554	1,779	562	1,999	4,019	4,799	4,076
Washington	2,115	1,547	1,669	3,908	3,819	3,257	1,676	4,390	6,526	5,785
Pacific Northwest	2,598	2,612	1,669	5,461	5,598	3,819	3,675	8,409	11,325	9,861

Table 10. Organic Wheat Acreage, U.S. Total and Pacific Northwest, 2008-2014

Nationwide, market demand for organic grain products is increasing, but not keeping pace with the other categories of organic production. A recent article in Nutrition Business Journal traced demand for the value of organic food sales in the United States by food product category over the period 2005-2014. The study found that national demand for organic bread and grain products had risen from $1.36 billion to $3.16 billion; however, this category's share of the national organic food market had fallen from 10.2% to 9.1%, as demand in the other product categories has grown faster (Economic Research Service 2015).

In summary, while organic grain growing in the Pacific Northwest is deserving of some attention, it has not been as transformative as the practices of no-till and conservation tillage.

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(Footnotes)

1 In the sample budget for garbanzo, fertilizers are not used, and fungicides are applied. In the corresponding budget for wheat in Table 4 above, fungicides are not used, and fertilizers are a significant input.

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