

**Modeling the Foodsystem  
A Webinar**

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**Introductory Comments**

**<Slide 1>**

We want to thank you for joining us as we share some thoughts on the use of systems thinking, and specifically on the use of system dynamics modeling to better understand our food systems.

We have been interacting with university and community partners for over three years, and many still do not have a clear understanding of what a model is or is not, and how building a model could help in this work.

**<Slide2>**

The model we share today is a highly condensed version of the larger model being developed for the Appalachian Foodshed initiative. <Slide>

We want to acknowledge the support of the National Institute of Food and Agriculture of USDA for their support of our efforts. This work is a part of the much larger Appalachian Foodshed project which includes as one of many approaches, a modeling component.

**<Slide 3>**

The obligatory Disclaimer:

This is not presented as a finished work. Nor do we claim that it would even accidentally apply to any know situation. The logic is sound, and the numbers we use are reasonable, but we make no claim to accuracy. Our goal is to show what a model is, and how models could be applied and used in a community setting.

**<Slide 4>**

This model is relatively simple: it consists of only three state variables or stocks: Food, People, and Farmers that increase or decrease over time. These changes occur through flows of materials and information involving only eight pathways, and a larger number of variables. The model structure attempts to model the behavior of a generic food system. It could be almost anywhere, but we will limit our remarks the Appalachian community of Huckleberry.....

**<Slide 5>****Home to Huckleberry**

Morgan came to Huckleberry to lay his father to rest. He loved the mountains, valleys and streams. It feels like home because it always was. He grew up here, helping his Dad run a small dairy farm, and working a patch of burley tobacco.

But over time, the tobacco allotment was sold, and without more land, the dairy became inefficient. Dad finally retired about the time Morgan graduated from high school. They sold off some of the high land to seasonal residents so Morgan could go to college, and then leased the better land to local farmers for grazing cattle — about the only farming enterprise left in the valley except for a small group of specialty crop farmers selling produce at the seasonal Huckleberry Valley Farmers Market. Like most of the young people in Huckleberry and the surrounding Valley who made it to college, Morgan took a job out of state when he graduated.

Huckleberry was pretty typical of much of Appalachia. The population had been stagnant or declining for several years as jobs in mining, farming, and factories departed the region. About the only thing increasing were the seasonal residents, and the number of summer tourists interested in hiking the hills and enjoying the scenic amenities.

Still, there were good people here, and there were some other positives. Between remaining factories, forestry, and the paper mill, there was still enough work that the population had stabilized at about 30,000. The high school still had enough students to stay open, and they had good teachers. After a decade of bridge closings and frequent transportation interruptions, the Valley highway had been widened and there were still some mighty good places to eat. *That may bring in some more tourists, but between snows, flash floods, forest fires, and wind storms, folks tended to wonder if they would be able to get out of Huckleberry once they got in.* The 15 year old Huckleberry industrial park still had just two occupants, and there were no new prospects. Still, the local leadership was interested in making sure Huckleberry was a safe, resilient, and fun place to live. They still had the county Ag fair, parks and playgrounds for kids, and several festivals for families and residents to get together and enjoy.

If only there was some way Morgan could make a living on the land his family had left him—life could be really good here.

**<Slide 6>****A Stirring in Huckleberry**

Amy Asparagus was determined that agriculture had a place in the Huckleberry Valley, and that it could help turn around the local economy. If only people could see the importance of buying their food locally rather than having most of it shipped in from Timbuktu and Kalamazoo! If more people would buy from local farmers, she thought, then more of their money would stay in the local community and contribute to the economy. Some of the young people could stay here and maybe make a living. She had struggled, but managed to

get by with only a part-time job during the school year. If only she had a few more customers.

While waiting for customers at the Huckleberry Farmer's Market one Wednesday morning, Amy started talking with Hub Gapper who was trying to organize small farmers in the area into forming a cooperative marketing group (he called it a food hub), and with Mary Market, who helped organize the farmers market. Hub was sure he could interest some of the local restaurants in using locally produced foods if he could supply enough of the products they were interested in. Mary knew that many people simply could not make it to the market on the two days it was currently open.

They decided to go talk with Huck Hucklesford, the town mayor, about some ideas they came up with and to see if he could help them build some inertia around the idea of expanding food production in the region. . .

<slide 7>

### **Blooming of the Huckleberry Food Council**

Huck listened carefully, and said, "You know, if we are talking about food, then there are other people who need to be here to talk about this. As good as things are in Huckleberry, we still have a lot of unmet hunger. We need to bring in Paul Pantry at the Interfaith Food Exchange. Without the ability to make electronic benefit transfers (EBT) the farmers market is pretty much off the list of people who rely on supplemental benefits. We better understand that side of the story, and how local foods might help.

Amy and Hub agreed.

The mayor went on, "Hub, before we go too far with that Food Hub idea, we need to bring in Helen Well from the health department to make sure that we are not setting ourselves up for a legal problem. And believe me, I know she is really concerned about the what people are eating in this community. She reminds me frequently that I need to lose a pound or 30, and to get some exercise every day. And I think if we are going to talk about food, we need to get Xavier from Extension, and Toby Global, the local manager of the FoodnStuff supermarkets", and the Huckleberry Restaurant Association here as well.

And that is how the Huckleberry Food Council began.

Things began to move pretty quickly after that. Huck invited several people to participate, and everyone except Toby Global, the supermarket manager was able to be there. The meeting started well, and each person began to express their concerns, ideas, and passions. They even used sticky notes and put things on charts.

<Slide – 8 chart>

Topics were organized around **farms, markets, food insecurity**, and the **local economy**. Huck summarized some of the discussion:

- Firstly, We have energy and a strong desire to grow our ability to:

- feed ourselves in times of market stress, health concerns, transportation interruptions
- Have access to high quality, very fresh, foods obtained from people we know and trust
- provide jobs in the agricultural sector for our young people who own, inherit, or purchase lands
- **This means we need to increase our ability to produce. This needs to be done in a way that does not threaten our developing tourism markets, our soils, or our water.**
- Secondly, We wish to grow our community through internal cycling of funds and growth - reducing the amount of funds exported out of the region and grow those that come into the region by
  - Buying local products
  - Exporting high quality goods
  - Providing ecosystem services
  - **So This means we need to spend more of our dollars at home and market our products outside the region**
- Thirdly, We have hunger, right here in our community, and unmet food needs that we as a community should address
  - **This means we need to find ways to get local foods to those with unmet food needs**
- Finally, We have a very high incidence of food and diet related illness
  - **This means we need changes in what we eat:**
  - This will involve products, education, and assistance

### <Slide 9- Action steps>

Huck thought they would be able to move on to some proposed solutions, but almost immediately there was no consensus on what could be done, should be done, and by whom.

Groups began to lobby for production incentives, required purchases by schools and government institutions, food market infrastructure, benefits for the food insecure, changes in tax structures, and on and on.

Frustrated, Huck exclaimed “How can we understand all of these interactions and best invest our limited resources, time, energy, and community spirit to improve the situation, not haggle over who gets the little that we have to offer?”

### <Slide 10>

#### **Xavier Has an Idea**

Xavier worked with Extension, and really viewed his job as helping farmers produce better and more profitable crops. He could see potential connections here with small farms, but this situation involved a lot more than crops and farmers, and was getting really complicated.

The council was focused on taking action, but each person was seeing only their part of the story. In such a complex situation, an action in one area affected others areas both directly

and indirectly, and often in ways that were really hard to predict- Especially when you could only see things from your perspective. Almost every action could help one group, hurt some, deny help to others, and end up with hurt feelings or worse.

Xavier had heard about a group of community partners in the next county working with some folks up at the university on regional food systems. He suggested that he contact the coalition and see if they had some ideas that could help sort this out.

He ended up talking with Gandy, and sharing some of the thoughts and discussion from the Council meeting.

### <Slide 11- chart again>

#### **Gandy Ponders the Huckleberry J.A.M.**

Gandy took a look at the charts and notes that Xavier sent him after their phone call. He saw that the Council had indeed identified many of the major components of their local food systems, and identified some key challenges that needed to be addressed. The focus however was on issues, policy actions, and funding; not on understanding the system, and certainly not on understanding how others in the room viewed the role, function, and operation of the food system - their mental models.

Nor had they considered that if in fact they wanted to change things in a complex system and ensure that the change would remain, they needed a time-based perspective as well. How did things work in the past? What are the expectations for the future, with and without actions?

Indeed, this was a situation that needed some systems thinking. A Journey in Applying Models (a J.A.M) would be just the thing for Huckleberry.

### <Slide 12 – Journey in Applying>

#### **Cooking a Huckleberry Model – What is a model?**

Gandy met with the H.F.C. later that month, and explained that this looked like a good situation to apply a modeling approach. He said that the main purpose of a model was to create a shared understanding of the system.

As different people with different perspectives share their understanding of the situation and how it worked (he called this a mental model), everyone would listen and he would record their ideas and try to help them shape the different viewpoints into a visual picture.

They would need to identify the key components of the system - things that increase and decrease over time as they interact with other pieces of the puzzle. He called these stocks. Then they would concentrate on the flows, or the things that cause changes in stocks over time. Finally they would try to understand what information they needed to tie to the flows

to describe changes in the levels of values of the stocks in the system. They would use only four simple modeling symbols to build this visual picture of the food system.

The major difference was that this visual picture could be converted into a working mathematical model that would allow them to see how the system behaved over time using different assumptions. He also stressed that this is not a forecasting model, like a weatherman uses. Its intent was to look at general behavior of the system, not to predict exact values at some point in the future.

Toby Global, who was able to join the meeting about this time, asked, “ I understand the sharing of ideas, but why bother making a running model at all?” Gandy said that a model not only created a learning environment, but would allow the group to run experiment or test assumptions in a low risk, low cost environment. Even if the numbers were not predictive, they would at least show the direction of change in a very complex and hard to predict situation.

### Designing a Model

And so they began. Gandy worked with the Huckleberry Food Council to:

1. First identify what they really wanted to accomplish. He tended to refer to this as a problem statement, but he did not mean this in a negative way. That is just what modelers tend to call the situation they want to understand and work on. One technique he used was to ask the Huckleberry Food Council how, in general, local food production and access had changed in the last 25 years.

- Everyone agreed that there were fewer local farms, fewer people growing gardens, and in general, about the only positive had been opening of the local farmers market. He drew a simple graph on the board showing a declining trend since 1990.
- When he asked them to identify what they expect to see or would like to see in the next several years, several indicated they would like to see an increasing trend in farmers, especially small farms, and in accessibility to locally grown foods for all members of the community, not just those who had the opportunity to shop at the downtown farmers market.

2. Next, He asked them to identify a timeframe. Do you want to see results in the next few months, the next few years, or the next few decades?

- They agreed that 25 to 30 years may be required to see changes and to make certain they would stick.

3. He asked them to identify the boundaries. Are we talking about Huckleberry the city, Huckleberry County, the whole Huckleberry Valley, or the State Planning District? We can only work to change things within the system, not things like state and federal policies or programs that are controlled outside our reach.

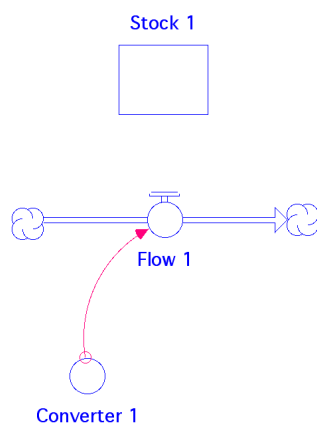
- They agreed that their major concern was the county level, although there was interest in exporting food outside the county to cities if possible.

### <Slide 13 - Four components of model building>

#### The Four Components of Model Building

Gandy then briefly explained the four model symbols they would use

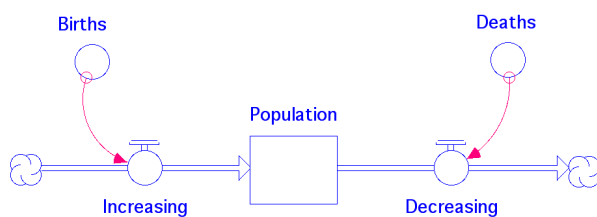
- stocks
- flows,
- converters, and
- connectors in constructing the visual model.



A **stock** holds things and the amount in the stock is referred to as the level of the stock. Things enter or exit the stock by passing through a **flow** that connects to the stock. The arrows on a flow indicate the direction of movement. The clouds on unconnected ends indicate the connection to something “outside the system.” The flow has a handle on it to indicate that the rate of flow is variable.

**Converters** contain information. This may be numbers, equations, or even descriptions. Converters pass their information to other converters or flows through **connectors** (like wires in a network). This is pretty much all the visual language required to build a systems model.

### <Slide 14-Simple Population model>



A good example of a simple model and how the components fit together is the population of a city, which we'll come back to. The stock level, or number of people, is the important component, and varies with time. It varies according to the flows in and out. These flows are regulated by the information contained in the converters for births and death, and this information is shared with the flow control valves by the wires.

### <Slide 15- Creating a shared model>

Adding the components

Before they actually started building the model, Gandy insisted that they keep it as simple as possible. The Council then went through a process of identifying the key components of the system.

They quickly identified that Food was the major component of the food system, and decided it would need to be the basic stock of the model. They then added Farmers and People. Although the population had not changed much in 15 years, they saw that changes could happen.

Although it took a while to catch on to using a new language for displaying their ideas, just watching it develop helped. It was good to see how people with very different concerns and perspectives could contribute and see their ideas expressed in a visual way.

As pieces were slowly added to the model, the group could see their ideas interacted directly and indirectly with other parts of the diagram. Even Toby from the supermarket, who had missed the earlier discussion, picked right up with the conversation, adding ideas about the role of local foods in his business perspective, noting how larger markets connected to the global system interact with the local system.

At the end of the modeling session, Gandy reviewed the visual model step by step. People were mentally tired, but excited by their new understanding of the food system.

### [Step by step through the "storytelling" script. Shift from Margaret to Steve]

1. We started with the stock of <Slide 16> local produce.

The committee suggested that the flow <Slide 17> [growing crops],

relies on another stock - <Slide 18> the number of farmers, <Slide 19>

As well as the <Slide 20> number of acres within a farm, and <Slide 21> the amount of crop produced by each acre every year.

[Gandy reminded the council that when a connector ran from one component to another, the information stored in that component was then used by the receiving component to determine its value or information content. In this case, the pounds of growing crops is determined by multiplying the Number of Farmers x the Ac per Farm x the lbs produced per acre. This equation is entered by double clicking on the "valve" of the growing crops flow component. ]



Within each year, we expect all the crops grown on farms to also flow out from the farm.

We assume small farms since good quality land is fairly limited. We averaged all farms together for purposes of production, sales, and income.

2. Small Farmers market their crops in essentially three different ways: <Slide 22>
- **direct sales** at Farmers market, at CSAs, or other farmer-to-consumer venues. This is very high quality produce, and has both a higher price and higher marketing cost. <Slide 23>
  - **Food hub, food aggregators**, or coops, which in turn can deliver larger volumes needed by local institutions and the food service industries, as well as act as agents for ensuring good agricultural practice certifications. This is also very high quality produce, but the aggregator handles the marketing and pays a lower price, and <Slide 24>
  - Export sales through **wholesale distributors**: this is primarily for exporting crops outside the region, with a primary focus on nearby cities in the region. Good quality produce is required, but most will be resorted after shipping. Prices are the lowest, but the marketing costs are much less.
  - Unfortunately, some of the products <Slide 25> go unused or go to **waste**.

We assume farmers will sell all available products to:

- direct markets first,
- Foodhubs second, and
- Export markets third.
- Anything left over will result in waste.

There are other forms of waste in the food chain that could be addressed for repurposing, but we currently do not address these in this simple model.

3. The amount farmers sell depends on the demand for locally produced food.  
(This can be affected by prices. We made no attempt to connect price and demand in this simple model).

The council assumed that demand is driven by two primary factors:

- The <Slide 26> number of people in the food system, and <Slide 27>
- The lbs of food required per person in the food system to achieve an adequate diet.
  - For this model Gandy insisted they use annual the MyPlate requirements for fruits and vegetables as their baseline for produce.
- The actual demand modeled <Slide 28> depends on whether sales include amounts for the <Slide 28> whole year, or for just the fresh season.
  - We cannot assume farmers are growing to meet the entire annual demand since Huckleberry currently has no processing or storage capacity.
  - We assume seasonal production provides about 40% of the annual demand although the can also use total demand to allow the council to consider the impacts of processing and storage facilities.

The demand at different markets depends on these overall factors, but additional factors for each market type. <Slide 30>

4. [Direct sales] depends on [Direct Demand] which is a function of <Slide 31>

the number of people <Slide 32>  
the product demand and <Slide 33> and  
the fraction or percentage of the total population who chose to purchase their produce  
directly from the farmer.

For many communities this is 2% or less, and many communities are aspiring to a level of  
10%. <Slide 34>

This is the Direct Market cluster.

5. The next market type, the Foodhub sales, is driven by <Slide 35>  
Institutional and Food service demand.

We assume that institutions, restaurants, and other food services will purchase primarily  
from food hubs or aggregators that handle volume and food safety certifications.

The demand from this sector is also determined by <Slide 36> the population, the fraction  
of the population served and the [produce demanded per person] served.

This represents the [Institutional and Food Services Demand for **all** produce]. But only a  
fraction <Slide 37> of that will be met by local production.

We chose to estimate that using <Slide 38>  
the same fraction of the population purchasing **directly** from farmers [FracPopPurcDirect].  
(one way of thinking about this could be is the % of produce in meals served by the In&FS  
sector using only local sourcing. This demand is the total times the fraction of the total  
purchased locally. <Slide 39>

This is the Institutional and Food Services cluster.

6. Export Sales are driven by <Slide 40>  
Wholesale demand;

We duplicate <Slide 41> this to reduce clutter. <Slide 42> Produce demand per person  
remains the same, but the people to be served are now outside the county.

The committee estimated the number of people by the Regional Population Density] and  
the [Food miles Radius], and fraction of these people that might purchase locally produced  
foods. <Slide 43>

This is the Export Cluster.

7. Any residual food (not sold) goes to waste at this point. This is calculated by subtracting  
<Slide 44> the sum of all sales of local food produced, from <Slide 45>  
the total crops produced by farmers.

8. With a strong desire to grow Farmers, the Council thought it essential that this also  
represent a stock within the system, since farmer numbers could increase (and decrease  
depending) on the actions taken and the conditions. <Slide 46>

- New farmers would be added if only if <Slide 47>

- Enough farmable land was available to create a new farm [Ac per Farm, Total Farmable land] and <Slide 48>
- Farmers the preceding year averaged an income level above <Slide 49>
- the Just and Fair threshold. [Just&Fair Min Threshold]. This was a difficult concept for the Council since it involved people and money. But Xavier and Amy assured them that this was a key issue on the mind of farmers who wanted to get involved in producing for local foods. How much might they expect to make from a small farm? <Slide 50>
- New Farmers were limited to adding two new farmers [New per year] per year.
- 

Of course, not all new farmers will remain if the economic situation is unfavorable.

Farmers will begin <Slide 51> departing as <Slide 52>

Total salary and wages drop below the threshold.

This <Slide 53> is the Production and Marketing cluster

9. So how did we determine the farmers' total salary and wage amount?

Currently we show flows for:

- Direct sales
- Foodhub sales
- Export sales
- These are all in pounds of produce

Sales income results from sales, prices per pound, and associated costs.

We now go off the main page to show those calculations. <Slide 54>

To simplify the model visually, we "stacked" the individual flows (reproduced here as converters) for <Slide 55>

direct, food hub, and export sales. We do the same to calculate <Slide 56>

Gross income from sales and <Slide 57> Price.

Gross Income is then used to calculate <Slide 58>

Sales Taxes, and then <Slide 59>

Net Sales are calculated from Gross income, minus taxes, and marketing costs for each type of market.

This comprises the <Slide 60> the Net income from Sales Cluster

To account for <Slide 61> net farm income, we must subtract the <Slide 62> costs of production. <Slide 63>

These costs were further subdivided into labor and purchased inputs, but we will not show those now for the sake of time and clarity.

Many farmers also have <Slide 64>

off-farm income, and we wanted to include that possibility.

We add Off farm income and Farm salary and Wages <Slide 65>

So this was how we derived the Total Farmer salary and Wage amount.

10. Several council members wanted to see how the local economy might actually would be affected as the local farm economy began to grow. After some discussion and simplifying assumptions, it was decided to break down farm costs into <Slide 66>

[Hired labor, Local taxes paid, Purchase taxes, State Income tax, and Purchased inputs and equipment.

The sum of these <Slide 67>

were used to represent the direct inputs into the local economy <Slide 68> from farming.

11. Finally, Paul Pantry asked where policy provisions to support the food insecure were being addressed? Paul suggested that a policy for implementing EBT payments may have limited appeal at the current low level of farmer market support for SNAP recipients. He suggested that the community could supplement SNAP benefits <Slide 69> using the “bonus bucks” concept for direct purchases. <Slide 70>

This would also benefit farmers and farmers markets by increasing direct sales. [Direct lb NutSupBenefits]

12. Helen Well was also interested in the farm to institution connection, and suggested that community policies could require <Slide 71>

a certain amount [lbs] of local foods to be purchased by public institutions such as hospitals and schools with food services, as appropriate. [InstPurcPolicy-Lb] This would also help farmers and food hubs, and get food to people who often had few opportunities to access local foods.

And with that, the review of simplified visual model was completed.

Filling in the blanks - Parameterization

<Slide 72>

Gandy explained the next steps would be to lay out the key assumptions used in the model, [ most of these summarized above] and to then begin adding values (parameters) to the model to make it “quantitative” and applicable to Huckleberry.

After that, they could begin to examine some of the key questions they had about growing the Huckleberry Local Food system. But that would need to wait until the next meeting....

When Gandy returned, he showed the how a simple interface to the model could be constructed. <Slide 73> This showed some of their key assumptions and a concept map of the model.

The software also allowed them to use this interface to clearly display and directly change the values they were using within key components of the model. <Slide 74>

He quickly reviewed three points.

1. Purpose statement:

Understand the food system of Huckleberry Valley and how it could be enhanced to improve production and access to local foods while improving the local economy.

2. Timeframe: 30 years
3. Boundary: The Valley with a population of 30,000. Regional connection to nearby populations considered only in the export.

### **Huckleberry Questions**

**The council then listed five questions they would like to address using the working model.**

They come up the the following prioritized list.

<Slide 75>

1. How do we increase the number of small farms in Huckleberry?
2. How do we estimate the impact of small farmers on the local economy?
3. How does the lack of processing and storage affect our food system?
4. How do we as a community improve access to locally grown foods?
5. How important is it to connect with the regional food system?

### **Huckleberry Scenarios**

Gandy indicated these were excellent questions, and began by asking for suggestions on how to address the first question. He suggested they take a quick look at the model and review the potential constraints on growing the number of farmers.

Constraints:

Farmers must have land, and they must have a just and fair livelihood.

Farms are small and farmable land is limited.

Prices are moderated by the abundance of cheaper alternatives in the supermarket; even under high demand, farmers cannot charge but so much or their produce will not sell.

Suggested solutions included:

Lets see what happens if we increase the fraction of people who are buying directly from farmers.

Gandy then took them to the model interface <Slide 76> which showed most of their assumptions about prices at different markets, and production factors in one table, and in the other assumptions about marketing costs, population size, and the annual produce demand. He showed them knobs that would allow them to change factors such as the fraction buying local and the Just and Fair threshold for farmers, and the amount of off farm income contributing to that number. The interface also had a toggle to switch from seasonal to annual production, and a slider that indicate how far from Huckleberry farmers would try to market their products for export.

Two more sliders were added to indicate the amount of supplemental benefits (lbs) the council would support, or the amount of institutional purchases the community would recommend.

He also explained that key outputs over time could be drawn on graphs and tables for the council to examine.

It was suggested that a farmer should be able to make \$30,000 a year, and that current levels of direct purchasing were 2% or less. Gandy suggested they make runs at 2% of the population purchasing directly from farmers to see how this would affect Farmer numbers. , but before he did, he asked the council to imagine what the numbers would look like 5, 10, 20, and 30 years later, and then draw the trend on a piece of paper. He waited..... Then ran the simulation.<Slide 77>

The graph indicated the numbers reached a maximum of 7-8 farmers in less than five years and then basically leveled off.

Gandy asked if anyone had an explanation, and Toby suggested that farmers appeared to be coming in and out of the market based on the small fluctuations. That had to be because they did not have land or they were not making enough money to stay in business.

Gandy shifted to another page <Slide 78> of graphs that showed similar trends the contributions to the local economy, and in the second graph (upper right) , that, indeed, farmers were leaving because they were not able to make enough money as full time farmers at the current farm size, prices, and level of sales to direct and food hub markets.

The graph on the lower right shows that as farmers were able to sell more products to the direct market, they are more profitable. When a new farmer was added, this forced more sales to the food hub market at a lower net income, and a farm total income dropped.

Amy suggested they increase the % to 5 <Slide 79> and 10% to see what would happen. So Gandy adjusted the knob for [FracPop] and reran the model, <Slide 80> once at 5% (red line), and then at 10% (magenta line).

Numbers of farmers increased as the volume of direct sales also increased, but as new farmers entered the market over the next 18 years, the numbers still still leveled out at around 37 <Slide 81>

The other graphs indicated in similar trend in contribution to the local economy, reaching 1.5 million before stabilizing, and again the salary graph (upper right) told the story: farmers were simply not able to make much above the Just and fair threshold suggested by the council. As long as they were able to sell primarily through direct sales, new farmers were able to come into the market, but after 15 years (lower left) all the direct market demand was being satisfied.

It was suggested export markets be added as well, <Slide 82>, so Gandy increased the RegionalRadius slider to 50 miles from zero.

But this did not increase the number of farmers (Magenta 3 and Green run 4 lie on top of each other). Xavier indicated that made sense, the farmers would receive an even lower price for export sales than they would from direct and food hub sales, so could not increase their income.

The committee concluded that to grow the number of farmers:

- Full-time Farmers would need to accept lower salaries and wages, below what was deemed just and fair
- Prices for local foods would need to increase at the same time as sales increased; this was deemed very unlikely.
- Farm size would need to increase, which would be hard (more land, labor and capital)
- The fraction of the population purchasing direct and through food hubs would need to grow; even at 10% the number of farmers would be reach a limit that was much lower than the council expected.

Paul suggested they redo the runs, starting at 2% again, <Slide 83> (Blue line, #1) and see the effect of adding supplemental benefits (50,000 lbs) first (red line, 2), and then adding 200000 lbs of institutional buying (line3, magenta).

These efforts added 1-2 farmers to with again the limit being the amount of income received by farmers.

Incentives: improve access to local foods, and help small farmers more when the money channels through direct sales (I.e. higher returns per lb sold). However, when the community invests in institutional and food service incentives, more food is directed to people with unmet food needs.

Only if farmers have the capacity to produce more than allowed by these assumptions does farm to institution make more sense to the farmer.

[Skip 84-85 - inadequate time to discuss]

<Slide 86>

Gandy showed that detailed tables could also be examined to better understand what was causing the system to behave like it was.

Finally, the runs are only as good as the assumptions used to run the model. The Values used here were appropriate for Huckleberry, and the model helped them understand the constraints they were facing and to set some realistic goals.

<Slide 87 - Conclusions>

## Conclusions

This concludes our demonstration. Please remember this is a very simplistic model and has not been verified by an actual Food Council.

Its purpose is to demonstrate how a system dynamics approach could be used to structure understanding, and to serve as a learning environment.

We believe that modeling has a place in food system learning and development.

- Use of system dynamics provides a way to share mental models and to intentionally include the dimension of time in the thought process
- Like all models, they are simplifications of reality that reveal general behavior of the system over time.
- Models allow testing of assumptions and reveal unanticipated consequences of actions in one sector on outcomes in another.

Models serve as a mutual learning environment and can leverage effective action.