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# Idaho Snowmelt Changes and the Impact on Non-Irrigated Crop Yields

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## Abstract

Non-irrigated agriculture is very susceptible to the changing climate conditions impacting crop yield results. The data in this study finds consistent results with respect to a changing climate altering crop yields. A multivariable regression analysis will later be used in order to determine the total impact of the changing climate upon non-irrigated agriculture. The first variable analyzed was the final snowmelt date. The results find that counties that reside in either the lower or panhandle portion of the state show consistent correlations, implying that the snowmelt date and crop yields mutually increase or decrease. The counties within the top of the state reveal more negative correlations, leading to earlier snow melts and resulting in increasing crop yields. Counties within the lower parts of the state show more positive correlations, illustrating that earlier snowmelts lead to declines in crop yields. Building upon the findings of Kunkel and Pierce (2009), this study suggests that non-irrigated crop lands in lower regions are susceptible to lower yields while cropland in higher regions will continue to see improved yields.

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## Abstract:

Non-irrigated agriculture is very susceptible to the changing climate conditions impacting crop yield results. The data in this study finds consistent results with respect to a changing climate altering crop yields. A multivariable regression analysis will later be used in order to determine the total impact of the changing climate upon non-irrigated agriculture. The first variable analyzed was the final snowmelt date. The results find that counties that reside in either the lower or panhandle portion of the state show consistent correlations, implying that the snowmelt date and crop yields mutually increase or decrease. The counties within the top of the state reveal more negative correlations, leading to earlier snow melts and resulting in increasing crop yields. Counties within the lower parts of the state show more positive correlations, illustrating that earlier snowmelts lead to declines in crop yields. Building upon the findings of Kunkel and Pierce (2009), this study suggests that non-irrigated crop lands in lower regions are susceptible to lower yields while cropland in higher regions will continue to see improved yields.

## How has climate change impacted agriculture in Idaho?

Ongoing and future climate change in Idaho is predicted to increase summer temperatures by 2-4 degrees C by 2080 (Climate Impacts Group). Changes in both summer temperature and the timing of spring snowmelt will likely have substantial impacts on Idaho's crops. Idaho is an agriculturally diverse state where a significant portion of the agricultural production is practiced by non-irrigated techniques (NASS 2010). These non-irrigated farms rely heavily on predictable environmental conditions; as a result, these operations are very vulnerable to changes in climate. Over the past 40 years, approximately 28.8 % of Idaho's barley production and over 60% of Idaho's wheat production have come from non-irrigated crop practices (NASS 2010). Non-irrigated crop yields depend on many environmental factors. Isik & Devadoss (2006) note that change in climatic conditions from year-to-year is one of the major determinants of the crop yield fluctuations. These climatic conditions include water availability from snowmelt runoff.

This study examines the statistical correlation between Idaho's snowmelt timing and its affects upon non-irrigated crop yields. Recent studies on the timing of snowmelt in Idaho find that final spring snow has melted an average of approximately 2 weeks earlier and variability has increased to ±20 days (Kunkel and Pierce, 2010).

Using statistical techniques we investigate correlations between snowmelt timing and wheat and barley yields in several counties of Idaho. Due to Idaho water laws and irrigation rights, this study focuses on non-irrigated crop yields for barley and wheat within several Idaho counties. These counties are associated by proximity to recorded SNOTEL sites and streamflow locations in order to examine any correlation between the final spring snowmelt date and crop yields. We find that snowmelt timing date has unique effects on crop yields in different regions of the state.

| Site Letter | Corresponding Stream # | SNOTEL SITE NAME | COUNTY |
|---|---|---|---|
| A | 2 | HIDDEN LAKE | Boundary |
| B | 3 | MOSQUITO RIDGE | Shoshone |
| C | 5 | MICA CREEK | Shoshone |
| D | 6 | ELK BUTTE | Clearwater |
| E | 7 | SAVAGE PASS | Idaho |
| F | 8 | MOUNTAIN MEADOWS | Idaho |
| G | 11 | BRUNDAGE RESERVOIR | Adams |
| H | 12 | SCHWARTZ LAKE | Lemhi |
| I | 16 | LONG VALLEY | Valley |
| J | 16 | SQUAW FLAT | Adams |
| K | 13 | DEADWOOD SUMMIT | Valley |
| L | 14 | MEADOW LAKE | Lemhi |
| M | 17 | JACKSON PEAK | Boise |
| N | 22 | MORES CREEK SUMMIT | Boise |
| O | 18 | STICKNEY MILL | Custer |
| P | 23 | ATLANTA SUMMIT | Elmore |
| Q | 20 | TOGWOTEE PASS | Teton, Wy |
| R | 19 | HYNDMAN | Blaine |
| S | 21 | TRINITY MOUNTAIN | Elmore |
| T | 24 | GRANITE CREEK | Teton, Wy |
| U | 25 | BLIND BULL SUMMIT | Sublette, Wy |
| V | 28 | BEAR CREEK | Elko, Nv |

**Chart 1**: SNOTEL Sites and Corresponding Stream and County Index for Figure 1.

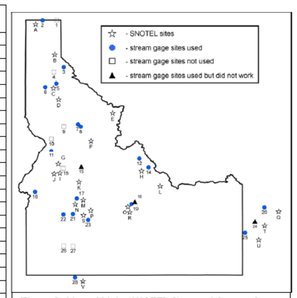


**Figure 1**: Map of Idaho SNOTEL Sites and Stream Gauge locations observed in this study. From Kunkel and Pierce (2009).

Chart 1 – SNOTEL Sites and Corresponding Stream and County Index for Figure 1.

Figure 1 – Map of Idaho SNOTEL Sites and Stream Gauge Locations. *Both From Kunkel and Pierce (2010)*

## Methods

Final spring snowmelt data was collected from the National Resources Conservation Services snowpack telemetry (SNOTEL) sites. Data prior to 1980 was obtained from Kunkel and Pierce (2009), which shows the final spring snowmelt day has increased by roughly two weeks over the span of their study.

Crop data was obtained from the National Agricultural Statistic Services (NASS) for both barley and wheat; two of the most common non-irrigated crops in Idaho. The crop records were then examined for several counties within close proximity to the SNOTEL sites and stream gauge locations used to find the yearly final snowmelt dates in the previous study. These records were sorted and analyzed by average yield for each county corresponding with the available yearly snowmelt data. Years without complete records were omitted from the study.

Once crop and snowmelt data was consolidated with the relevant SNOTEL sites and counties, graphical representations and statistical tests to examine correlation between crop yields and snow melt date were constructed. Nearly all of the crop yields revealed a positive linear trend; an expected result which is most likely associated with technological changes and advancements in agriculture. The statistical methods to account for this yearly trend involved calculating how much the expected crop yields differ from the actual crop yields. Our representations within the graphs are the standardized crop yields and the final snowmelt dates. The correlations values found in Figure 5 and Figure 6 reveal the measure of correlation between the calculated residual values of the final snowmelt date and crop yields. These residual crop values were derived from the difference between the expected and observed crop yields.

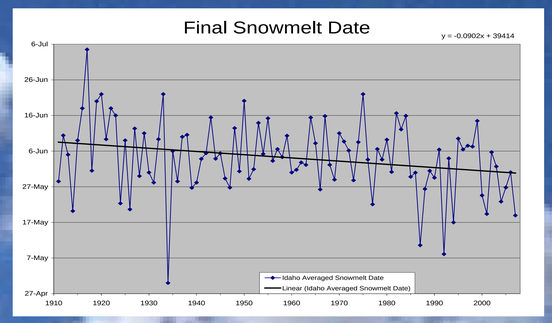


**Figure 2**: Idaho average final snowmelt dates. *From Kunkel and Pierce (2010)*

### *Example of the Significant Correlation Patterns*

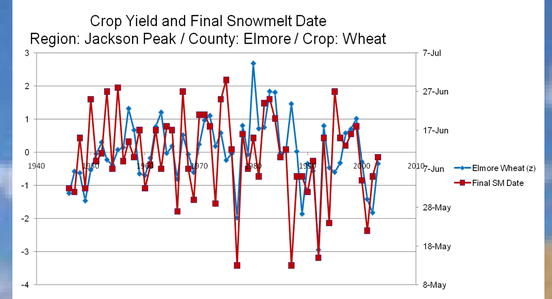


**Figure 3**: Example of the correlation results found between the final snowmelt dates and crop yields within several Idaho counties. These results are from the Jackson Peak SNOTEL site and its correlation with non-irrigated wheat yields within Elmore County.

### *Example of the Increased Variability in Recent Years*

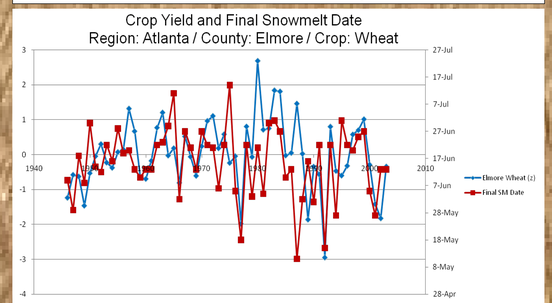


**Figure 4**: Example of the increased variability in the final snowmelt dates observed in the Atlanta SNOTEL site , and the correlation with non-irrigated wheat yields within Elmore County.

## Results

A comparison of crop yields and timing of snowmelt reveals some strong correlation patterns as well as increasing variability in more recent years (Figure 3 and Figure 4). The data shows correspondence between crop yields and timing of snowmelt based on their particular regions within the state.

Southern and lower elevation counties: The counties observed within the lower part of the state illustrate some relatively strong positive correlation results, particularly in Gem, Boise, Elmore, Camas and Blaine counties. This implies that earlier snowmelt corresponds with crop yields.

Northern and higher elevation counties: The counties within the top of the state show more negative measurement of correlation; this indicates that the earlier snow melt is correlated with higher crop yields.

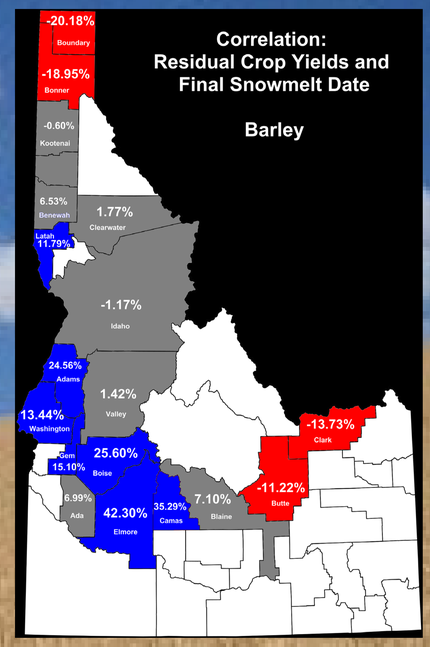


**Figure 5**: Map illustrating the resulting correlation results (in percentage form) for Barley.

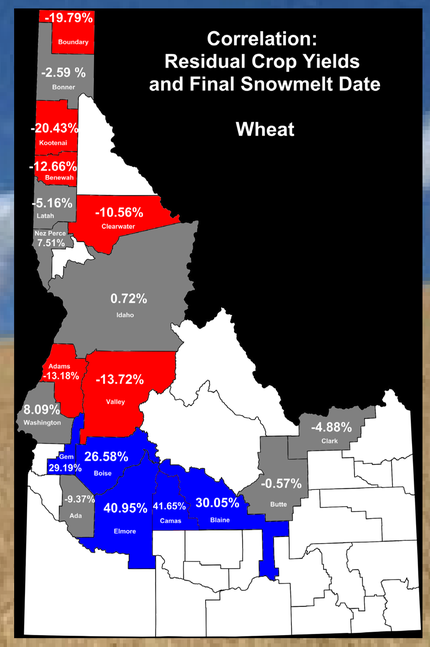


**Figure 6**: Map illustrating the resulting correlation results (in percentage form) for Wheat.

## Discussion and Further Research

This preliminary study suggests that with continued earlier snowmelt (Kunkel and Pierce, 2010), non-irrigated crop lands in lower elevations will have lower yields while cropland in higher elevations may have improved yields. Visual inspection of the graphs shows significant correlation between the final snowmelt dates and crop yields. Furthermore, many of these graphs also reveal an increased variability in the later years of the study data.

Final snowmelt dates are only one of the several climate-related variables that affect Idaho's crop yields. In order to have a greater understanding of the climate's impact on Idaho's non-irrigated agriculture, a multivariable regression analysis involving temperature, precipitation, and last frost dates as well as other variables will likely result in a more complete analysis.

Both of the correlation maps in Figure 5 and Figure 6 reveal the correlation results between snowmelt and crop yield. These results include all data points, and as previously mentioned, are significantly altered due to the outlier years on the relatively small number of data sets (an average of 35 years had complete data) ran in each correlation matrix. Wildfires, extreme weather anomalies, farm and tax programs, advance technological breakthroughs, and several other environmental and political abnormalities can create these outliers. Any adjustments made to account for these outliers would likely increase the correlation percentages between final snowmelt date and crop yields.

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