Crossroads Resource Center

7415 Humboldt Ave. S. / Minneapolis, Minnesota 55423 / 612.869.8664
kmeter@crcworks.org www.crcworks.org/

Tools for Community Self-determination

Photo from British Broadcasting Corporation

Three Potential Value-Added Opportunities for the San Luis Valley

Prepared for Adams State University
Value-Added Committee
Alamosa, Colorado

By
Ken Meter
Megan Phillips Goldenberg
Crossroads Resource Center
Minneapolis
March 16, 2018

Table of Contents

Executive Summary

Adams State University has launched a Value-Added Committee, consisting of stakeholders in the San Luis Valley (SLV) who are pursuing new economic opportunities for the Valley's farmers and businesses. This group has written a strategic plan that suggests several specific opportunities for the Valley. Adams State wishes to have several of these options researched to see which ones would be most fruitful to pursue.

The following specific opportunities, identified in the strategic plan, were prioritized by Adams State:

- Grow organic feed for grinding by a Valley mill to serve as feed for two SLV poultry producers selling eggs to Organic Valley.
- Explore the potential for an industry that produces pelletized organic fertilizers for SLV farms.
- Identify markets for quinoa that is produced by Valley farms.

Purposes:
To pursue economic development strategies that will help build health, wealth, connection, and capacity in the San Luis Valley.

To the greatest extent possible, rely upon resources, materials, goods, and services that can be found or produced in the Valley.

Goal:
With these purposes in mind, Crossroads Resource Center and New Growth Associates have researched the three potential value-added business opportunities in order to determine which ones hold the highest potential value to the San Luis Valley.

Our interviews showed that Valley growers are pursuing deliberate and effective trials of all three opportunities identified by the Value-Added Committee, although they may wish to enhance their knowledge by reviewing literature cited in this report.

Moreover, since one of the key purposes of this study is to "pursue economic development strategies that will help build health, wealth, connection, and capacity in the San Luis Valley," Adams State may wish to encourage growers to focus their attention less on export markets, and more on farm inputs that can be sourced within the Valley, as well as on crops, and livestock that can be sold to Valley consumers. Marketing through shorter and more localized market channels may offer growers better opportunities to hold power over the prices they charge, and will also build effective social and commercial networks within the Valley.

Such strategies may also create new opportunities for farmers and consumers to take advantage of the relative isolation of the Valley. Rather than operating at a distance from markets and incurring long-distance transportation costs, growers may find that more localized opportunities help insulate them from market pressures (assuming sufficient buyer loyalty can be built) and may create special opportunities to grow seeds and crops that are relatively free from cross-contamination.

Action Priorities for Part I, Organic Feeds

- Collaborate with CSU researchers and Jeremy Yoder to learn more about the feasibility of using flax seed as a feed for laying hens.
- Collaborate with Patrick O'Neill to pursue feed options that tested well in his field trials.
- Explore at a small scale the use of other Valley-grown small grains as feed for organic poultry, including trials that involve feeding heritage poultry varieties.
- Foster the transition of more SLV farm acreage to organic production; continue to build soil organic matter in order to increase water retention capacity.

Action Priorities for Part II, Pelletized Organic Fertilizer

- Place a priority on refining the pelletizing of green matter from alfalfa and woody plants to identify commercial opportunities.
- Continue to collaborate with CSU to study actual benefits of pelletized alfalfa as a fertilizer.

Action Priorities for Part III, Valley-Grown Quinoa

- Continue to expand sales in US markets, contracting with sales experts as possible to obtain wider reach.
- Continue to build soil organic matter and fertility to improve quinoa yields.
- Continue to enroll new growers as possible.
- Explore marketing campaigns to increase consumption of organic quinoa by San Luis Valley consumers.
- Explore value-added products (such as locally made veggie burgers) that could use quinoa grown in the Valley.

Other possibilities

- Explore sales of organic potatoes to Organic Valley.
- Explore production and processing of pork, beef, eggs, and broilers for San Luis Valley consumers.

People Interviewed

Name	Position	Organization	Location
David Bruce	Egg Coordinator	Organic Valley Co-op	La Farge WI
Ted Heersink	Owner	Majestic Valley Farm	Alamosa CO
Beverlee McClure	President	Adams State University	Alamosa CO
Paul New	Owner	White Mountain Farm	Alamosa CO
Patrick O'Neill	Coordinator	SLV Soil Health Working Group	Alamosa CO
Brendon Rockey	Owner	Rockey Farms	Alamosa CO
Karla Shriver	Owner	Pro Mountain Farms	Monte Vista CO
Dr. Will Winter	Owner	Holistic Management for The Land and Animals	Minneapolis MN
Randy Wright	Coordinator	Alamosa County Economic Development	Alamosa CO
Jeremy Yoder	Owner	Yoder Farms	Trinidad CO

Part I: Organic Poultry & Dairy Feed Based on SLV Inputs

Valley Activity to Date

A group of Valley growers participated in a meeting in which several farms expressed interest in raising feed for local farms that sell to Organic Valley. Our sources said this meeting was convened by David Toews, who raises organic barley and potatoes.

Organic Valley is the primary buyer of organic egg and milk production in Valley. The Co-op, based in La Farge, Wisconsin, was formed by 8 farmers in 1988 and now partners with more than 2,000 farmers across the US. Its sales exceed $1 billion each year. Co-op leaders say that the firm has sustained at least a 2% profit throughout its history.

The Organic Valley web site once showed all of its farmers in an interactive map, but was redesigned recently and this function is not available as of this writing. As of July, 2017, the co-op listed 2 laying hen operations near Alamosa, with 3 others near Del Norte. It also listed 2 dairy farms in Alamosa, and 1 in Del Norte. It further showed one grain farm in the far northwest of the Valley. These farms are primarily, but not exclusively, run by Mennonite farmers, and one Amish farmer.

The main source of organic grain for the poultry and dairy farms is Jeremy Yoder, who farms near Trinidad, more than 100 miles east of Alamosa. On these plains east of the Front Range, conditions for growing grains are more reliable than in the Valley itself. Yoder, who is Amish, was introduced to us through David Bruce, egg coordinator at Organic Valley, who added that Yoder grows high-quality organic alfalfa. Bruce cautioned that "we don't have a lot of volume" in the Valley (Bruce interview 2017), but he encouraged this conversation to move forward.

Yoder says that in the past few years he has supplied each of the 8 livestock farms supplying Organic Valley with corn and soy as feed grains, but added that he only supplies 4 right now, because farmers change their purchasing priorities over time. Yoder told us that he can supply all 8 farms with all the feed they need. Yet he envisions that as organic production expands in the region, there may be more demand in the Valley than he could supply (Yoder interview 2017).

Yoder currently farms 1,500 acres of certified organic acreage, upon which he rotates corn, alfalfa, bearded winter wheat, and oats. Holding 500 acres out of production for wildlife, he also has his own laying hen operation, and a feed mill that he added in the Spring of 2017. "We have enough capacity that we could supply all of the chicken and diary barns," but he added that there is potential for the industry to grow beyond this capacity. "In 5 to 10 years, hopefully there will be quite a few more chicken barns," he added. At that time, other farmers would be needed to supply the demand.

Yoder believes that "corn and soybeans are the best option for chicken feed. It is hard to improve on those," but he is open to substituting other grains especially since growers have expressed a desire to switch to other feeds [seeking to avoid GMO soybeans]. So far, he says, these substitutions never pencil out when compared with current corn and soybean prices. "Farmers won't raise those grains for the price I can pay for them."

He added that he is happy to work with other growers in the San Luis Valley to consider other options. "I am open to talking any time," he said.

In particular, he said that he is interested in efforts to produce "any protein" in the Valley that can complement the corn and soybeans he currently grows. "We struggle to grow field peas here [in Southeast Colorado]," he added. He has even stronger interest in flax because of its omega-3 content, and this cannot be grown in his region. He thinks it would do well at higher elevations.

Yet barley and field peas were historically important feed grains in SLV. In fact a century ago, the two grains were prized as a feed that lent pork a distinctive flavor to pigs raised in the Valley. The Colorado Experiment Station concluded in 1909 that, "The chief pea feeding section in Colorado is the San Luis Valley, where the altitude is from 7,500 to 8,000 feet….The pork from hogs well fattened on peas is firm, sweet, and tender, and has a most delicious flavor," (Colorado Experiment Station 1909). The report further stated that pigs were turned into the fields to eat field peas after frost had killed the vines. It made the bold prediction that, "The San Luis Valley has a tillable area equal to the State of Connecticut, and if one-half of this tillable area was devoted to hog raising, there could each year be marketed from the valley over three million well-fattened hogs" (Colorado Experiment Station 1909).[1]

According to the respected former farm magazine *The Country Gentleman*, "Prof. George E. Morton, of the Colorado Experiment Station, demonstrated with carcass tests that barley-fed pork is whiter, firmer, and of better flavor than pork produced with any other grain. He demonstrated that barley added to peas as a ration for hogs eliminates the shrinkage that is well known in pea-fed pork," (The Country Gentleman, 1916b). Whether these claims would hold up under current scientific scrutiny, or with current breeds of pigs or varieties of grains, is unknown.

The magazine continued by calling out the San Luis Valley specifically. "The finest pork that comes to the Denver market is from the San Luis Valley of Southwestern Colorado. The growers have learned what a fine feed barley and peas make, and every year they finish 40,000 hogs at an elevation of 7,500 feet — too high for the growing of corn" (The Country Gentleman, 1916b).

However, the Experiment Station further cautioned that "Hogs fed peas alone fatten unevenly, some finishing quickly, while others gain, but become unthrifty, showing that a diet of this one grain does not agree with them" (Colorado Experiment Station 1909).

Organic Valley feed specialists stated that they had the impression that there are "hard challenges" in feeding field peas to poultry, but their technicians did not specify what these challenges were.

SLV consultant Patrick O'Neill added that there were limitations to the quantity of field peas one could add to poultry feed. He said that in Canada and Washington State there have been successful trials of a feeding ration using wheat, field peas, and a complex assortment of other items. These rations require special attention to get nutrient balance correct, he added. He said it is easy to get corn from Colorado farms, but not soybeans. "There are a lot of other locally produced products that we could feed." He

[1] One farmer, veterinarian, and owner of an animal feed company in Minnesota said that he typically uses the same feed rations for pork as for laying hens (Winter, 2017).

performed feeding trials in the summer of 2017, and said he would have data by October that he would be willing to share (O'Neill interview 2017).

The Country Gentleman also reported that hempseeds were highly favored as part of a poultry feeding ration a century ago. "In recent tests at a Kentucky station chickens that were fed hemp made the best growth. Besides hempseed they received wheat, cracked corn, sunflower seed, bran, finely ground wheat, barley, rice, and hominy. The mash, composed of the finely ground feeds, was wet down with sour skim milk. The birds' appetite for hempseed was remarkable. They would pick out the hempseed from a grain mixture before eating the other grains." (The Country Gentleman 1916a).

All the same, it must be kept in mind that current chicken varieties are also bred for their compatibility with corn and soybeans as a feed, and this may make old-time feed rations untenable unless heritage varieties are raised. Heritage varieties tend to be less productive from an absolute feed conversation perspective, but they are also better foragers if allowed proper pasture access.

Yoder outlined a rough formula for what he feeds chickens, listed below. He added that each farmer in the Organic Valley cluster selects his own feed ration, so feeding will vary from farm to farm (See also the Appendix for several poultry feeding formulas) and vary on each farm over time.

- At most 300 lb. per ton (15%) of protein grains other than soybeans
- 200 lb. per ton (10%) of wheat
- 150 lb. per ton (8%) of calcium and other mineral supplements
- The rest (1,350 lb.; 67% or more) is "basically corn and soybeans."

Patrick O'Neill added that one essential nutrient, methionine, might be taken off the list of approved organic supplements, which will pose a big challenge to organic production (O'Neill interview 2017). Other organic poultry proponents are also concerned about this possibility.

Organic Valley's David Bruce said that the firm has been in the region for about 4 years, and does not feel a strong need to seek additional sources of feed for the farmers who grow for them, because Yoder can supply all that is needed. He further expressed concern that the dairy farmers in the Valley "don't have a good home for their milk right now." It is not clear at this time what potential this might represent for the Valley. Indeed, dairy farmers in New England tell us that Organic Valley will reduce its milk purchases and lower the price it pays farmers in 2018.

Of greater interest to Bruce at Organic Valley was the prospect of San Luis Valley farmers raising organic potatoes for them as they increase produce sales.

Patrick O'Neill added that Organic Valley does not market their eggs as a locally grown product; they simply become commodities that are packed in Organic Valley cartons and shipped wherever the market takes them. This may limit opportunities for farmers to hold power to set prices for their products or create a dedicated consumer base.

To assist San Luis Valley farmers and their partners in exploring feed choices, we have prepared a review of feed requirements for poultry.

Overview of Feed Requirements

One of the most valuable and critical components of any feed regime is the protein source. This is particularly true for poultry and hogs, which are historically omnivorous, versus ruminants, which are strictly herbivores. Still, a lactating dairy cow requires at least 16% protein in its feed while pullets and laying hens require 15-20% protein during various stages of growth and production.

Small grains, such as barley, wheat, and rye, can have crude protein levels between 10 and 15% and are a very common component of feed rations. Corn contains an average of 7.5% crude protein and is valued more for its energy or calorie content. Soybeans contain about 38% crude protein and are typically the number one protein source in any feed ration. Byproducts of either corn or soybeans, such as meal, can have higher protein concentrations. Some feed rations have included flaxseed meal as a helpful, value-adding supplement, but it does not easily replace soybean meal since it has an average 22% crude protein, lacks some vital nutrients, and at levels above 2-3% of feed ration, retards growth, causes liver hemorrhages, and is potentially toxic through unknown biological pathways (Jacob, 2015; Kratzer & Vohra, 1996).

Similarly, limited research suggests that while quinoa is a fantastic source of protein and vital amino acids, its not suitable as a replacement for soybeans. Preliminary studies suggest that even with some processing to remove the toxic outer layers, quinoa retards poultry growth and layer production, though the reasons are unknown (Jacob, 2014).

Interesting research suggests that hemp meal, a by-product of industrial hemp production, could be a good substitute for soybeans, but this is not well studied. There is currently very limited published research in the United States for the use of hemp and marijuana products or byproducts in animal feed (Washington State Department of Agriculture, 2017). Furthermore, the use of hemp and marijuana products or byproducts for commercial animal feed is currently not allowed in the United States, even in states that allow the production of cannabis (Washington State Department of Agriculture, 2017). However, it is allowed in the EU; and Canada is currently allowing research to be conducted. Hemp products generally have protein levels between 24 and 32%, which is comparable to rapeseed, linseed, flaxseed, and soybeans (Washington State Department of Agriculture, 2017; Gakhar, Goldberg, et al, 2012). Hemp products are also significant sources of fiber within a feed diet, making up for the lack of fiber in cornmeal and soybean meal, thus improving digestive health in the animals (Washington State Department of Agriculture, 2017).

For all of these reasons, most commercial feed regimes rely on soybeans to supply necessary proteins for raising animals. Organic corn and soybeans for livestock feed are widely considered solid emerging markets. Ironically, while the United States is the largest grower and exporter of soybeans and corn in the world, exporting 40% and 20% of annual production (Widmar, 2016), respectively, organic soybeans and organic corn are some of our largest organic imports. US Imports of organic corn from Romania toped $12 million in 2014, and imports of organic soybeans from India doubled to $74 million in the same year. Total organic imports for the year hit $1.3 billion, when accounting for all items including produce and coffee (Bjerga, 2015). Furthermore, organic milk continues to be in high demand [though as noted above this may be softening], yet supply is constrained by shortages in the organic livestock feed industry.

Many livestock growers prefer to move away from soybeans as a feed for a wide variety of reasons. Beans are not grown in all climates, notably the Valley itself. Conventional beans are typically genetically modified (GMOs), which many farmers and consumers wish to avoid, while organic beans are often considered too expensive to utilize in a feeding regimen. Nutritionists have raised concerns about soy's suitability for human consumption. All the same, there is little research on economical replacements that are nutritionally comparable. Replacing soy with other heat-treated legumes such as beans and peas has the most potential. Yet as with small grains, it is difficult to get poultry to eat enough to satisfy their protein requirements (Hermes, 2010). Commercially available soy-free feeds rely on proprietary mixes of field peas, fishmeal, alfalfa meal, and flaxseed meal.

Pasture-raised poultry may be able to "hunt" enough protein on a well balanced and maintained pasture to overcome a soy-free diet, yet studies concluded that unlike ruminants, poultry will only graze 5-20% of their typical feed requirements (Mattocks, 2002). One study of pasture-raised broilers found that soy-free birds ate more feed per unit of weight gain, resulting in an average total cost increase of $0.75 per pound of carcass weight. General observations also concluded that birds on a soy-based diet are "more robust and healthy" (Mattocks, 2013). Studies are exceedingly limited and the vast majority of publications recommend staying with soybeans as a protein source. Moreover, most of the available chicken breeds are Cornish Cross varieties that have been bred to gain weight maximally eating soybean meal, so many growers who wish to avoid soybeans also switch to heritage varieties that are not as adapted to soybean meal. Making this switch may require growers to charge more per pound to help compensate for slower growth rates.

Production and Supply

Any environment that is suitable for growing small grains, and/or GMO soybeans and corn is suitable for their organic counterparts. The biggest difference, however, is that organic grains need to be grown on certified organic land. Certified land is limited in availability and has not kept up with emerging demand for organic crops. The conversion of conventional acreage to certified organic acreage takes three years, during which producers must use organic practices but market their products as conventional for the first two years. Furthermore, organic crops need to be isolated from their GMO counterparts through their growing-to-distribution cycle to avoid cross contamination. One of the potential barriers to widespread adoption of organic production is the lack of information regarding efficient production practices and costs of production (McBride, Greene, Foreman, & Ali, 2015).

Organic production practices have been the focus of much research, both in controlled experimental settings and in real, on-farm situations. The general conclusion is that organic crops outperform their conventional counterparts, both in gross and net profits, even when accounting for the costs of transition and reductions in total production (McBride, Greene, Foreman, & Ali, 2015). For example, in most years, conventional crops will produce higher yields, but the higher price premiums and lower seed costs make up for any decreased yields experienced in organic cropping systems. In drought years, organic crops may even out produce conventional crops because soil with higher organic matter retains more moisture. This could lend an economic advantage to farmers who adopt organic practices in places like Colorado (Pimentel, Hepperly, Hanson, Doubs, & Seidel, 2005). Organic crop yields may be lower due to weed pressure, but well planned crop rotations and mechanical interventions can make up for some of this[2].

[2] A review of national ARMS data suggested that the mean total economic cost of organic corn is $552.24 per acre, versus conventional corn at $552.23 per acre. Soybeans, however, are much more disparate, with total economic costs of organic soybeans estimated at $340.07 per acre versus $275.89 per acre for conventional soybeans (McBride, Greene, Foreman, & Ali, 2015). Supply data regarding organic crop production is not robust and largely

Given the lack of corn and soy produced in the Valley today, nearby poultry growers have turned to the Yoder farm in Southeast Colorado, as noted above. The last time acres of corn planted were recorded for SLV[3] was 1980. There is no production data for soybeans in SLV, however the area research center is piloting it as an alternative crop, along with canola, quinoa, naked barley, cucumbers, durum wheat, fava beans, pinto beans, and soybeans. Historic Colorado State University Extension Bulletins do advocate for growing soybeans under irrigation as a feed ration. Some small grains — barley, oats and wheat — are grown in some quantities in SLV, suggesting that additional production is possible, should demand rise. This suggests that an appropriate, locally produced protein source is scarce in the Valley and that a 100% local grain feed regime will be difficult to deliver at scale, either organically or conventionally under current climate constraints and market prices.

Additional supplements, such as oyster shell fragments for calcium, can be easily and economically shipped in from other regions, including commercially available vitamin supplements. Without these amendments, a commercial feed will be difficult to market, especially an organic one. These vital nutrients also limit the ability to produce a 100% locally grown poultry feed. Grains are typically low in lysine while legumes are typically low in methionine. Synthetic amino acids like lysine and methionine are restricted in organic production and many believe they will be banned soon, as Patrick O'Neill pointed out above. Organic producers make up for these shortfalls with commercially available nutrition supplements, fishmeal, or other animal byproducts.

The Appendix contains several different feed rations, scaled by feeding 1,000 hens annually, and related to acreage required, based on reported yields for Colorado growers where appropriate.

Infrastructure and Equipment

The processing of organic grains into feed is nearly identical to their conventional and GMO counterparts. They are harvested with a combine and can be sufficiently cleaned in the fields. Grains must be stored until milling, and then they are milled, blended, bagged, and sold. At this time, the same processing infrastructure, storage units, and equipment can be used for organic and conventional inputs, with proper cleaning in between runs of GMO or other conventional grains and organic grains.

Because of this, the infrastructure and equipment needed to process organic grains for livestock feed typically already exist. Mills, however, are cautious about embracing these alternative crops because they do require separate storage bins and cleaning protocols and thus result in higher handling costs (unless large volume is attained) and less flexible systems. Furthermore, a Certified Non-GMO product or an organic product may be susceptible to contamination by GMO products outside of the allowed tolerances of the certification. This is unlikely to be a concern in the local livestock feed market, where consumers are less likely to demand certification and are more willing to trust the feed manufacturer, but could become an issue when contracting with Organic Valley or serving more distant markets.

---

excludes crops other than corn and soybeans. The USDA only started tracking this information in 2008 as part of the Census of Agriculture.

[3] The San Luis Agriculture District, as defined by USDA NASS, includes Saguache, Alamosa, Rio Grande, Conejos, Costilla, and Mineral Counties, however data from Mineral County is largely suppressed.

A crucial piece of infrastructure is a facility for organic dairy and egg processing and packing. Where facilities already exist, organic certification is a matter of proper cleaning and dedicating specific days to organic processing.

Another valuable piece of processing infrastructure that is often missing in an organic livestock feed supply chain is a certified organic livestock processing facility. Without a slaughterhouse able to preserve the organic identity of the byproducts of a poultry layer or dairy industry (male, meat animals) to the end consumer, there's little opportunity for the local organic livestock industry to grow beyond an extremely niche market.

Market Potential

In general, sales of organic foods are considered the fastest growing sector of the food retail industry and have shown double-digit growth year over year for nearly twenty years. Organic foods are estimated at 5-10% of total food sales, depending on the source, with some estimates putting the demand of organic eggs around 20% of the market (Roseboro, 2014; Jennings, 2014).

As a percentage of total national fluid milk sales, organic milk sales have grown from 1.9% in 2006 to 4.4% in 2013 and 5.2% in 2016 (USDA AMS, 2017), though a glut was predicted for 2017 (Bauer, 2017), and New England farmers tell us that organic quotas are being cut in that region by 14% in 2018. Similarly, about 4.6% of national beef production by pounds and sales is organic (Cattlemen's Beef Board & National Cattlemen's Association, 2016). Yet, as noted above, availability of organic lands to produce organic feed is limited.

In Northeast Indiana, a thriving cluster of organic grain growers have scaled up production rapidly as nearby poultry, egg, and dairy facilities ramped up production. More than 100 farms, mostly Amish, grow grain to meet this demand. The poultry processors are also Amish-owned, while dairy farmers sell to Organic Valley. A local grain mill transformed itself into a cooperative, owned by Amish farmers, so it could expand to meet rising demand. Sales grew from $1.6 million to $15 million in its first three years. The mill owner says he sources from about 1,000 acres of local, organic grain, but also imports grain to keep up with demand (Meter, 2016).

Mills everywhere in the United States import the majority of their organic grains. In fact, given the rising global demand for organic grains, and the need to isolate these crops from their GMO counterparts, there is great potential for a region to specialize in organic and non-GMO production and export these foods to other regions in the country.

Conclusions

The most clear market opportunity expressed by Organic Valley was to purchase organic potatoes, not feed for laying hens or dairy operations. Still, the booming demand of organic foods and growth in market share suggest that farmers in the San Luis Valley should seriously consider converting more of their acreage to organic. The Organic Trade Association describes the gap between domestic supplies of organic grains and imports as a " 'Help Wanted' message for American farmers. It shows substantial missed opportunities for the U.S. farmer by not growing organic—whether to meet the demand outside the U.S. or to keep up with the robust domestic demand for organic," (McNeil, 2015). As farmers look at historically low commodity crop prices for the next several years, now might be the best time for producers to start transitioning acreage, especially if federally funded cost sharing programs continue to incentivize this[4]. Indeed, industry analysts are predicting increased acreage conversion to organic production as producers look for ways to weather global commodity crop price uncertainty (Smith, 2015; Bunge, 2015; Roseboro, 2014; Best, 2015).

Yet this enormous market potential may be difficult to capture in places like San Luis Valley, where the elevation of the land has historically limited production of corn or soybeans. Moreover, water resources are increasingly limited — yet this is also an excellent reason to build soil organic matter through organic production, since this will heighten water retention in the soil, giving farmers greater flexibility.

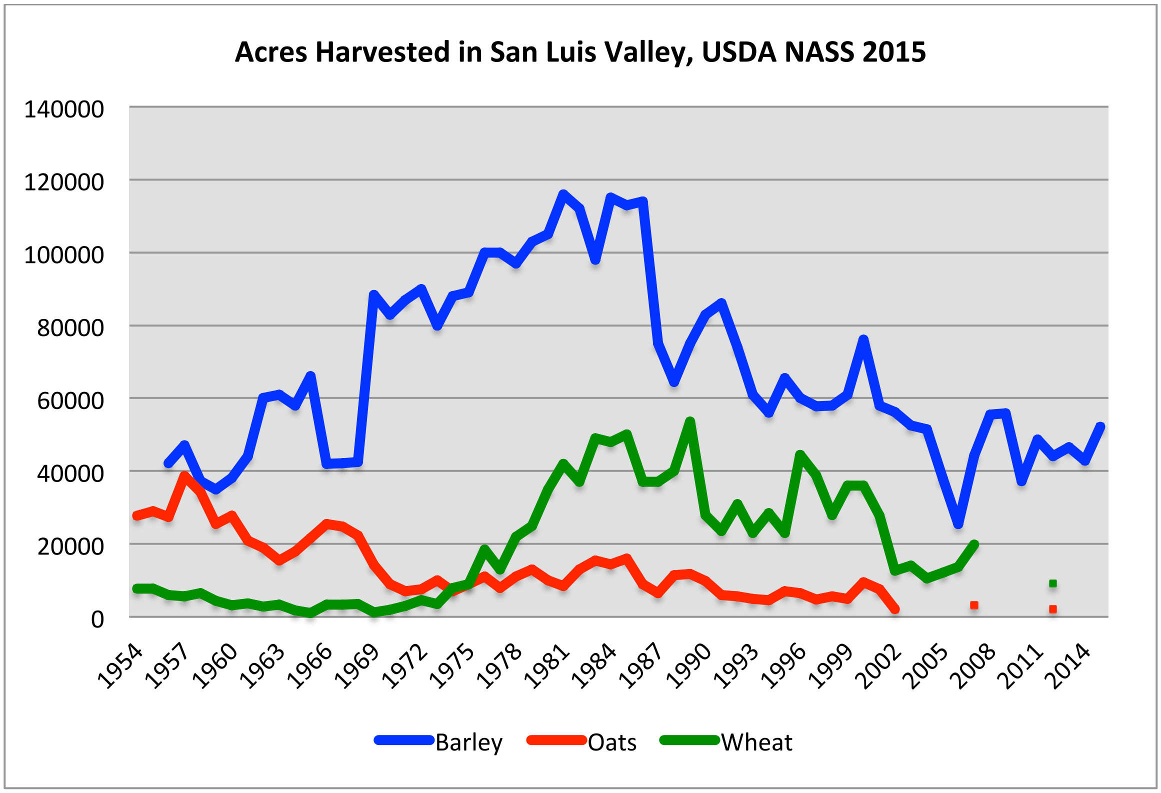
Feed mixtures using locally grown small grains that are easily grown in the Valley supplemented with affordable imported feedstocks, may be more feasible, especially given the enormous national expansion of demand for organic eggs and dairy products. These may also allow differentiated livestock products to be created that are unique to the Valley.

One farmer expressed the sentiment that "if you give us a market, we will grow for it," but such an approach places farmers in a relatively reactive position of waiting for others to determine their options. It would seem even more valid for Valley farmers to develop their own markets, and power to set prices, through collaborations within the Valley, rather than being limited to chasing commodity markets as they ebb and flow in response to global conditions.

This suggests that more localized efforts raise livestock and related products for sale within the Valley could be explored to determine which are feasible. Selling differentiated products may offer more power to set prices, closer connections to consumers, and an alternative to raising commodities for global markets that often are quite fickle.

[4] These programs can reimburse up to 75% of certification costs per category.

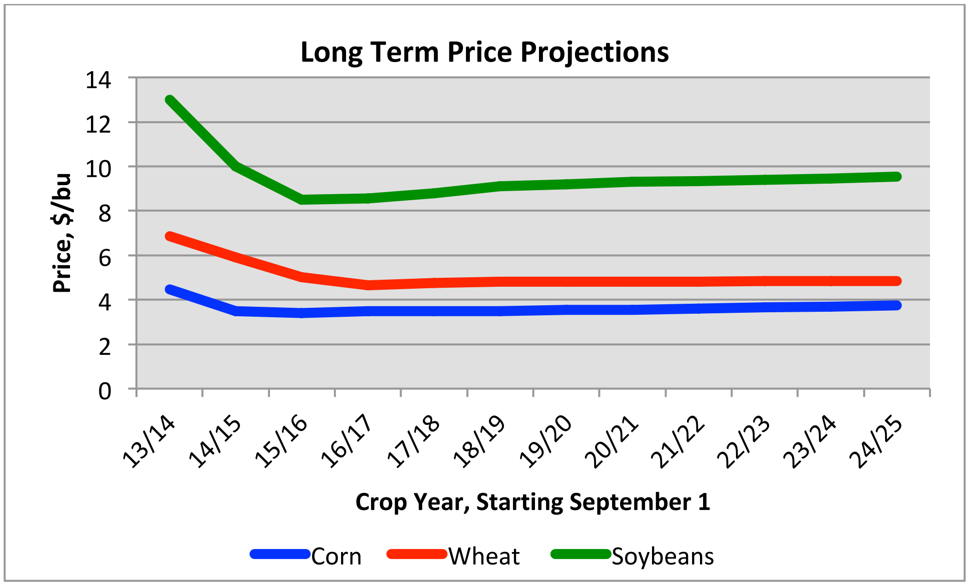
Chart 1: Small Grains Harvest in San Luis Valley[5]



Source: USDA NASS Census of Agriculture

[5] The San Luis Agriculture District, as defined by USDA NASS, includes Saguache, Alamosa, Rio Grande, Conejos, Costilla, and Mineral Counties, however data from Mineral County is largely suppressed.

Chart 2: Long-Term Farm Price Projections



Source: Interagency Agricultural Projections Committee, 2015

Part II: Pelletized Organic Fertilizer

Valley Activity to Date

The Value-Added Committee has also posed the question of whether it would be feasible to pelletize poultry manure from the Valley's laying operations to create an organic fertilizer. This section explores that possibility, drawing upon interviews held with practitioners.

If such a product were available, this alone might encourage more growers to adopt organic farming practices, because pellets could be spread using machinery farmers already own. Some view this as a better alternative to spreading raw manure because it is a drier product presumably having fewer odors, and one that can be stored for later use with less loss of nutrients, and both cheaper and easier to ship.

On the other hand, if farmers were to apply pelletized fertilizer in the same way they now apply chemical amendments, this might foster a sense that fertility is strictly a matter of adding amendments, rather than pursuing a more integrated strategy involving crop rotation, rotational grazing, and cover cropping to add nutrients and build soil organic matter, etc.

Even if this were true, having the option of applying a pelletized fertilizer to San Luis Valley fields could become part of a rotational crop improvement strategy, and would be a welcome choice for some farmers.

Yet our first conversation with Organic Valley placed a sharp limit on this discussion. Egg coordinator David Bruce stated quite early in our interview that there was little manure available in the Valley. "Poultry manure is a hot commodity right now. Farmers are either spreading it on their own lands, or selling to their neighbors."

It would seem, then, that pelletizing chicken litter would be a difficult business to establish at this point in time because there is essentially no supply — or at best an erratic supply — of poultry manure to be pelletized. At times when it is available, it might command such a high price in its raw state that processing would be prohibitively expensive. While this could change if the organic laying-hen industry expands in the Valley, it would be speculative to direct close attention to that possibility at this point in time.

Patrick O'Neill, however, suggested that there could be significant potential in pelletizing alfalfa as a fertility amendment. Early trials suggested this was not a clear-cut case. O'Neill said that in greenhouse trials, production actually decreased after pelletized alfalfa was applied. Microbes "sucked up all of the nitrogen," he said. "It may not be the resource it appears to be." One key issue, he added, was whether nutrients in the alfalfa pellets would release into the soil over time.

"The carbon-nitrogen ratio is one of the big hangups [with alfalfa pellets]," O'Neill added. "It is high in both carbon and nitrogen. But there is less potential if the nitrogen is not released into the soil." He added that adding more microbiological diversity into the fields might well help accelerate this release, but scientific studies to date have been inconclusive. "I have no knowledge of any trials that were performed by a third party with no financial interest in the outcome."

Ted Heersink of Majestic Valley Farms runs a pelletizing operation on his farm in the Valley. He said he primarily pelletizes sawdust for use in wood stoves at the present time, but he is engaged in several trials to test new products. “I am open to anything,” he added. He sees promise in pelletizing spent brewing grains, and is exploring alfalfa and other green crops. He said he was very open to developing products that were primarily for local use (Heersink interview 2017).

Heersink believes there is currently no good organic amendment to serve as a source of nitrogen for growing potatoes in the Valley. He has been in contact with an agronomist who thinks alfalfa has strong potential as a fertilizer.

Pelletizing alfalfa makes sense, he said, because it reduces the water content and makes it easier and cheaper to ship. Compared to bales that are left out in the rain, there is less leeching and less waste, and pellets are easier to handle.

Heersink also believes there is strong potential for alfalfa as feed, even as an export crop. He told the Alamosa County Board that “China is importing 60% more alfalfa than they had in the past” (Board of County Commissioners, Alamosa County, 2016). He also said he has heard that buyers in both Taiwan and Japan are looking for high-quality organic and non-GMO feed. The Valley is isolated enough to grow alfalfa without cross-contamination, so he thinks SLV holds a competitive advantage. This, of course, depends on how many non-GMO growers operate in the Valley, since intra-Valley contamination is also possible.

Pellets can be packed in bags for feeding smaller animals, and this is where Heersink sees the most promise. Cattle, he said, are served well by large alfalfa bales. His shop is capable of adding additional nutrients into the pellets as needed. He added that one area farmer is growing alfalfa now and is interested in exploring pelletizing.

Heersink has been exploring markets for pellets as feed. He said he is talking to a small feed store in New Mexico that sells 40# bags of pelletized alfalfa for $9.50/bag, while good alfalfa sells for $140-$150 per ton in bales, and organic prices are even higher. He knows of a woman in Golden who sells bags of organic alfalfa pellets for $22-$23 for a 40-pound bag. He told the County board in 2016 that she was interested in purchasing alfalfa pellets from him (Board of County Commissioners, Alamosa County, 2016).

He also said that pelletizing spent grains makes sense since they are 30-35% protein. He has begun to explore this possibility with a malting company.

His plant has experienced difficulties in pelletizing fibrous green plants because the “haws” (stalk fibers) are very strong, and can jam up the machine. Essentially the fibers have to be chopped with a hammermill to 1/8” before pelletizing so they will not plug up the equipment. He is now setting up machinery to test this, in collaboration with a grower from another part of the state. The costs of adding this step on a commercial basis do not seem clear at this point in time (Heersink and Wright interviews, 2017).

Heersink told the County board in 2016 that he wants to pelletize wood from beetle-killed trees for use as firewood. He added that since the pellets are heated to 200 degrees in the process, alfalfa (or other undesired seeds) seeds that are pelletized will not germinate so there is little risk of introducing unwanted plants into farm fields (Board of County Commissioners, Alamosa County, 2016).

Production and Supply

See above. Until a specific market opportunity is identified, it is difficult to characterize production and supply.

Infrastructure and Equipment

Ted Heersink owns a pelletizing operation in Alamosa County and said he was quite open to testing new products in his machinery to see what works the best. He says he can currently process as much as 2 tons per hour, and "we have the capacity to put in other machines if we need to." Having this facility in the Valley greatly increases the opportunities for growers to become involved in co-creating custom products for use by Valley farmers. Since Heersink is a member of the CSU Extension advisory committee, he is well placed to participate in such collaborations. "The trick," he said, "is to find a market."

Market Potential

At this stage, it appears that further R&D is called for to explore potential products, and then the market potential can be assessed. Shriver believes the best current opportunity for pelletizing is to continue to make wood pellets and explore bio-char production. She added that processors in New York State are processing bone char from animal-processing facilities to make a soil amendment, and this holds promise if sufficient supply can be identified. Yet she added that transportation costs may limit commercial potential for exporting these products out of the Valley (Shriver interview, 2018). Our team also has heard that similar trials are underway in Kansas, but this is not verified at this time.

Conclusion

We concur with local practitioners that additional R&D is the priority.

Part III: Feasibility and Marketability for Valley-Grown Quinoa

Valley Activity to Date

Paul New has taken the lead in fostering quinoa production in the Valley, in collaboration with several growers. Twenty-five years ago, he began to introduce quinoa. Today, he says, the Valley boasts from 600-800 acres of quinoa production (New Interview, 2017). Quinoa is held up with great promise by those who know it is an excellent dry-land crop well suited to high altitudes. New's efforts have been nationally pioneering, as will be shown later.

Yet getting to this point was not easy. At first, New told us, "it took quite a while. At first it was a production issue. We almost oversold ourselves. We learned a lot by growing, but we were always running out. We had to do quite a bit of work on developing the right seeds," that were well suited to Valley conditions. New worked extensively with Colorado State scientists to improve the product. At first, yields fell below those of potatoes or alfalfa, so the growers learned how to plant an optimal spacing of rows. Several growers tried the new crop once or twice and gave up. "I was one of the stubborn ones," New said.

About five years ago, once the initial trials were over and markets were established, New began to collaborate with Sheldon and Brendon Rockey (Rockey interview 2017). "The past three years we have done really well," New said. "Our production has been higher and more consistent. We have higher quality seeds. We grow quite a lot now, and we have more than we can sell. We exported a little." When the market for organic quinoa became saturated, New and his partners began to grow for a conventional market that was newly opening up. New has begun talking to several large distributors who have expressed interest in SLV quinoa. Yet he does not know how big the potential market can be. "How do we get more people eating it?"

Today, New said, there are 8 Valley growers raising quinoa. "About half are doing really well, and the other half not so well." Quinoa does require good soil, he added, and farmers have had pressure from both weeds and pests. One observer suggested that those farms with better fertility in their soil fared better than those with less. Global markets have also played a role, New added, "The market is certainly suppressed right now, with production in South America rising quite a bit. It is a very popular crop." Quinoa is valued for its culinary qualities and nutritional properties. "We're probably at volume now," but markets are also fairly mature. "Chain restaurants pretty much have it on their menus already," (New interview 2017).

There are also strong pockets of production in other states, such as Idaho, Montana, and Northern California, with smaller cells in Washington State. New went to visit some of the Western growers a few years ago and found them collaborative, but their presence certainly impacts markets for Valley growers.

New feels that local markets are already well served. The growers market through Valley Roots, a food hub in Alamosa, and they supply local supermarkets and restaurants, as well as several clients on the Front Range. Yet New has his eyes set upon longer distances — "It would not take too many acres to fill the Valley demand."

One expert source added that access to broader markets for SLV growers will be limited unless they are able to mount modern marketing campaigns to become a "known entity in the food processing world. Right now, they are not getting the good contracts."

One of the obstacles they encountered was that the seed has a protective shell containing toxic substances, saponins, which have to be removed before marketing the product. Farmers remove this coating with a dry process that is effective but leaves a residual dust that has to be washed off, New added. "It may be time for us to set up a washer, but that has some drawbacks." The growers have had to obtain training in safe handling of the product so they could be certified. New added that there may be economic potential in developing by-products from this process, but these would have to be researched.

Similarly, New believes there are processing opportunities in the Valley, but he has not yet had time to explore them. One firm in Denver and Boulder manufactures a quinoa patty. He added, however, that he does not see much potential in quinoa serving as an animal feed, because it is too high in price.

Origins of Quinoa

Quinoa's domesticated beginnings are cited as 5,000 BC, emerging from the central highlands of Peru, and other areas in South America simultaneously (Gomez-Pando, 2015). Quinoa is known to have had great cultural significance to indigenous peoples of South American, with some considering it a sacred offering for the gods. The cultural importance of this crop, termed a "pseudo-cereal" by scientists, is perhaps not surprising. It is considered a complete food and is known to be highly nutritious, offering a nutritional composition high in quality protein and containing all essential amino acids (Wu, 2015). Quinoa remains prevalent in the high plains of South America (also known as the altiplano region), where it is considered a main source of protein for millions of people (National Research Council Staff, 1988).

Quinoa's rich ancestral history as a staple food in the Andean region, nutritional heft, and its ability to be grown in marginal soils worldwide has led to the growth of the crop elsewhere (Gomez-Pando, 2015). The Food and Agricultural Organization (FAO) of the United Nations (UN) declared 2013 to be the International Year of Quinoa, first to acknowledge that indigenous peoples have preserved *in situ* practices and knowledge for growth, breeding, and post-production; and second, to draw from this knowledge in order to promote quinoa to combat food insecurity (Food and Agricultural Organization of the United Nations, 2017).

Congruent to FAO's hopes for quinoa, quinoa's popularity has steadily expanded beyond South America. It is now grown in over 70 different countries. In 2008, the Andean region accounted for 92% of production worldwide, with the remaining 8% being produced by the United States, Ecuador, Argentina, and Canada combined. In North America, growth occurs largely in the Prairie Provinces of Canada, and in the San Luis Valley in Colorado (Food and Agricultural Organization of the United Nations, 2013). It has also been grown in Wyoming, northern New Mexico, and northern Washington State (Peterson and Murphy, 2013). The largest obstacle to widespread domestic production of quinoa is climate — temperatures above 90*F will sterilize the plants. Still the plant is considered "tolerant and hardy" under most other growing conditions, including drought (AGMRC, 2017).

Domestic production of quinoa clearly has potential for market growth, and for the Colorado grower, it becomes a question of how to move forward this niche grain and under what conditions. Recent market volatility has diminished the eagerness of some growers in both the United States and South America. Many have returned to their more accustomed commodities.

Production and Supply

Commercial efforts to grow quinoa in the United States began in the 1980s in a cooperative effort between Colorado State University and Sierra Blanca Associates (Peterson & Murphy, 2015), led by Alamosa's Paul New. In 1987, this collaborative work became centered on his White Mountain Farm. There, field trials continued and ultimately four varieties suited for the San Luis Valley region were developed: 407 White, 407 Black, Short Blanca, and Cahuil Cross (White Mountain Farm, n.d). John McCamant and his associates at White Mountain Farm work with only ten or so lines, narrowed down from the many quinoa varieties and originally collected from various regions in South America. "In 1987, there were still 37 different varieties, but now we're working with only about ten lines, and the ones we currently grow have radically changed from their predecessors" (White Mountain Farm, n.d.). Washington State University is also leading more recent research efforts and commercialization in collaboration with Lundberg Family Farms, a California based company (Valdes, 2016).

Quinoa is dependent on conditions specific to its preferred region; highly specialized varieties have to be developed for each area. Buckland (2016) points this out in her doctoral dissertation for Utah State University, "There is a handful of growers in the United States, mostly in southern Colorado, who have developed varieties for an arid mountain environment where strong winds and cooler summer temperatures prevail, similar to the Altiplano ecosystem."

Domesticated quinoa can cross with its wild relatives, such as lamb's quarters and red-rooted pigweed (Smith, 2017), both prevalent weeds in Colorado. This of course can disrupt breeding programs aimed at achieving true seed, and further it is problematic for growers when spontaneous crosses lead to undesirable outcomes. Ward (1994) points out that goosefoot (*C. berlandieri*) has been a problem for quinoa growers in Colorado because the cross leads to woody and black-seeded plants. Interestingly, in the Andean region of South American, farmers are known to care outright for the wild relatives of quinoa, as they are used for food, medicine, and ritual purposes. The young leaves in particular are used in salads, and the seed is made into flour (Gomez-Pando, 2015). There is potential to utilize quinoa's tendency to cross with native related species in order to create a locally competitive variety of quinoa. A successful White Mountain Farm cultivar exemplifies this — spontaneous hybrids between quinoa and wild *Chenopodium spp* were developed by the farm into a black-seeded quinoa cultivar (Peterson & Murphy, 2015). White Mountain Farm notes that crosses with native *Chenopodium* weeds provide good stock for genetic change (White Mountain Farm, n.d.).

Infrastructure and Equipment

To harvest quinoa it is recommended to use a sorghum header attachment on a combine, though a platform header can also work without to large of a crop loss. (E.A. Oelke, D.H. Putnam, T.M. Teynor, and E.S. Oplinger, 1992). As such, an established small grains farmer should be able to integrate it into their crop rotation with minimal equipment investment.

Quinoa does have a mildly toxic outer coating and requires processing before marketing. This step is simple enough, involving multiple washes in cold water and then drying to below 12% moisture. However some estimate that 462 gallons of water are required to produce a pound of quinoa (ANA, 2013). In comparison, a pound of corn requires an average of 107 gallons of water to produce (Hoekstra, 2008).

Market Potential

Due to its delicate taste and texture, quinoa is easily incorporated into many dishes. It is also considered a safe, gluten-free alternative for those with celiac disease. Some contribute the meteoric rise in popularity of quinoa in the United States to the prevalence of gluten-free diets. In recent years, the United States began to consume relatively large amounts of quinoa (Prince, 2017). Between 2004 and 2013, the U.S.' consumption rate of all quinoa produced globally increased from 4% to 30%; in 2004, the U.S imported 1,548 metric tons (3.4 million pounds), and in 2013, it imported 36,038 metric tons (79.4 million pounds) (Nunez de Arco, 2015). Peru produced 63,100 metric tons (139 million pounds) in 2013 (Statista, 2013). The United States produces very little – some estimate 5,000-8,000 acres in total (6-16 million pounds).[6] In 2016, Lundberg Family Farms contracted 2 million pounds of domestically produced quinoa from West Coast growers (Valdes, 2016).

An oversupply of quinoa has caused prices to fall by 40%-60% over the last four years. Lower prices have allowed some manufactures to incorporate quinoa into common grain products like breads and cereals, however growth in consumer demand hasn't made up for the oversupply (Logan, 2017).

Shriver added that her understanding is that growers are limited by the amount of seed available.

Conclusions

The commercial viability of domestically produced quinoa is still being proven. Recent fluctuations in supply and demand have caused uncertainty and volatility in the market. Some market analysts suggest that current global levels of quinoa in storage will cause the price to fall further in the coming years, pushing smaller operations in marginal soils out of the commercial market.

Overall Conclusions

Our interviews showed that Valley growers are pursuing deliberate and effective trials of all three opportunities identified by the Value-Added Committee, although they may wish to enhance their knowledge by reviewing literature cited in this report.

Moreover, since one of the key purposes of this study is to "pursue economic development strategies that will help build health, wealth, connection, and capacity in the San Luis Valley," Adams State may wish to encourage growers to focus their attention less on export markets and more on farm inputs that can be sourced within the Valley, as well as on crops and livestock that can be sold to Valley consumers. Marketing through shorter and more localized market channels may offer growers better opportunities for San Luis Valley farmers to hold power over the prices they charge, and will also build effective social and commercial networks within the Valley.

[6] Quinoa yields average between 1,200 and 1,800 lb/acre (E.A. Oelke, D.H. Putnam, T.M. Teynor, and E.S. Oplinger, 1992).

Such strategies may also create new opportunities for farmers and consumers to take advantage of the relative isolation of the Valley. Rather than operating at a distance from markets and incurring long-distance transportation costs, growers may find that more localized opportunities help insulate them from market pressures (assuming sufficient buyer loyalty can be built) and may create special opportunities to grow seeds and crops that are relatively free from cross-contamination.

Action Priorities for Part I, Organic Feeds

- Collaborate with CSU researchers and Jeremy Yoder to learn more about the feasibility of using flax seed as a feed for laying hens.
- Collaborate with Patrick O'Neill to pursue feed options that tested well in his field trials.
- Explore at a small scale the use of other Valley-grown small grains as feed for organic poultry, including trials that involve feeding heritage poultry varieties.
- Foster the transition of more SLV farm acreage to organic production; continue to build soil organic matter in order to increase water retention capacity.

Action Priorities for Part II, Pelletized Organic Fertilizer

- Place a priority on refining the pelletizing of green matter from alfalfa and woody plants to identify commercial opportunities.
- Continue to collaborate with CSU to study actual benefits of pelletized alfalfa as a fertilizer.

Action Priorities for Part III, Valley-Grown Quinoa

- Continue to expand sales in US markets, contracting with sales experts as possible to obtain wider reach.
- Continue to build soil organic matter and fertility to improve quinoa yields.
- Continue to enroll new growers as possible.
- Explore marketing campaigns to increase consumption of organic quinoa by San Luis Valley consumers.
- Explore value-added products (such as locally made veggie burgers) that could use quinoa grown in the Valley.

Other possibilities

- Explore sales of organic potatoes to Organic Valley.
- Explore production and processing of pork, beef, eggs, and broilers for San Luis Valley consumers.

Works Cited

AGMRC (2017). *Quinoa.* Agicultural Marketing Resource Center.

ANA (2013). *Water Requirements of Quinoa.* Peru: National Authority of Water.

Bauer, A. (2017). *The organic milk market is overflowing.* Hoard's Dairyman Intel.

Best, J. (2015, April 16). Suddenly We Like Organic Corn So Much We Have to Go to Romania to Get It. *Take Part*.

Bjerga, A. (2015, April 15). U.S. Forced to Import Corn as Shoppers Demand Organic Food. *Bloomberg Business* .

Board of County Commissioners, Alamosa County (2016). June 29 minutes.

Bruce, David, telephone interview July 21, 2017.

Bunge, J. (2015, February 2). Fields of Gold: GMO-Free Crops Prove Lucrative for Farmers. *The Wall Street Journal* .

Cattlemen's Beef Board & National Cattlemen's Association (2016). Natural/Organic Share of Total Beef. *Beef Retail Marketing.*

Colorado Experiment Station (1909). "Publications of 1909: Raising Hogs in Colorado." The State Agricultural College, Fort Collins, pp 17-26.

The Country Gentleman (1916a). "Feeding Value of Hempseed." page 2016, November 18.

The Country Gentleman (1916b). "The Oldest Cereal in the World." LXXXI:3, December 23.

Heersink, Ted. Telephone interview August 2, 2017

Hermes, J. (2010). *Soy Free Diets for Poultry.* Oregon State University, Cooperative Extension.

Hoekstra, A. (2008). *The Water Footprint of Food.* University of Twente, Twente Water Centre. University of Twente.

Interagency Agricultural Projections Committee (2015). *USDA Agricultural Projections to 2024.* United States Department of Agriculture.

Jacob, J. (2015). *Using Flax in Poultry Diets.* University of Kentucky, Cooperative Extension.

Jacob, J. (2014). *Using Quinoa in Organic Poultry Diets.* University of Kentucky, Cooperative Extension.

Jennings, D. (2014, January 6). Farmers Abandoning GMO Seeds And The Reason Will Surprise You. *Off the Grid News*.

Kratzer, F., & Vohra, P. (1996). *The Use of Flaxseed as Poultry Feedstuffs.* University of California, Cooperative Extension, Davis, CA.

Logan, T. (2017, June 29). Quinoa price falls dramatically, but industry hopes it will help long term. *ABC*.

Mattocks, J. (2013). *Feeding Pasture-Raised Poultry.* Midwest Organic & Sustainable Education Service.

Mattocks, J. (2002). *Pastured-Raised Poultry Nutrition.* Heifer International.

McBride, W., Greene, C., Foreman, L., & Ali, M. (2015). *The Profit Potential of Certified Organic Field Crop Production.* United States Department of Agriculture, Economic Research Service, Washington D.C.

McNeil, M. (2015, April 15). *Benchmark study yields key insights into global organic food trade.* Retrieved March 3, 2016, from Organic Trade Association: https://ota.com/news/press-releases/18062

Meter, K. (2016). *Northeast Indiana Local Food Network — Phase I Report.* Crossroads Resource Center. Available at www.crcworks.org/innetworks16.pdf

New, Paul. Telephone interview, December 27, 2017.

O'Neill, Patrick. Telephone interview, July 26, 2017.

Pimentel, D., Hepperly, P., Hanson, J., Doubs, D., & Seidel, R. (2005). Environmental, Energetic, and Economic Comparisons of Organic and Conventional Farming Systems. *Bioscience , 55*, 573-582.

Roseboro, K. (2014, December 27). More farmers may grow non-GMO and organic in 2015. *The Organic & Non-GMO Report*.

Rockey, Brendon. Telephone interview, November 20, 2017.

Shriver, Karla. Telephone interview, February 27, 2018.

Smith, C. (2015, February 5). Non-GMO crops: hurdles and premium prices. *Agri-view*.

Statista (2013). Viewed Feb. 19, 2018 at https://www.statista.com/statistics/486411/us-quinoa-imports/

USDA AMS (2014). *Estimated U.S. sales of organic and total fluid milk products, monthly and annual, 2006-13.* United States Department of Agriculture, Agricultural Marketing Service.

USDA NASS (2012). *2012 Census of Agriculture.* United States Department of Agriculture, National Agricultural Statistics Service. Washington D.C.: United States Department of Agriculture.

USDA NASS (2014). *USDA-NASS Quick Stats*. Retrieved September 29, 2015, from United States Department of Agriculture: http://quickstats.nass.usda.gov/results/E2ED3586-EFF0-3E92-833C-3818A6A3D3FB

Valdes, M. (2016, October 6). Washington farmers help feed U.S. appetite for quinoa. *The Seattle Times*.

Widmar, D. (2016, February 22). Trends in Corn and Soybean Exports. *Agricultural Economics Insights*.

Winter, Will. Telephone interview, July 10, 2017.

Wright, Randy. Telephone interview, July 10, 2017.

Yoder, Jeremy. Telephone interview, August 24, 2017.

Appendix: Several Poultry Feeding Rations

	% by weight	Pounds Required, per 1000 Hens, Annually	Acreage to feed 1,000 hens annually based on listed recipes
Protein = 18.0%			
Corn, Yellow	60.5	55,206.25	5.4
Soybean meal (47.5% CP)	21.5	19,618.75	
Meat and bone meal (50% CP)	5.09	4,644.63	
Animal-Vegetable Fat	3	2,737.50	
Limestone or oyster shell	8.66	7,902.25	
Dicalcium phosphate	0.49	447.13	
salt	0.2	182.50	
sodium bicarbonate	0.2	182.50	
vitamin-mineral premix	0.25	228.13	
DL-Methionine	0.11	100.38	
Protein = 15.2%			
Yellow Cornmeal	60	54,750.00	5.36
Wheat	15	13,687.50	6.00
Soybean meal	8	7,300.00	
Fish meal	3.75	3,421.88	
Meat and bone meal	1	912.50	
Skim milk, dried	3	2,737.50	
Alfalfa meal	2.5	2,281.25	0.34
Iodized salt	0.4	365.00	
Ground limestone	6.35	5,794.38	
Protein = 15.7%			
Yellow Cornmeal	55	50,187.50	4.91
Wheat	15	13,687.50	6.00
Soybean meal	8	7,300.00	
Flaxseed meal	9.75	8,896.88	1.24
Skim milk, dried	3	2,737.50	
Alfalfa meal	2.5	2,281.25	0.34
Iodized salt	0.4	365.00	
Ground limestone	6.35	5,794.38	
Protein = 14.9%			
Corn	20	18,250.00	1.79

Ground field peas/lentils	30	27,375.00	
Ground barley	25	22,812.50	3.83
Ground wheat	25	22,812.50	10.01
Protein = 20%			
Ground shelled corn	48.75	44,484.38	4.35
Ground roasted soybeans	32.5	29,656.25	
Ground oats	10	9,125.00	4.75
Aragonite	2.5	2,281.25	
Fish meal	2.5	2,281.25	
Poultry Nutri-balancer	2.5	2,281.25	
Kelp	1.25	1,140.63	