Price Efficiency Analysis of Heterogeneous Goods

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Food Distribution Research Society
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Heterogenous Goods

- **Heterogeneous goods** are comparable products with some attributes significantly different from each other.
  - Price and cost differentiation
  - Substitutes
  - Traded in same markets

Price Premiums and Discounts

- **Hedonic analysis** is the standard approach to untangle the complex role that perceived attributes play on price determination:

$$p = f(\boldsymbol{Z})$$

- <u>Limitations:</u>
  - Not generally applicable – *exogenous factors*
  - Cost-benefit of modifying attributes is not considered
  - Magnitude and distribution of actual transaction efficiencies are unknown

p = observe price
$\boldsymbol{Z}$ = vector of attributes

Objectives

- To develop a benchmarking methodology to assess the relative *price* and *profit* efficiencies of heterogeneous goods.
  - $\varepsilon = \frac{f(\boldsymbol{Z})}{f(\boldsymbol{Z}^*)}$
- To identify viable changes to current marketing practices that could result in higher profit margins.

ε = price or profit efficiency
$\boldsymbol{Z}^*$ = optimal array of attributes

Methods

- Price and cost are functions of *endogenous* and *exogenous* characteristics.
- Data Envelop Analysis (DEA)
  - Estimate technical price and profit frontiers
  - Identify Efficient Composite Unit (ECU)
- Proposed a unique set of optimization constraints:
  - Continuous/discrete and exogenous/endogenous attributes

Sketched Formulation – Price Oriented

- Given a set of N observed prices, the relative price efficiency of the i_0th price is obtained by

$$\min_{\boldsymbol{\lambda}} \ \varepsilon = \frac{p_{i_0}}{\sum_i^N \lambda_i \, p_i}$$

s.t. $\sum_i^N \lambda_i \, p_i =$ same or higher price than p_{i_0}

$\sum_{i=1}^N \lambda_i \, z_{ij}^{v,c}$ = within a feasible range of $z_{i_0 j}^{v,c}$

$\sum_{i=1}^N \lambda_i \, z_{ij}^{f,c}$ = same or worse condition than $z_{i_0 j}^{f,c}$

$\sum_{i=1}^N \lambda_i \, z_{ij}^{v,d}$ = feasible level

$\sum_{i=1}^N \lambda_i \, z_{ij}^{f,d}$ = same as $z_{i_0 j}^{f,d}$

$\sum_{i=1}^N \lambda_i = 1$ (*convex linear combination*)

v = endogenous variable f = exogenously fixed

c = continuous d = discrete

Empirical Application

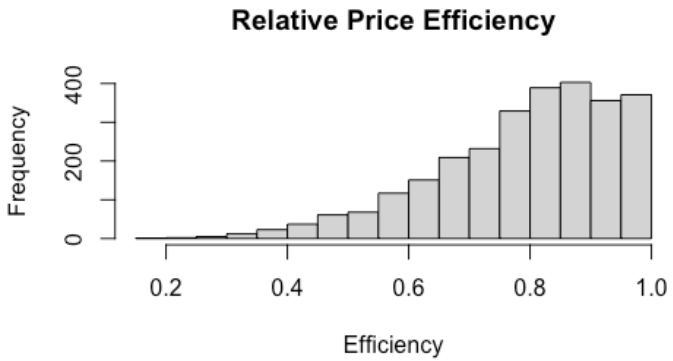
- Feeder cattle prices
- Auction market sales in South Texas
  - 2014 - 2019
  - 11 markets
- 6,065 observations
- Characteristics include:
  - Hide color, sex, frame size, fill, body condition, muscle score, Brahman influence, dehorn status and weight

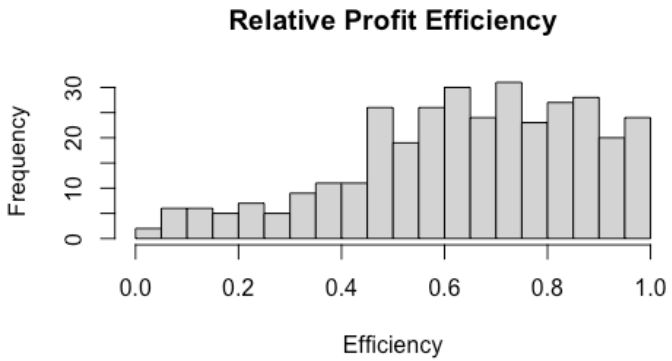
Cattle Characteristics

	Endogenous	Exogenous
Continuous	Weight	Market conditions: • Feeder cattle • Live cattle • Corn • Soybean meal
Discrete	Fill Body Condition Horns Castration	Frame Muscle Score Brahman Influence Hide Color Sex Location

Efficiency Results

	Price Oriented	Profit Oriented
Observations	6,065	1,492 - *weight [600lb, 1,000lb]*
Inefficient obs.	45.61%	22.79%
min ε	0.16	0.03
mean ε	0.79	0.64
max ε	0.99	0.99





Example

	Original	Price ECU	Profit ECU
Weight (CWT)	9.25	5.30	6.30
Fill	Avg.	Avg.	Avg.
B. Condition	Avg.	Avg.	Avg.
Horn	Yes	No	No
Sex	Bull	Steer	Steer
Price ($/hd)	730.75	893.10	
Profit ($/hd)	-383.77		-167.50
Efficiency		0.82	0.64

Exogenous Variables:

- Color: *BWF*
- Frame: *Large*
- Muscle score: *2*
- Brahman influence: *25%*
- Location: *Auction B*

- Feeder cattle ($/cwt) ≤ *149.7*
- Live cattle ($/cwt) ≤ *130.1*
- Corn ($/bu) ≥ *3.67*
- Soybean meal ($/bu) ≥ *$3.73*

Summary and Conclusions

- Proposed a data-driven method to estimate existing transaction efficiencies in agricultural markets.
- Model can be used to develop effective value-added management practices and educational programs.

Questions

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Untapping Terroir

Experimental Evidence of Regional Variation in Hop Flavor Profiles

Aaron J. Staples, Trey Malone, Vincenzina Caputo, Rob Sirrine, Alex Adams, Alec Mull, and Scott Stuhr

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Roadmap

01

Introduction

- America's hop industry
- Emerging local hopyards and their many challenges
- Terroir: What is it?

02

Methodology

- Professional chemical analysis
- Blind taste tests
- Brewer willingness to pay for local hops

03

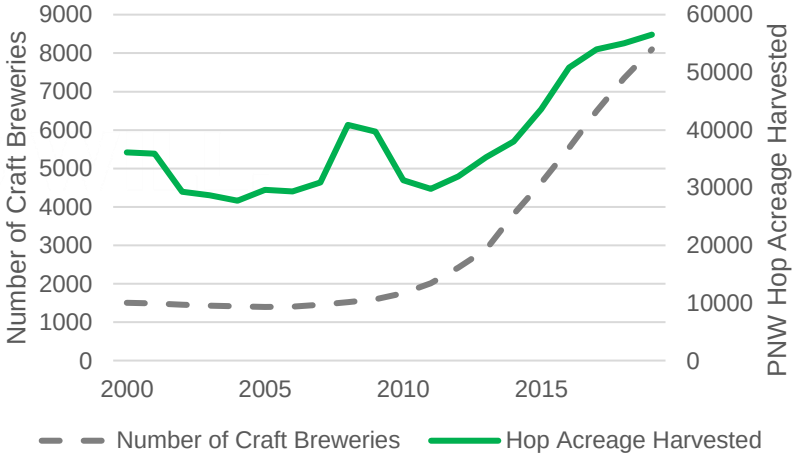
Results & future work

- Different chemical compositions
- Statistical significances in blind taste test
- 35% premium for state-grown hops, holding all else constant.

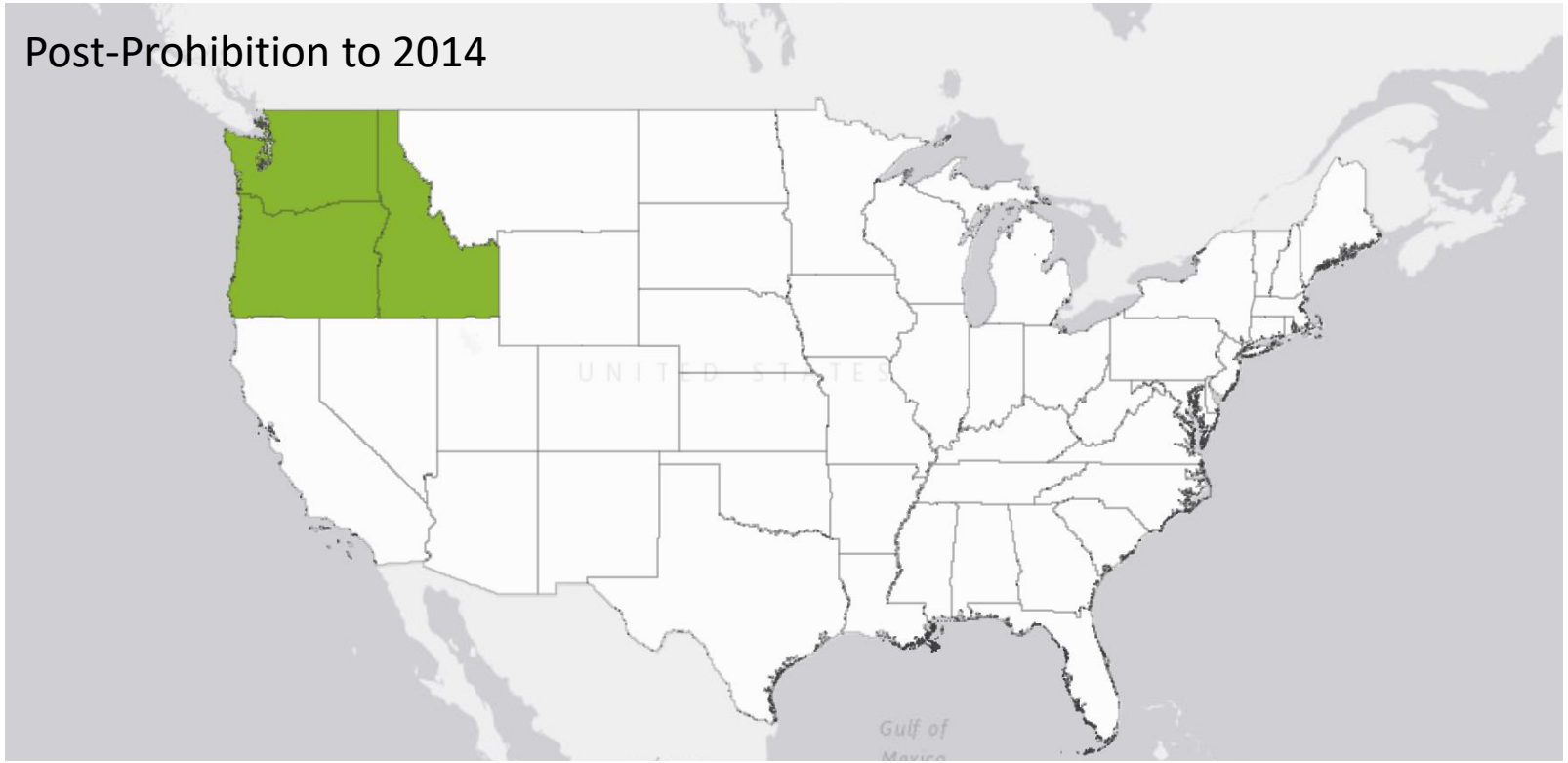
Hops

- Provides bitterness, flavors, and aromas to beer
- Over 160 hop cultivars used by craft brewers in 2019 (Swersey, 2020)
- Used in various quantities depending on the beer style and desired flavor profile of the beer
- Since 2010:
  - Number of craft breweries: 350%
  - Acres of U.S. hops: 92%

Hop production is driven by the craft beer revolution.



Hop production is becoming more regionally diverse



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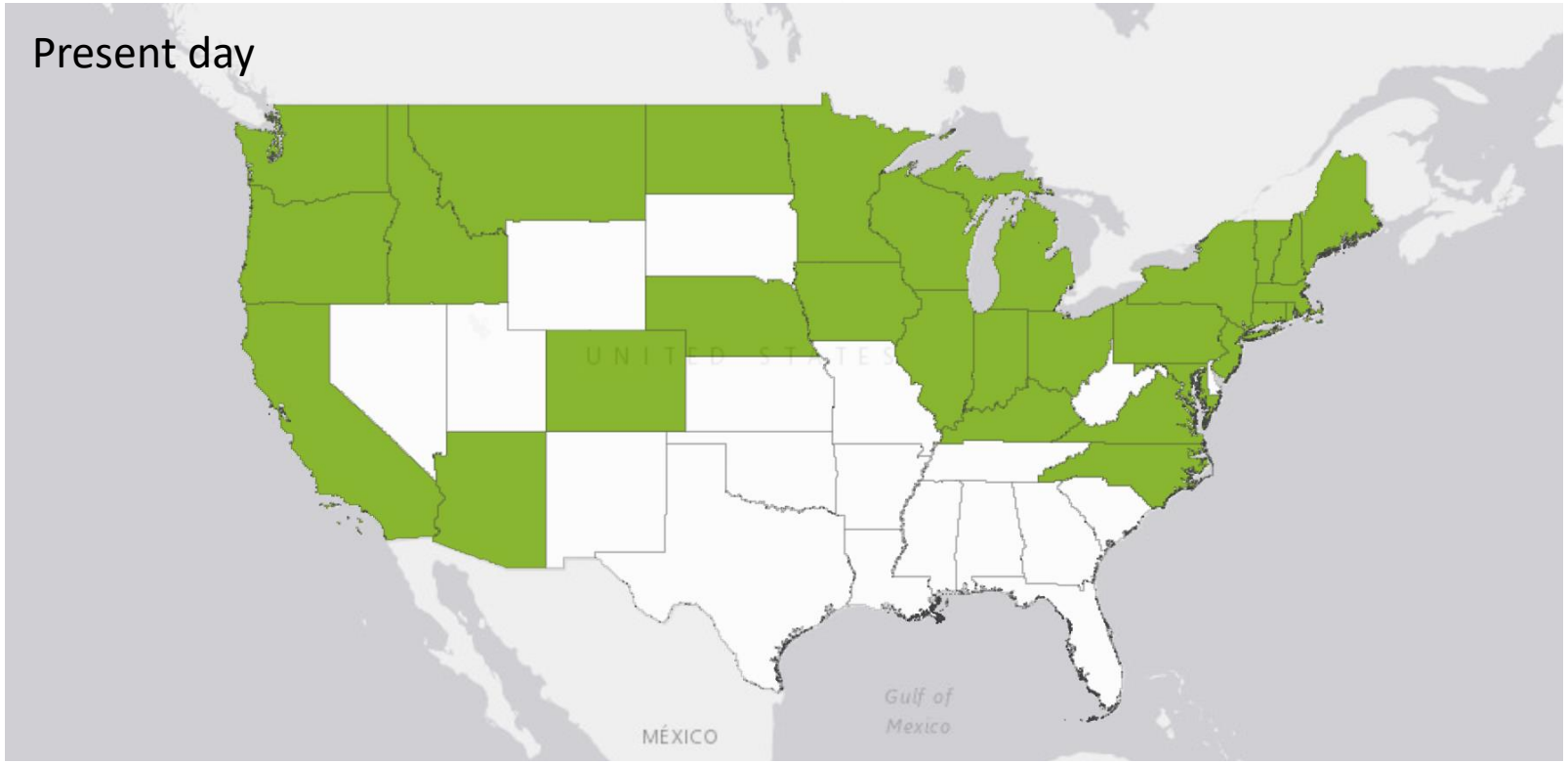


Terroir: What is it?

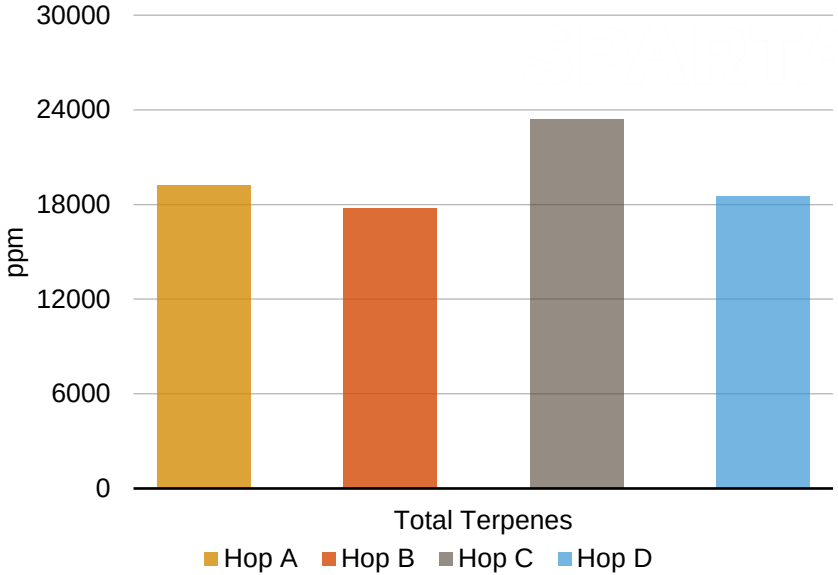
- Terroir: tastes and flavors are a product of the environment from which a commodity is produced
- Studied extensively in grapes and wine (Costanigro et al., 2010; Cross et al., 2011; Haeck et al., 2019; Vaudour, 2002) but less so in hops and beer (Morcol et al., 2020; Van Holle et al., 2017).
- Could provide hop growers (and brewers) outside the traditional growing regions with a unique marketing avenue.

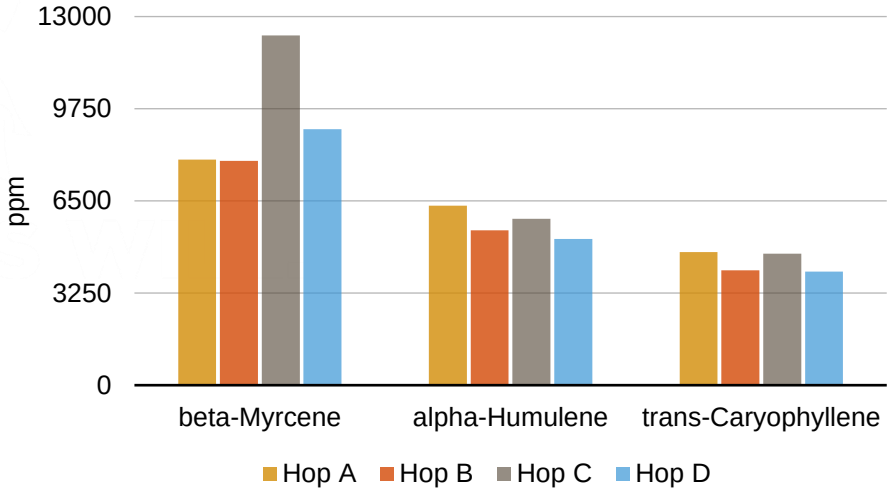
Photo credits: Vivino (2020); Firestone Walker (2019)

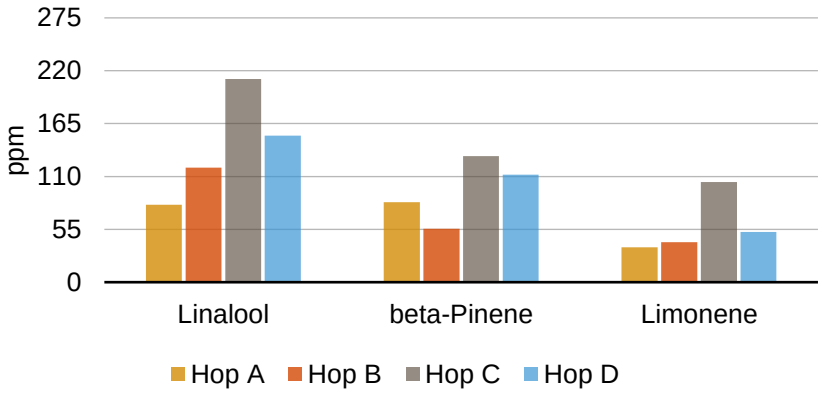
Methodology: Purchase four Chinook hop samples from four different eco-regions

1. Chemical analysis
   - Professional tests examining hop terpenes, fruity esters, and secondary microbes
2. Blind taste test with sensory panel
   - Brew a 5 bbl baseline beer
   - Separate into smaller fermenters and *dry hop* with the hops from different regions
3. Labeled, hypothetical choice experiment
   - Brewer willingness to pay for local hops
   - Data collected in 2019 from 74 craft breweries

1. Chemical analysis







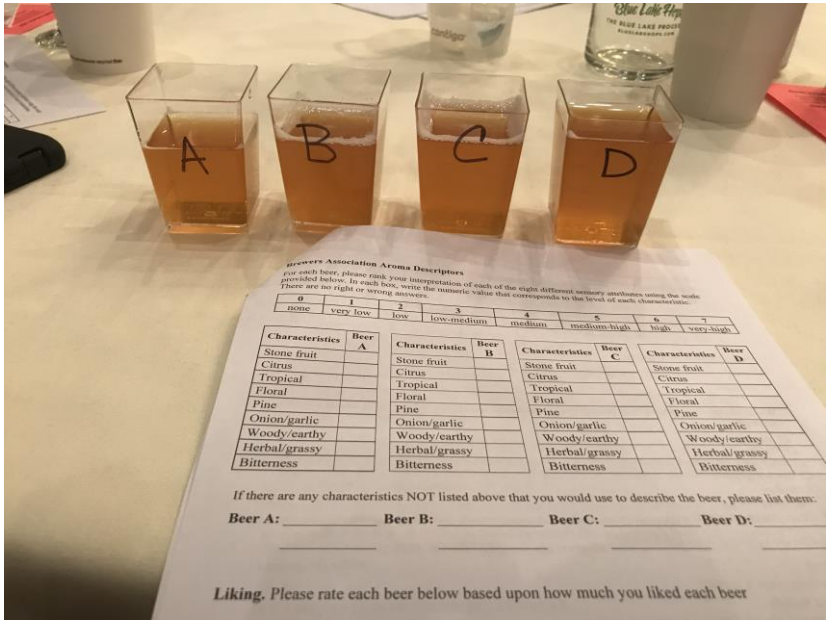
Terpenes are aromatic compounds responsible for providing distinct character to a variety of plants.

2. Blind taste test (n=55)

0	1	2	3	4	5	6	7
none	very low	low	low-medium	medium	medium-high	high	very high

Aroma characteristics	Beer A	Beer B	Beer C	Beer D
Stone fruit				
Citrus				
Tropical				
Floral				
Pine				
Onion/garlic				
Woody/earthy				
Herbal/grassy				
Bitterness				

Beer career industry professionals rated the presence of various sensory attributes in the four beers

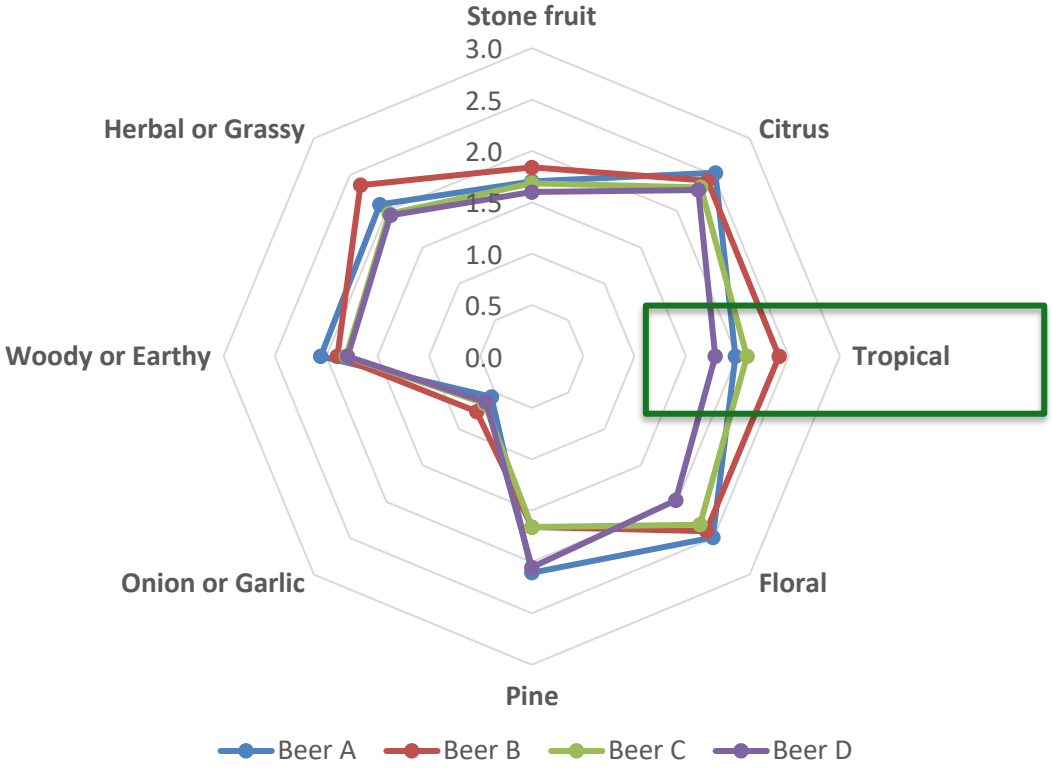


2. Blind taste test: Results

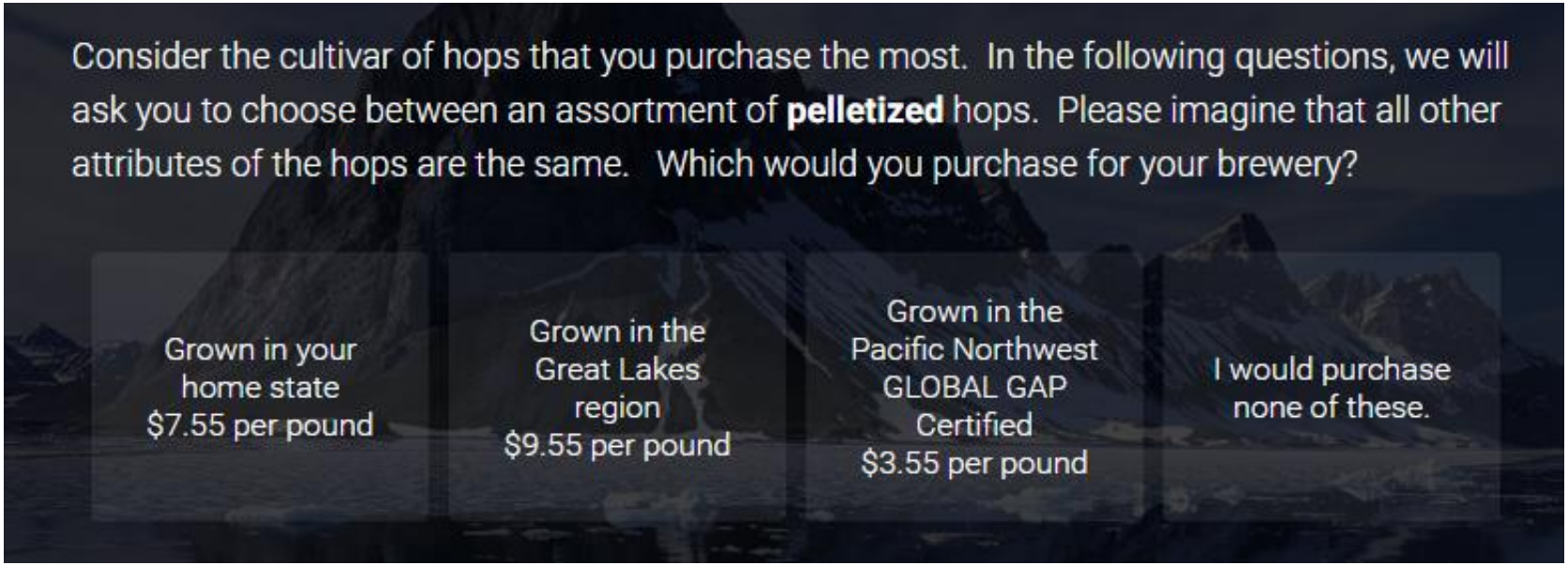
Characteristic	Beer A	Beer B	Beer C	Beer D
Aroma				
Stone fruit	1.70	1.84	1.69	1.60
	(1.70)	(1.93)	(1.66)	(1.65)
Citrus	2.53	2.42	2.33	2.29
	(1.90)	(1.64)	(1.59)	(1.74)
Tropical	1.98	2.41*	2.09	1.79*
	(1.86)	(2.07)	(1.61)	(1.70)
Floral	2.49	2.40	2.31	1.98
	(1.96)	(1.75)	(1.54)	(1.61)
Pine	2.11	1.66	1.66	2.05
	(1.91)	(1.54)	(1.46)	(1.68)
Onion or Garlic	0.56	0.76	0.65	0.63
	(1.20)	(1.36)	(1.31)	(1.23)
Woody or Earthy	2.06	1.89	1.81	1.79
	(1.98)	(1.94)	(1.75)	(1.61)
Herbal or Grassy	2.09	2.36	1.96	1.94
	(1.51)	(1.99)	(1.61)	(1.51)
Bitterness	3.42**	2.84**	2.88**	3.09
	(1.46)	(1.44)	(1.27)	(1.42)

[a] Indicates a statistically significant difference at the 10% level.

[b] Indicates a statistically significant difference between Beer A and Beers B and C at the 5% level.



3. Choice experiment (n = 74 craft brewers)

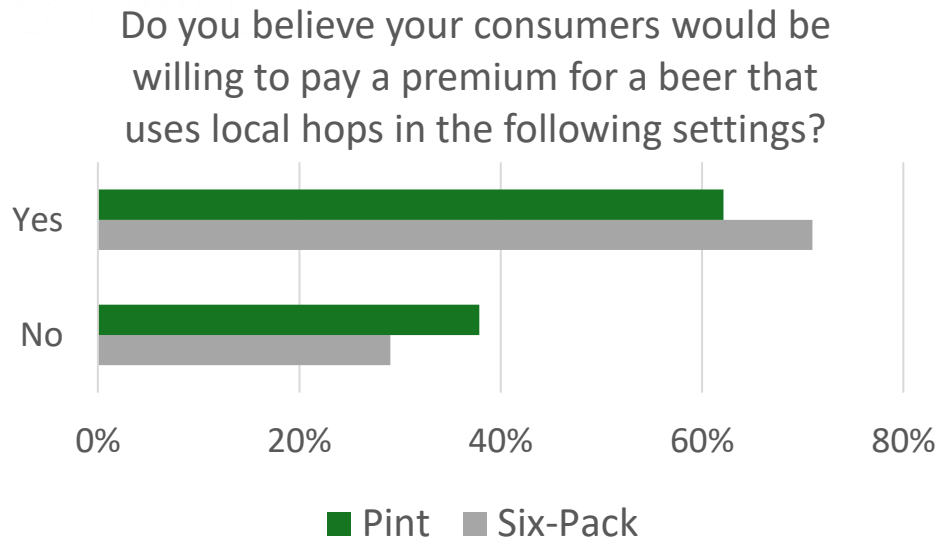


3. Choice experiment: Results

Ceteris paribus, craft brewers are willing to pay 35% more for state-grown hops

What is driving this premium?

1. Brewer preference for localness
2. Expectation that consumers are willing to pay premium on beers using local hops
3. Perception that local hops taste different than non-local hops



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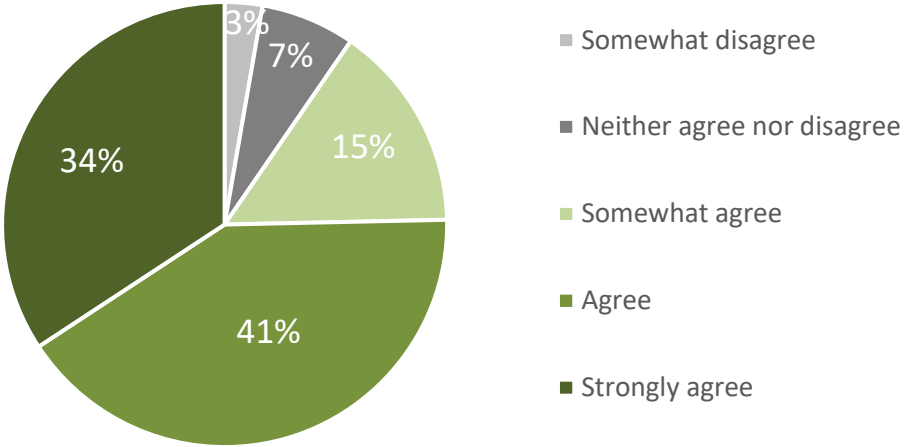
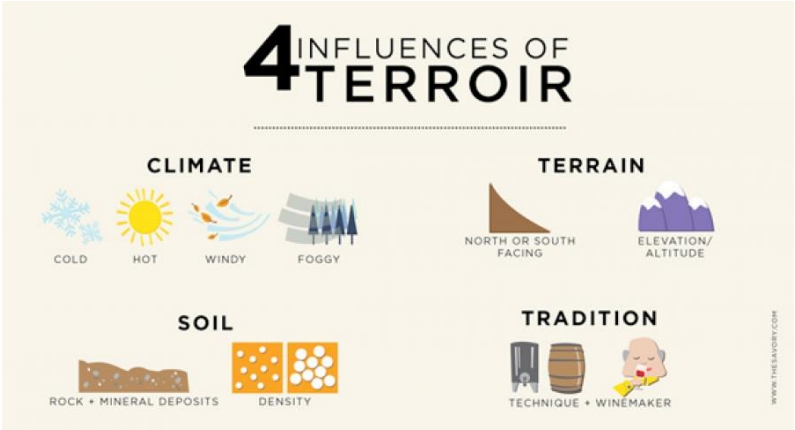
2. Expectation that consumers are willing to pay premium on beers using local hops
3. Perception that local hops taste different than non-local hops

To what extent do you agree or disagree with the following statement: Local hops taste different than non-local hops.



Marketing implications

- Craft brewers are searching for ways to differentiate their product
- Hop growers are searching for ways to overcome production and marketing challenges
- Nested names
  - Michigan Chinook versus PNW Chinook
- Farm brewery legislation: initiative to incentivize the use of state-grown inputs



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Cheers!

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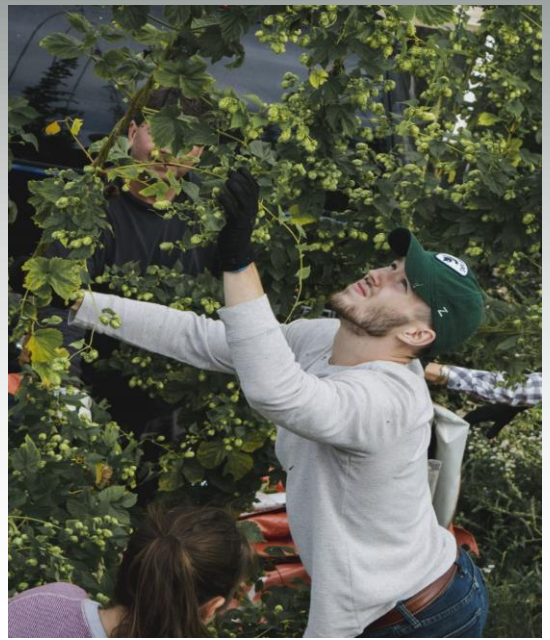


Appendix

Table 2. Likert scale responses to attitudes and beliefs towards purchasing local

Statement	Mean Score (1-7)	Percentage of responses						
		Strongly Disagree (1)	Disagree (2)	Somewhat Disagree (3)	Neutral (4)	Somewhat Agree (5)	Agree (6)	Strongly Agree (7)
Propensity to buy locally produced inputs								
I like to buy inputs that are locally produced.	5.78	0%	2%	0%	12%	16%	44%	26%
Whenever possible, I intentionally buy locally produced inputs.	5.46	0%	4%	0%	14%	30%	32%	20%
I make it a priority to buy locally produced inputs.	5.20	0%	6%	4%	18%	26%	28%	18%
Beliefs about locally produced inputs								
Buying locally produced inputs is good for the local economy.	6.38	0%	0%	0%	4%	4%	42%	50%
Buying locally produced inputs helps the environment.	5.30	0%	4%	4%	28%	12%	26%	26%
Buying local inputs means more money goes to the farmer.	5.22	0%	4%	4%	26%	16%	32%	18%

Footnotes: Statements were introduced by asking each of the 50 respondents, “To what extent do you agree or disagree with the following statements?”

Appendix

Table 3. Brewer attitudes regarding the likely success of initiatives incentivizing local purchases

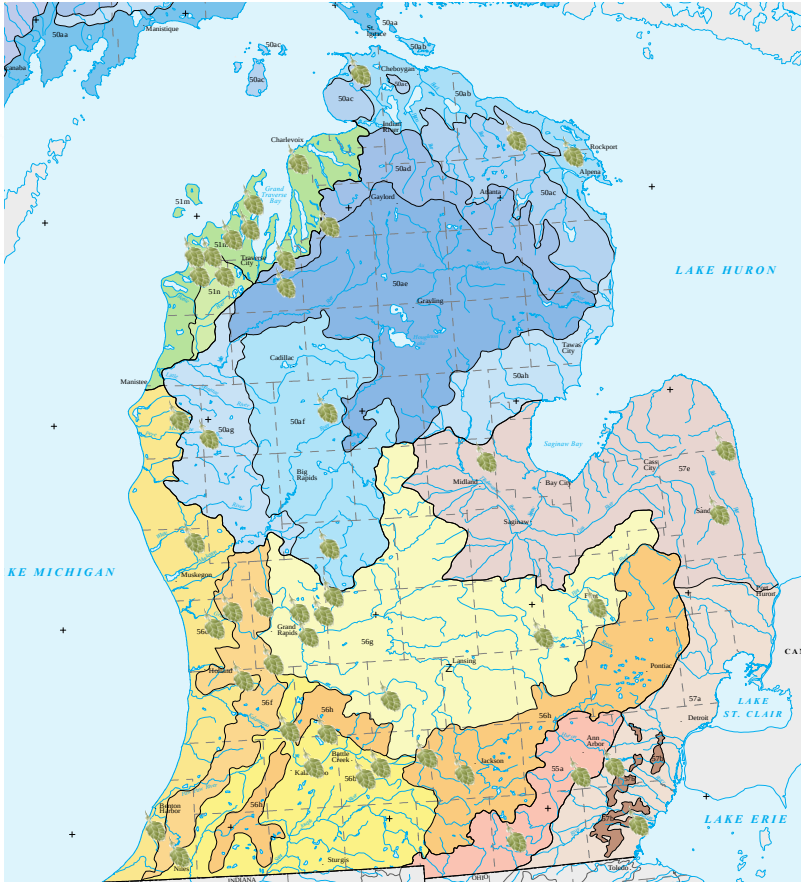
Attitudes towards incentivizing localness	Mean Score (1-5)	Percentage of respondents: Definitely Not (1)	Probably Not (2)	Neutral (3)	Probably Yes (4)	Definitely Yes (5)
A local hop showcase at a major brewer event.	3.44	2%	18%	30%	34%	16%
Farm brewery legislation that incentivizes the use of local ingredients.	3.84	8%	8%	16%	28%	40%
Improved cultivar selection.	4.06	0%	4%	22%	38%	36%
Locally unique cultivars.	4.36	0%	2%	14%	30%	54%
Improved marketing by growers.	3.18	4%	22%	36%	28%	10%
A local grower cooperative that functions as a broker to more cultivars and economies of scale.	3.68	4%	6%	30%	38%	22%
A quality and food safety verification program that emphasizes use of best practices.	3.02	8%	20%	40%	26%	6%

Footnotes: The initiatives were introduced by asking each of the 50 respondents, “Would any of the following help you decide to utilize or increase your use of local hops?”

Appendix

Locations of MI hop farms in different Level III and IV Eco-Regions

EPA map overlayed with hop farm locations based on personal accounts



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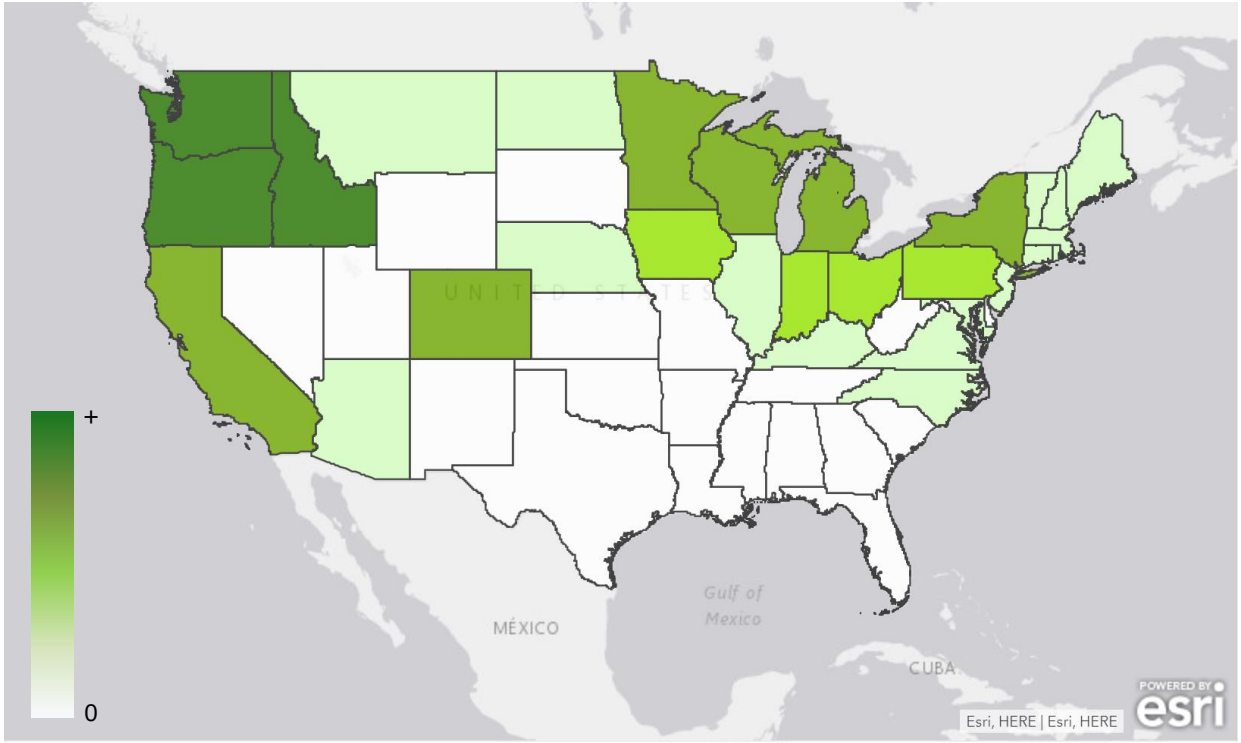
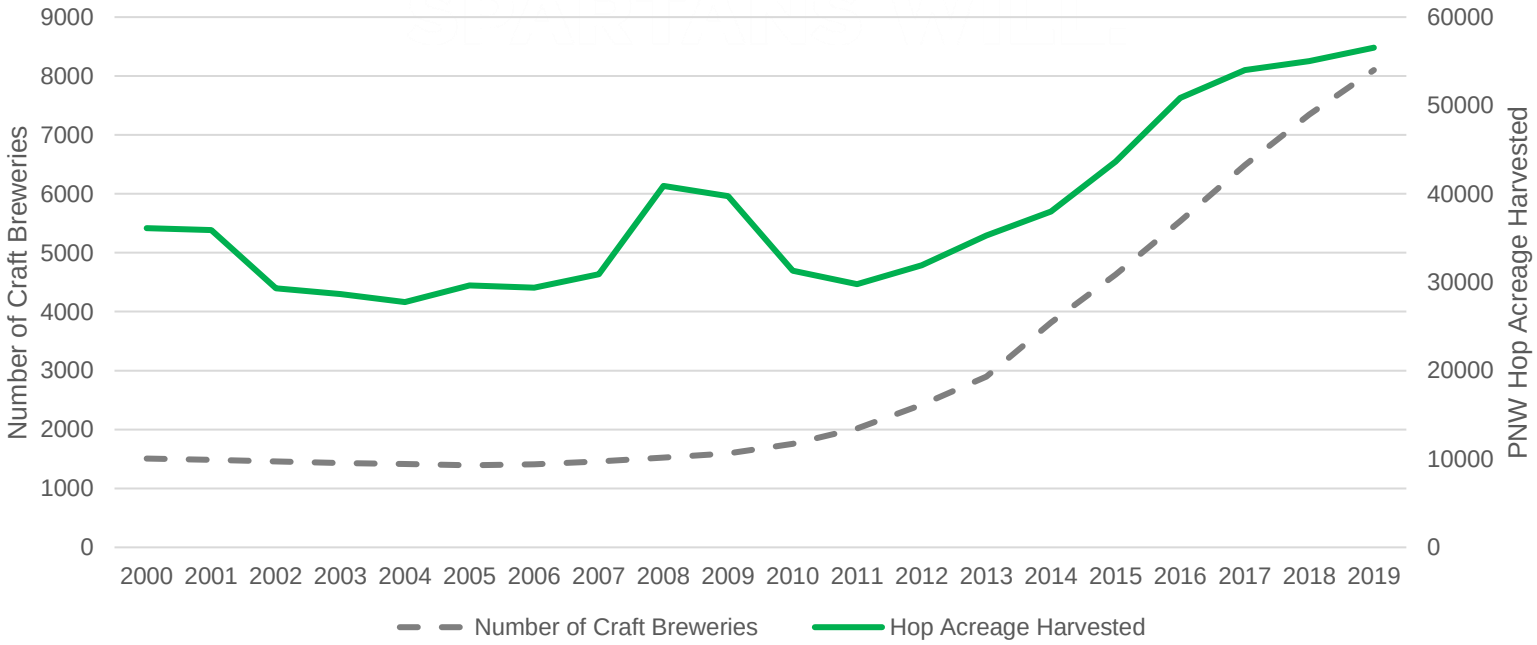

+
0
MÉXICO
Gulf of Mexico
CUBA
Esri, HERE | Esri, HERE
POWERED BY esri

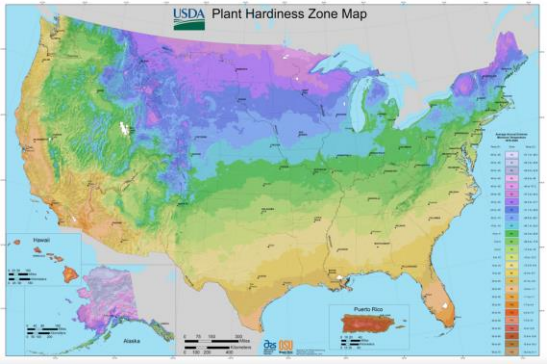
Hop production is driven by the craft beer revolution.



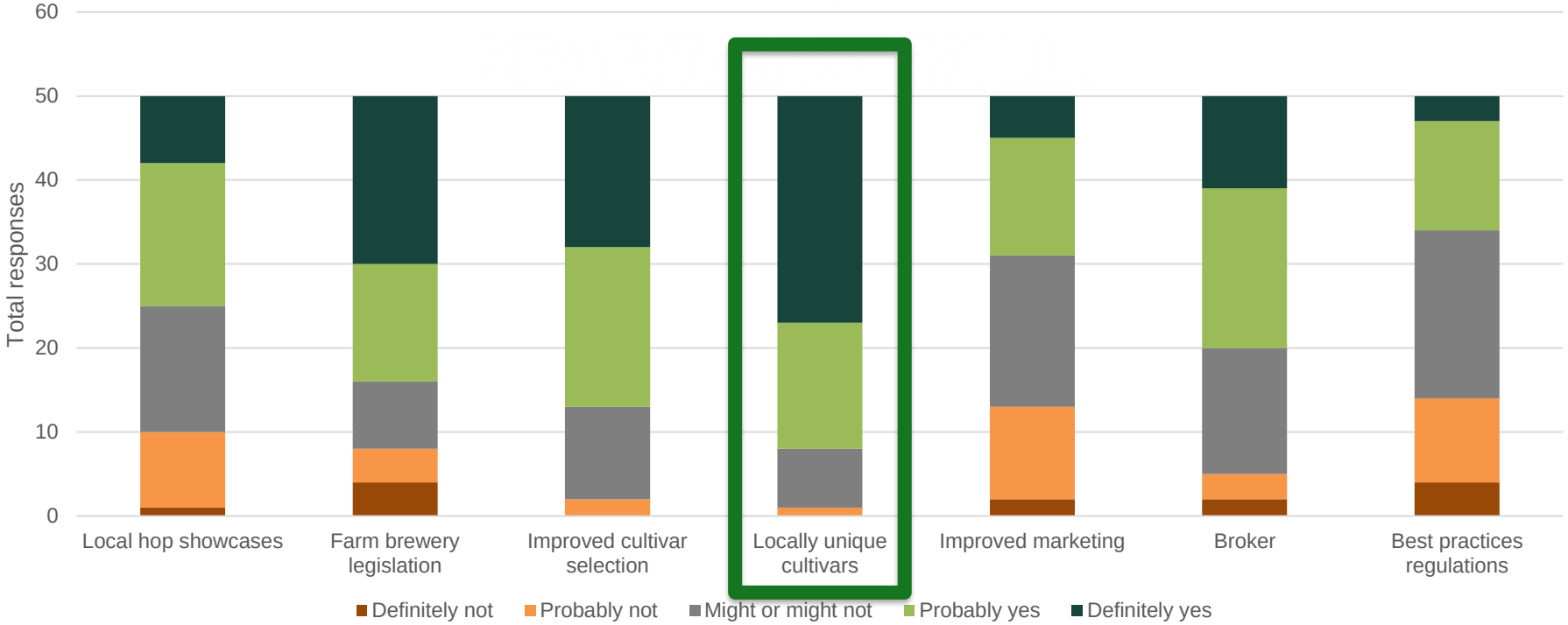
Sources: Brewers Association (2020); Hop Growers of America (2020)

Uphill battle for hop growers outside PNW

- Higher production costs
- Crop insurance policies
- Lack of access to proprietary hops
- Pests and disease
- Sub-optimal growing conditions
- Forward contracts



Would the following initiatives incentive you to use more local hops?



Methodology: Multi-dimensional, exploratory analysis

Purchased four Chinook hop samples from various regions

- Two from the Pacific Northwest
  - One from Washington,
  - One from Oregon
- Two from Michigan
  - One from Northwest Michigan
  - One from East Michigan

Why Chinook?

- 4th most planted public variety cultivar in the Pacific Northwest
- MI Chinook Cup

Photo credits: MSU CANR (2020)

Beer brewing

- 5-barrel *baseline* beer
  - 95% Wayermann pale and 5% Simpsons Crystal light
  - 45 oz PNW cascade 45 oz. at 7.2% alpha to 40 IBUs
- Fermentation, 001 yeast from White labs California Ale
  - 10 days at 67°F then down to 50°F
  - Fined with Biofine on day 12 and moved on day 14
- Transferred to 4, 1 bbl fermenters and dry-hopped Chinook 16 oz./bbl for 72 hours
  - Moved 50 degrees beer to walk-in cooler
  - Cooled to 34°F over the course of 1.5 days
- 5% ABV, 40 IBU

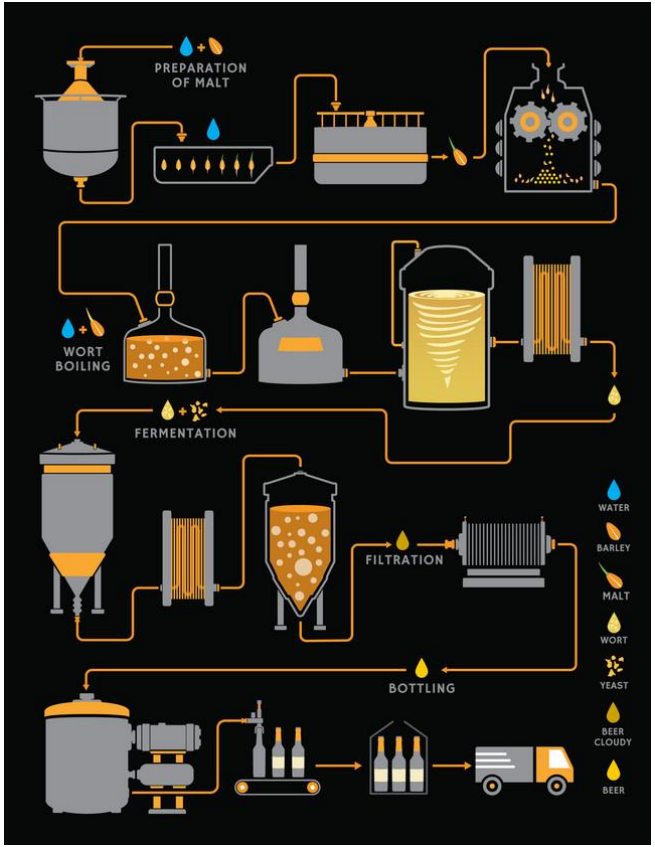
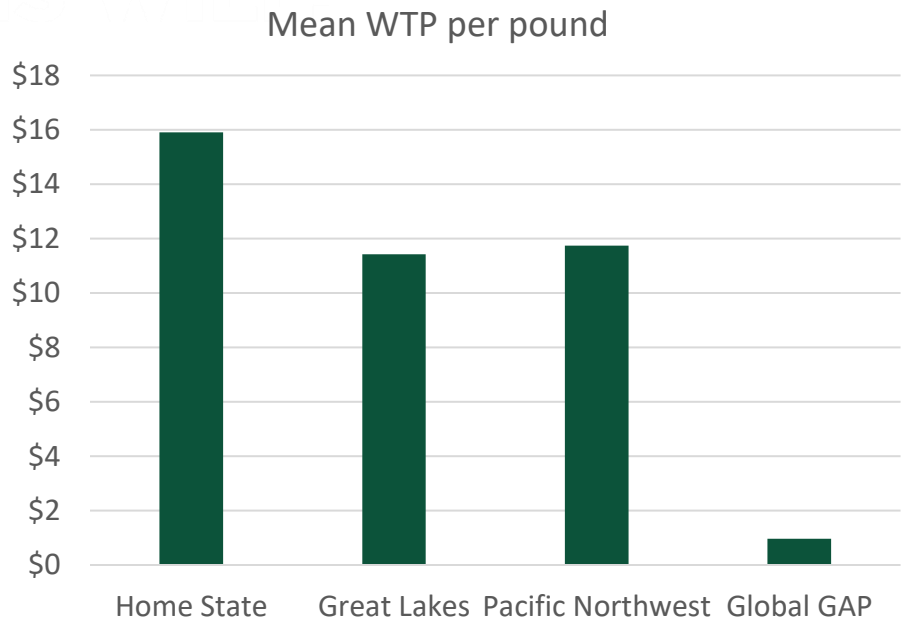


Photo credits: VectorStock (2020)

3. Choice experiment: Results

- Brewers are, on average, willing to pay:
  - $16.36 per pound of state-grown hops
  - $12.03 for Great Lakes hops
  - $12.30 for Pacific Northwest hops
- *Ceteris paribus*, craft brewers are willing to pay 35% more for state-grown hops



Limitations and future research

Limitations

1. Isolating the effect of geographical origin is inherently difficult.
2. Small sample sizes
3. Asking brewers to envision their most purchased hops has innate shortcomings given the current hop landscape.

Future research

- Chemical analyses
  - Additional chemical tests on hop chemical composition
- Economics
  - Consumer preference research
  - Policy implications of farm brewery legislation

California Fruit Industry: Challenges and Solutions

Serhat Asci and Karthik Ramaswamy

FDRS

Virtual Meeting
October 12-13, 2020

Outline

- Fruit Farming in California
- Importance of Fruit Farming in California
- Issues in Fruit Farming
  - Water curtailment
  - Groundwater requirements
  - Immigration policies
  - Labor regulatory compliances
  - Invasive pest
  - Food safety compliances
  - Trade disruptions
- Economic Impact
- Possible Policy Implications

Source: Agricultural Marketing Resource Center

Fruit Farming in California

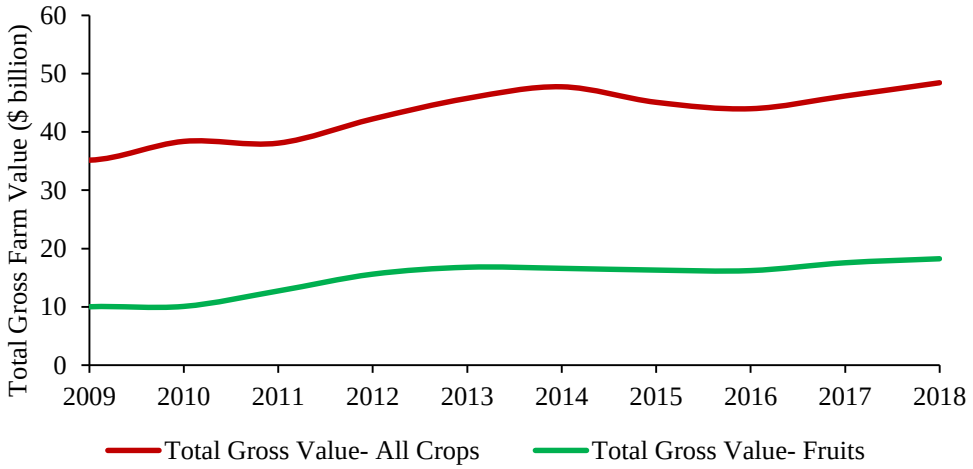
- Fruit production in California: >$18 billion in 2018 (~2/3 of the total US fruit farming).
- The sole commercial producer of six fruits (dates, figs, raisin grapes, kiwifruit, olives, and clingstone peaches).
- Leads in the production of 22 fruits among US states.
- The daily consumption of fruits is still low (2015-2020 Dietary Guidelines for Americans).
- Traditionally minimal assistance to the fruit farming in Farm Bill.
  - reducing farming risks,
  - government programs encouraging more fruit consumption

Importance of Fruit Farming in California

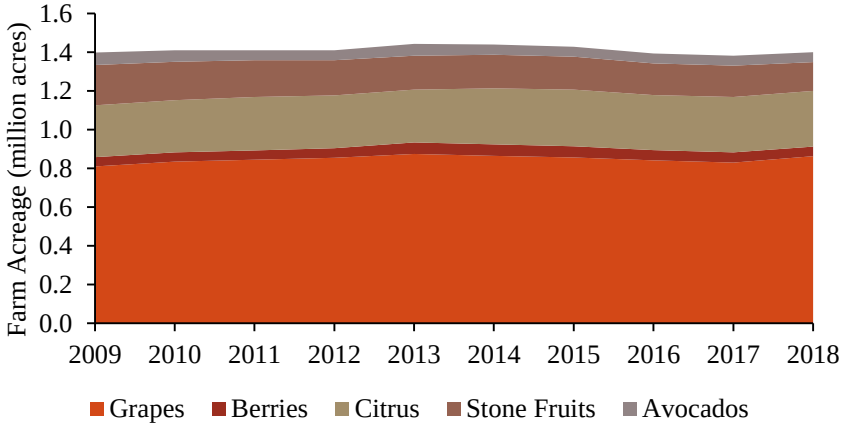
- Fruit production accounts for 37.6% of California's total gross farm value.

Commodity Group	Total Value (in $1000)	Percentage
Fruits	18,242,251	37.63%
Nuts	10,691,252	22.06%
Vegetables	9,825,213	20.27%
Field and Seed	5,872,205	12.11%
Nursery Products, Flowers	3,842,385	7.93%
ALL CROPS	48,473,306	100.00%

Fruit production values increased from $9.9 billion to $18.2 billion in the last decade



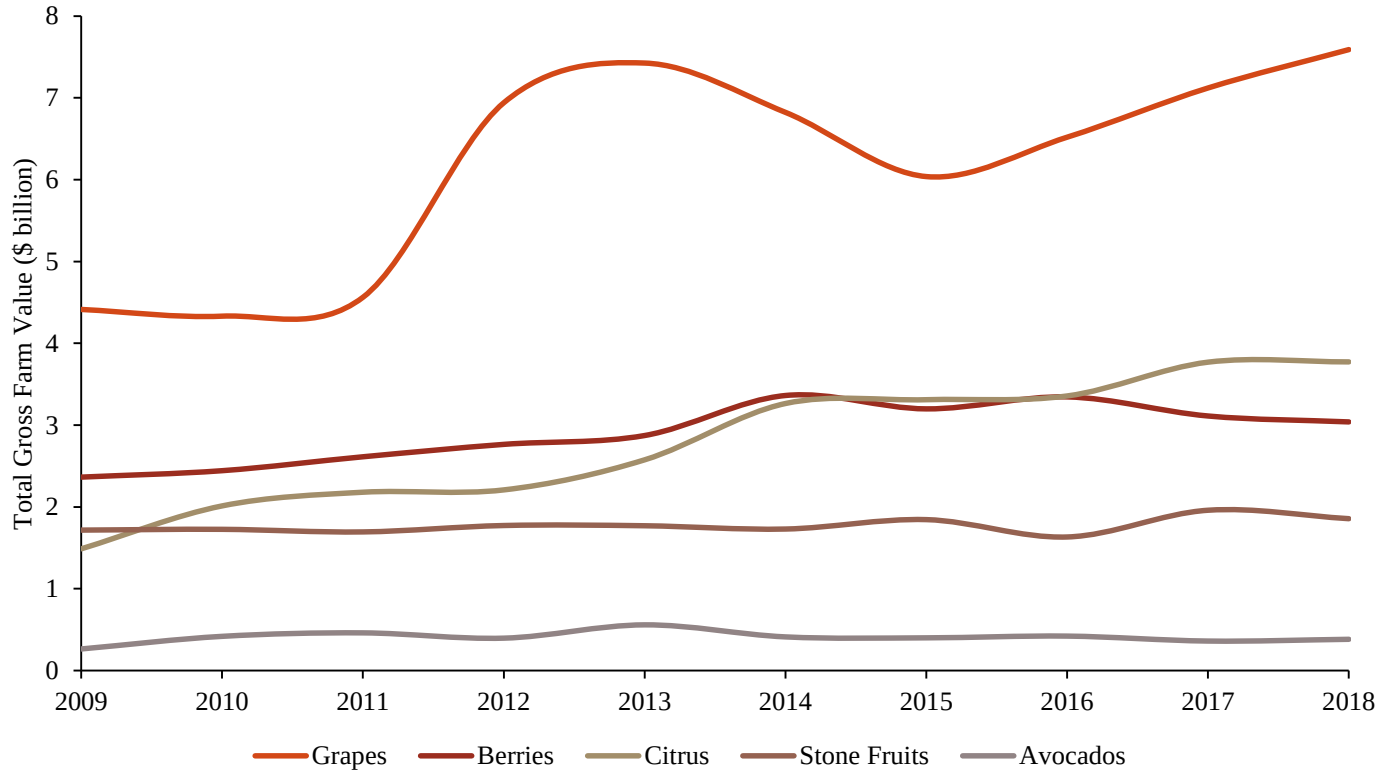
Total fruit acreage has fluctuated around 1.5 million acres in California since 2009



Source: CDFA, 2020

Farm Value by Fruit Groups

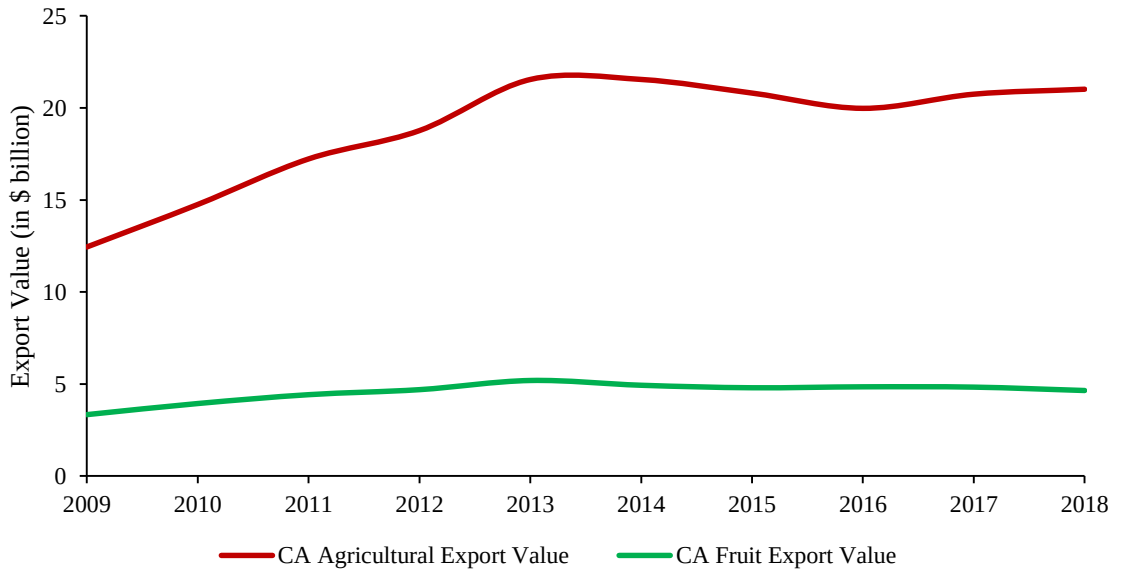
- The gross farm value of production of selected fruits in California



Source: CDFA, 2020

Domestic Consumption and Exports

- Californian fruits utilized for domestic consumption: ~$13 billion in 2018.
- Californian fruit exports $4.7 billion in 2018.
- The United States a net fruit importer since 1970s (Johnson, 2016).
- per capita US fruit consumption 241 pounds in 2018 (USDA-ERS, 2020).

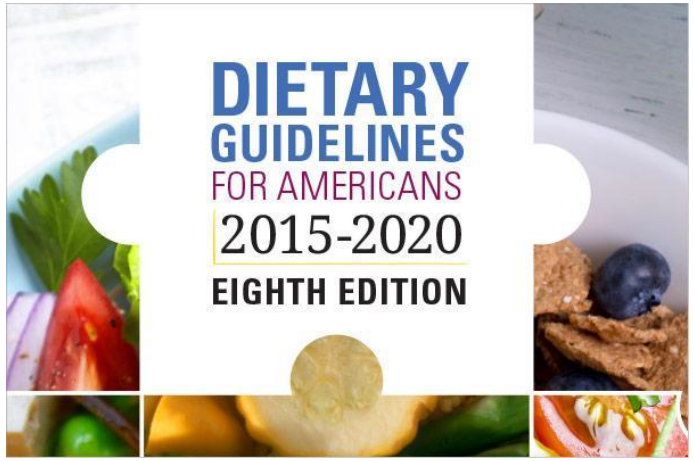


Source: CDFA, 2020

Issues and Trends in Fruit Farming

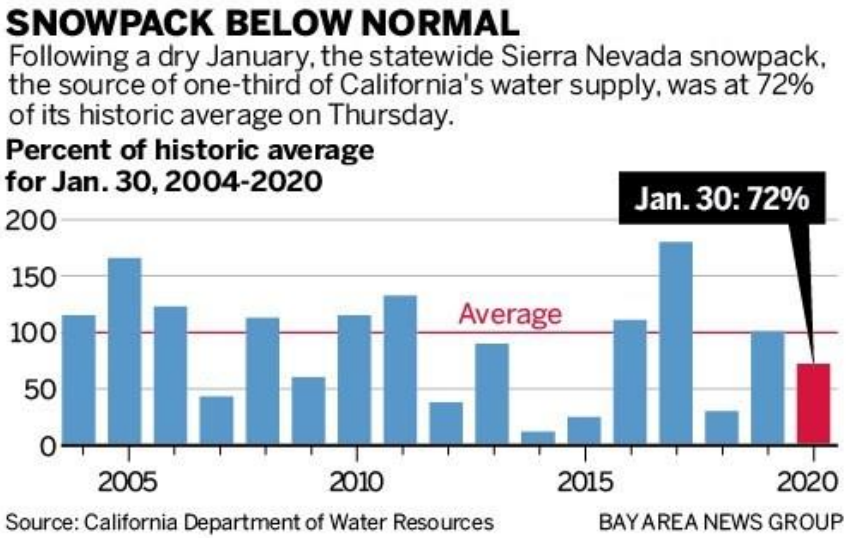
- Fruits are an important part of a healthy diet: reduce the risk of many chronic diseases, type 2 diabetes, some cancers, and obesity (CDC, 2018).
- The 2015–2020 Dietary Guidelines for Americans recommend that adults should consume 1.5–2.0 cups of fruits per day.
- CDC surveys in 2015 show that only 12.2% of respondents met the daily fruit intake recommendations (Lee-Kwan et al., 2017).
- Federal programs to increase per capita consumption of fruits: the Food and Nutrition Service nutrition programs
- USDA assistance programs: Federal Crop Insurance and Disaster Assistance programs; Market Access and Technical Assistance for Specialty Crops programs; Federal Marketing Orders; and specialty crop grants and farmers market programs.
- California Fresh Fruit Association's annual top-ten issues (main ones):
  - groundwater regulation,
  - water supply availability,
  - immigration policies,
  - changing labor standards,
  - food safety compliance,
  - and invasive pest issues (CFFA, 2020).

CALIFORNIA FRESH FRUIT ASSOCIATION



Water Curtailment

- The snowpack from the Sierra Nevada Mountains in California's San Joaquin Valley (SJV).
- California has also suffered a long term drought.
- La Niña years, water service contractors in the SJV have received ever declining water allocations.
- Howitt et al. (2015): the fallowing of over 36,000 acres of orchards and vines.
- We estimate at least a 2.4% decline in total land dedicated to fruit farming (out of total 1.5 million acres).



Groundwater regulation

- The Sustainable Groundwater Management Act (SGMA): provide a framework for long-term sustainable groundwater management in California.
- SGMA requires water agencies to halt overdraft and bring groundwater basins into balanced levels of pumping and recharge.
- Sunding and Roland-Holst (2020) suggests that SGMA may lead to 260,000 acres decline in harvested acreage for tree fruits and vines in SJV.
- This accounts for 17.3% of fruit acreages coming out of production in California.

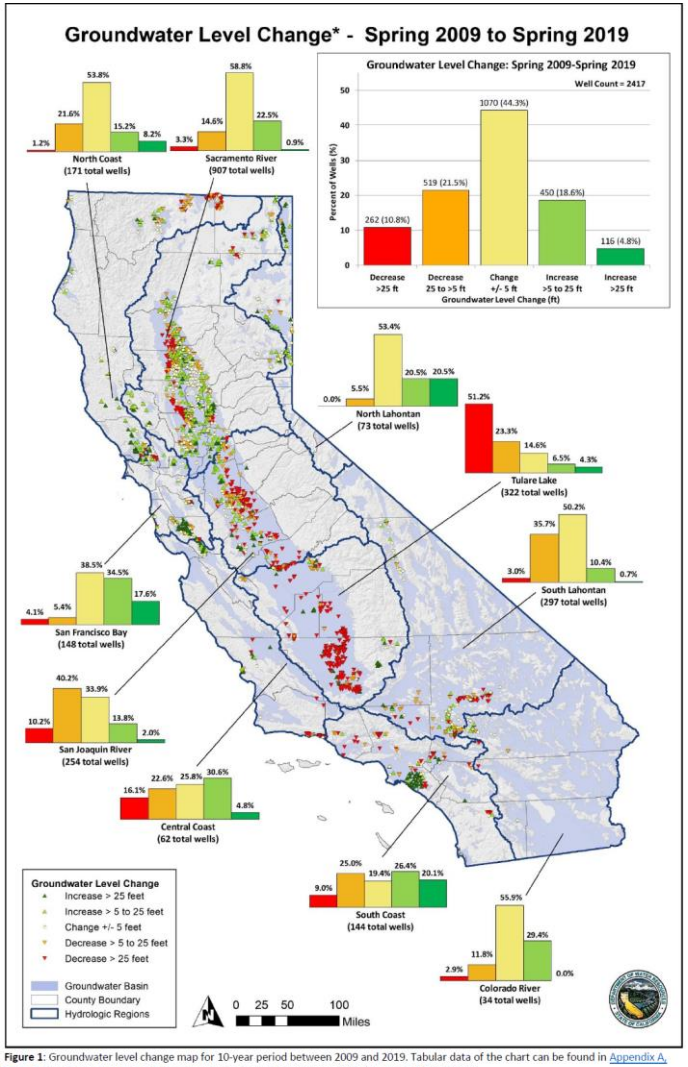


Figure 1: Groundwater level change map for 10-year period between 2009 and 2019. Tabular data of the chart can be found in Appendix A, Table 1. *Map and charts based on available data for the DWR Water Data Library as of 08/15/2019.

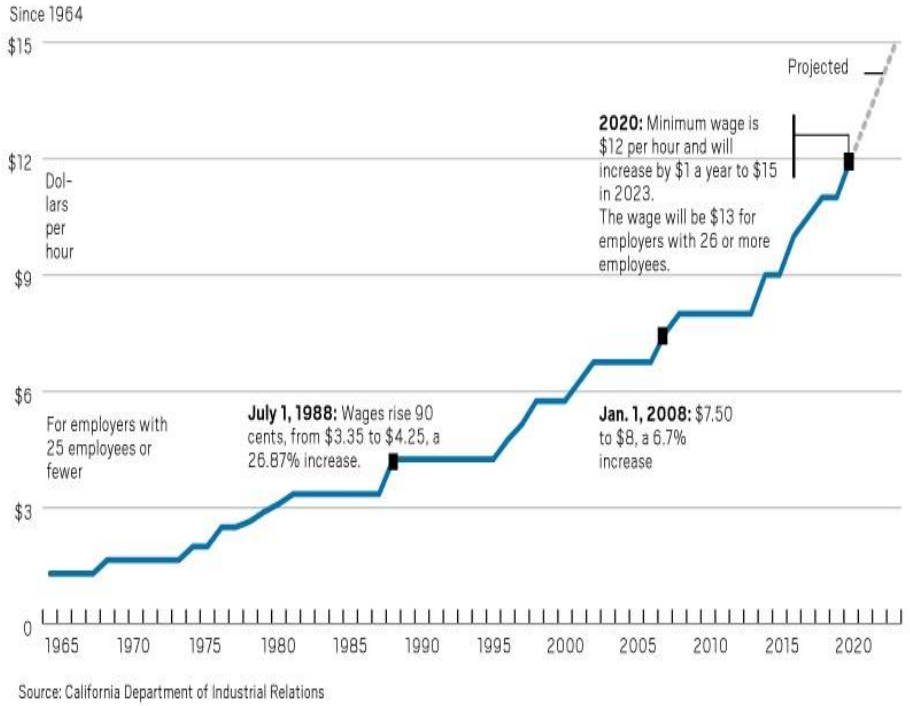
Immigration Policies

- Over 60% of crop workers in California are unauthorized or undocumented (Martin, Hooker and Stockton, 2017).
- The rate of substitution between domestic and immigrant labor is fairly low (Wei et al., 2019).
- Current immigration policies are removing unauthorized foreigners and limit H-2A guest workers who are the significant workforce for US agriculture.
- California fruit and tree nuts establishments employ 100,000 full-time equivalent (FTE) employees who receive around $3 billion total wage (Martin, Hooker and Stockton, 2017).
- Richard (2018) suggests that removing 50% undocumented farmworkers would increase the salary by 22% to replace them with domestic workers.
- We estimate that the salary increase will account for additional $500 million annual labor cost for fruit farmers.

Source: Public Policy Institute of California

Labor Regulations

- The rising cost of labor due to strict state regulations and increasing minimum wage.
- California minimum wage legislation set the new level to $15 per hour by 2024 (Hill, 2018; Scheiber and Lovett, 2016).
- California fruit industry mostly employs seasonal farmworkers who generally receive minimum wage.
- We calculate that half of the farmworker earnings has been paid to seasonal workers at minimum wage since 2016 based on Martin, Hooker and Stockton (2019).
- At the new $15 minimum wage level, labor cost for California fruit farmers will increase $390 million per year in 2018 price level.



Invasive Pests

- California fruit production has been suffering from invasive pest.
- The spotted wing drosophila (SWD), a pest of berry and stone fruits: Bolda, Goodhue, and Zalom (2010) estimate the SWD in California may cause 20% yield reduction in berry and cherry production. We calculate $660 million decline in gross crop value for berry and cherry farming given $3.3 billion total value of these fruits in 2018.
- Asian citrus psyllid (huanglongbing (HLB) disease- a.k.a. citrus greening): In California, the HLB disease was first detected in 2012, Babcock (2018) assumes that Asian citrus psyllid invasion and HLB disease could reduce citrus yields by 20%. Based on our calculations, we expect to see $740 million decline in gross production value.

Source: CDFA, 2020

Food Safety

- The food safety modernization act (FMSA): fully implemented by 2024 for small and very small businesses (FDA, 2019).
- Fruit growers are generally small or very small farms, and compliance cost to FMSA have already begun to impact fruit growers.
- Bovay, Ferrier, and Zhen (2018) estimates the cost of compliance with FSMA for California fruit and vegetables producers will be 1.32% of their revenue.
- Our estimates show that, by 2024, fruit growers in California may bear an additional $240 million cost.

Number of Fruit and Tree Nut Farms in California

Farm Size	Area Operated	Average Sales Value	Number of Farms
Very Small	1.0 to 69.9 acres	$59,319	24,742
Small	70.0 to 139 acres	$378,948	3,359
Large	140 acres and more	$2,428,893	6,986

Source: USDA 2017 - Agricultural Census

Trade Disruption

- US fresh and processed fruits have been imposed to retaliatory tariffs by China recently.
- USDA projects 4% decline in US agricultural exports due to continuation of retaliatory tariffs (Regmi, 2019).
- If conditions remain the same, we estimate $190 million export revenue loss annually when we apply 4% decline in California fruit exports.

Source: The Packer, 2020

Possible Policy Implications

- Since government programs aim to increase per capita intake of fruits, California fruit growers might require additional assistance to tackle many issues which increase their production costs and decrease their revenue.
- The industry might benefit from innovative research and promotion programs which can decrease production costs and open new markets which will allow fruit industry to reach consumers from all demographics.
- The industry would benefit highly from expanded crop insurance programs, favorable farm labor and immigration policies, export promotion and market expansion efforts, and providing incentives for agricultural research and development.

Thank you!
Questions…

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