

# Economic Component of Columbia River Basin Long-term Water Supply and Demand Forecast

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# Overview of discussion today

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- ▶ Describe our overall approach.
- ▶ Layout steps in the process.
- ▶ Discuss what characteristics of agriculture in Washington are the most important drivers of our modeling decisions.
- ▶ Discuss the construction of a baseline forecast and provide some preliminary results.

# Overall Approach

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- ▶ Develop the economic component of a long-term water supply and demand forecast for the Columbia River Basin (CRB) in support of the CRB Water Supply Development Program (HB 2860) complementing physical models.
- ▶ HB 2860 considers a number of issues related to water needs from the Columbia River including:
  - ▶ Replace increasingly scarce groundwater supplies
  - ▶ Approve pending water right applications
  - ▶ Interruptible to uninterruptible rights
  - ▶ Additional demands from municipal, domestic, and industrial sources.
- ▶ Our task is to use economic concepts to look at historical changes in agricultural production in Washington to forecast what is likely to happen in the future and assess the implications for water resources.
- ▶ Two basic questions :
  - ▶ How is the crop mix likely to change? Why?
  - ▶ How are production methods likely to change? Why?

# Overall Approach

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- ▶ **The Columbia River is a complex system:**
  - ▶ Physical system: climate, terrain, soil, land cover
  - ▶ Ecology
  - ▶ Economic/political/social systems that rely on it as a resource for production and environmental amenities (5 states and 2 countries).
  
- ▶ **Rest of U.S. and rest of the World affect what goes on in the CRB through:**
  - ▶ Population migration
  - ▶ Production and trade
  
- ▶ **As discussed at the July PAG, a number of very different scenarios could have significant impacts on the CRB region of Washington. Such as:**
  - ▶ Changes in production in competing growing regions like California
  - ▶ Changes in terms of trade
  - ▶ Production technology
  - ▶ Consumer preferences and income

# Overall Approach

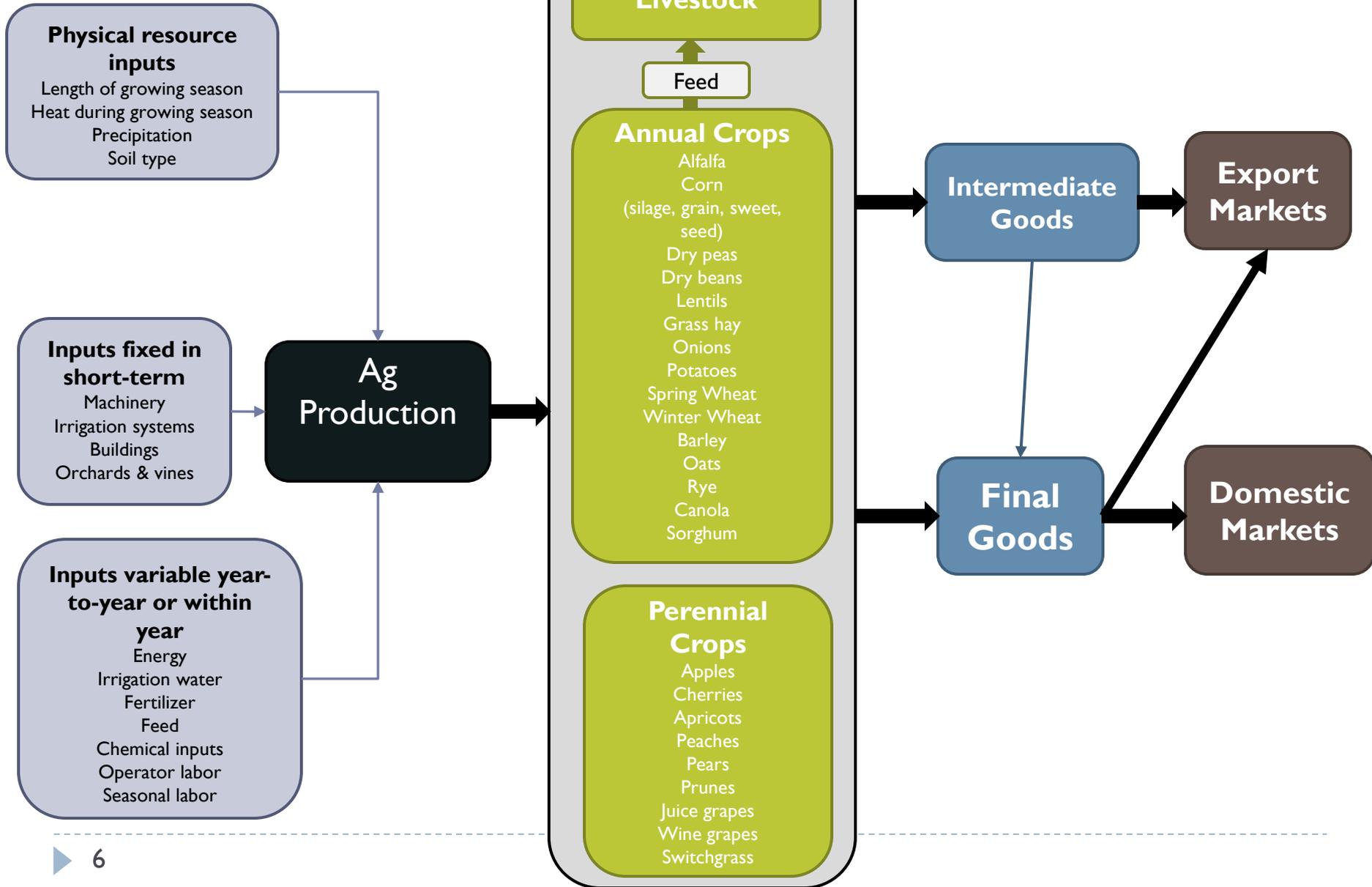
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- ▶ Economics provides us with a framework for systematically analyzing this huge array of factors.
- ▶ “Event” or “scenario” affects Washington growers through one of four pathways.
  1. Market price for goods
  2. Input costs
  3. Physical limitations to growing
  4. Uncertainty about 1-3 in the future
- ▶ This allows us to make direct comparisons about how two very disparate events like a reduction in the availability of seasonal labor and higher interest rates (both increase input costs) will affect production decisions.
- ▶ Many details, but put simply: If the profitability of growing a crop increases relative to other crops, production will increase.

# INPUTS

# OUTPUTS

# CONSUMERS



# Overall Approach

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- ▶ Important issues requiring additional attention that have come up in Huppert et al., Texas A&M studies, and elsewhere.
  - ▶ **Adaptation:** If a wave of change is coming in don't just stand there.
    - ▶ Growers respond and adapt to changes in growing conditions, prices, resource availability, etc. to maintain profitability.
    - ▶ Example: do higher energy costs increase investment in more efficient irrigation infrastructure?
  - ▶ **Market price** depends on Washington production for some crops.
  - ▶ **Exports** of high value crops makes Washington sensitive to economic conditions in export destination countries.
  - ▶ **Crop mix:** With additional irrigation permits what is the crop mix on
    - ▶ Land brought into production
    - ▶ Land previously in production
- ▶ **Challenges**
  - ▶ Historical data limitations for sub-state production.
  - ▶ Washington is not lowa: Variation over short distances in physical conditions, irrigation permitting, and the market value of what is grown.

# Overall Approach: Summary

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1. What are the major changes in production in Washington in recent decades and what are the underlying forces driving them?
  2. How are these forces likely to change production trends in the future?
  3. What is likely to happen under certain scenarios relative to the “baseline”?
- ▶ **End goal:** Provide guidance to the Department of Ecology on how to best meet future demands for water use in the Columbia River Basin by:
    - ▶ Using the best economic data and methods available.
    - ▶ Taking advantage of the opportunity to integrate economic and bio-physical expertise.
    - ▶ Taking advantage of the on-the-ground knowledge of PAG members, the Department of Ecology, and the WSDA.

# Stages of Analysis

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1. Create baseline forecast of agricultural production in Washington for 2030. Separate process for 'land constrained' vs. 'non-land constrained' crops (currently underway).
  2. Model economic focused scenarios (GDP growth, export demand) looking at changes relative to the baseline (near future).
  3. Incorporate information from physical models (coupled VIC/CropSyst) to look at changes in growing conditions and resource availability (final stage).
- ▶ **Goal:** use an approach that is simple enough to be transparent but complex enough to capture important economic phenomena like input substitution, producer adaptation, and risk management that will affect production choices.

# Baseline Forecast Model Development

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- ▶ **Current focus:** develop baseline forecast of water requirements based on crop acreage
  - ▶ State level
  - ▶ Specific sub-state regions
- ▶ Foundation scenarios that provide “shocks” to the baseline including policy with respect to irrigation permits.
- ▶ Previous forecasts have either not done a baseline forecast or have used more limited models than we will develop.
- ▶ Forecast acreage and yield for crops important to the region.
- ▶ Consider yield effects from changes in water availability based on CropSyst/VIC.
- ▶ Incorporate forecasts from outside sources, such as the USDA Baseline Projections, U.S. Energy Information Administration, Bureau of Economic Analysis, and Ag Commissions in Washington (ie. Tree Fruit Commission).

# Baseline Forecast Model Development

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- ▶ Trends for tree fruits and vines modeled a bit differently because they involve:
  - ▶ Multi-year production decisions
  - ▶ Relatively high value production
  - ▶ Currently constitute smaller proportion of land
- ▶ These more developed models allow us to test the influence of outside factors such as income growth in export destinations, which was
- ▶ The forecast provides an estimate of the most probable path **AND** a distribution that defines the range of what is likely outcomes. becomes larger further into the future.

# Baseline Forecast Model Development

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- ▶ Separate factors that affect decisions in the agriculture sector into either the:
  - ▶ Supply side
  - ▶ Demand side
- ▶ Supply side factors characterize the cost associated with producing different quantities.
  - ▶ Input costs
  - ▶ Resource constraints
- ▶ Demand side factors characterize consumer behavior.
  - ▶ Preferences
  - ▶ Price response
  - ▶ Income
- ▶ Demand and supply side factors come together to determine the market price for goods.
- ▶ What aspects of supply and demand are most important in determining production trends in Washington?

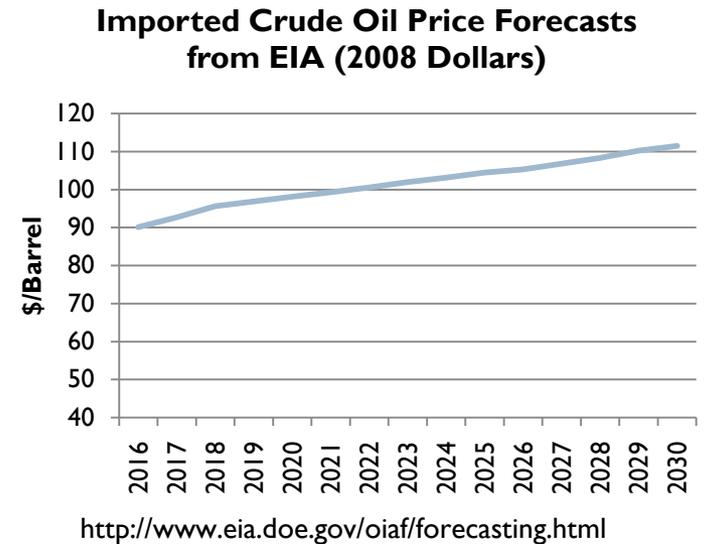
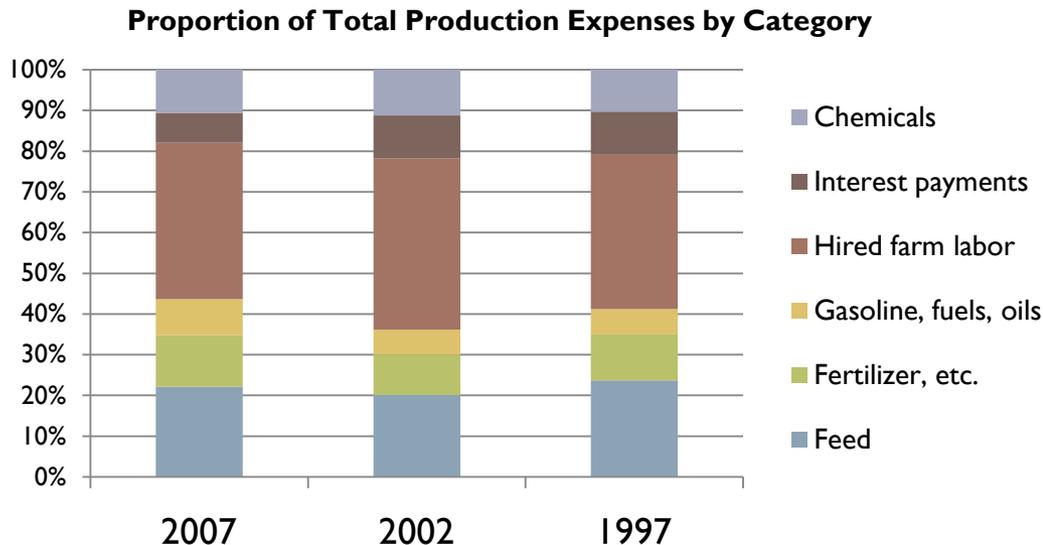
# Important Supply Side Factors

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- ▶ Production costs
  - ▶ Define three kinds of inputs based on how readily they can be adjusted:
    - ▶ **Exogenous:** not under the control of producers (climate...yet!).
    - ▶ **Short-term fixed:** inputs that can't be changed in one season or year.
    - ▶ **Variable:** can be adjusted annually or even within a growing season.
- ▶ Changes in exogenous inputs captured primarily through changes in yield according to CropSyst/VIC.
- ▶ Crops that require the same short-term fixed inputs can be switched into at relatively low cost.
- ▶ Crop rotations dictate coordinated changes between some crops.

# Important Supply Side Factors

- ▶ On average, from 1997 to 2007 there have been some changes in the relative magnitude of different input costs.



Source: Census of Agriculture; 1997 (area adjusted), 2002, 2007

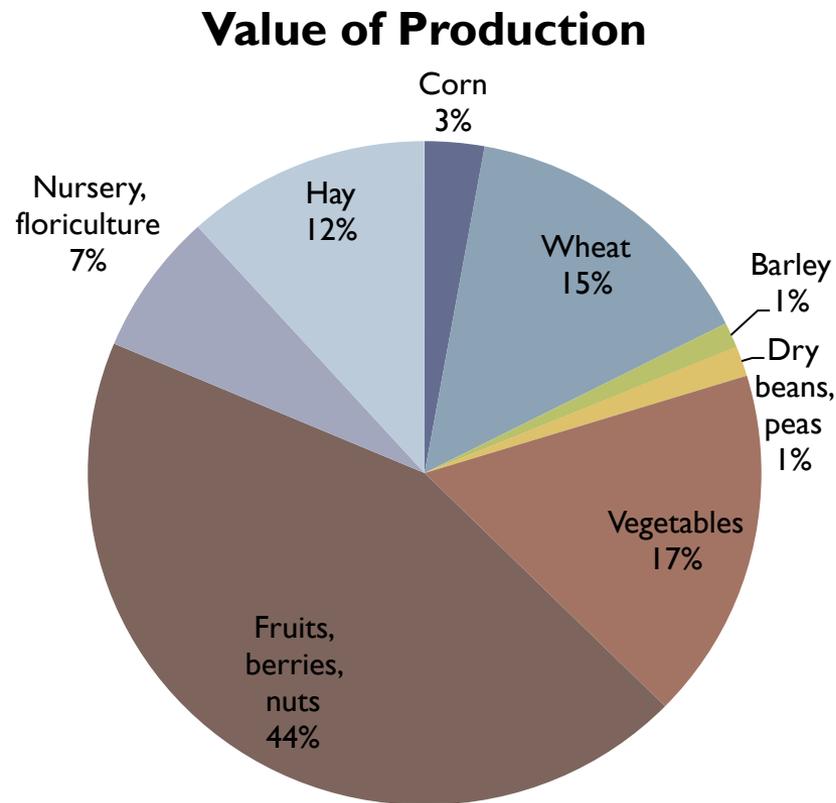
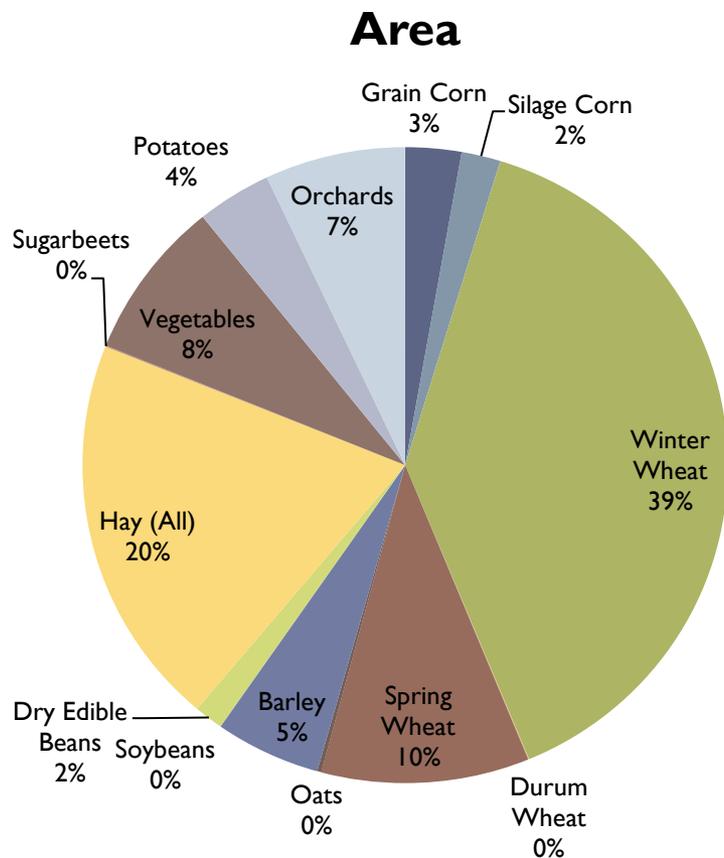
- ▶ Also take advantage of enterprise budgets for crop specific effects of changes in input costs.
- ▶ Will be collecting data more detailed for the state such as location specific pumping costs, Irrigation District assessments, NW Power Planning Council.

# Important Supply Side Factors

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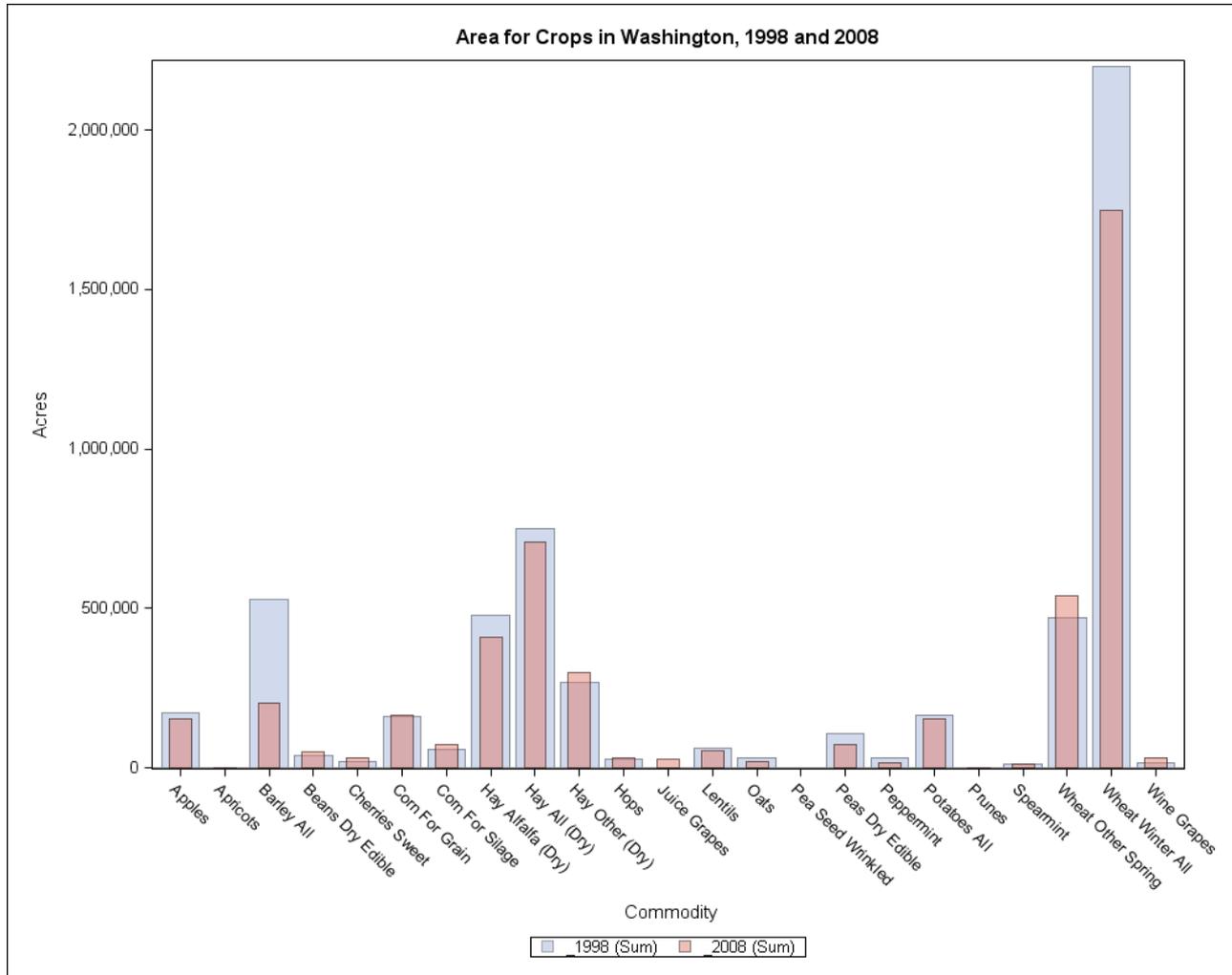
- ▶ What are the major trends revealed from historical data on crop acreage?
- ▶ Quick Summary\*:
  - ▶ Based on data from 2007, of the 45 million acres that the state encompasses about a third is categorized as being in farmland of one type or another.
  - ▶ All Land in Farms = 15 million acres
  - ▶ Cropland = 7.6 million acres
  - ▶ Harvested Cropland = 4.5 million acres
  - ▶ Irrigated Cropland = 1.7 million acres
- ▶ Total land in farms for the 13 counties in the CRB with the most farmland in 1948 was 11.2 million acres, which decreased to 10.4 million acres in 2008.
- ▶ Most counties have held steady or seen a decrease in farmland in the last 30 years.
- ▶ Data for many crops, particularly tree fruit, are not available at the county level outside of Census of Agriculture years (area adjustment method changed in 1997).

# Area compared to value of production by crop (category for value) for Washington (2007)

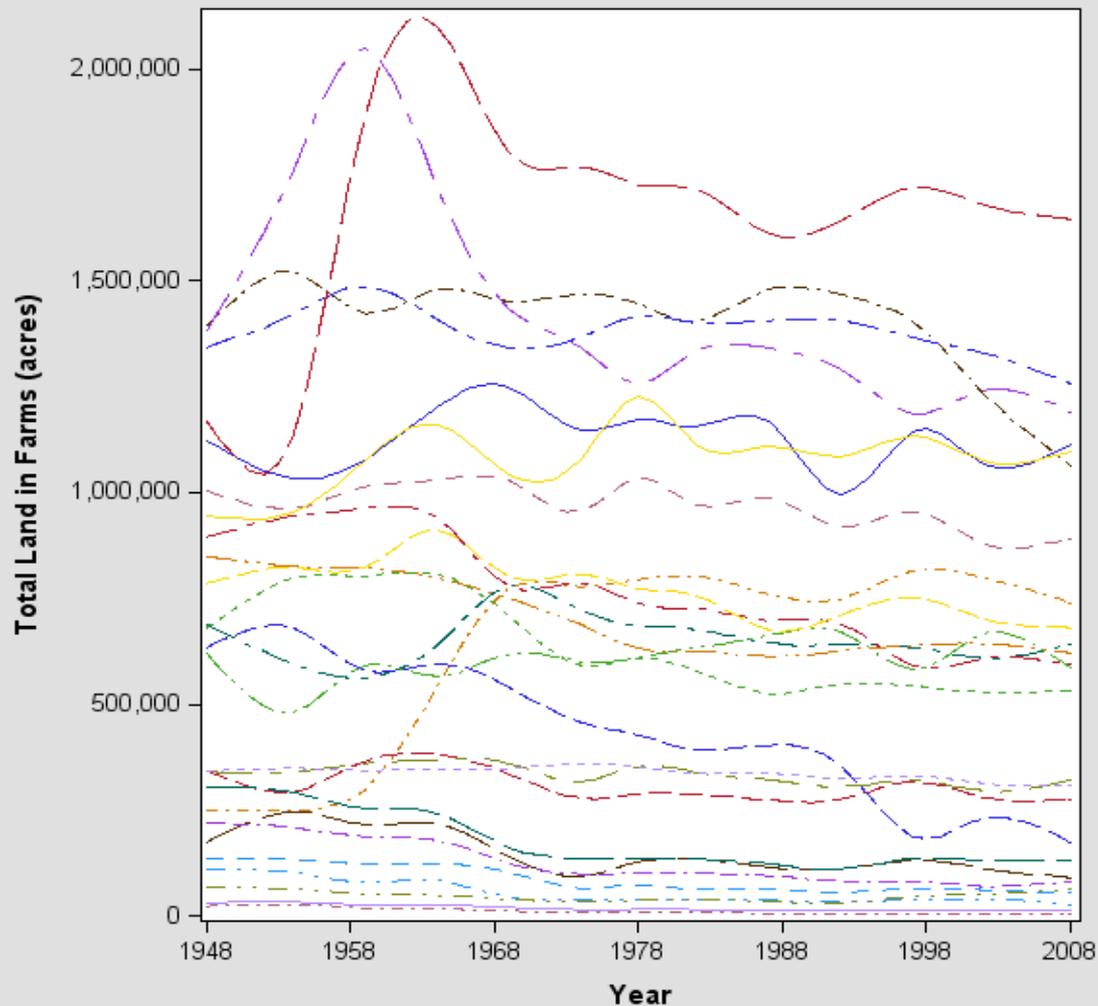


Source: 2007 Census of Agriculture

# State level change in crop acres 1998 to 2008



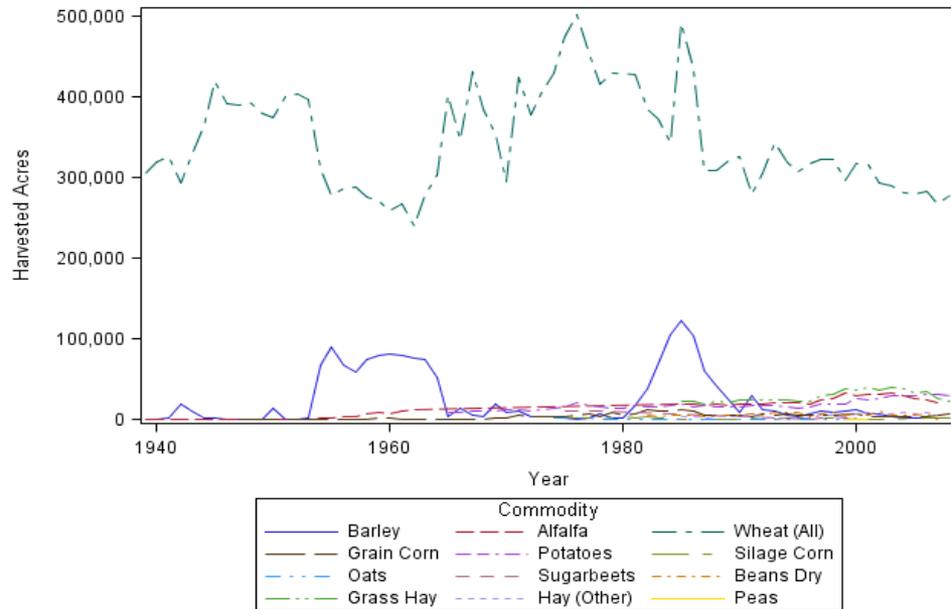
### Counties in the Columbia River Basin



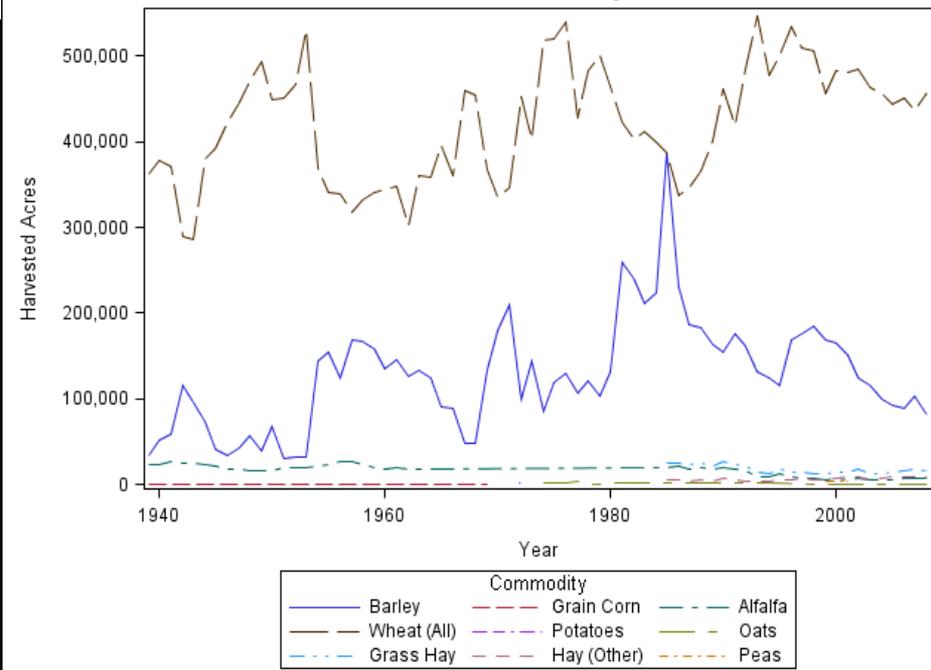
county		
— Adams	- - - Asotin	- - - Benton
- - - Chelan	- - - Clark	- - - Columbia
- - - Cowlitz	- - - Douglas	- - - Ferry
- - - Franklin	- - - Garfield	- - - Grant
- - - Kittitas	- - - Klickita	- - - Lewis
- - - Lincoln	- - - Okanogan	- - - Pacific
- - - Pend Ore	- - - Skamania	- - - Spokane
- - - Stevens	- - - Wahkiaku	- - - Walla Wa
- - - Whitman	- - - Yakima	

Source: Census of Agriculture Historical Series. Between census year interpolations by E. Ball, ERS, USDA.

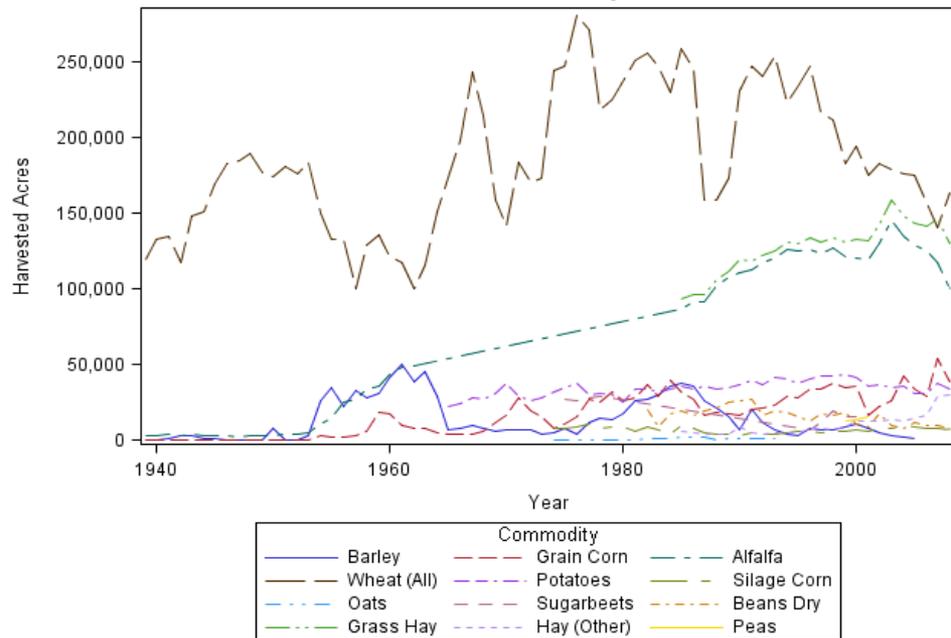
### Adams County



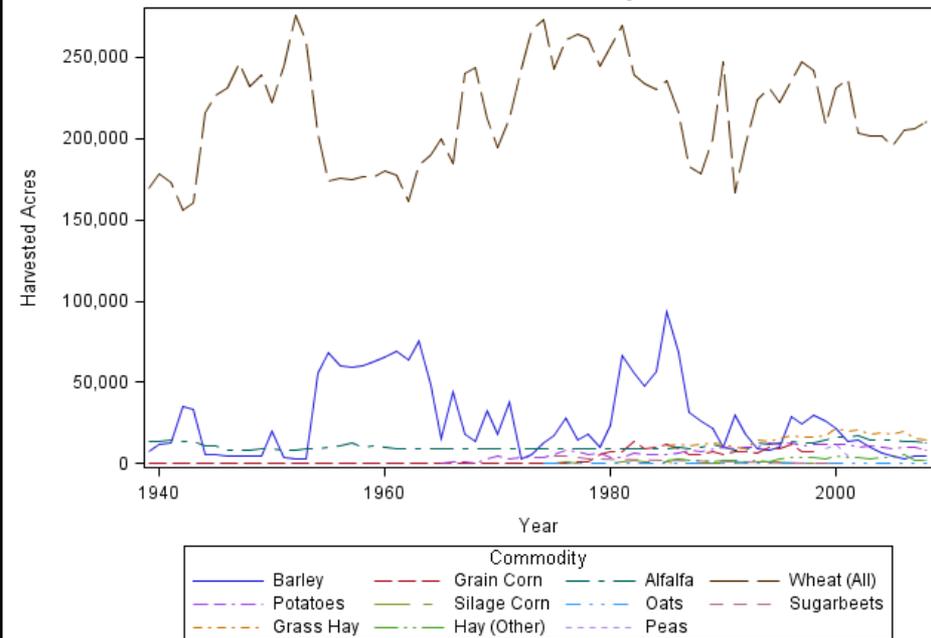
### Whitman County



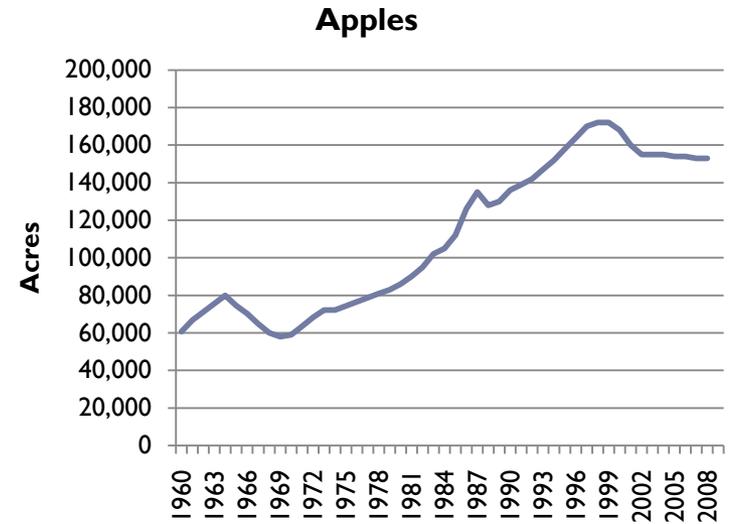
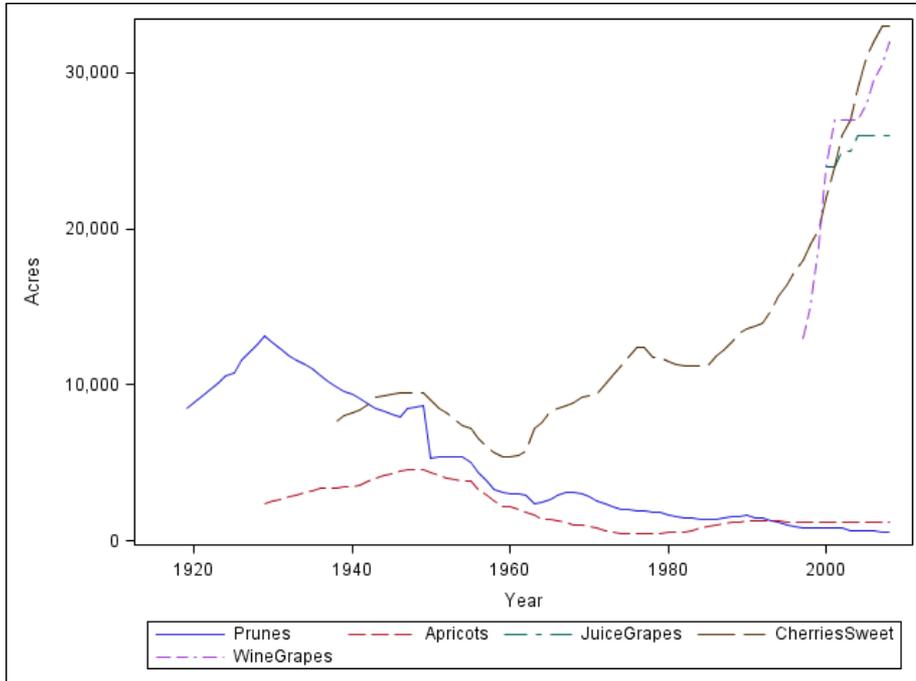
### Grant County



### Walla Walla County



# Tree Fruit



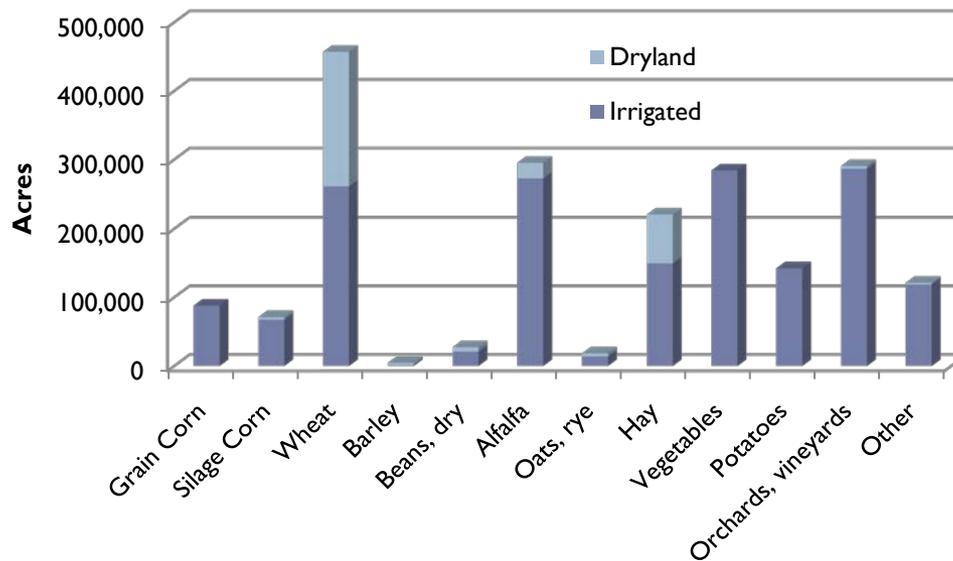
# Land Use Trends and Model Development

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- ▶ Tree fruits and vines use a much smaller land area so they are assumed to be limited by other factors.
- ▶ As expected, the long-term process of growing tree fruits and vines causes significant momentum.
- ▶ Crops with high variability in the past will have wider confidence intervals in the forecasts.

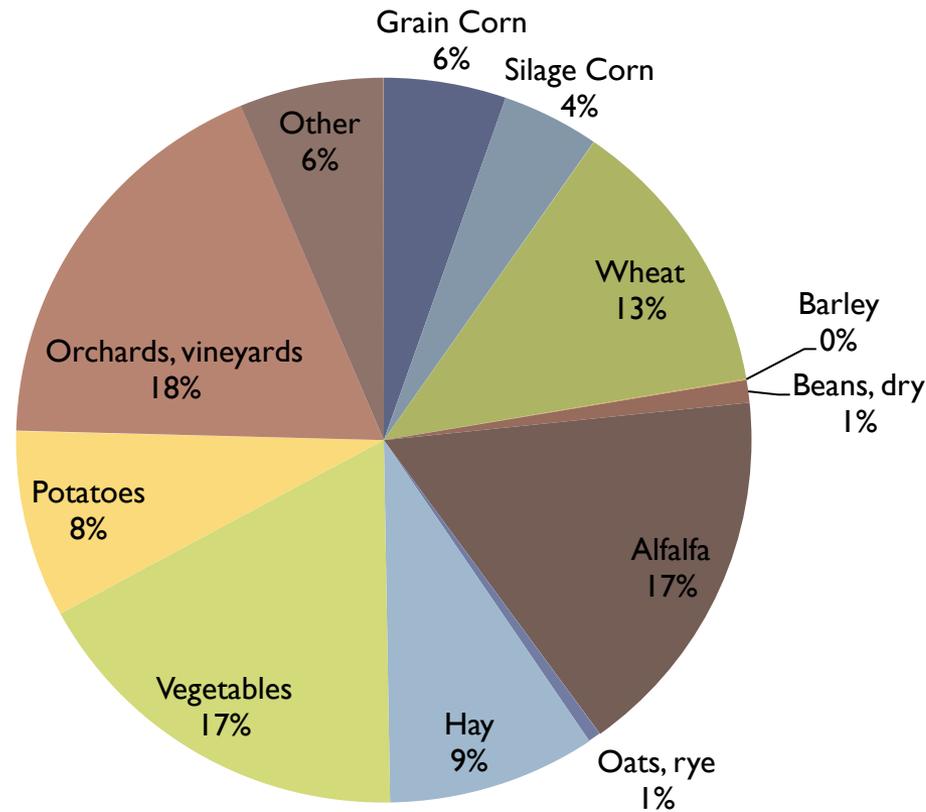
# Water

- ▶ 1.7 million acres of irrigated cropland in the state that receive a total of about 4 million acre-feet of water per year.
- ▶ On average, each irrigated acre receives just under 2.4 acre-feet per year.
- ▶ Irrigated acreage was largely constant from 1997 to 2007.



# Important Supply Side Factors: Water

Water use by crop in Washington (2008)



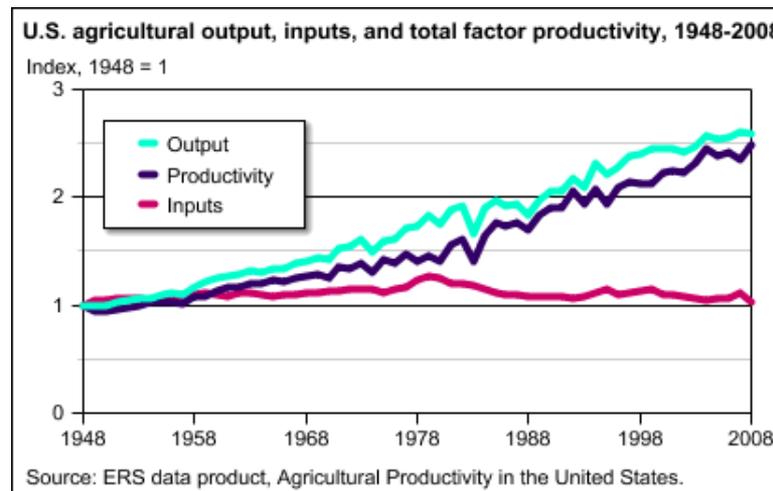
# Important Supply Side Factors: Water

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- ▶ Sub-state forecasts particularly important for wheat and hay (alfalfa to a lesser extent) to account for both dryland and irrigated production.
- ▶ Account for variation in new irrigation technology across the state/by crop.
- ▶ Coupled CropSyst/VIC provides valuable information on changes in temperature, precipitation, irrigation requirements, and instream flow rates at fine resolution for the state.

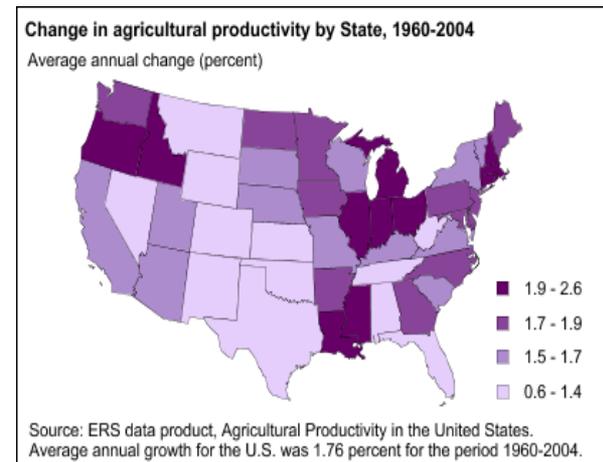
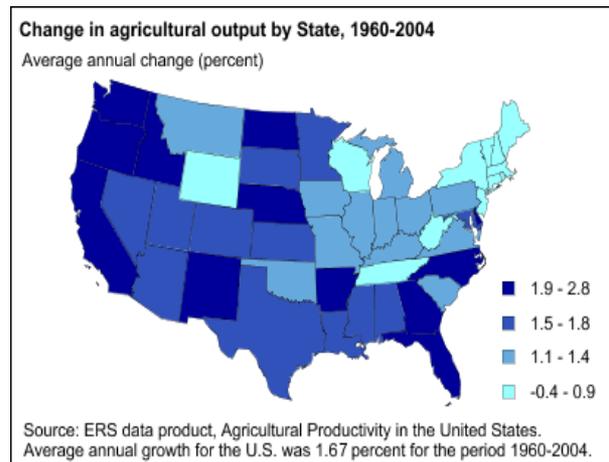
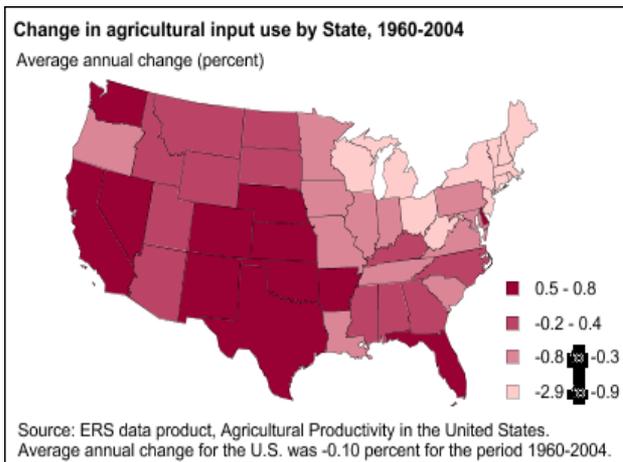
# Yield

- ▶ Assumptions about inputs required to produce given level of output are important.
- ▶ Increase in agricultural output in U.S. has primarily come from increased productivity in recent decades (E. Ball).
- ▶ Increased productivity means that increased production can be achieved with fewer demands on resources.



# Yield

- ▶ Washington on high end of both production growth and increases in inputs.
- ▶ Washington is slightly above average in productivity growth.
- ▶ “yield scenarios” are a good way to isolate the effect of productivity growth.



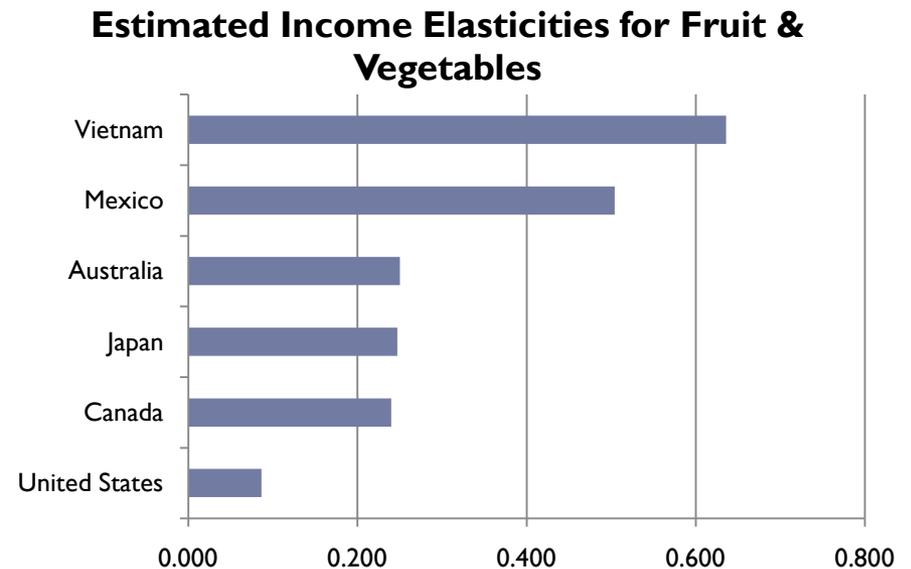
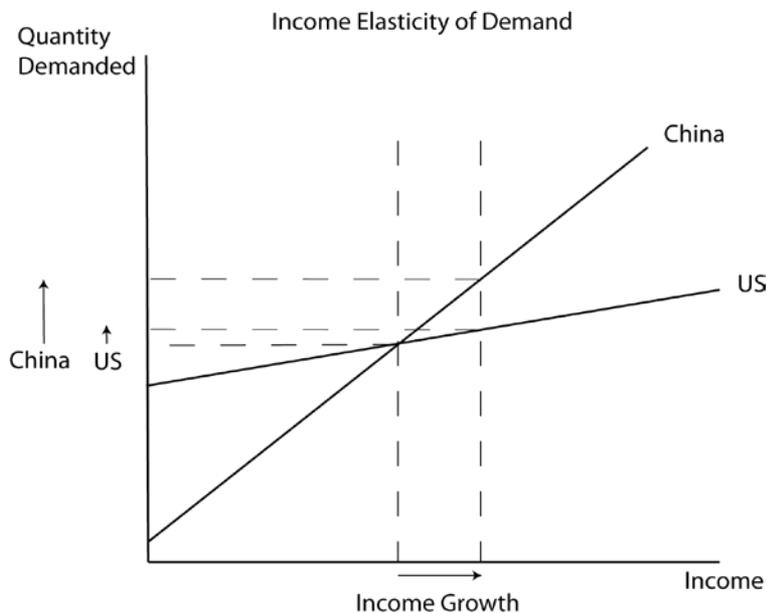
# Important Demand Side Factors

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- ▶ In addition to the costs of producing, the market price for agricultural goods also depend on consumers.
- ▶ A few obvious assumptions (all other things equal):
  - ▶ The more something costs the less people buy.
  - ▶ The more people want to buy of something the higher the market price will be.
  - ▶ People buy less of something if an alternative becomes cheaper.
  - ▶ The quantity demanded of more 'high value' food products (fruits, vegetables, meat) goes up as income grows, although the rate of growth depends on income levels. Important for exports.
- ▶ What are the important factors driving demand for agricultural commodities produced in Washington and what are future trends?
- ▶ The usual suspects of demand side factors
  - ▶ Population growth
  - ▶ Economic growth (income)
  - ▶ Food consumption preferences
  - ▶ Demographic trends
  - ▶ Trade policy and terms of trade

# Important Demand Side Factors: Income response

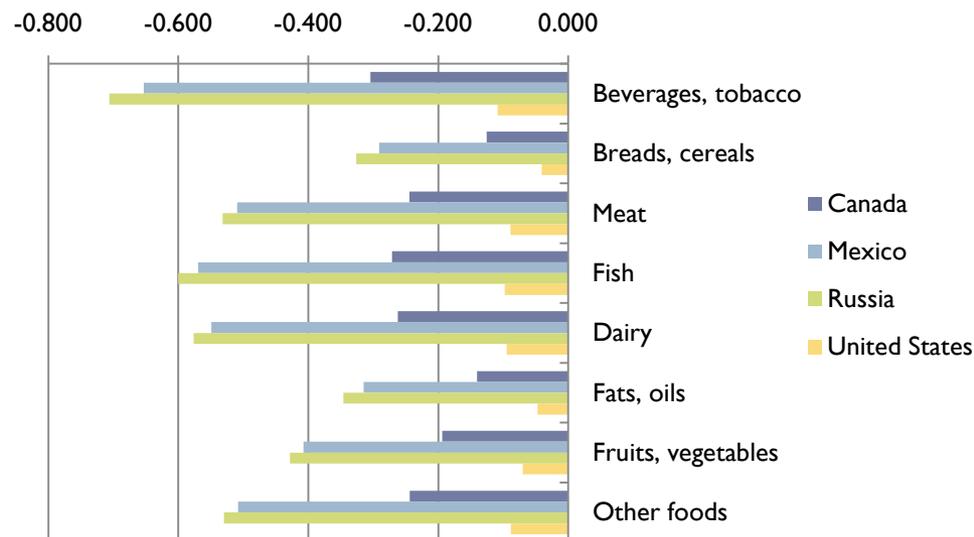
- ▶ Consumer demand for a good will depend on changes in the price of the good, the price of other goods, and their income.
- ▶ What is the likely effect of changes in income for domestic consumers compared to incomes for those in important export markets?



# Important Demand Side Factors: Price response

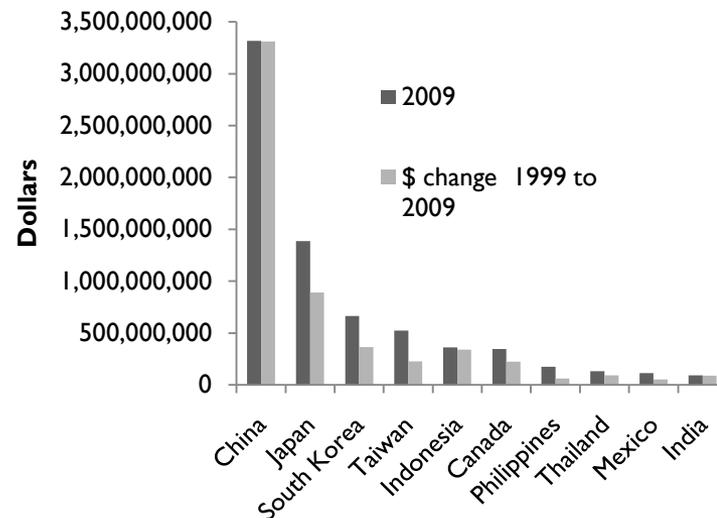
- ▶ “Price elasticity” measures the percent reduction in quantity demand for a percent increase in price.
- ▶ Price effects are most significant for high valued food groups in lower income countries.
- ▶ Important consideration for Washington because of fruit and vegetable exports to Asia.

**Price elasticities for food groups  
across countries**



# Exports

- ▶ A large portion of Washington production, \$3.2 billion worth, is exported.
- ▶ Fruits account for \$1 billion followed by wheat (\$618 million) and vegetables (\$606 million).
- ▶ Canada, China, India, and parts of SE Asia were the most important export destinations in 2009 and also saw the most growth from 1999 to 2009.
- ▶ Likely a strong connection with income growth (GDP per capita).



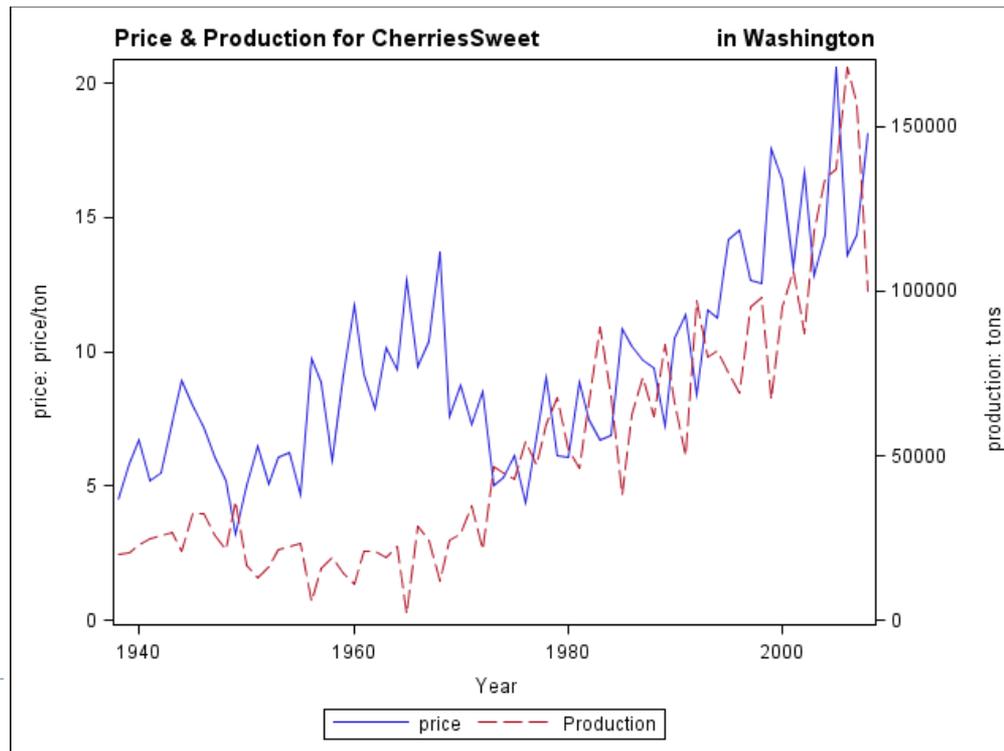
# Prices that depend on WA production

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- ▶ State level production for many crops is not likely to significantly affect market prices.
- ▶ However, Washington production of some crops is large enough to affect market prices.
- ▶ The degree of the price response depends on how responsive consumer demand is to the price for the commodity in question.
  - ▶ The more sensitive consumers are to a price increase the bigger is the price response.
  - ▶ Consumers tend to be more price responsive to non-staple goods.
- ▶ Must also consider how responsive producers are to changes in market price. Given the long-term investment for tree fruit responsiveness likely to be lower than for an annual crop.
- ▶ Directly related to concerns of over-supply among some tree fruit growers.
- ▶ Production growth from forecasts for some crops is assumed to induce a market price response.

# Prices that depend on WA production

- ▶ Time series for cherry prices (deflated to 1982 dollars) and production shown below.
- ▶ Long term upward trend in both. Short term increase in production corresponds with decrease in price.



# Supply and Demand Side Factors Summary

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- ▶ Identify the aspects of the supply side and the demand side that are the most important drivers of production trends to inform model development and scenarios.
- ▶ Supply side factors:
  - ▶ Different assumptions made about land restrictions for major field crops versus higher valued tree fruit and grape vines.
  - ▶ Spatial disaggregation of forecasted production. Particularly important for crops grown with both irrigated and dryland agriculture.
  - ▶ Adjustment to yield forecasts is a primary pathway for integrating economic component with physical models. Also for spatially disaggregated state or county level forecasts.
- ▶ Demand side factors:
  - ▶ Motivates considerable attention towards trade and economic growth in important exporting destinations.
  - ▶ Production quantity dependent price response (depends on both supply and demand).

# Review of project stages

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- ▶ Stage 1 Part 1: Start with state level crop specific forecasts that extrapolate historical trends.
- ▶ Stage 1 Part 2: Use understanding of the supply and demand side of this market to enrich simpler forecasts improving significantly what was done in previous reports
  - ▶ Crop rotations
  - ▶ Crop specific fixed inputs (short-term)
  - ▶ Long-term investment commitment with tree fruit and grape vines
  - ▶ Timing of major shifts in consumption trends
- ▶ Stage 1 Part 3: Conduct sub-state level (mostly county) forecasts. Data limitations for some crops limit explicit finer scale forecasts.
- ▶ Stage 2: With baseline forecasts as a foundation, use elasticities that capture likely supply and demand responses to consider how certain “shocks” affect production trends. To reiterate, prices of inputs and outputs provide the common pathway to compare the relative magnitude of very different events.
- ▶ Stage 3: Develop techniques to incorporate output from CropSyst/VIC with economic component, and vice versa. The most challenging but also the most interesting and novel part of the project.

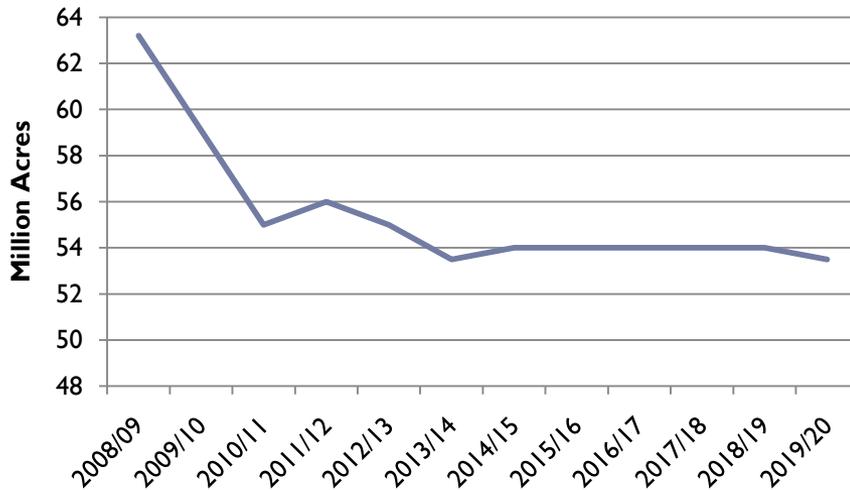
# USDA Baseline Projections

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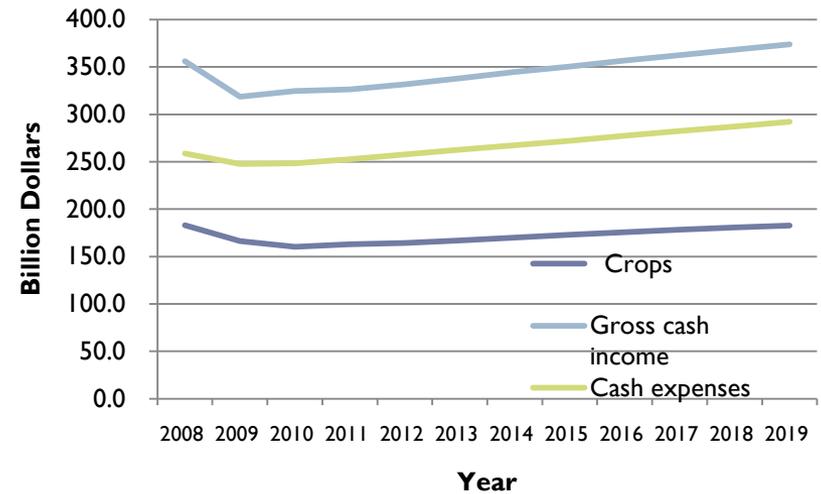
- ▶ Highly aggregated but provides an important benchmark.
  
- ▶ Highlights from 2010 projection to 2019
  - ▶ Macroeconomic assumptions
    - ▶ Slow recovery from financial crisis.
    - ▶ Expect resumption of high growth rates in India and China.
    - ▶ Growth in export demand will benefit farm cash receipts.
    - ▶ U.S. dollar expected to depreciate over the next decade.
  
  - ▶ Agriculture Policy
    - ▶ Based on 2008 Farm Act, maximum acreage enrolled in CRP will decrease about 7 million acres nationally.
    - ▶ Continued growth in U.S. ethanol industry but at a slower rate.
  
  - ▶ Ag Prices
    - ▶ Prices for crops will remain at historically high levels.
    - ▶ Inputs costs also expected to increase but will only partially moderate higher prices received.

# USDA Baseline Projections

## U.S. Wheat (Planted Acres)



## Receipts, Expenses, and Income for U.S. Agriculture



# Simple Forecasts

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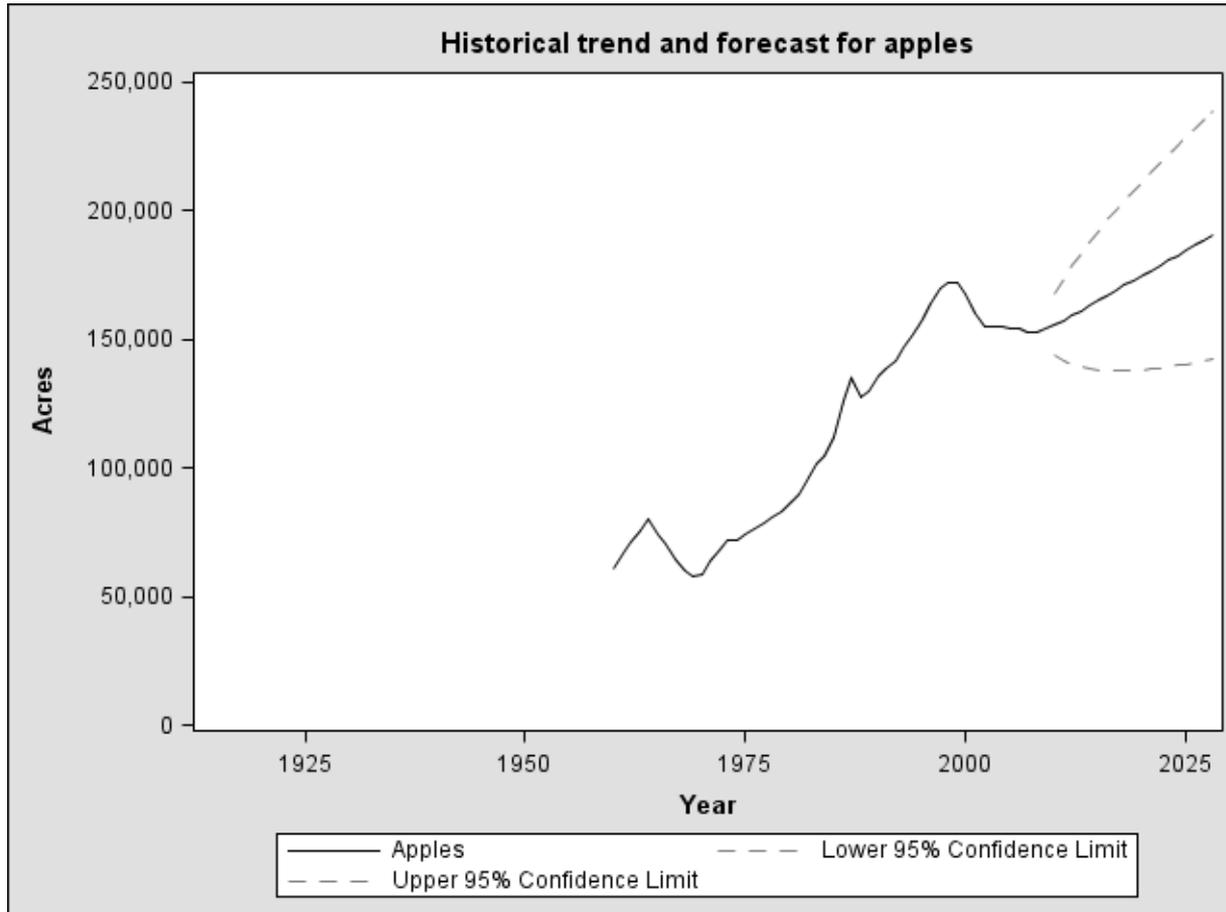
- ▶ Looking back 10 or 20 years much has changed, so do not want to assume production today will be production in 2030.
- ▶ Baseline forecasts from previous studies simply seek to extrapolate area, production, or yield based on historic trends just in each series (Huppert et al., Texas A&M).
- ▶ Rationale:
  - ▶ Factors affecting acreage decisions historically will continue to.
  - ▶ Simpler methods do little to statistically test causal relationships.
  - ▶ What has been the effect of historical variation in income growth, trade, drought, energy prices, interest rates, etc.?
  - ▶ If acreage for crop x has been highly variable, acreage response is very sensitive to changes in profitability and will continue to be highly variable in the future.
  - ▶ Which crops show a steady upward or downward trend?

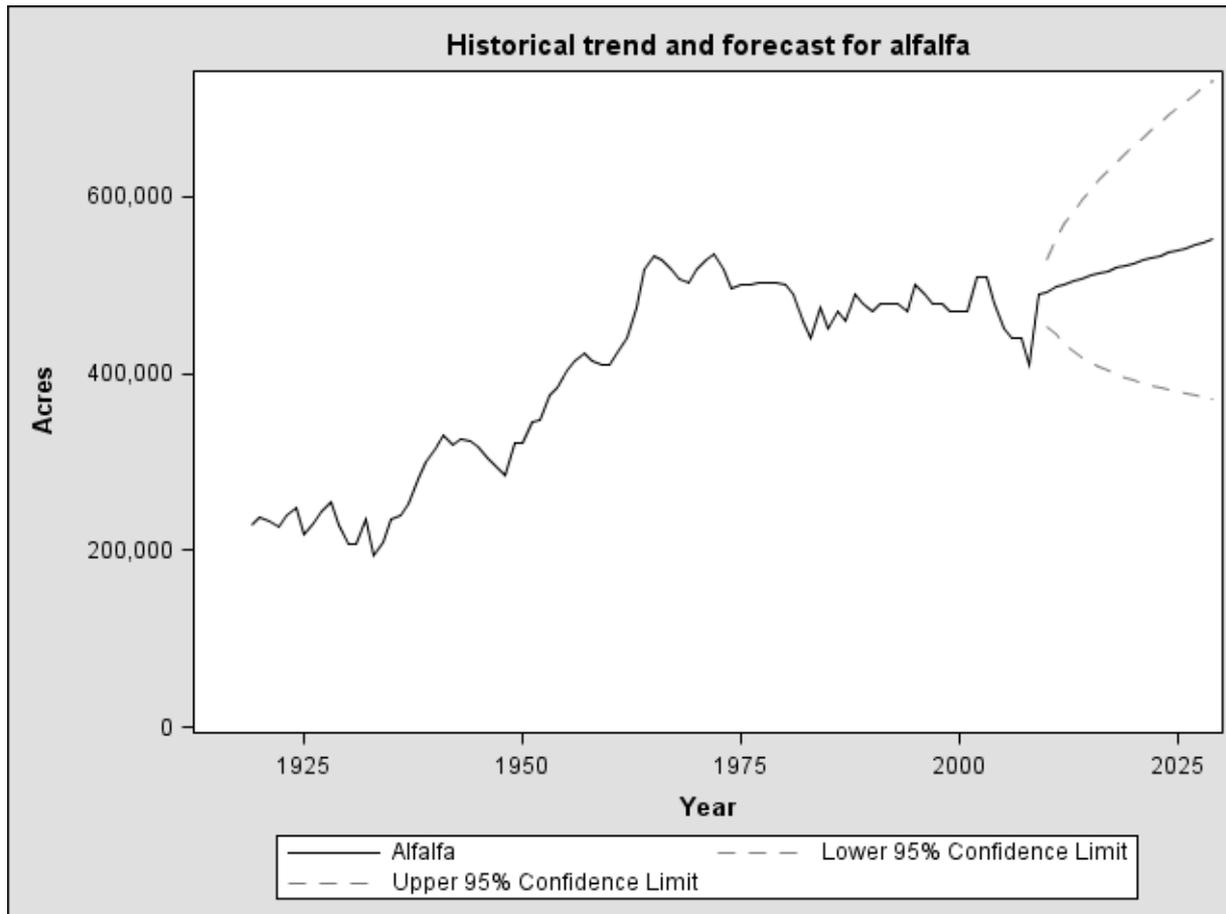
# More complex forecasts

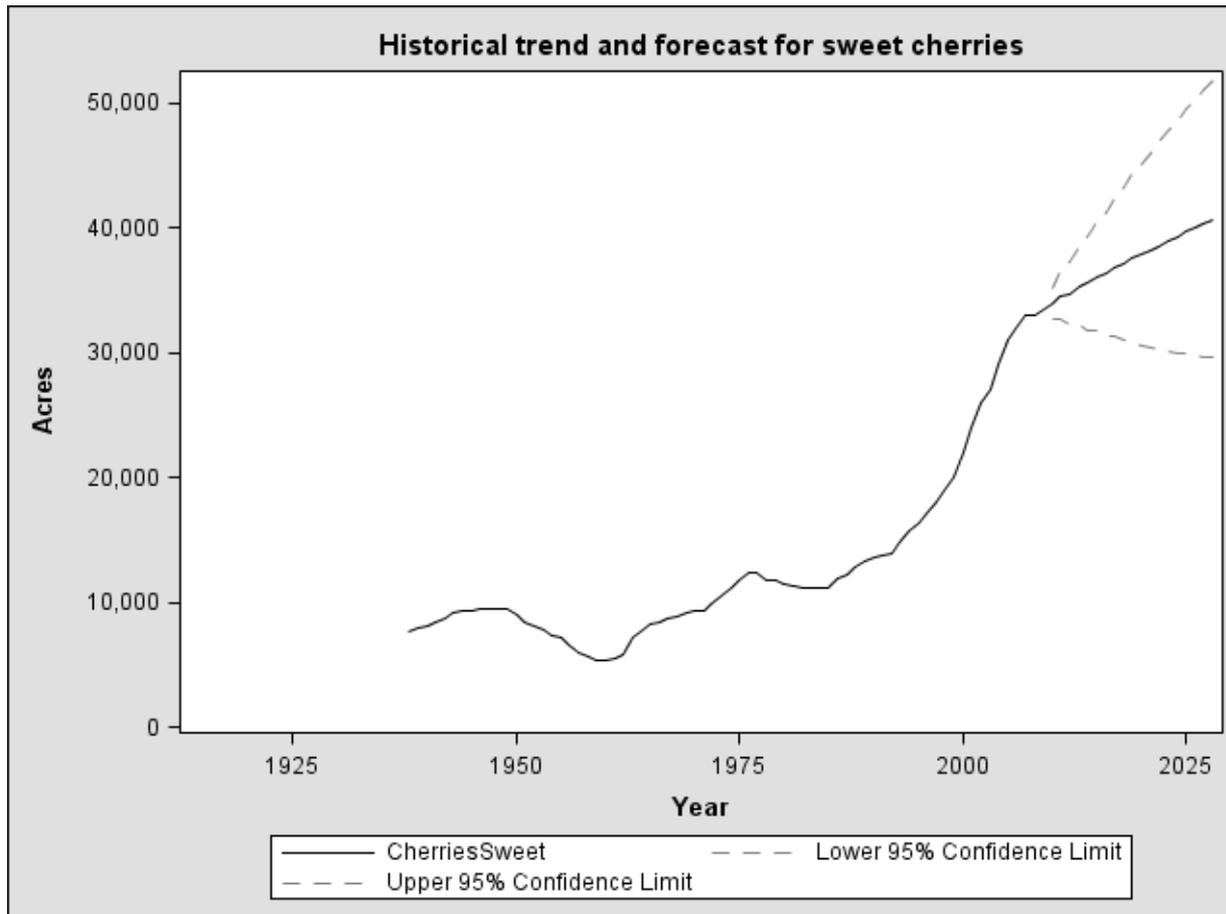
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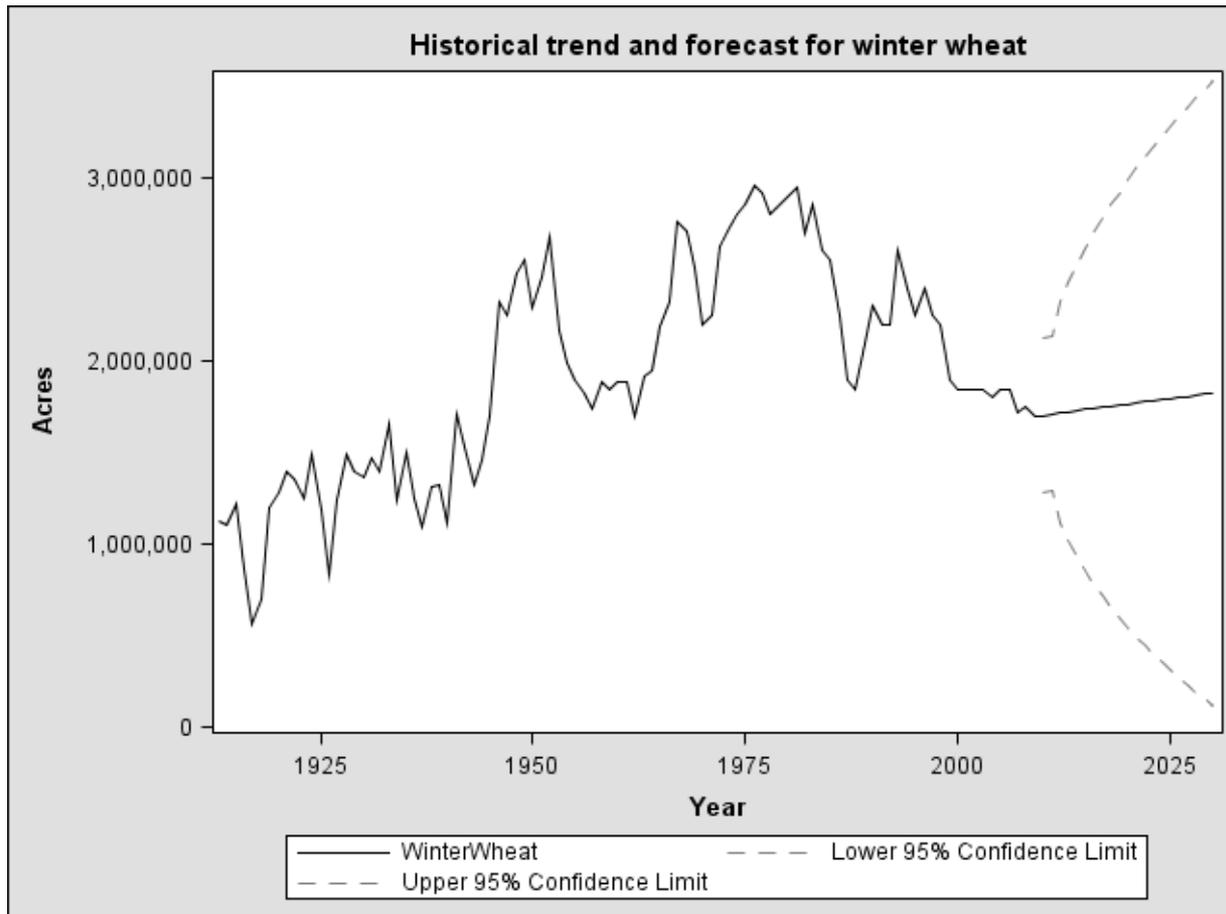
- ▶ Due to constraints such as land and water, assume that change in acreage in one crop will have repercussions for other crops.
  - ▶ Positively related if used in rotation together.
  - ▶ Negatively related if competitors for same land.
  
- ▶ Better able to statistically measure the influence of an external factor on crop production.
  - ▶ Trade
  - ▶ Changes in other regions producing the same crop
  - ▶ Market demand (wine)

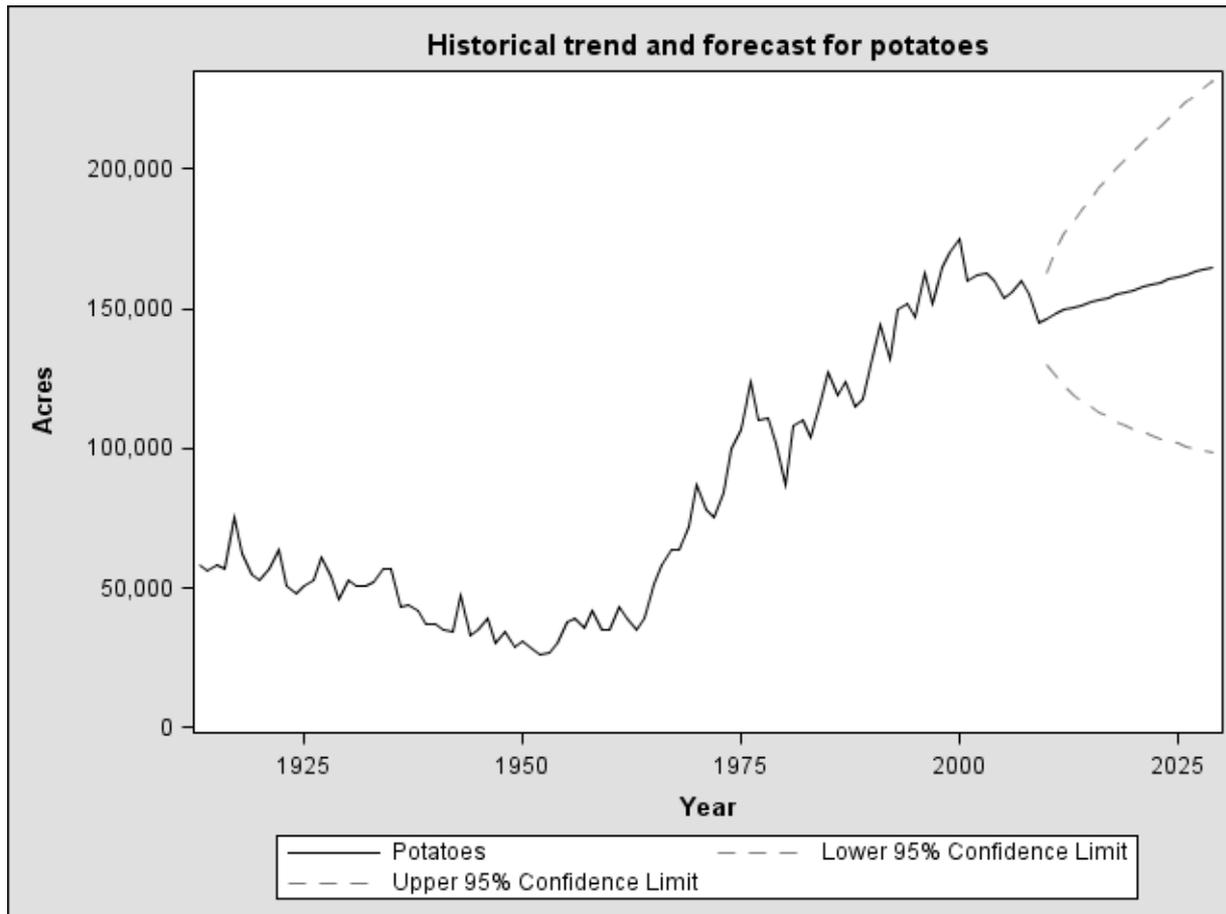
# Overview of some preliminary forecast results (DO NOT CITE OR REFERENCE)

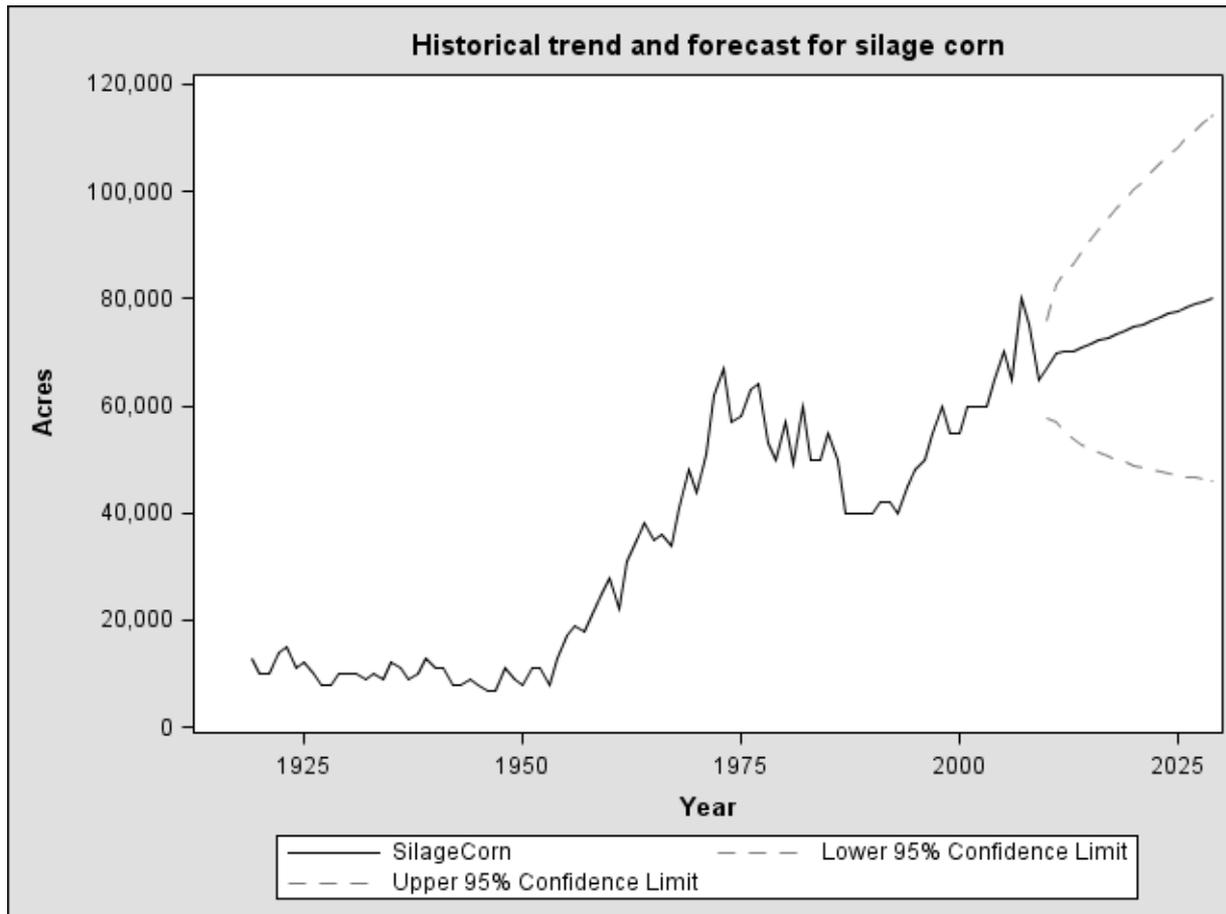






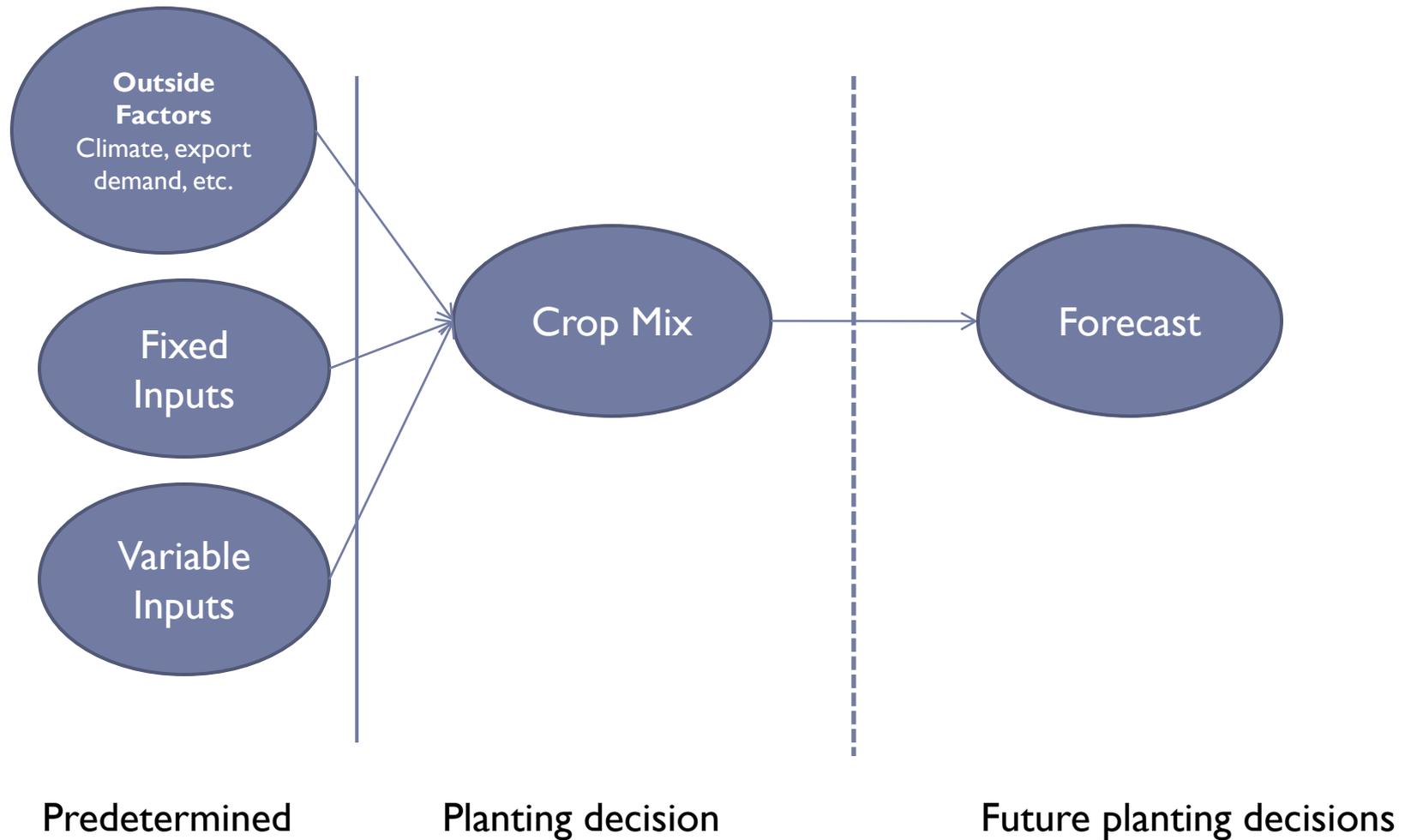




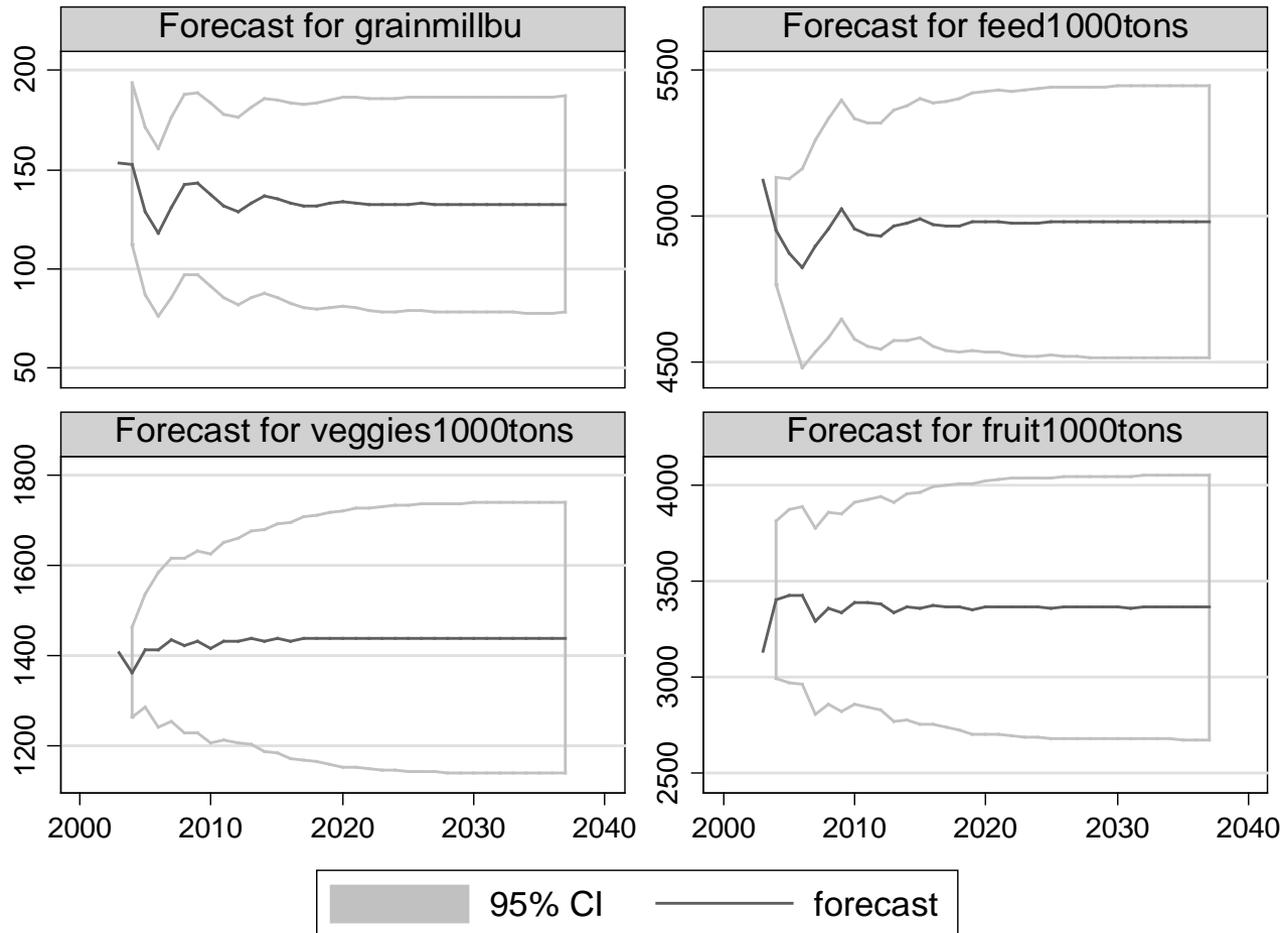


# More complex forecast structure

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# Example of forecast from more complex model



# Summary

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- ▶ Construction of baseline forecast is the first step.
- ▶ From here, better developed forecasts that represent a significant improvement to what has been done in the past.
- ▶ Forecasts serve as foundation for considering scenarios.
- ▶ Thanks for your time!