Evaluating Thresholds of Meteorological Variables in Pacific Northwest Crops and their Potential Economic Impacts on Regional Production

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The Problems

- Growers want to know how climate change is going to impact their crops in the future

- Climate models offer future predictions for many different variables

- Analyzing historical weather data and its impacts on reported crop yields is very difficult, in most cases

Research Questions

- Which meteorological variables are most closely monitored by PNW growers?

- What are the thresholds within these variables that cause great advantages/losses to the growers' crops?

- How can we model these thresholds into the future to make them useful in a grower's decision making process?

AgBiz Logic™

- ***AgBiz Logic™*** is a suite of economic, financial, and environmental decision tools for businesses that grow, harvest, package, add value, and sell agricultural products[1].
— ***AgBizClimate*** is a module within this suite that will present relevant climate projections to growers

[1]Seavert, C. (2015). AgBiz Logic™. Retrieved August 4, 2015, from http://www.agbizlogic.com/

Previous REACCH Research

- 2011 - *Climate Change Risk Perceptions and Adaptive Strategies among inland Pacific Northwest Wheat Producers*
  — **80% of survey respondents agreed that they have observed changes in weather patterns over their lifetime (36% "strongly agreed" with the statement)[2]**

[2]Gantla, S., Bernacchi, L., & Wulfhorst, J. (2015). Climate Change Risk Perceptions and Adaptive Strategies among Inland Pacific Northwest Wheat Producers.

What other questions should we be asking?

- *<u>What are these "observed weather changes," and how have they impacted crops, thus far?</u>*

- Growers are unsure about climate change and the future of weather, but instead have a strong understanding of how to adapt from year to year[2].

[2]Gantla, S., Bernacchi, L., & Wulfhorst, J. (2015). Climate Change Risk Perceptions and Adaptive Strategies among Inland Pacific Northwest Wheat Producers.

Methodology

1. Create a discussion with local growers
   — For this case study, the discussion was limited to wheat and apple growers

2. Utilize a consistent questionnaire with all growers to discover important thresholds within a variety of meteorological variables

3. Analyze grower response

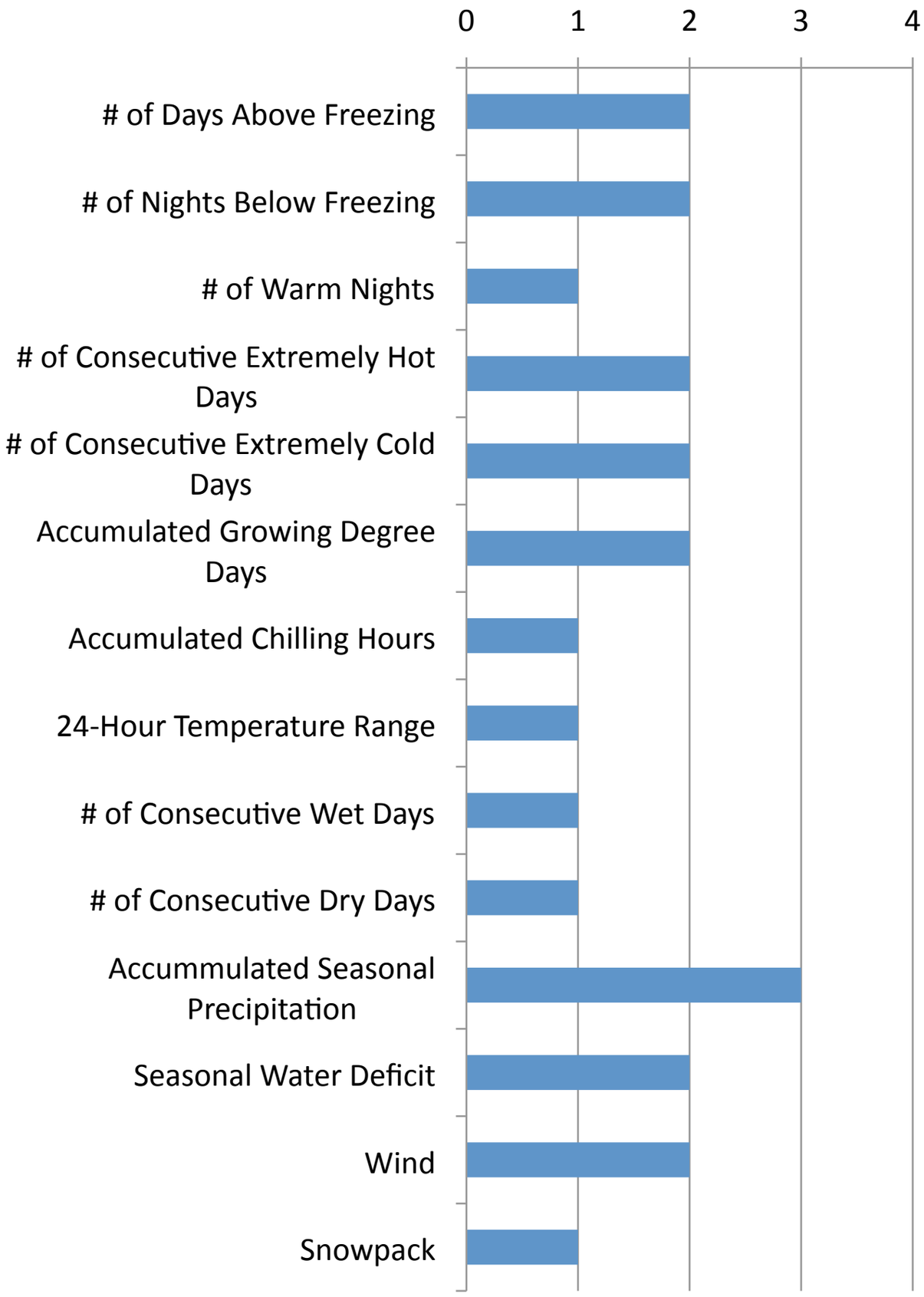
4. Consult relevant climate models and evaluate grower risk based on variables that they consider to be important

5. Use results of the study as input into the *AgBizClimate* module in *AgBiz Logic™*

Growers were asked to rate (on a scale from 1 to 5) how often they monitored the following meteorological variables within the growing season of their crop.

Number of days above freezing
Number of nights below freezing
Number of warm nights
Number of consecutive extremely hot days
Number of consecutive extremely cold days
Accumulated Growing Degree Days
Accumulated Chilling Hours
24-Hour Temperature Range
Number of Consecutive Wet Days
Number of Consecutive Dry Days
Accumulated Seasonal Precipitation
Seasonal Water Deficit
Wind
Snowpack

The Frequency of Meteorological Variable Monitoring from PNW Wheat Growers



Most frequently monitored variable by this group of wheat growers is accumulated seasonal precipitation.

Wheat Thresholds

- Rain during the growing season is the best indicator of crop predictability - an inch of rain can add 7-12 bushels/acre
  — “Million dollar rains”

- A week (approximately 7 consecutive days) of hot weather in May can shut down wheat plant production at critical times

More wheat grower input is needed to do further analysis on response results - the timing of the wheat harvesting season severely impacted this study’s ability to gather wheat grower inputs

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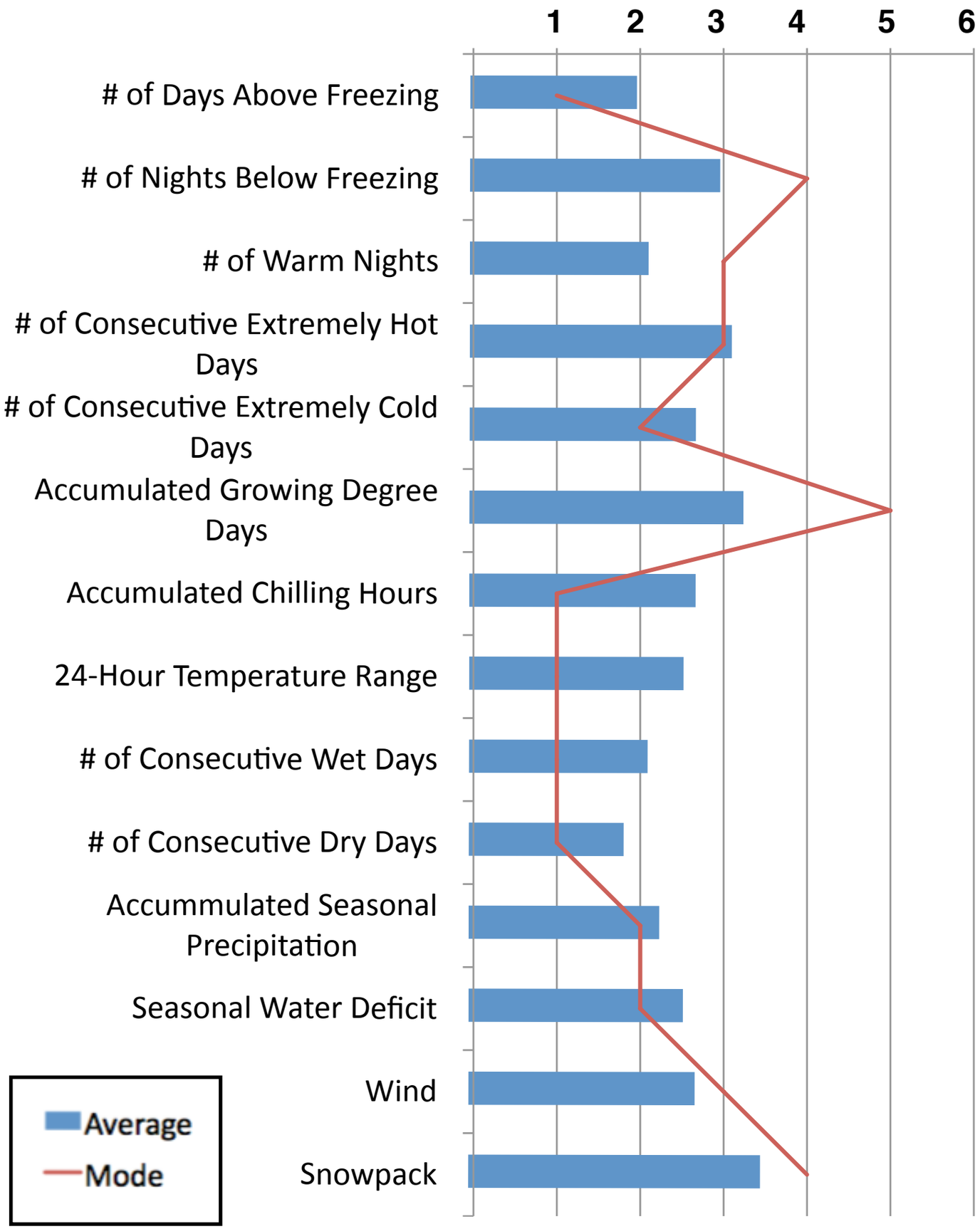
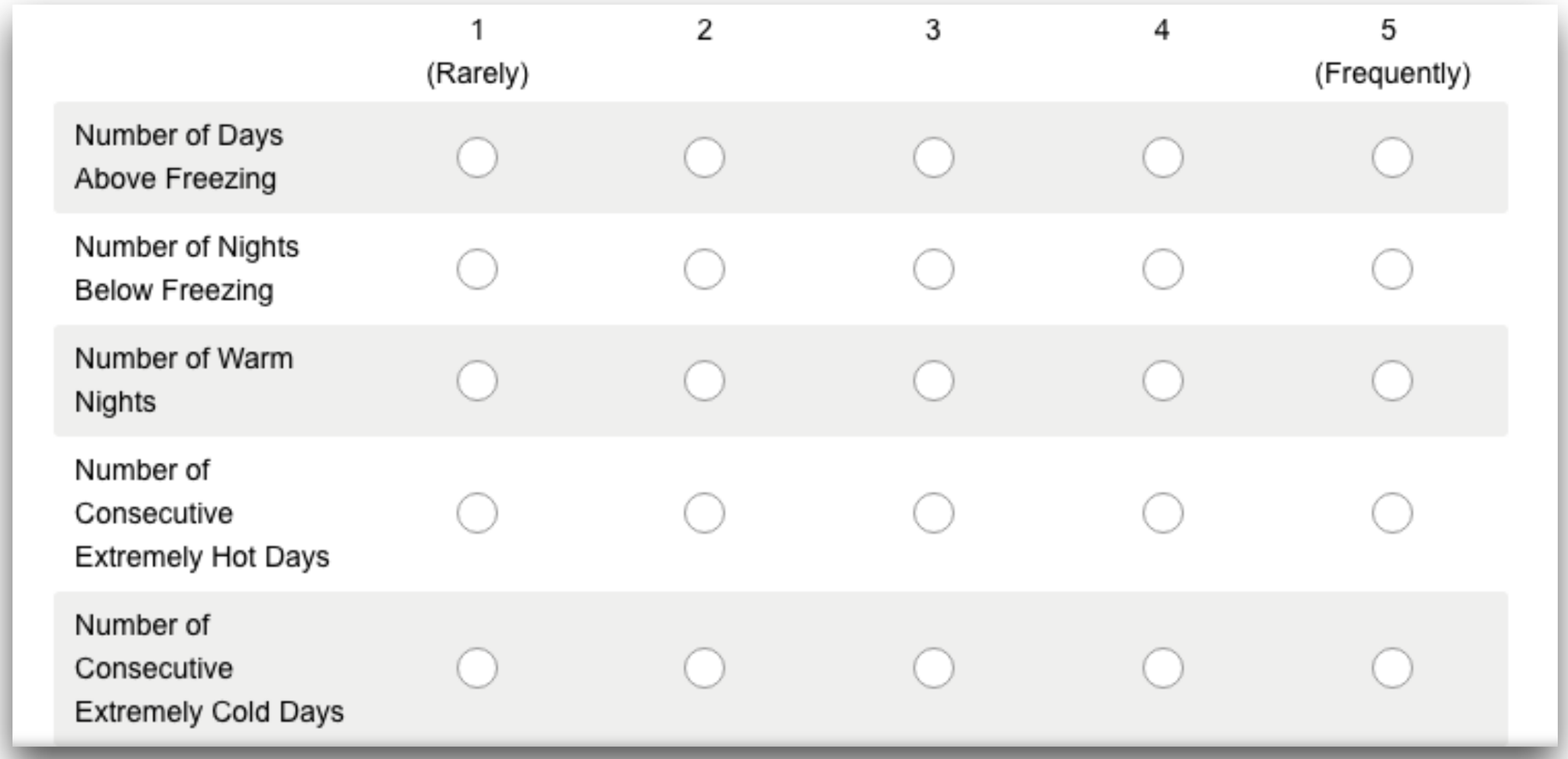


Most useful thresholds came from variables that had the highest mode values, with the exception of wind and snowpack.

- Survey population: 19 apple growers
- Survey response rate: 37%
- Margin of Error: 26% for 90% confidence interval
  — This will be reduced with more time allowed to collect survey responses
- Online response: 86%
- Telephone response: 14%
  — Growers were much more willing to respond online via SurveyMonkey
  — Drawback: some growers were not as specific in their threshold answers as the phone respondent



	1 (Rarely)	2	3	4	5 (Frequently)
Number of Days Above Freezing	○	○	○	○	○
Number of Nights Below Freezing	○	○	○	○	○
Number of Warm Nights	○	○	○	○	○
Number of Consecutive Extremely Hot Days	○	○	○	○	○
Number of Consecutive Extremely Cold Days	○	○	○	○	○

Variable	Thresholds and Comments
# of Days Above Freezing	• Determines the developmental stage of the fruit
# of Nights Below Freezing	• Winter Injury from Nov-Mar, spring frost from Mar-May • Overnight low temperatures in the spring can freeze fruit buds • Contributes to cost of frost protection
# of Consecutive Extremely Cold Days	• Three days or more with temperatures less than 0°F can cause winter injury
# of Consecutive Extremely Hot Days	• Three days or more with temperatures greater than 95°F can cause sunburn
Accumulated Growing Degree Days	• Drives various pest models Apr-Aug (most importantly codling moth)
Accumulated Chilling Hours	• Granny Smith apples require at least 400+ chilling hours to avoid blush
Snowpack	• Amount of snowpack is 100% of the seasonal supply to all water rights holders in Yakima • Determines the severity of drought which impacts/limits irrigation and overhead cooling strategies

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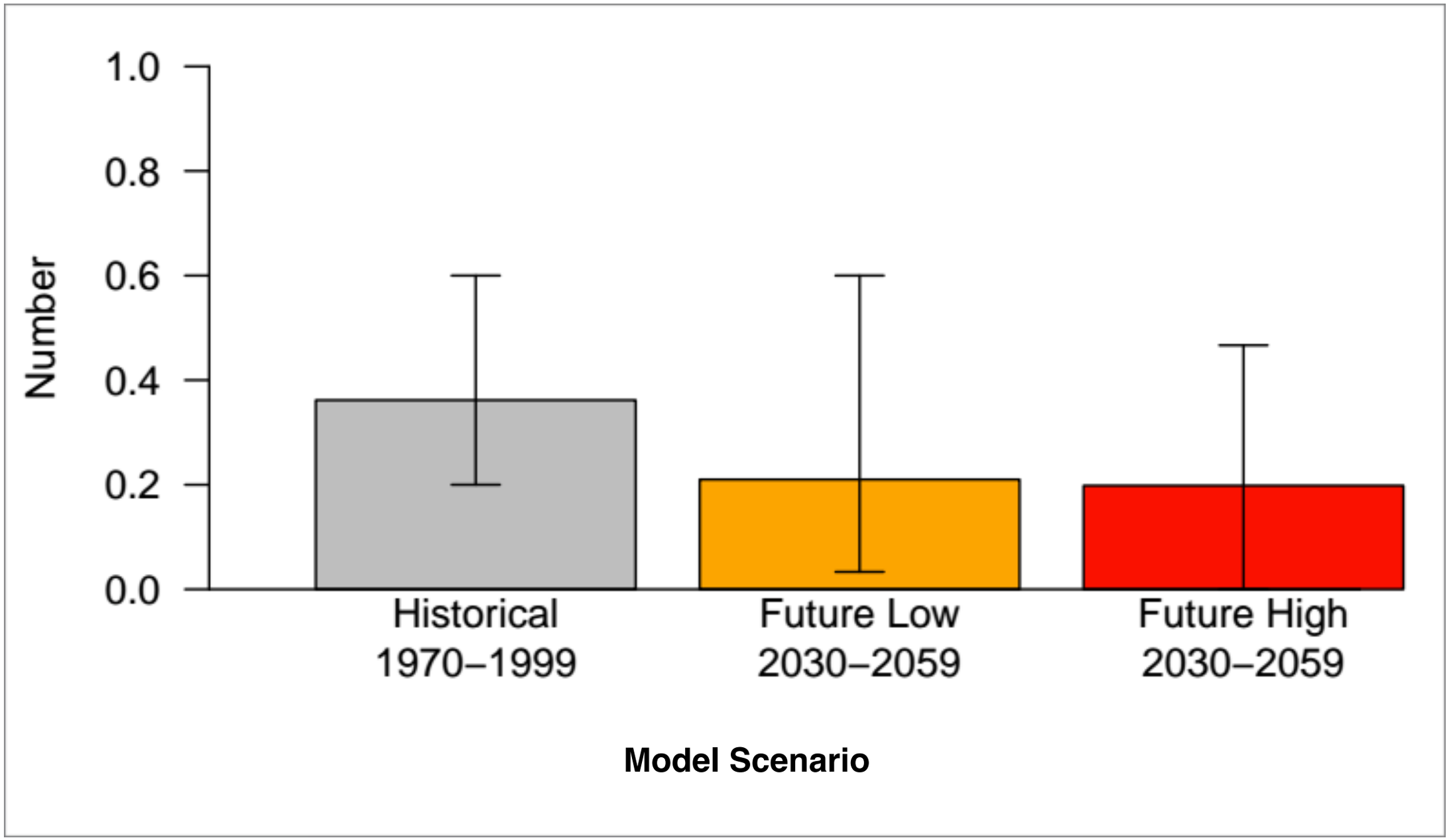
Number of Consecutive Extremely Cold Days

Average Number of Cold Snaps per Year in Wenatchee, WA



Benefits of Future Decreases in Cold Snaps

- Historical models indicate approximately 11 cold snaps occurred from 1970-1999

- Future models expect 5 cold snaps to occur from 2030-2059

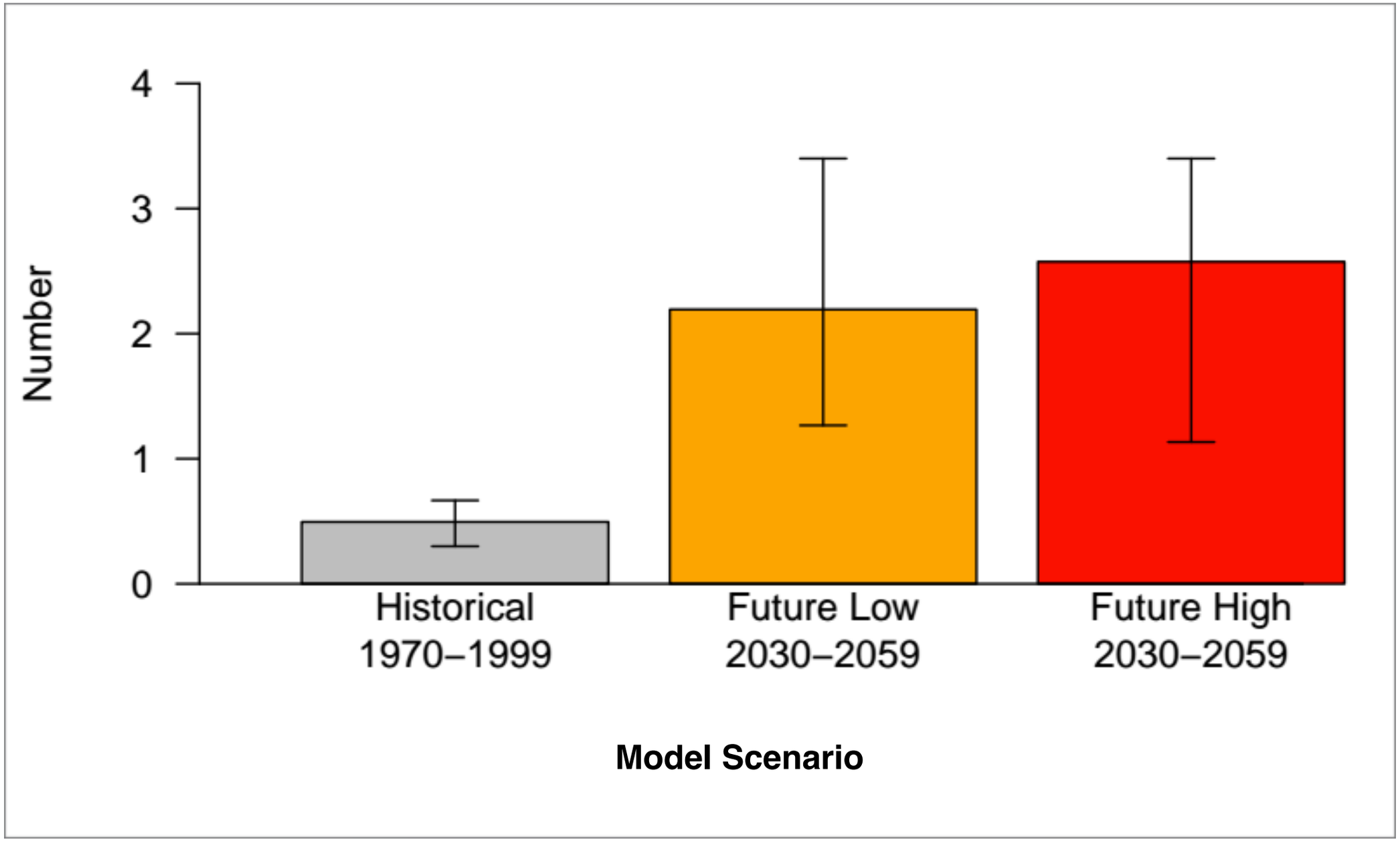
- Decreases the likelihood of loosing trees to winter injury[3]
  — increased yields
  — decreased tree deaths
  — longer tree life expectancy

- Very difficult to analyze monetary benefits

[3]Huffman, L. (2013, February 5). Weather Risks: Strategies to Mitigate the Risk of Winter Injury. Retrieved August 6, 2015, from http://www.omafra.gov.on.ca/english/crops/facts/weather-winter.htm#what

Number of Consecutive Extremely Hot Days

Average Number of Sunburn Events per Year in Wenatchee, WA



Heat Wave Risks and Costs

400% increase in extreme sunburn events in the period from 2030-2059

Costs

— Shade cloth
  — Decreases air temperature 2-7 °C[4]
— Overhead cooling systems
  — Evaporative cooling (EC)

[3]Vossen, P. (n.d.). Color Enhancement of Apple Fruit. Retrieved August 6, 2015, from http://cesonoma.ucanr.edu/files/27144.pdf

Projected Costs of Water Usage for Managing Sunburn in Wenatchee Apple Orchards with Evaporative Cooling

$4.10 per 1,000 gallon = $0.0041/gal[5]

Sessions occur in intervals of 20 minutes on, 20 minutes off (from 2:30 pm - 6:30 pm)[6]

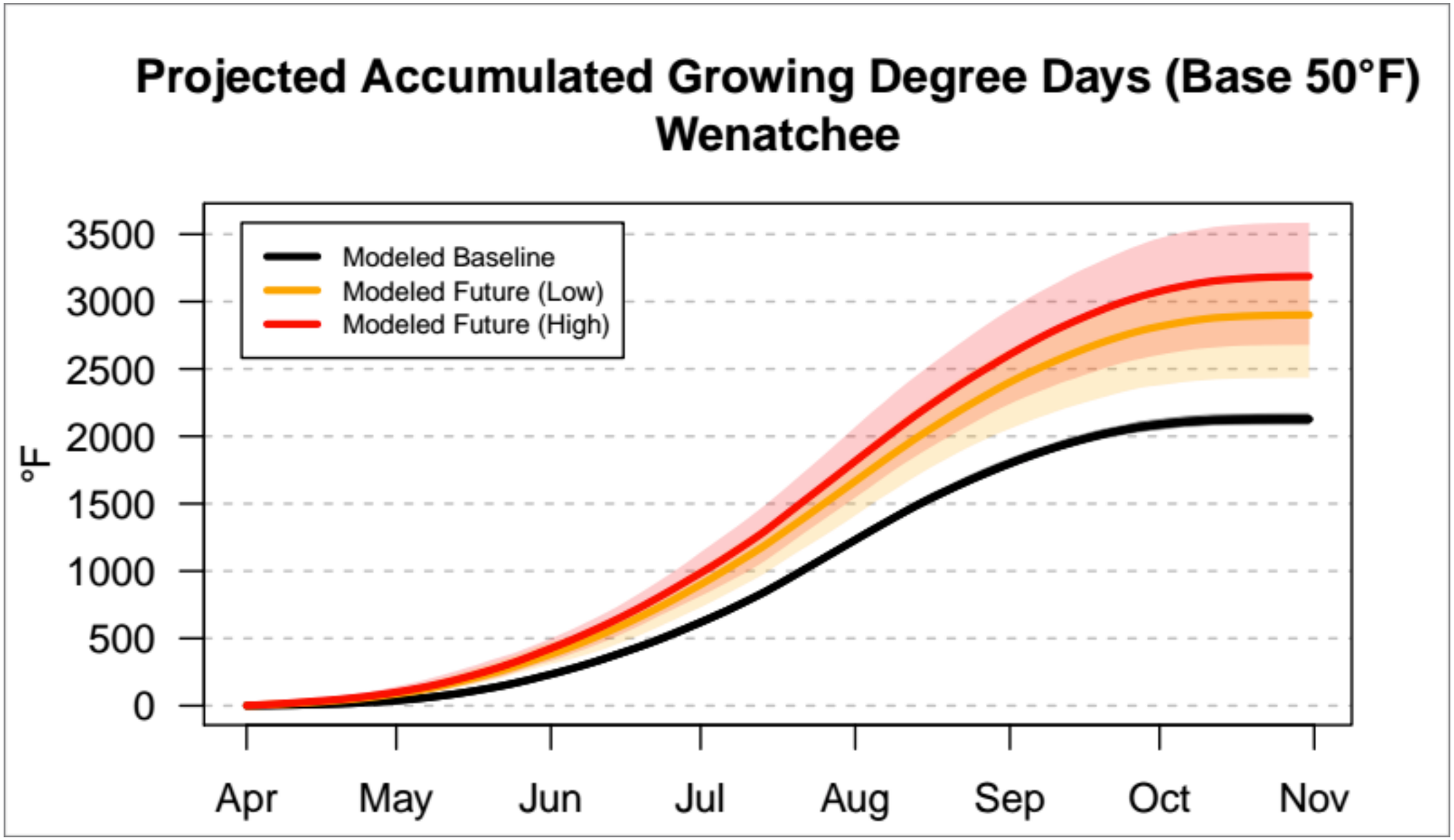
55 gal/acre = $4.51/acre for each cooling session

	Historical	**Low Emissions Scenario**	**High Emissions Scenario**
Number of Extreme Heat Events/year	0.5	2.2	2.5
Number of Required "Cooling Days" (Row 1 * 3 days)	1.5	6.6	7.5
Total Number of Cooling Sessions (Row 2 * 6 sessions)	9	39.6	45
Total seasonal cost of Cooling Sessions, per acre	**$40.59**	**$178.60**	**$202.95**

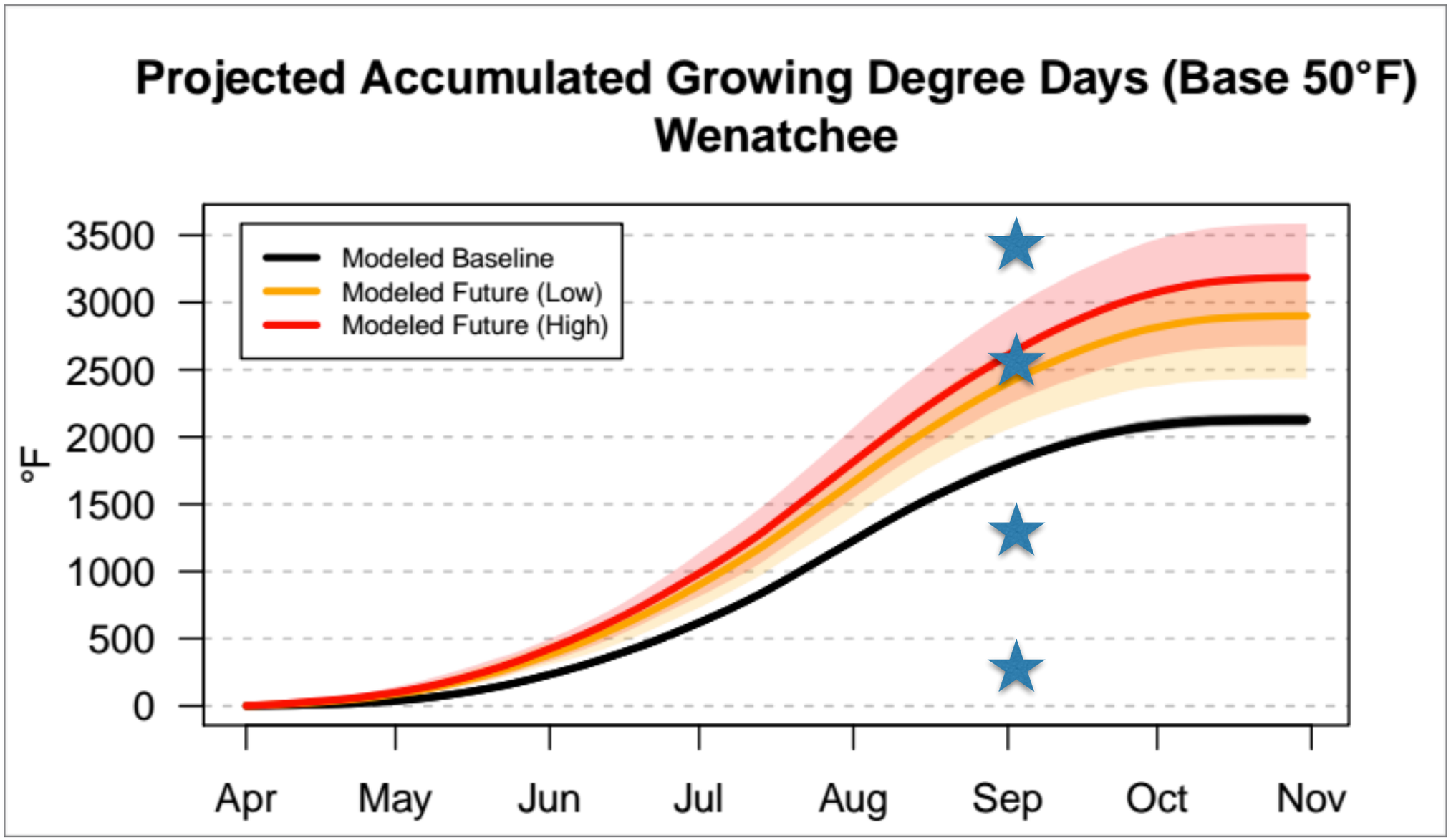
[5]Customer Services Rates and Policies. (2012). Retrieved August 6, 2015, from http://www.chelanpud.org/rates.html

[6]Evans, R. (1999). Overtree Evaporative Cooling System Design and Operation in the Pacific Northwest. Retrieved August 6, 2015.

Accumulated Growing Degree Days



Modeled Baseline is averaged over 1970-1999.
Modeled future is averaged over 2040-2069 for a high and low emissions scenario.
Solid line shows the average and the shading shows the 5-95th percentile range of 20 climate models.



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Increased…

— Insecticide costs

— Labor costs (especially for non-chemical treatments such as thinning)

If growers do not invest in more treatments, they can have significant losses in yields

1. First Biofix – 175 DD50 from Jan 01
   - First Spray – 375 AGDD
2. Second Biofix – 1235 DD50
   - Second Spray – 1435 AGDD
3. Third Biofix – 2345 DD50
   - Third Spray – 2545 AGDD
4. Fourth Biofix – 3455 DD50
   - Fourth Spray – 3665 AGDD

The timing of each spray after the biofix depends on the insecticide that is being applied, but the above model is valid for the insecticides **Intrepid** and **Confirm**

Apple with codling moth damage

Pheromone trap

UC Management Guidelines for Codling Moth on Apple. (2011, August 1). Retrieved August 6, 2015, from http://www.ipm.ucdavis.edu/PMG/r4300111.html

Application procedure:

- Rate: 20 oz/acre (no more than 120 oz/acre/season)[7]
- Timing: 200 days after biofix and reapply 10-15 days after

Market Price:
$770.00 for 2.5 gal
Cost per Application:
$48.13/acre

Projected Costs of Managing Codling Moth in Wenatchee Apple Orchards, using Confirm			
	Historical Model	Low Emissions Model	High Emissions Model
Number of Biofix Dates	2	3	4
Total number of Confirm Applications Required	4	6	8
Total Annual Cost of Confirm Insecticide, per Acre	**$192.52**	**$288.78**	**$385.04**

[7]Confirm 2F Label. (n.d.). Retrieved August 6, 2015, from http://www.gowanco.com/Document.aspx?id=955

Conclusions

With no changes in current management practices…

- Apples will fair **better** during the winter months due to decreases in winter injury conditions

- Apples will fair **worse** during the summer with and increased frequency of consecutive hot days and AGDD

In the future, growers will experience increased costs in summer months and increased benefits in winter months.

Conclusions

When conducting grower surveys and discussions…

- More useful threshold information usually comes from **person-to-person conversation**, such as focus group conversations or phone calls

- A larger response rate occurs with **online survey**

There is a trade-off between the quality of responses and the number of responses.

Future Work

- Additional survey work with wheat growers - possibly those who have been previously surveyed by REACCH
- Expand apple grower survey population to decrease margin of error
- Deeper cost analysis of other variables and their relevant thresholds
- Receive input from growers of different crops, besides wheat and apples

USDA Northwest Regional Climate Hub

REACCH Regional Approaches to Climate Change – PNA

OSU Oregon State University

Thank you.

Clark F. Seavert
Dr. Susan Capalbo
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Meghan Dalton
Sandy Macnab
Jenna Way

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