INTEGRATING CLIMATE AND WILDFIRE EDUCATION IN THE CLASSROOM: DEVELOPMENT AND IMPLEMENTATION OF K-12 PLACE-BASED WILDFIRE EDUCATIONAL MODULES

by

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The following individuals read and discussed the thesis submitted by student Danielle Marquette, and they evaluated the student's presentation and response to questions during the final oral examination. They found that the student passed the final oral examination.

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DEDICATION

To my children, Madalyn, Mika, Maverick, and Myron Marquette

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ABSTRACT

In the United States, even though most parents would like their children to be educated about climate change, and most teachers support including climate change in K-12 curriculum, many schools fail to educate students about the causes, consequences, solutions, and personal connections to climate change. Teaching anthropogenic climate change through the local context is one of the most effective methods of teaching climate change. In Idaho the lengthening fire season and the increasing occurrence of larger, more severe fires is a tangible impact of climate change. Yet students from Idaho and other high wildfire risk states in the western United States report that they received little to no wildfire education at the K-12 level. Surveys indicate that K-12 educators do not teach wildfire or climate change for a variety of reasons including lack of confidence, background knowledge, awareness of resources, and understanding of how it relates to grade level standards and subjects.

This study was designed to investigate the following questions: 1) Do incoming college students from the western United States receive climate change and wildfire education at the K-12 level? 2) What barriers do K-12 educators report regarding teaching about climate change and wildfire? 3) Does a place-based wildfire education unit at the 4th grade level result in demonstrable increases in climate change and wildfire knowledge? 4) Do teachers who have observed the instruction of wildfire education

modules report increased perceived content knowledge, confidence, and willingness to teach wildfire?

To assess gaps in K-12 climate change education, and wildfire education, we surveyed Idaho teachers and students to reveal trends in backgrounds, understanding and perceptions of climate change and wildfire education. We surveyed Idaho K-12 educators to assess teachers' perceptions of climate change, climate change education, and hesitations towards teaching climate change. We find that K-12 teachers overwhelmingly support climate change curriculum, but often do not believe that climate change is related to the subjects they teach and do not feel prepared to teach the subject themselves.

We surveyed 100 level courses (2019, 2021, and 2022) at Boise State University to assess incoming college students' backgrounds in climate change (n=298). We find that 51% of these students had one or more classes that covered climate change in their K-12 education. Idaho students reported the lowest rate of climate change education (44%). We surveyed two of these same university courses (2021 & 2022) at Boise State University to assess incoming college students' backgrounds in wildfire education (n=201). Although most students attended high school in fire-prone areas of the western United States, the majority of students received little to no wildfire education.

We develop and implement four place-based wildfire educational lessons for K-12 classrooms (https://sites.google.com/boisestate.edu/wildfire-unit/home), and tested the lessons in five different fourth grade classrooms located in southwest Idaho. We gave the students pre and post lesson assessments to measure the effectiveness of each lesson; these lessons were taught to classes with the classroom teacher observing. We surveyed teachers before and after completion of the unit's instruction to measure their perceived content knowledge, understanding, confidence, and willingness to teach wildfire on their own. While our sample size for a paired analysis of teacher surveys was low (n=7), we found that teachers reported an increase in content knowledge, confidence and willingness to teach about wildfire after observing these lessons being taught. The results were compared for the demographics of urban and rural schools. We hypothesized that students from higher wildfire risk areas might test higher on background (pre-assessment) wildfire knowledge. Three of the schools are categorized as rural and two are categorized as urban, and all rural schools are considered to be in the wildland-urban interface (WUI). Two of the rural schools are located within forested, high wildfire risk areas, and one rural school is located in an agricultural area, adjacent to rangelands.

We find that students from rural schools scored lower on their pre-assessments, but had greater improvement between the pre and post-assessments than students from urban schools. A paired t-test of pre and post assessments indicates a statistically significant improvement in student knowledge for lessons 1, 2, and 4 ($p < 0.001$), but not for lesson 3 ($p = 0.058$). Cohens d effect sizes for each lesson were large for lesson 1 (1.4), medium for lesson 2 (0.6), small for lesson 3 (0.3), and large for lesson 4 (1.2).

This study demonstrates that these K-12 wildfire modules provide both a needed and successful intervention, which can better prepare students to address challenges presented by wildfire and climate change in communities in the western United States.

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LIST OF ABBREVIATIONS

IRB	Internal Review Board
K-12	Kindergarten through 12th grade
NPR	National Public Radio
NGSS	Next Generation Science Standards
SNOTEL	Snow telemetry
STEM	Science, technology, engineering, mathematics
SWE	Snow Water Equivalent
VPD	Vapor Pressure Deficit
WUI	Wildland Urban Interface

CHAPTER 1: SETTING THE STAGE: PRELIMINARY ASSESSMENTS OF K-12 CLIMATE CHANGE EDUCATION IN THE WESTERN USA

Introduction

In the United States, most people believe that climate change is happening (Marlon et al., 2022), most parents would like their children to be educated about climate change (Marlon et al., 2022; Kamenetz, 2019), and most teachers support including climate change in K-12 curriculum (Kamenetz, 2019; Pierce, unpublished data). A 2019 poll by National Public Radio (NPR)/Ipsos found that 86% of teachers and 84% of parents in the United States support climate change education at the K-12 level (Kamenetz, 2019). Yet in the United States, K-12 schools are failing to properly educate students about the causes, consequences, solutions, and personal connections to climate change (Shapiro-Ledley et al., 2017; Allen & Crowley, 2017).

The reasons for this are many. Climate change and the role of human contributions to climate change are part of the Next Generation Science Standards (NGSS), which serve as a framework for educational benchmarks that students should achieve within certain subjects by grade level. However, individual states decide whether to adopt the NGSS into their own state standards. State standards largely influence what benchmarks are covered in public schools (The Aspen Institute, n.d.). Individual states' inclusion of climate change varies drastically, from New Jersey, which includes climate change in every subject at every grade level (New Jersey Department of Education, n.d.), to Pennsylvania, which does not include climate change at all (The Aspen Institute, n.d.).

Anthropogenic climate change is included in 29 states' standards as well as the District of Columbia (The Aspen Institute, n.d.). Fifteen other states include climate change within their standards, but without emphasis on human contributions. Five states include climate change, but only in optional high school courses, and one state does not include any mention of climate change in their standards (Pennsylvania) (The Aspen Institute, n.d.). Therefore, in states with weak standards on climate change, the decision about whether or not to even mention climate change is often left to individual teachers. Without the requirement from their state standards, teachers lack the support necessary to become competent in the content, and to find opportunities to implement it within their subject matter. Many teachers lack the background knowledge, awareness of resources, and understanding of where climate change can fit into grade level standards and subjects (Ennes et al., 2021; Hestness et al., 2014; Monroe et al., 2017; Pierce, unpublished data). According to a recent survey, 76% of K-12 teachers have never received any professional training or education on climate change or how to teach the subject (Will & Prothero, 2023). Learning and then implementing new curriculum is a challenge when teachers are already short on time in the classroom (Ennes et al., 2021). Many teachers are also hesitant to teach what they perceive as a controversial topic which may incur pushback from their students' guardians (Ennes et al., 2019; Monroe et al., 2017).

In Idaho, the NGSS have not been adopted into the state standards. The current Idaho educational state standards include climate variability, without emphasis on the human contributions to it.

To assess this gap in K-12 climate change education, we survey Idaho teachers and K-12 students and incoming first year college students at Boise State University to reveal trends in background, understanding and perceptions of climate change education.

Background

Youth Climate Change Education: Effective Teaching Methods and Benefits

Youth climate change education is critical to prepare the next generation with the understanding and skills to address the causes, consequences, and solutions to climate change. However, simply imparting climate change knowledge is not enough to motivate action and behavioral changes (Littrell et al., 2020; Shapiro Ledley et al., 2017; Valdez et al., 2018).

One effective method of climate change education is teaching through local, observable impacts. Teaching climate change through the local context allows students to observe real world impacts, problem solve within their own communities, use locally acquired data sets, and integrate their knowledge into solutions (Hestness et al., 2014; Khadka et al., 2021; Monroe et al., 2017; Shapiro Ledley et al., 2017). With climate change leading to an increase in the frequency and severity of natural disasters, teaching with examples of local natural disasters provides an opportunity for critically needed education (Stevenson et al., 2017). Local disaster risk reduction education increases student awareness of local risks, and better prepares students for their occurrence. Climate change education that is presented through the lens of local disaster risk reduction can contribute to better prepared, more resilient communities (Stevenson et al., 2017).

Numerous studies highlight the importance of emphasizing hope when educating youth on climate change (Li & Monroe, 2017; Ojala, M., 2012; Ratinen & Uusiautti, 2020). Including climate change mitigation and solutions in climate education provides sources of hope, since students are more hopeful when they believe that society has the skills necessary to take meaningful action (Li & Monroe, 2017). Students also report feeling more empowered when climate education is tied to addressing impacts within their local communities (Monroe et al., 2017). A study of pre-service K-12 educators found that teachers would like more information about climate mitigation and solutions that provide practical, real life applications (Stevenson et al., 2017).

An additional benefit to youth climate education is that children may be highly effective at conveying climate change knowledge to their parents, leading to behavioral changes (Lawson et al., 2019). A study measured this effect and found that females were most effective at increasing climate change concern in their parents, and the greatest increase was observed in conservative male parents (Lawson et al., 2019).

K-12 Climate Change Education in Idaho

Idaho's state standards include climate variability (See Appendix), but do not emphasize human contributions to it, and do not specifically use the term "climate change" (Idaho State Department of Education, 2022). Incorporating climate change into Idaho's state science standards has been a contentious battle since 2015 (Worth & Hand, 2019). According to the most recent survey results from the Yale Program on Climate Change Communication, 68% of Idahoans believe that global warming is happening and 74% of Idahoans believe that schools should teach about the causes, consequences, and potential solutions to climate change (Marlon et al., 2022). This is only slightly lower than the 77% national average of people who believe the same (Marlon et al., 2022). In addition, a 2019 poll by NPR/Ipsos found that 86% of teachers and 82% of parents in the United States support climate change education at the K-12 level (Kamenetz, 2019).

Despite the overwhelming support of students, teachers, and parents to include anthropogenic climate change into the Idaho state standards, the House Education Committee in the Idaho State Legislature has continued to reject wording that emphasizes human contributions to climate change (Worth & Hand, 2019). Idaho House Representative Scott Syme reportedly opposed wording that blames human contribution, arguing that students should come to their own conclusions. He further stated, "I don't care if the students come up with a conclusion that the earth is flat – as long as it's their conclusion, not something that's told to them."(Stark, 2018).

Gaps in K-12 Educators' Climate Change Knowledge

When teachers lack the background in the fundamental science of climate change themselves, they cannot be expected to properly educate their students. Worse, they may disseminate commonly held misinformation about climate change to their students. Fundamental misconceptions about climate change are rampant. For example, 46% of teenagers believe that the hole in the ozone layer is a major factor in global warming (Will & Prothero, 2022). According to the Yale Program on Climate Change Communication, only 57% of people in the United States believe that global warming is caused by humans (Marlon et al., 2022). Surprisingly, only 57% believe that most scientists think that global warming is happening, with 23% of people surveyed stating that there is a lot of disagreement among scientists about whether global warming is occurring or not (Marlon et al., 2022). Scientists overwhelmingly agree that the earth's climate is changing, and that humans are the main driver of this (Cook et al., 2013). This inaccurate perception of scientists' agreement on climate change is found among educators as well. In a national survey of K-12 teachers, only 30% of middle-school and

45% of high-school science teachers chose the correct selected response answer that more than 80% of climate scientists believe that climate change is human caused (Plutzer et al., 2016). Among teachers who cover climate change, 31% emphasize both human and natural causes for the current change in climate (Plutzer et al., 2016). Climate change education professional development is not widely available in Idaho. The lack of teacher preparation to teach climate change is observed not only in Idaho, but at the national level. In a national survey of teachers, 40% of science teachers said they took a class that covered the science of climate change in college, only 12% said their teacher-preparation program taught them how to teach about it and only 12% said their district or school provided professional development on how to teach climate change (Will and Prothero, 2023). Members of this Boise State research group (Marquette and Pierce) collaborated with other local educators from the city of Boise and Idaho Forest Products commission to co-instruct professional development courses in Idaho on wildfire, water and climate (2020, 2021, & 2022). These courses could provide models for future teacher professional development; however, analysis of these teacher training opportunities is beyond the scope of this study.

Given this background, we wanted to assess the educational experiences of incoming college students from the western United States to find out if they had received climate change education at the K-12 level. Further, we wanted to know what barriers K-12 educators in Idaho report regarding teaching about climate change.

Methods

<u>Idaho Teacher Survey</u>

We collected survey data from Idaho K-12 educators in a voluntary, anonymous, convenience sampling survey at the start of a week-long professional development STEM workshop, during the summer of 2019. We surveyed these educators to analyze trends in perceptions of climate change and climate change education, as well as hesitations toward teaching climate change. We surveyed these teachers using the same questions as a national poll conducted by NPR/Ipsos and compared our results to theirs. The teachers we sampled are not representative of the general Idaho teacher population as they were voluntarily participating in a summer continuing education STEM workshop which covered a variety of STEM related subjects. Of the approximately 200 teachers enrolled in the workshop, nine signed up for a class specifically on climate change. All of the teachers enrolled in the workshop were provided the survey. Ninety teachers completed one or more questions on the survey. Seventy five of the respondents stated that they currently taught a K-12 grade level, with 20 reporting they taught K-3rd grade, 22 reporting they taught 4th-6th grade, 23 reporting that they taught 7th-9th grade, and 10 reporting they taught 10th-12th. Teachers were asked:

1) As far as you know, do you think the world's climate is changing or not?
2) Should climate change be taught in school?
3) As a parent, do you talk to your kids about climate change?
4) As a teacher, do you talk to your students about climate change?
5) As a teacher, do you cover climate change in your curriculum?

6) If you do not teach climate change in your classroom, why not?

Selected response options for each question matched the responses from the NPR/Ipsos poll.

The selected response options for question 1 were:

1) Changing
2) Not changing
3) Don't know

The selected response options for question 2 were:

1) Schools should teach about climate change and its impact on our environment, economy and society.
2) Schools should teach that climate change exists, but not potential impacts.
3) Schools should not teach anything about climate change.
4) Don't know.

The selected response options for question 3 were:

1) Yes
2) No

The selected response options for question 4 were:

1) Yes
2) No

The selected response options for question 5 were:

1) Yes
2) No

The selected response options for question 6 were:

1) It's not related to the subjects I teach.
2) Students are too young.
3) I don't know enough about it.
4) I don't have the materials I need to teach the subject.
5) I don't believe in climate change.
6) State mandates it to be taught in a different grade level.
7) My school does not allow it.
8) Students have already learned about it in school.

The survey included a blank response at the end that allowed participants to provide open-ended feedback. Themes in the responses were identified and reported.

The survey was provided to the teachers at the start of the workshop in paper form. The responses were collected and recorded into an Excel spreadsheet. The responses were analyzed and graphed in Excel.

Boise State University Student Survey

We surveyed a university-wide 100-level course on climate change in 2019, 2021, and 2022 at Boise State University to assess incoming college students' backgrounds in climate change education (n=298). The survey was conducted in a 100 level, semester long climate change course, which is primarily composed of incoming freshman students, and is offered every fall semester. While some students choose the course because the topic focuses on climate change, other students select this particular 'foundational studies' course because it fits best with their schedule. All three classes had approximately 100 students. Students were required to complete the survey for class points. The survey contained numerous questions pertaining to the student's educational backgrounds, interests, class schedules, and perceptions of climate change. For this analysis we looked at only the following questions:

1) In what state did you attend high school?

2) What best fits your experience regarding climate change in your K-12 education? Selected response options for question 2 included:

1. I had multiple teachers cover aspects of climate change (science, social science, etc.)
2. I had one teacher or one class that included climate change topics.
3. Climate change was not covered in my school at all.
4. I had teachers bring it up, but we never had lessons or homework on the topic.
5. I had one or more teachers deny or dismiss climate science.

A blank response was also available at the end of question 2 where students could leave a short answer. A short answer was not required and there was no additional prompt for this other than a selectable "other" category, which allowed for a short answer response. These responses provided some context for the scope of student's climate change education and were assigned to an existing category by the researchers. Each year there were several short answer responses which were each assigned to an existing category for this analysis. An example of this is the response, "I had a Current Issues class where students would select articles and write a paper on them, multiple of these papers were written on the topic of climate change". This response was assigned to the existing category, "I had one teacher or one class that included climate change topics".

Limitations of This Study

The teacher sample in this study do not represent the wider population of K-12 teachers in Idaho. The teachers that enrolled in the STEM workshop were likely more interested in STEM subjects, and may have had greater content knowledge of climate change. It is also possible that these teachers were more supportive of climate change education, given their interest and desire to take a STEM workshop. These factors may contribute to biased results showing greater support of climate change education and greater understanding of climate change than is representative of K-12 teachers in Idaho.

We ask freshman students to recall climate change education that they received at the K-12 level. It is unlikely that students remember every lesson they received over their entire K-12 experience. Therefore, it is reasonable to assume that our results show an underestimate of climate change education in our survey results. It is also possible that students who enrolled in this course were interested in the subject of climate change due to having some prior education in climate change, which would show an overestimate of K-12 climate change education, as opposed to the population of all freshman students who attended high schools in the western United States.

Results

Idaho STEM Workshop Teacher Survey Data

Survey data of Idaho STEM workshop participants was compared to the national results of the same survey, conducted by NPR/Ipsos (Kamenetz, 2019). The results of survey responses in figures 1, 2, 3 and 5 show greater belief in climate change and greater support for climate change education in the Idaho STEM workshop participants than teachers in the national survey. The Idaho STEM workshop survey included a question asking if teachers talk about climate change with their students (Figure 4). This question refers to informal discussions which may not necessarily be part of a lesson. This question was not included in the NPR/Ipsos survey.

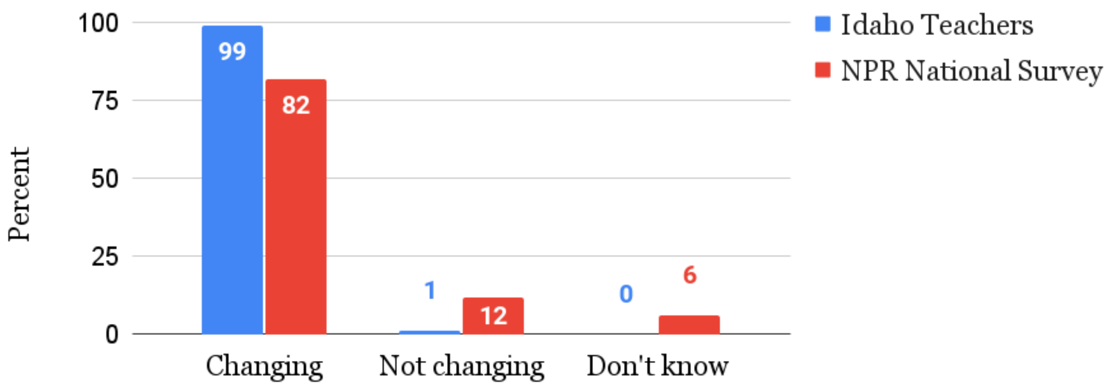

Figure 1 Most teachers believe that the earth's climate is changing. Idaho STEM workshop participants were asked, "As far as you know, do you think the world's climate is changing or not?" The results are compared to the same survey conducted at a national scale by NPR (Kamenetz, 2019). Idaho STEM workshop teachers (n=79) vs. NPR/Ipsos national survey of teachers (n=505).

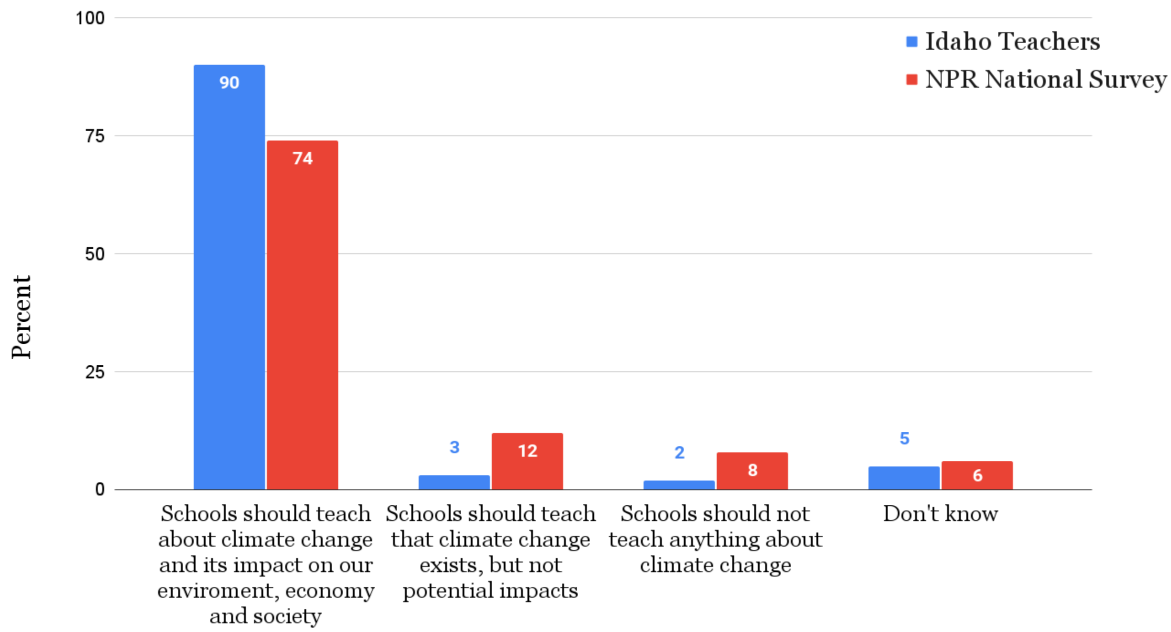

Figure 2 Teacher's perspectives on climate change education. Most of the K-12 teachers surveyed (in Idaho and nationally) believe that schools should teach about climate change, and its impact on our environment, economy and society. Idaho STEM workshop teachers (n=62) vs. NPR/Ipsos national survey of teachers (n=505).

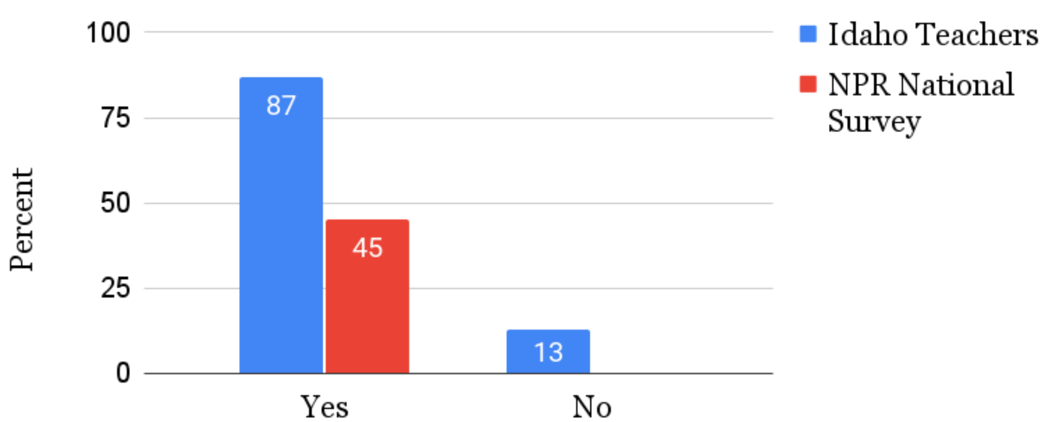

Figure 3 More Idaho teachers talk to their own children about climate change than teachers in a national survey. Idaho STEM workshop teachers were asked, "As a parent, do you talk to your kids about climate change?" The results are compared to the same survey conducted at a national scale by NPR (Kamenetz, 2019). Idaho STEM workshop teachers (n=69) vs. NPR/Ipsos national survey of teachers (n=505).

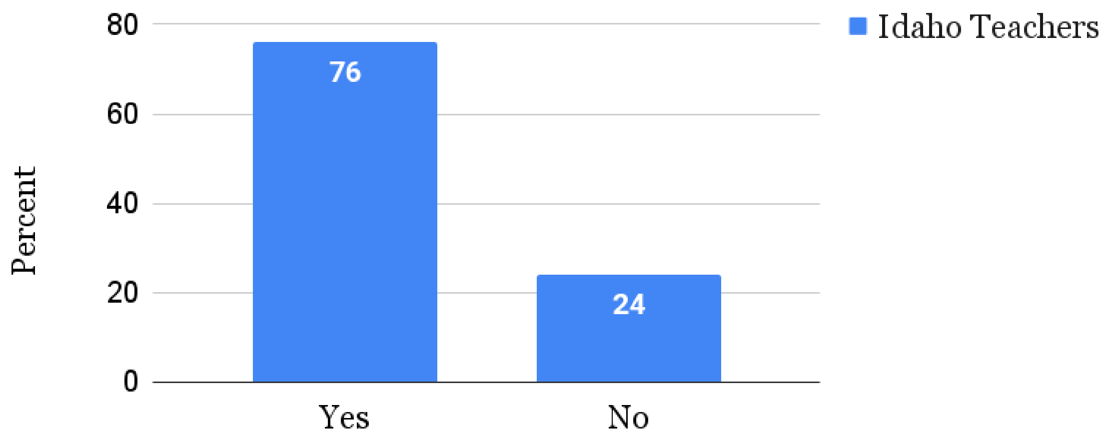

Figure 4 Idaho STEM workshop teachers were asked, "As a teacher do you talk about climate change with your students?" (n=90). This question was not included in the NPR/Ipsos survey.

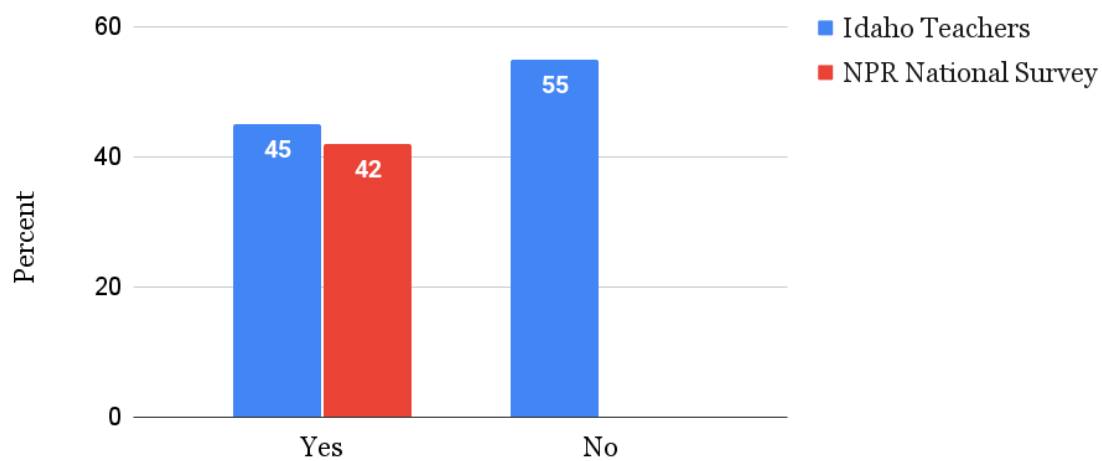

Figure 5 Less than half of teachers surveyed cover climate change in their curriculum Idaho STEM workshop teachers were asked, "As a teacher, do you cover climate change in your curriculum?" The results are compared to the same survey conducted at a national scale by NPR (Kamenetz, 2019). Idaho STEM workshop teachers (n=86) vs. NPR/Ipsos national survey of teachers (n=505).

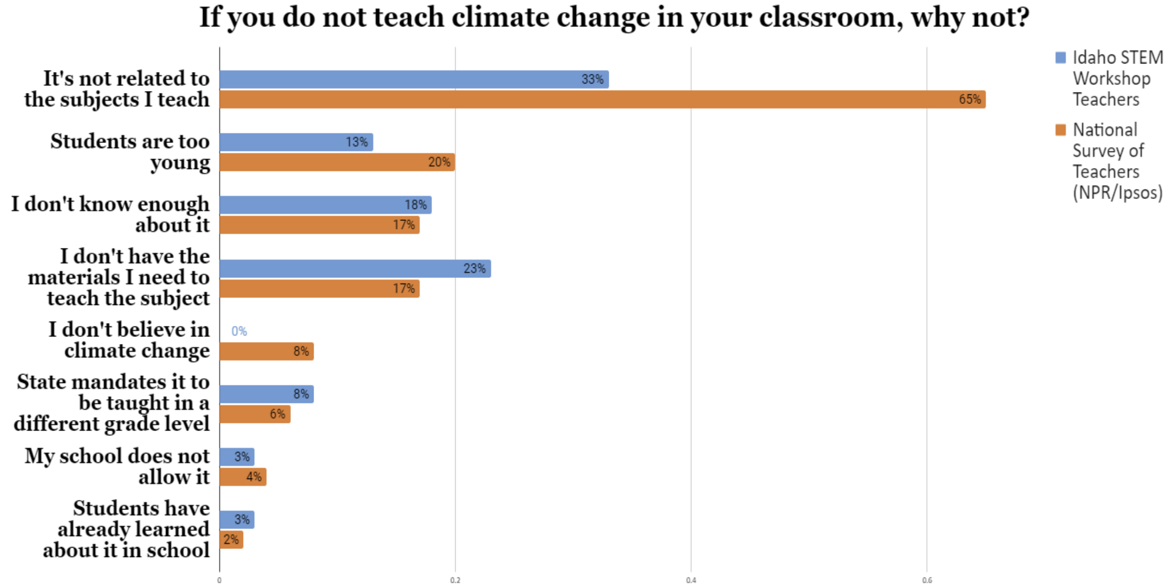

Figure 6 Teachers' reasons for not covering climate change in their classroom. Idaho STEM workshop teachers took the same survey that was conducted nationally by NPR (Kamenetz, 2019). Most teacher's believe that climate change is not related to the subjects they teach. Idaho STEM workshop teachers (n=39) vs. national NPR/Ipsos survey (n=505).

The results of the NPR/Ipsos poll differ from the Idaho poll (Figure 6), however both groups reported that the number one reason teachers do not teach climate change is that they do not believe that it is related to the subject(s) they teach. The other most common responses for both populations of respondents are that teachers do not have the materials needed to teach the subject, they do not know enough about it, and they believe that their students are too young. There were 16 responses in the open feedback at the end of the survey. Several of the responses simply stated support for the survey, such as "I appreciate that we are having this discussion as it is very important", and "Great survey follow-up to this NPR (survey)". One teacher stated, "I believe it (climate change) should be in our standards, because it is real and happening right now". Of the six responses that pertained to reasons why they do not teach climate change in the classroom, five of the teachers responded that they did not have the resources to teach about climate change.

Some of these statements include: “We lack the resources”, “(The) Library does not have good books on it”, “We teach about climate & weather but do not have the materials enough to teach about climate change”, and “I would like someone to create a grade level curriculum for climate change that would be easily implemented & that could be completed in a short time frame.” One teacher stated that they do not teach climate change because it is not included in the curriculum and they have no time.

Boise State University Students’ Backgrounds in Climate Change Education

We surveyed three 100 level courses at Boise State University to assess incoming college students' backgrounds in climate change education (n=298). We found that the majority of students reported attending high school in Idaho (40%). This was followed by California (28%), and Washington (15%). We examined spatial trends in results from states with the highest student responses; (Idaho, California, Washington, Oregon, and Nevada); other reported locations were categorized as “other”. We found consistent trends throughout the three cohort’s responses. These responses are shown in Table 1. The most common selected response was, “I had teachers bring it up, but we never had lessons or homework on the topic. This was followed by the responses “I had multiple teachers cover aspects of climate change (science, social science, etc.)” and “I had one teacher or one class that included climate change topics”. These responses were combined into one category defined as, “I had one or more classes that covered climate change”. Three students reported that they had one or more teachers deny or dismiss climate science. All three of these students reported attending high school in Idaho. The three years of combined survey data were used to create maps of student responses by the location that they attended high school (Figures 7, 8, & 9).

Table 1 Boise State University student responses regarding climate change education backgrounds for 2019, 2021, and 2022 (n=298).

Selected Response	Percentage of Total Responses
Climate change was not covered in my school at all	9%
I had one or more classes that covered climate change	51%
I had one or more teachers deny or dismiss climate science	1%
I had teachers bring it up, but never had homework or lessons on the topic	38%

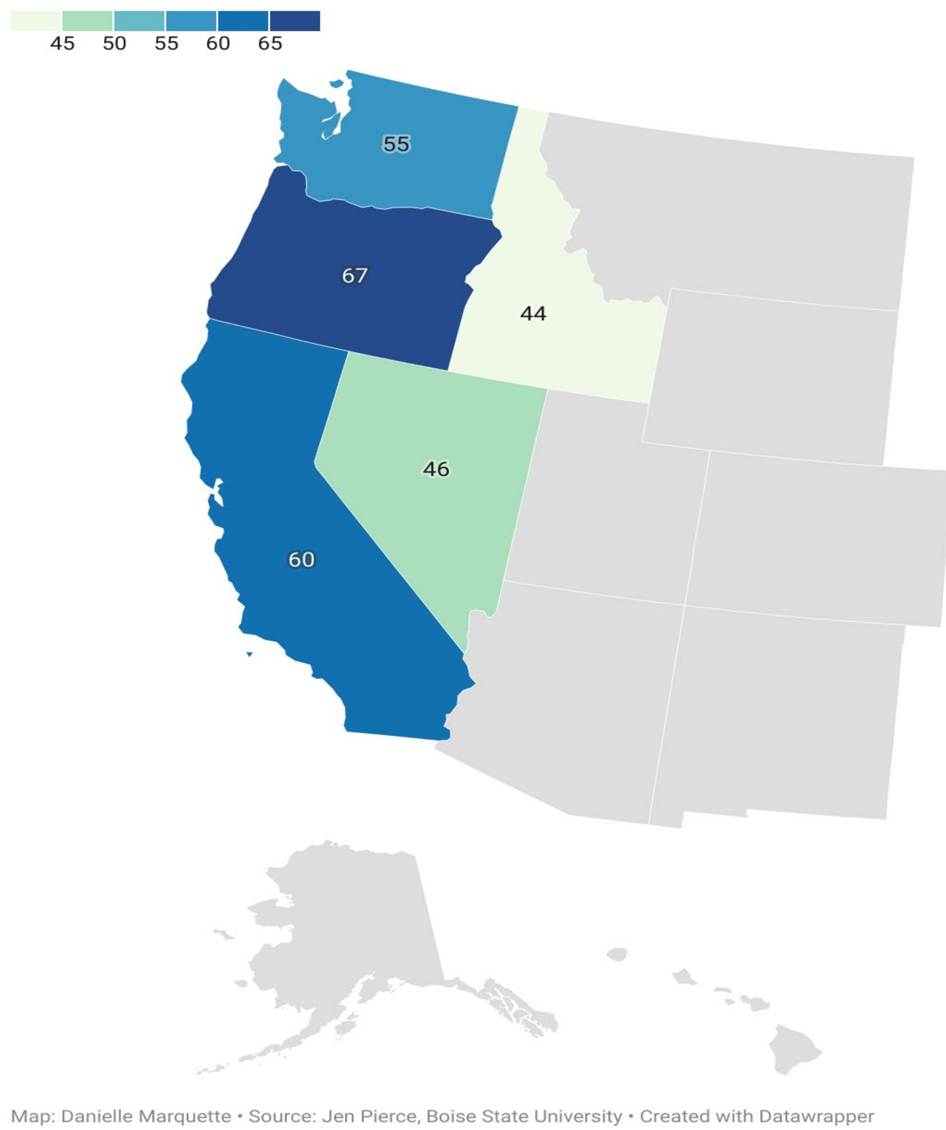

Figure 7 About half of the students surveyed at Boise State University reported receiving at least some climate change education at the K-12 level. Map showing the percentage of students from each state who reported taking one or more K-12 class that covered climate change. Of the 298 students surveyed, 153 reported covering climate change at some level. n=298

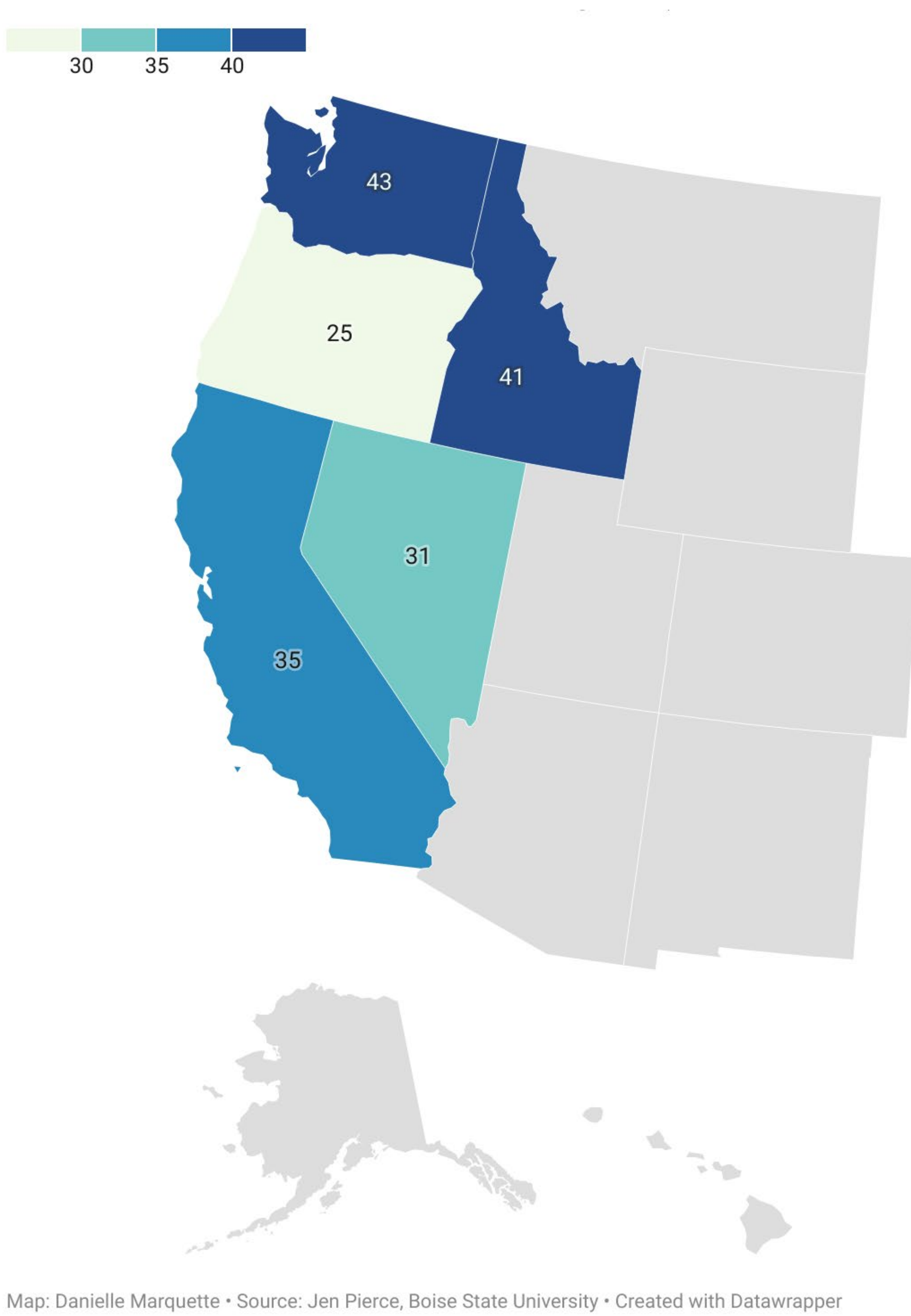

Figure 8 Many students surveyed at Boise State University reported having teachers informally discuss climate change. Map showing the percentage of students from each state who reported that they had teachers bring up climate change, but never had homework or lessons on it. Of the 298 students surveyed, 114 reported having climate change discussed. n=298

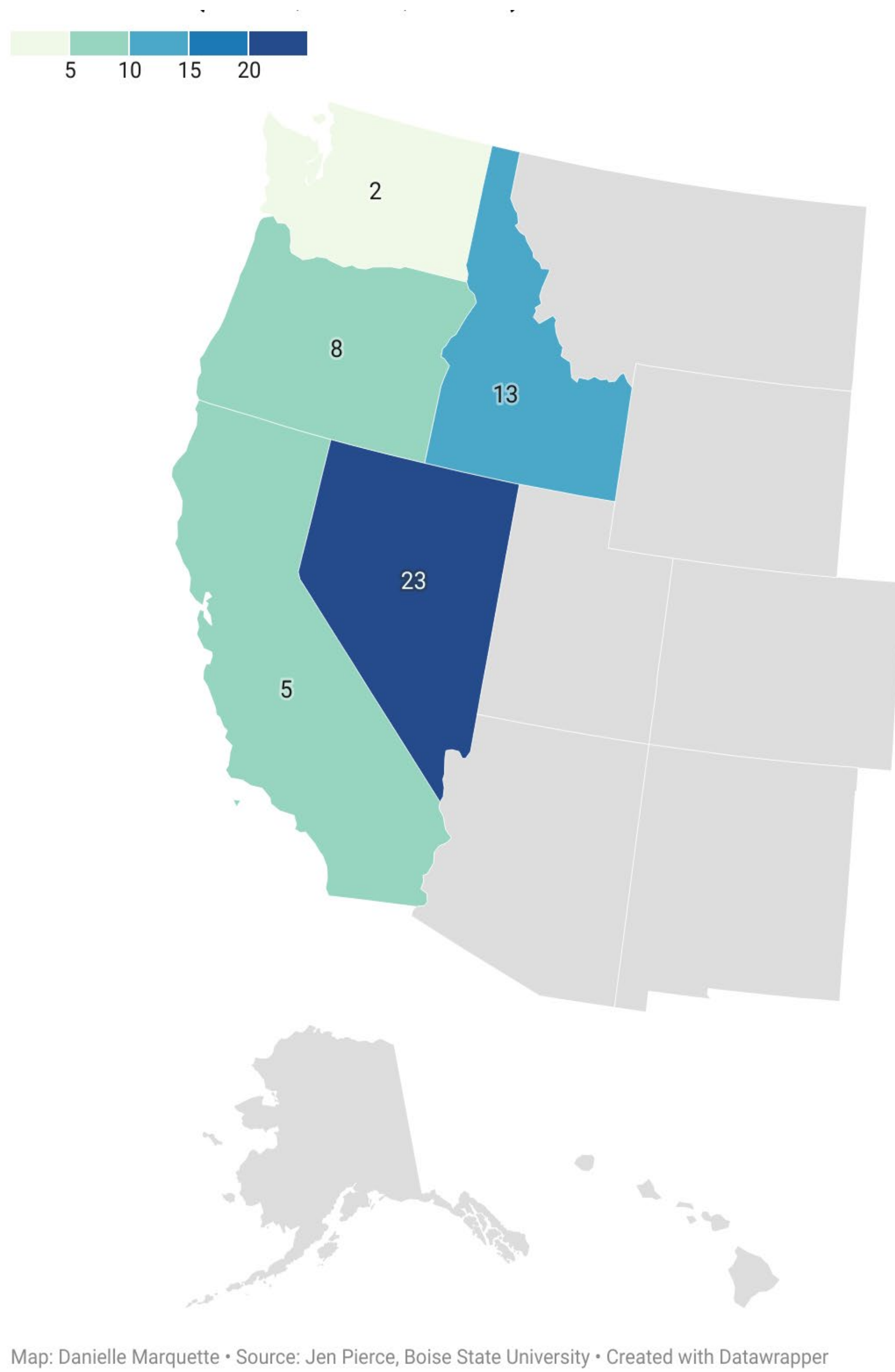

Figure 9 Students at Boise State University who had attended high school in Nevada and Idaho had less climate change education than students who came from other nearby states. Map showing the percentage of students from each state who reported receiving no climate change education in their K-12 classes. Of the 298 students surveyed, 28 reported that there was no mention of climate change in any of their K-12 classes. n= 298

Discussion

Idaho STEM Workshop Survey

The results of the Idaho STEM workshop survey and national surveys highlight the need to better equip K-12 teachers with the knowledge, understanding, and resources to teach climate change effectively and accurately.

The Idaho teachers consistently showed greater support for climate change education in the survey compared to the NPR/Ipsos poll. The higher number of Idaho teachers who support teaching and discussing climate change in schools, compared to the NPR/Ipsos poll, can likely be attributed to the background and interests of the Idaho teachers. The Idaho teachers all chose to take a professional development workshop focused on STEM subjects, which indicates an interest in science. The Idaho teachers' background education, knowledge, and beliefs likely favor more robust science education standards in the K-12 classroom, than adults surveyed in the national NPR/Ipsos poll. While the Idaho teachers expressed support for climate change education, less than half of these teachers actually teach climate change. The fact that these educators, whose backgrounds likely favor a stronger STEM foundation, express inadequate understanding of climate change and how to incorporate it into their subjects, is telling. The need to better prepare K-12 educators to cover climate change in their curriculum is likely much greater than what is shown by this small study of Idaho STEM workshop participants.

The results of the NPR/Ipsos poll and the Idaho teacher poll show that teachers by and large support climate change education at the K-12 level, but either do not believe that they are best suited or prepared to teach it themselves. Both polls show that most teachers do not believe that climate change is related to the subject they teach. These results highlight the widely held misconception that climate change resides solely within the confines of a science class. Professional development and teacher training could emphasize opportunities to include climate change in subjects other than science. New Jersey includes climate change in every subject and grade level and serves as a model for how to successfully include climate change in a comprehensive approach. Some examples of including climate change in subjects other than science include: 1) Greenhouse gas tag in physical education. Greenhouse gas tag is an interactive game of tag, where students learn the basic concept of the greenhouse effect. The game is modeled after the popular children's game "Sharks and Minnows" (Greenhouse Gas Game-Climate Centre, n.d). 2) The health impacts of climate change can be included in numerous health focused courses, from a basic health class to a more focused anatomy and physiology class. 3) The discovery of the heat trapping properties of carbon dioxide by Eunice Foote can be included in a history class. 4) The impacts of climate change on countries geopolitics can be included within social study courses. 5) Graphed data that shows changes in climate can be used in math.

There are countless options to include the subject of climate change into K-12 education in subjects other than science. However, K-12 educators require the training to properly teach climate change, understanding of how it connects to the subjects they teach, and where to acquire resources to use.

<u>Boise State University Student Survey</u>

Of the five western United States that we included in this analysis, all but Idaho have fully adopted NGSS into their state standards. Students who had reported attending high school in Idaho ranked the lowest in responses indicating at least some climate change education, with only 44% of students from Idaho saying they had received some climate change education. This was followed by students who had attended high school in Nevada, with 46% of students saying they had received some climate change education. Students from Nevada were also the most likely to say that they had not received any climate change education at all, with 23% of students from Nevada saying that they had no climate change education at the K-12 level. This was followed by students from Idaho, with 13% of students from Idaho reporting that they had not received any climate change education. The 3% of students who reported having one or more teachers deny or dismiss climate change is similar to a national survey, which found that 2% of educators deny global warming altogether (Plutzer et al., 2016). The dearth of climate change education in Idaho, including several students that reported having one or more teachers deny or dismiss climate change, can be partially attributed to the weak climate change standards, which were only recently adopted. However, the politicization of climate change is also a likely factor. While the majority of Idahoans believe that K-12 students should be educated about the causes, consequences, and potential solutions to climate change (Marlon et al., 2022), a small but vocal faction, as exemplified by the Idaho House Education Committee, persists in diminishing or removing climate change from the state educational standards (Worth & Hand, 2019). The deficient climate change education reported by the students who had attended high school in Nevada is more difficult to interpret. Nevada fully adopted NGSS into their state standards in 2014, so the students who attended high school in Nevada should have been exposed to climate change education at the middle and high school level. One possible explanation is that the NGSS do not state how much time must be devoted to a particular standard, and that a recent study found that the median time spent on climate change in classes that cover the subject was just 1-2 hours over the given course (Plutzer et al., 2016). Our survey of incoming college students did not include questions about the length of the educational unit. It is possible that with such minimal median time spent on the subject, students may not recall having received the instruction, or could have missed it altogether if they were absent for a class. This may partially account for the 9% of Boise State students, who reported they had not received any climate change education at the K-12 level. This is considerably higher than a national survey which found that only 3-4% of students had completely missed any instruction on climate change (Plutzer et al., 2016).

Conclusion

This study assesses the background of student and teacher K-12 climate change education. Surveys of Idaho teachers and students reveal the majority of K-12 teachers enrolled in a STEM professional development workshop believed that climate change should be covered in K-12 curriculum; however, fewer than half of these teachers covered it in the classroom themselves. Teachers who did not cover climate change most commonly reported that they did not believe it was related to the subjects they taught, followed by a lack of resources and content knowledge to teach it. Our results were similar to a national survey of K-12 educators.

Surveys of 100 level classes at Boise State University show that approximately half of incoming freshman students have received some climate change in their K-12 education. We found that students who attended high school in Idaho reported the lowest rate of climate change education out of the five western US states that we included in our analysis.

Educational standards in climate change are not consistent nationally. This gap leaves many students without understanding of the causes, consequences, and solutions to climate change. There is a crucial need to create and develop material that connects climate change to real world impacts and to equip educators with the understanding, confidence and resources to effectively implement climate education in the classroom.

CHAPTER 2: K-12 WILDFIRE EDUCATION

Introduction

An effective method of teaching anthropogenic climate change is through the local context, where students may observe climate change impacts directly (Khadka et al., 2021; Littrell et al., 2020; Monroe et al., 2017). Approaching climate change through local observable phenomena and tying local climate impacts to relevant state standards provides opportunities for teachers to incorporate climate change into their curriculum (Hestness et al., 2014). In the western United States, the lengthening fire season and the increased frequency of large and severe fires is one of the most direct effects of a warming climate. Wildfires directly impact communities and human health; the 2020 western United States wildfire season resulted in 46 deaths and cost an estimated 16.5 billion dollars (NOAA, 2021). In addition to the direct impacts of wildfires, smoke from wildfires spreads great distances and affects whole regions, posing serious health hazards to large populations (e.g. Kirk et al., 2018).

Increasing development in fire prone areas contributes to communities that are often vulnerable and ill-prepared to respond to fire related impacts (Auer, 2021; Fleeger and Becker, 2010). In 2021, the National Association of Foresters identified approximately 64,000 communities in the United States as at risk for wildfire (CAR, 2021). As our climate continues to warm, wildfire frequency and burn area will continue to increase, impacting more and more people (Brown et al., 2004; Erni et al., 2021).

Direct and indirect impacts from these fires are felt across the western United States, from catastrophic destruction of homes and communities in burned areas to the widespread impacts of smoke, which impacts health in communities nationwide (Kirk et al., 2018).

While wildfire preparedness often focuses on land management and fire mitigation practices, such as fuel reduction and structure hardening, an important component of building resilient communities includes comprehensive wildfire education (Sturtevant & Meyer, 2013). However, our research shows that wildfire education is not widely included in the K-12 school system. Wildfire education provides a valuable tool to increase environmental literacy, introduce and reinforce important scientific concepts, and connect ongoing climate change to real world impacts (Ballard & Evans, 2012). Wildfire education provides a natural opportunity to use interactive teaching and learning methods to address a real world phenomenon that directly impacts students (Ballard & Evans, 2012).

Given the multiple needs for wildfire education in the western United States, why is wildfire not part of the K-12 curriculum? Our research indicates that K-12 educators do not teach wildfire for a variety of reasons. First, teachers report a lack of content knowledge, awareness of resources, and limited time in the classroom as reasons why they do not cover wildfire education. Additionally, teachers express hesitations in teaching scientific content with which they are unfamiliar (Jarrett, 1999; Mulholland and Wallace, 2001). This is particularly true in the elementary grades, where nationally less than 5% of educators hold a STEM related degree (NSSME, 2018; Science and Engineering Indicators, 2014). This is unfortunate, because the elementary level is a pivotal point in education when student interest in science is often determined (Adams et al., 2014). In a study of K-12 educators, it was found that a positive experience in an elementary science class was the highest ranked predictor of a continued interest in science, into adulthood (Jarrett, 1999).

State and federal firefighting agencies (USDA Forest Service, Bureau of Land Management) have produced the most comprehensive wildfire curriculum, but there is still a need for educational material connecting climate change and wildfires. *We address this gap in wildfire curriculum by developing, testing, and implementing place-based wildfire modules in rural and urban fourth grade classrooms.*

Background

Wildfire and Climate in the Western United States

Since the early 1980's, wildfire regimes in the western United States have changed drastically compared to historical records (Abatzoglou & Williams, 2016; Coogan et al., 2019; Westerling et al., 2006). Fire seasons are lengthening, and larger areas are burning (Figure 10) with increasing intensity and frequency (Coogan et al., 2019). The area burned in the western United States each year is now ten times that of just a half century ago (Abatzoglou et al., 2021).

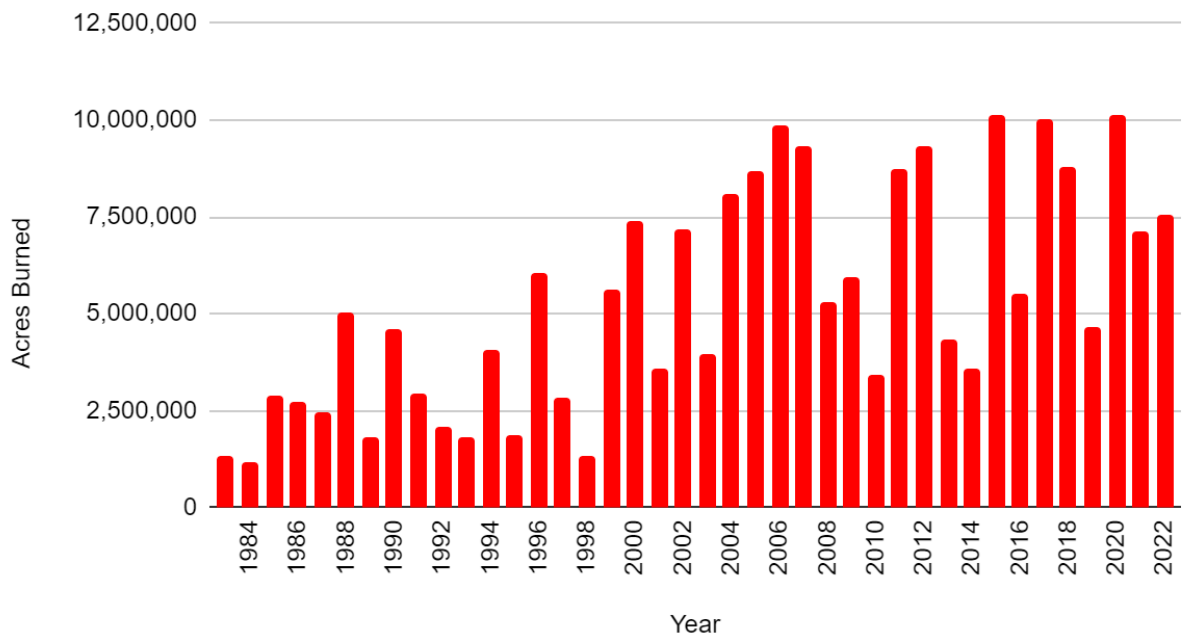

Figure 10 The total acres burned in the United States each year has increased since the early 1980's; shown here is the area burned in the United States from 1983 to 2022 (data from the National Interagency Fire Center, *Wildfire and Acres*, 2022).

Increasing temperatures and earlier snowmelt contribute to drier fuels and longer fire seasons, creating more opportunities for ignitions. High elevation forests that were once too wet to burn more than once a century are experiencing the highest rate of increase in fire activity (Sadegh et al., 2022). Warm and dry conditions in formerly wet and cold high elevation forests increases the forest area in the western USA at risk for wildfire by 11% as compared to 30 years ago (Sadegh et al., 2022).

Approximately half of the acres burned in the western United States can now be attributed to climate change (Abatzoglou & Williams, 2016) (Figure 11). Increasing vapor pressure deficit (VPD), or the difference between the amount of moisture in the air and how much moisture the air can hold when it is saturated, is the primary driver of this increase in wildfires (Fu, 2021). A 2021 study determined that approximately 90% of the current VPD trend can be attributed to anthropogenic warming (Zhuang et al., 2021).

Models predict that wildfire potential will continue to increase at an anomalous rate (Liu et al., 2013), with a shift towards temperature driven fire regimes (Pechony & Shindell, 2010).

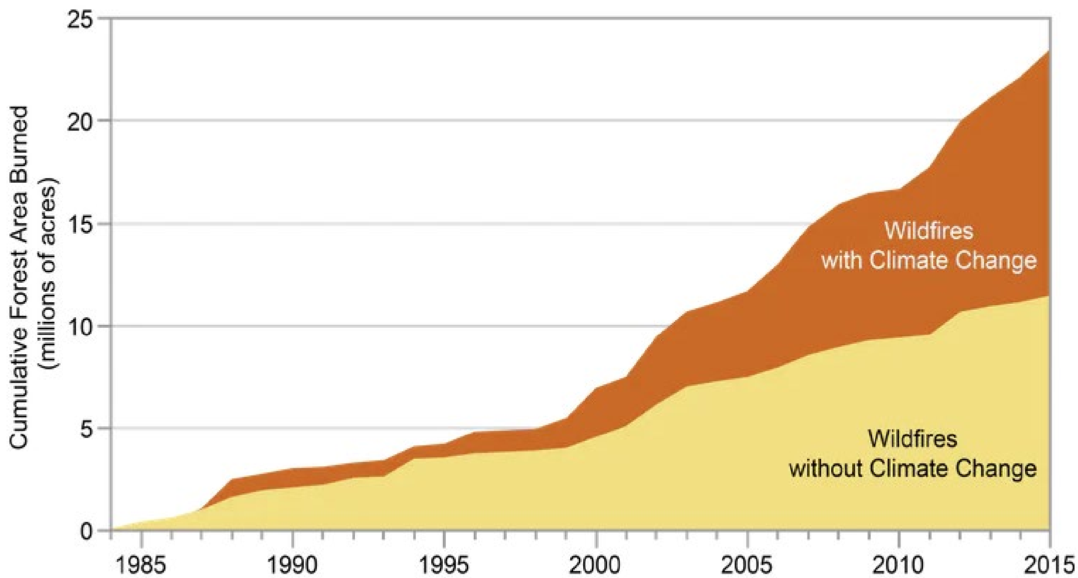

Figure 11 Climate change has roughly doubled the occurrence of wildfires in the United States since the 1980s, according to model results. From (Gonzales et al., 2018 and adapted from Abatzoglou & Williams, 2016).

A warming climate and shorter fire recurrence intervals may further alter forest ecosystems by preventing forest regeneration. Rising temperatures can stress new seedlings in post fire forests. This may prevent forest regeneration and hasten vegetation migration of non-native species (Halofsky et al., 2020), drastically changing the landscape of the western United States. Wildfire behavior is very site specific. It is impacted by variables such as the local climate, vegetation, topography, as well as current and historic land management practices (Andrews & Rothermel, 1982; Sadegh et al., 2022, USDA, 2003).

Wildfire in Idaho

In Idaho, the lengthening fire season and the increasing occurrence of larger, more severe fires is one of the greatest impacts of climate change. Idaho is one of the most wildfire prone states in the United States (USDA, 2023) (Figure 12). Communities in Idaho have a higher risk of homes being affected by wildfire than 94% of other states in the United States (USDA, 2023). Meanwhile, the most updated U.S. Census Bureau estimates rank Idaho second in the nation for population growth in 2022 (Idaho Department of Labor, 2022). Furthermore, much of the population growth occurred in rural, forested communities, which have been experiencing exponential growth since COVID-19 restructured work settings and allowed many workers to relocate and work remotely (Auer, 2021).

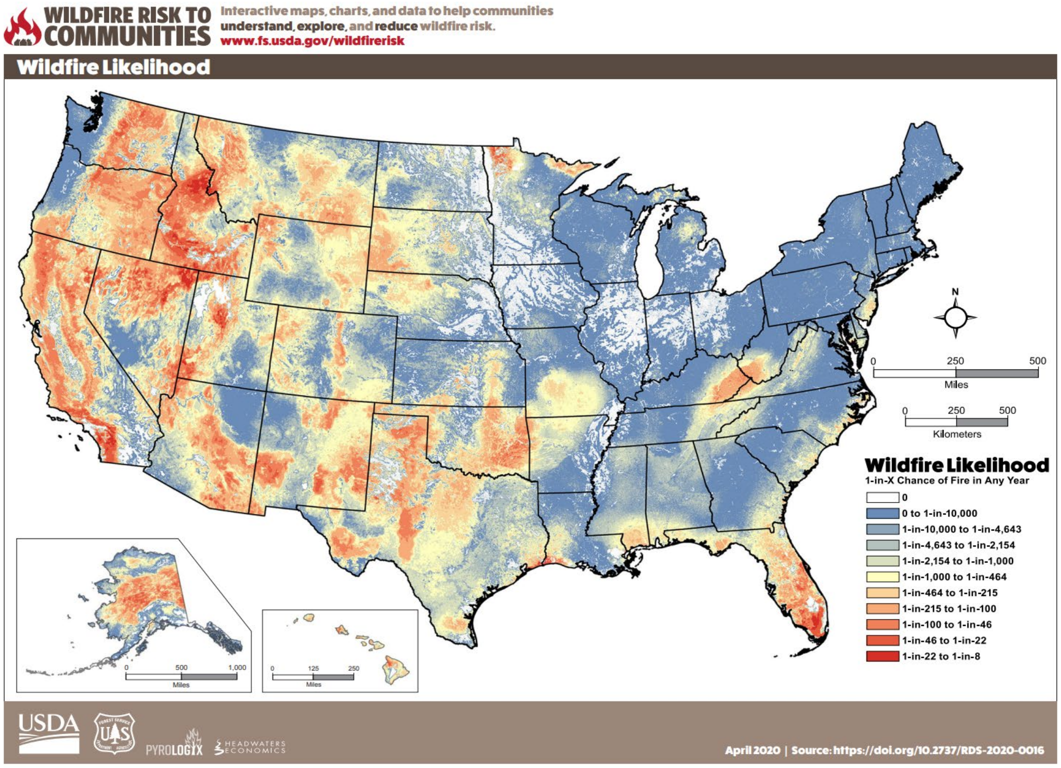

Figure 12 This map shows the much higher likelihood of wildfire in the western United States. Within the western states, Idaho's forests and rangelands have more area at the highest risk of wildfire (USDA, 2023).

<u>The Importance of Teacher Training and Workshops</u>

Teachers express hesitations in teaching content with which they are not familiar, particularly in STEM related subjects (Adams et al., 2014). When teachers lack background knowledge, it is not enough to simply connect them to the resources and lesson plans available; they need to be taught the material before they can effectively teach it themselves (Lehman, 1994). Increasing teacher literacy increases confidence to teach the material and improves teacher self-efficacy (Basista & Matthews, 2002; Bray-Clark & Bates, 2003; Jarrett, 1999; Supovitz & Turner, 2000). One method to accomplish this is through teacher training and workshops. Supovitz & Turner (2000) hypothesize that teacher professional development may be a better tool to change teaching practices and behaviors than through actions such as policies. Research has shown that there is a strong correlation between teacher professional development workshops and increased student achievement (Yoon et al., 2007). Teachers also report being most interested in professional development that focuses on learning about real world, problem-based issues (Owens et al., 2018). Successful models of teacher professional development instructs teachers in a manner that situates them as the student learner. In this way, classroom instruction is modeled to the teachers, whereby they are in the role of their students (Owens et al., 2018).

Place-Based Education

Place-based education is a pedagogical design which uses the local community and environment as starting points for teaching and learning, and provides students with a better understanding of the concepts, and their connections to the places they live (Sobel, 2004). Place-based learning allows students to connect and engage with their local community and environment to explore and solve real world problems, and implementation of place-based education often involves hands-on, inquiry led learning (Sobel, 2004). A 2018 report by The National Survey of Science and Mathematics Education shows that teachers overwhelmingly believe that science should be taught by doing, within the real-world context, and where students can see how it is connected to their lives (NSSME, 2018). Place-based pedagogy supports each of these points. Place-based teaching increases student learning achievement, and appreciation for their communities and environments (Sobel, 2004). When teachers are provided with the tools to teach with a place-based approach, they report an increase in confidence and self-efficacy in STEM teaching (Adams, 2014).

Overview of Youth Wildfire Education

K-12 wildfire education can be traced back to the advent of Smokey Bear in the 1940's (Story of Smoky, 2020). This campaign is the longest running public service advertisement campaign in the United States and focuses heavily on prevention and fire safety with the slogan, "Only you can prevent forest fires" (Story of Smokey, 2020). For decades, the dominant message and focus of wildfire education remained on fire prevention and safety. Federal and state firefighting agencies later developed more comprehensive sets of curriculum, which incorporated fire science, behavior, history, and impacts. The FireWorks Educational Program was published in 2000 by the U.S. Forest Service (FireWorks Educational Program, 2021) and is one of the most popular K-12 wildfire curricula. These lessons are tied to the NGSS standards and are categorized by elementary, middle, and high school level, and cover various regions and ecosystems. While this curriculum provides excellent resources about many aspects of fire science, the lessons do not include a robust discussion of how climate change is impacting wildfire. There are a couple of small connections made in the middle school and high school curriculum; however, connections between wildfire and climate change are absent from the elementary curriculum.

Research on youth wildfire education, in or outside of a school setting, is limited (Ballard et al., 2012). Shortly after the FireWorks Educational Program was launched, a study was conducted to measure the effectiveness of the curriculum (Thomas et al., 2000). An evaluation of 7th grade students in Montana showed that the FireWorks program increased student understanding of wildfire behavior and ecology (Thomas et al., 2000). Additionally, students perceived themselves as being more attentive and interested in the material, their classroom as a more positive environment, and their teachers as more invested and fostering of creative thinking than students who did not receive the instruction (Thomas et al., 2000). Since this study, the FireWorks curriculum has grown considerably, as new material continues to be developed and added to the collection.

A series of publications through the USDA Forest Service recognizes the importance of youth wildfire education programs to create better prepared communities and have written reports on several case studies (Ballard & Evans, 2012; Jakes, 2012; Sturtevant & Meyer, 2013) The series is titled *Youth Working With Communities to Adapt to Wildfire.* One of the reports in this series examines the 'Fire Up' program, which is a three week summer program sponsored by the Bureau of Land Management and hosted by local specialists, as well as retired and current teachers in Boise, Idaho (Sturtevant & Meyer, 2013). The program is for high school students and allows them to gain college credit, community service, and job skills related to fire management (Sturtevant & Meyer, 2013). This field based program was started in 2004, and allows students to assess wildfire risks in the wildland urban interface (WUI) and discuss those assessments with homeowners who could be impacted by wildfire, leading to better informed communities (Sturtevant & Meyer, 2013).

Another paper in the series examines the results of a 6th grade module, consisting of five one-hour lessons. The module is focused on fire science, behavior, mitigation, and safety (Ballard & Evans, 2012). This program is carried out in public schools in Paradise

Ridge, California, where numerous wildfires, in recent years, have impacted the community (Ballard & Evans, 2012). This program includes a homework assignment for each lesson that transfers information to the students' guardians. The goal of this program is to create better informed and prepared communities by reaching people through their children. By the end of this program, students create a family disaster plan with their guardians, and assess the defensible space around their home. This study increased student understanding, literacy, and ability to use correct terminology when discussing wildfire (Ballard & Evans, 2012). Follow-up surveys with the student's guardians showed that approximately one third of the guardians interactively participated with the students' take-home work (Ballard & Evans, 2012).

A third study in this series focused on a Firewise (proactive steps taken to reduce wildfire risk) program developed for Minnesota middle school students (Jakes, 2012). The program was originally designed as a 21 lesson unit, however, teachers preferred a shorter unit, so it was reduced to five lessons (Jakes, 2021). The lessons were often taught in the classroom by a coordinator. This approach removed the demand on teachers to become familiar with the material. Teachers who participated in the study credited the success of the program to the coordinator (Jakes, 2012). The coordinator also provided teacher training and workshops to better prepare teachers to teach the curriculum on their own (Jakes, 2012).

These studies demonstrate the importance of youth wildfire education, the positive downstream effect on the communities, and provide models for successful implementation.

The Boise School District, located in Boise, Idaho, has a 10 lesson 4th grade integrated fire unit embedded in its science curriculum. The unit was developed by Boise School District faculty member, Christopher Taylor, to provide a comprehensive understanding of wildfire behavior, history, as well as the positive and negative impacts of wildfires on ecosystems. The unit was developed in 2016 and is taught to all 4th graders in the Boise School District. The unit has had some minor revisions since its launch in 2016 based on suggestions and feedback from teachers, though it has not been formally tested.

To better assess the gap in wildfire education, we survey university students to find out what wildfire education they received at the K-12 level.

To address the gap in wildfire education, we develop a four lesson wildfire unit to increase wildfire, and climate literacy in both students and educators and to provide educators with a curriculum to continue to implement within their classroom.

Methods

Survey of Boise State University Students: Background K-12 Wildfire Education

We surveyed Boise State University 100 level climate change courses in 2021 and 2022 to assess the students' backgrounds in K-12 wildfire education. The survey was conducted in a 100 level, semester long climate change course, which is primarily composed of incoming freshman students, and is offered every fall. Two cohorts were surveyed; one in the fall of 2021, and one in the fall of 2022. Both classes had approximately 100 students. Two hundred four students were provided the survey. Out of this sample, 201 students answered at least one question on the survey.

Students were required to complete the survey for class points. The survey contained numerous questions pertaining to the student's educational backgrounds, interests, class schedules, and perceptions of climate change. For this analysis we looked at only the following questions:

1) In what state did you attend high school?

2) In your K-12 education did you ever receive wildfire education? (Wildfire education refers to uncontrolled fire spread through vegetation and while it may burn residential structures, it is different from education on home fire safety, such as how to prevent grease fires from starting on your stove.)

3) Outside of your K-12 education, did you ever receive wildfire education, as previously defined, in an environment such as a camp, club, community program, etc.

4) If you answered yes to the previous questions, please describe the length of the educational unit (e.g. 1 day, 2 weeks, semester class, etc.) and the scope of what was covered (e.g. how to recreate in wildlands safely, fire ecology, fire history, how to create a Firewise area around the exterior of your home, etc.)

Selected response options to questions 1 and 2 included "Yes", "No", and "Maybe". Question 4 was an open ended short answer response.

Short answer responses to question 4 were combined for the two years and analyzed for common themes. Analysis of common themes was performed by reading through each response. These common themes were used to categorize and code the responses. Common themes were identified in regards to the length, scope and the setting of the wildfire education. After the common themes were identified, the responses were read through again and assigned to the appropriate categories. The responses were coded and analyzed for three different educational lengths; 1) one day, 2) two days to one week, and 3) greater than one week. The scope of the content was categorized and coded as 1) safety and prevention (example: "How to prevent wildfires"), and 2) science (example: "Causes and impacts of forest fires, as well as what species may benefit from wildfires"). Educational settings for the wildfire education were coded and analyzed for six categories, which included; 1) camp, 2) class, 3) family, 4) place of relevance, 5) Scouts, and 6) work. The categories were assigned based on the specific terms that students used in their responses. While the types of camps may have varied from an overnight summer camp in the mountains, to a community day camp, if students used the term *camp*, it was categorized as such. Likewise, if students used the terms *class*, *Scouts*, or *work*, in their response, it was categorized to those codes. Responses stating that wildfire education was obtained through a family member were categorized as *family*. An example of *family* is, "My grandpa owns a water truck and gets sent out to fires all over during the summer, so he has taught me a little bit about it". *Place of relevance* is a category that was identified based on responses citing wildfire education that was obtained due to visiting or living in a location that had been recently impacted by fire, or was a high wildfire risk. An example of this response is, "Growing up and living in Colorado we were always taught preventative measures for wildfires. We learned about how droughts and warming of the atmosphere, there would be a possibility of more fires. After this past year with the Marshall fire that happened close to my town, I think I was heightened to learn more about wildfires, and learning about climate change would be interesting to the learn the ties to fire. I was never taught anything about it in schools." Not all of the responses could be categorized into one of these. Some responses were categorized into more than one category.

Intervention: 4th Grade Wildfire Unit

We sought to increase climate change and wildfire literacy in K-12 students and teachers by addressing gaps in K-12 wildfire and climate change education through our study design. We designed a four lesson wildfire unit that provides the basics of fire science and connects the changing fire regimes in the western United States to climate change. We taught these lessons to students and teachers in elementary schools located in southwest Idaho. Pre and post lesson assessments were used to measure students' content knowledge. Pre and post unit surveys were used to measure teachers' perceived content knowledge, confidence, and willingness to teach about wildfire. We hypothesized that students would show improved content knowledge after each lesson by testing higher on post lesson assessments. We hypothesized that teachers would report an increase in perceived content knowledge, confidence and willingness to teach wildfire after observing the lessons. We further hypothesized that students who resided in high wildfire risk areas would demonstrate greater wildfire knowledge in their pre assessment scores.

4th Grade Wildfire Unit Study Design

Five individual 4th grade classrooms were selected to participate in this study. The classroom instruction portion of this study was carried out from the fall of 2021 through the spring of 2022. The five classes were part of five different schools located throughout southwest Idaho and represent various demographics, including urban, rural agricultural, and rural forested. The five teachers were contacted by the researchers via email and invited to participate in this study. One of the classroom teachers was previously known to the researchers. Another classroom teacher was recommended to the researchers by a school district employee. The other three teachers were contacted by emails found on school staff websites and invited to participate in the study. The four lessons were taught by the researchers, at the convenience of the teachers' schedule. In some schools, these were taught on consecutive days, and others would take place once or twice a week. The teachers were present for the lessons, and often assisted with passing out papers, and guiding groups to complete their work, however, the researchers taught the wildfire unit.

Additionally, several of the wildfire unit's lessons were taught to educators at teacher training workshops during the summers of 2021 and 2022. These were offered for professional development credits. The teachers that signed up for these workshops were all K-12 teachers from Idaho, however not all of them were actively teaching at the time.

Pre and post lesson assessments were completed by the students to measure the effectiveness of the lessons. Immediately before each lesson, the pre-assessment was completed by the students and then collected. At the end of each lesson, this same assessment was completed again by each student. The assessments focus on the curricular aims of each lesson and range from four to six questions. They contain both short answer and selected response questions. The pre and post assessments for each student were then paired, and coded. Binary responses were coded 0 for incorrect responses and 1 for correct responses. Questions with multiple responses received one point for each correct response. Each of the lessons had accompanying worksheets. Students kept these worksheets at the end of the lessons. The only material that we collected back were the pre and the post assessments.

<u>Lesson Assessment Analysis</u>

The wildfire unit's pre and post lesson assessments were analyzed by individual questions for each school, by average normalized gain for school demographic categories of urban vs. rural, and by the total aggregated data of the paired pre and post assessment results for each individual student, for each lesson assessment.

School assessment data are graphed by the percentage of correct responses of all the gathered assessments for each individual school, by question. The percent correct was calculated for each question by totaling the number of points possible for each question, given the number of assessments being analyzed, and dividing that by the number of points accumulated for those assessments. (Example- School 1, Pre-assessment 1: Question 1 had one correct response, for a total of 1 point. Twenty assessments were analyzed so the total possible points for the class were 20. Two students answered question 1 correctly in the pre-assessment, so the correct response was 10%).

Each lesson's aggregated results were analyzed using IBM SPSS software's paired T-test to compare the pre and post total score of each student's assessment. (Example- Assessment 1 had a total possible score of eight. Student 1A scored zero on the pre-assessment and six on the post-assessment. Student 1A's paired scores for assessment 1 are zero and six. The paired score is analyzed for each individual student for all of the Lesson 1's assessments). This yielded a p value for each lesson's assessment. p values of less than 0.05 were considered statistically significant for this study. The exact p values are reported, except for when the p value is less than 0.001, in which case it is simply reported as p<0.001. Statistical analysis for t and df are included as t(df) = t-value. The standardized effect size is reported by the Cohen's d value. A value of 0.2 is considered a small effect size, a value of 0.5 is considered a medium effect size, and a value of 0.8 is considered a large effect size.

Results were also analyzed by school demographic categories of urban and rural. Schools 1 and 4 were categorized as urban. Schools 2, 3 and 5 were categorized as rural. All three of the schools that were categorized as rural reside within areas described as Wildland Urban Interface (WUI). Two of the rural schools are located in dense conifer forests, and the third is located in a rural agricultural area, adjacent to rangelands. The results by school demographic are analyzed by the average normalized gains between the pre and post assessment scores.

Internal Review Board (IRB# 001-SB21-102) approval of this study required an informed consent form signed by each student's guardian as well as an assent form signed by each student. All of the students who were present in the classrooms participated in the lessons and completed the pre and post assessments, however, only the assessments completed by students who had submitted both a signed informed consent and assent form were processed for this analysis. Some of the schools that participated in this study did not return enough of these required forms to yield adequate sample sizes for further analysis of individual school results (Example: Three students, out of a class of 21 students, returned the required IRB forms and completed both the pre and post assessments. School data in this case would not be graphed or analyzed by school). These three student assessments were, however, added to the scores for analysis of school demographics (rural vs. urban), as well as the total pool of paired assessments for final statistical analysis of each lesson’s aggregated assessment results (Lesson 1 total aggregated assessments).

Teacher Sample and Surveys

We sought to measure teachers' perceived content knowledge of wildfire, as well as their confidence and willingness to teach wildfire before and after observing these lessons being taught. To do this, we had teachers complete a short online survey before and after completion of the wildfire unit instruction. The teacher survey population was composed of the five 4th grade educators who observed the in-class lesson demonstrations, as well as five professional development workshop participants. The workshop participants consisted of educators who were taking the workshop for professional development credit. Many of the participants were active K-12 teachers, however some were not currently teaching. The grade levels and subjects taught by these educators varied. Two workshops were offered (summer of 2021, and summer of 2022). The 2021 workshop was instructed in collaboration with two other climate and environmental educational organizations, and the focus was not entirely on wildfire education. Three of the activities from the wildfire unit were covered in this workshop. The 2022 workshop focused entirely on the curriculum instruction of the wildfire unit.

Participant registration for both workshops was low, despite advertising, and offering a full tuition reimbursement to the workshop participants in 2022. This resulted in minimal total teacher survey data (n=10). Additionally, not all of the teacher survey respondents took the post-lesson survey. Ten educators completed the pre-instruction survey. Seven of these educators also completed the post-instruction survey.

The seven question survey contained yes/no, seven point Likert scale, and open ended questions. The purpose of this survey was to measure the teachers’ perceived content knowledge of wildfire, confidence to teach and communicate about wildfire, ability to answer student questions about wildfire, knowledge of where to acquire materials to teach wildfire, previous experience in teaching wildfire, and what hesitations would prevent them from teaching about wildfire.

Survey participants responded to five questions on a 7-point Likert scale, with 1 corresponding to “very poor” and 7 corresponding to “excellent”.

The survey also offered a short-answer response to the question, “What hesitations, barriers, logistics, or other reasons might prevent you from teaching about wildfire in your class?” on both the pre and post-instruction survey. The post-instruction survey asked if the educators planned to use any of the lessons that had been taught and if so, which ones. These short answer responses were reviewed for themes in the educator’s perspectives towards teaching wildfire curriculum on their own.

The same survey was provided to the teachers upon completion of the classroom instruction with an added question about if they would use any of the material from the wildfire unit. Due to the small sample and low response rate, a paired t-test was not performed on this data. Instead, the average self-reported rating for each question was analyzed.

4th Grade School Demographics

The five schools selected to participate in this study are all public schools and are located in southwest Idaho. The school environments were categorized as urban or rural, with the rural schools residing in areas described as WUI. Title 1 funding is also reported for each school (Table 2). Race and ethnicity data was acquired from the United States Department of Education website (National Center for Education Statistics, n.d.).

Table 2 Demographic information and setting of schools that participated in the wildfire education study.

School	Environment	Title 1 Funding	Average Assessments Collected for each lesson with IRB approval	Race/Ethnicity
School 1	Urban	No	18.5	White- 91.8% Hispanic- 3.3% Other- 4.9%
School 2	Rural-Agricultural (WUI)	Yes	2.75	White- 58.8% Hispanic- 40.2% Other- 1%
School 3	Rural- Forested (WUI)	Yes	2.5	White- 89.5% Hispanic- 7.6% Other- 2.9%
School 4	Urban	No	7.5	White- 85.1% Hispanic- 6.6% Other- 8.3%
School 5	Rural- Forested (WUI)	Yes	16.5	White- 92% Hispanic- 4.9% Other- 3.1%

4th Grade Wildfire Unit Lessons

Four one-hour lessons were selected to create the wildfire unit that was tested in this study. The lessons address fire history, fire behavior, the impact of climate change on wildfire regimes, post fire debris flows, and post fire revegetation. All four of the lessons are tied to the local context of Idaho and integrate place-based knowledge and ecosystems familiar to local students. Additionally, we include standards and curricular aims that are covered in 4th grade in the state of Idaho. The learning outcomes and standards are stated on each lessons lesson plan (Appendix). Lessons 1 and 2 are part of the Boise School District 4th grade Integrated Fire Unit. Lesson 3 is a newly developed lesson that was created to address the lack of curriculum relating climate change to our changing fire regimes. Lesson 4 is an adaptation of the FireWorks Educational Program's Northern Rocky Mountain and Cascades Curriculum, M10: Fire, Soil, and Water Interactions lesson, which was redesigned to integrate a local wildfire and made appropriate for the 4th grade level. The four lessons were selected to provide students with a basic understanding of fire science and impacts. The lessons scaffold off of one another, with lessons 1 and 2 providing the foundation for students to grasp the impacts of climate change on wildfires that is covered in lesson 3. Lesson 4 addresses the impacts of the post fire period. Lesson assessments were designed to measure the effectiveness of each lesson's ability to increase understanding of the learning outcomes (Table 3).

Table 3 The learning outcomes for each Lesson and what assessment questions target that outcome.

Lesson	Learning Outcome	Assessment Question Tied to Learning Outcome
1	Can name and recognize the three variables of the fire triangle	3, 4
1	Can recall where the 1910 Big Burn occurred and state three weather factors that contributed to it	1, 2
2	Can predict how fire behavior is affected by topography, fuel density, and fuel moisture	1, 2, 3, 5
2	Can name multiple ways to make a home Firewise	4
3	Can list two variables that contribute to high fire danger (fire weather)	2
3	Analyze, interpret, and recall graphed data	1,4,5
3	Define what climate is and recognize how it has changed	3,4,5
4	Recognize the processes leading to post fire erosion	1, 2, 4, 5
4	Can describe a debris flow	6
4	Can identify top priorities in an emergency response strategy plan	3

Lesson 1 covers the fire triangle and the Big Burn of 1910 (See Appendix). This lesson uses materials from the Boise School District 4th grade Integrated Fire Unit. We chose two concepts from two different lessons of the Boise School Districts 4th Grade Integrated Fire Unit to combine into one lesson. Lesson 1 begins with an introduction of the fire triangle, the three necessary components of fire, through a visual demonstration and slide show. Students are then instructed to create their own paper fire triangle. This lesson includes a short video about the 1910 Big Burn, an important event in Idaho history, and one of several large fires in the early 20th century that shaped firefighting and forest management practices throughout the western United States for the remainder of the century (The 1910 Fires, n.d.). We chose to integrate the history of the 1910 Big Burn fire because of its connection to Idaho History. Idaho History is a state standard in the 4th grade, and this connection allows this lesson to be taught in a class other than science.

A worksheet accompanies the video and is completed as a group. The important takeaways of this lesson are that combustion requires heat, oxygen and fuel. These variables relate to the weather variables, as the 1910 fires were fueled by drought, lightning and high winds.

Assessment 1 (See Appendix) was developed to assess the learned content of Lesson 1. Assessment 1 consists of 4 questions. Question 1 is a selected response question. Questions 2 and 3 are short-answer, fill in the blank responses, which each requiring three answers. Question 4 is a single fill in the blank response. Question 1 requires students to select what state the 1910 Big Burn occurred in. Question 2 asks students to list three natural variables that contributed to the spread of the 1910 fires. Question 3 requires students to list the three components of the fire triangle. Question 4 requires students to identify one variable in the fire triangle from a photo.

Lesson 2 uses material from the Boise School District 4th grade Integrated Fire Unit and covers the effects of fuel density, fuel moisture, and topography on fire behavior (See Appendix). This lesson uses two different forest types found throughout Idaho, the ponderosa pine, and lodgepole pine, to explore how variations in tree density and forest ecology in these forest types affect fire behavior. This lesson begins with students making observations about photos of ponderosa forests and lodgepole pine forests, on fire and post fire. Ponderosa forests dominate the lower elevation mountains that experience less precipitation. Lodgepole pine forests are common throughout the higher alpine mountains of Idaho which experience greater winter snow precipitation. These are forest types that are familiar to students from Idaho. Students observe the densely situated lodgepole pine forests which usually experience stand replacing fires. Tree adaptations are also covered in discussion, such as ponderosa pine's thick bark and tendency to have more space between trees, and the serotinous cones (cones which open during high temperatures in forest fires) of the lodgepole pine.

Students work in small groups of three to five to develop and test hypotheses regarding the effects of fuel density and topography on a fire's ability to spread. These are then tested in hands-on experiments called matchstick forests. Matchstick Forest is a popular activity in wildfire education. Material to support this lesson can also be found in the USDA FireWorks Educational Program (FireWorks Educational Program, 2021). We used the activity supporting worksheets from the Boise School Districts 4th grade Integrated Fire Unit. Groups are supplied with a situation card, a peg board, and a box of matches. The situation card provides instructions for how to set up the peg board and the orientation of ignitions. Some peg boards have holes closer together and others further apart. The boards with holes closer together represent the lodgepole pine forests, and the boards with holes spaced further apart represent the Ponderosa pine forests. Students record their pegboard set up on the supplied worksheet and hypothesize how these will burn based on variables of fuel density and topography. Each group ignites their board, one at a time, so that everyone in the class may observe. The time that it takes for the matches to finish burning, and the number of remaining matches are then recorded on the student's worksheets. Students discuss how their experiment differed from their hypotheses. The general trends that were observed are also discussed.

Following this activity, students observe the effects of fuel moisture on a fire's ability to spread through a visual demonstration. Two different fuel types are burned in pie tins to demonstrate how fuels with low and high fuel moisture burn differently. The high moisture fuel types varied throughout this study, with whatever was readily available at the time. The low fuel moisture example used throughout this study was dry cheatgrass. This demonstration allowed us to introduce the impacts of invasive species on wildfires, as cheatgrass is an invasive species that has transformed the fire regimes of rangelands in the western United States (Bradley et al., 2018).

Important takeaways of this lesson are 1) fuels with low fuel moisture burn more easily, 2) fire spreads more easily when fuels are more densely arranged, 3) fine fuels ignite more easily but burn for shorter lengths of time, and 4) fire spreads more quickly uphill. Another important takeaway from this lesson is the effect of wind on fire behavior. This variable cannot be controlled in this experiment, but it is often observed when conducting these experiments outdoors in various weather conditions.

Assessment 2 (See Appendix) was developed to assess the learned content of Lesson 2. Assessment 2 consists of five selected response questions, with multiple correct responses to question 4. Question 1 asks students to select which type of forest has trees more spaced apart, question 2 asks students if fires spread more easily uphill or downhill, question 3 asks students to select if fuels burn more easily if they have high or low fuel moisture, and question 4 asks students to select correct steps to make a Firewise perimeter around a home. In question 5, students are shown two photographs of forests. They select the photograph that they predict fire would spread more easily throughout.

Lesson 3 covers fire weather and climate (See Appendix). We developed this lesson to connect changing fire regimes with climate change. This lesson builds upon the weather variables discussed in previous lessons and introduces new variables, including: temperature, wind, precipitation, fuel moisture, and humidity. These variables are discussed to provide a better understanding of fire weather. Students follow along to a slideshow presentation and match vocabulary terms to their correct definitions on their worksheets. Students are then shown an image of a local snow telemetry (SNOTEL) site and are informed of the weather data that is collected there. Students analyze and interpret 37 years of weather data from the SNOTEL site to determine that the climate has changed during this period of time, trending towards lower SWE (Snow Water Equivalent) in the snowpack, and an increase in summer temperatures. Connections are made to how these variables affect fuels and the coinciding increase in wildfire acres burned during this same period of time. This lesson includes a short video on fire weather forecasting, and includes a video worksheet, which is completed as a group. The lesson concludes with a role playing game, in which students act as land managers to analyze a combination of weather variables in a daily weather report to determine the fire danger that day. Students work in small groups and are provided a Fire Danger Today spinner board. Weather conditions are shown on a slideshow and read aloud. Each group decides what level of fire danger their board should be set to and then each group shares their reasoning for their decision with the rest of the class.

An important takeaway of this lesson is that warming temperatures and less precipitation lead to longer fire seasons, and more opportunity for ignitions. These trends are observed from local data over the past 37 years to show a change in the local climate.

Assessment 3 (See Appendix) was developed to assess the learned content of lesson 3. Assessment 3 consists of five questions. Questions 1, 4, and 5 are selected responses that require students to recall the trend of graphed data that was observed and discussed during the lesson. Question 2 is a short answer, requiring two responses, listing variables that contribute to fire weather. Question 3 is a selected response, defining climate.

Lesson 4 explores post fire erosion and managed revegetation (See Appendix). We use some materials from the FireWorks Educational Programs Northern Rocky Mountain and Cascades Curriculum, (Lesson M10: Fire, Soil, and Water Interactions), to introduce the concept of soil burn severity. We added additional content to connect this to a local fire. Students learn about post fire erosion through an accompanying slide show and the observation of a soil and water demonstration. Two soda bottles that have been cut in half are used for this experiment. One bottle contains loose soil, and the other contains growing grass, intact O horizon and soil. These bottles are situated at an incline with a catchment container placed at the mouth of the bottles at the bottom of the slope.

Water is poured over each of these, one at a time, and students observe the amount of time it takes for the water to drain, as well as the amount of sediment that is displaced to each of the catchments. Students observe that when the water is poured over the bottle containing grass, it takes longer for the water to finish draining, and there is considerably less sediment lost. A short USGS video showing a debris flow from start to finish is included in this lesson.

The lesson concludes with two short videos produced by the Idaho Rangeland Resources Commission. These videos discuss the period following the Pony and Elk Complex Fires that occurred in the Danskin Mountains of southwest Idaho in 2013. The Pony and Elk Complex Fire videos discuss post fire debris flows, managed revegetation, and how post fire erosion impacts the ecosystems, recreation and communities. Remediation efforts included various planting and reseeding methods. Students follow the video with a note catcher worksheet, and then share answers at the end of the videos.

An important takeaway from this lesson is that post fire debris flows are a dangerous, natural hazard posed by fires, and that ecosystems and habitats regenerate over time. Idaho state standards include erosion and its effects on a landscape in 4th grade earth science, which allows another opportunity to include this lesson. This lesson may also be used as a stand-alone lesson.

Assessment 4 (See Appendix) was developed to assess the learned content of Lesson 4. Assessment 4 consists of six questions. Questions 1 through 5 are selected responses, and question 6 is a fill in the blank response. Question 1 asks students to select the conditions that would most likely contribute to high soil burn severity. Question 2 is a selected response question relating the loss of vegetation to flooding and erosion.

Question 3 is a selected response question about the top priority in an emergency response strategy plan. Question 4 requires students to select one of two images that would experience a higher soil burn severity if they were to burn. Question 5 asks students to select one of two options to make the statement correct, regarding soil's ability to absorb precipitation with or without vegetation. Question 6 is a fill in the blank response describing a debris flow with the correct response “debris flow”.

Limitations of This Study

We ask freshman students to recall the wildfire education that they received at the K-12 level. It is unlikely that students recall every lesson that they received throughout their K-12 experience, so the results of this study may underestimate the prevalence of wildfire education. The teacher sample for this study is small (n=10); a greater sample size would increase the confidence in the results. The lesson effectiveness is measured using pre and post lesson assessments. The design and wording of these assessments impacts their ability to accurately reflect student learning and comprehension.

Results

Boise State University Students Background in Wildfire Education

We surveyed two 100 level climate change courses at Boise State University about student’s background with wildfire education. The combined two years of data had 201 student responses to at least one question in the survey. The locations that these students reported attending high school (Table 4) was used to create maps (Figure 13, Figure 14) showing the percentage of students from each state who reported receiving wildfire education in their K-12 education, or in a setting outside of a school. We only show the percentage of students who responded “yes” to our survey questions. Several "maybe" responses were re-categorized to "yes", if they included a short answer that described some type of education.

Table 4 The total student responses for 2021 & 2022 by the state that the student reported attending high school in.

State	California	Idaho	Nevada	Oregon	Washington	Other
Number of Responses	58	83	11	5	27	17

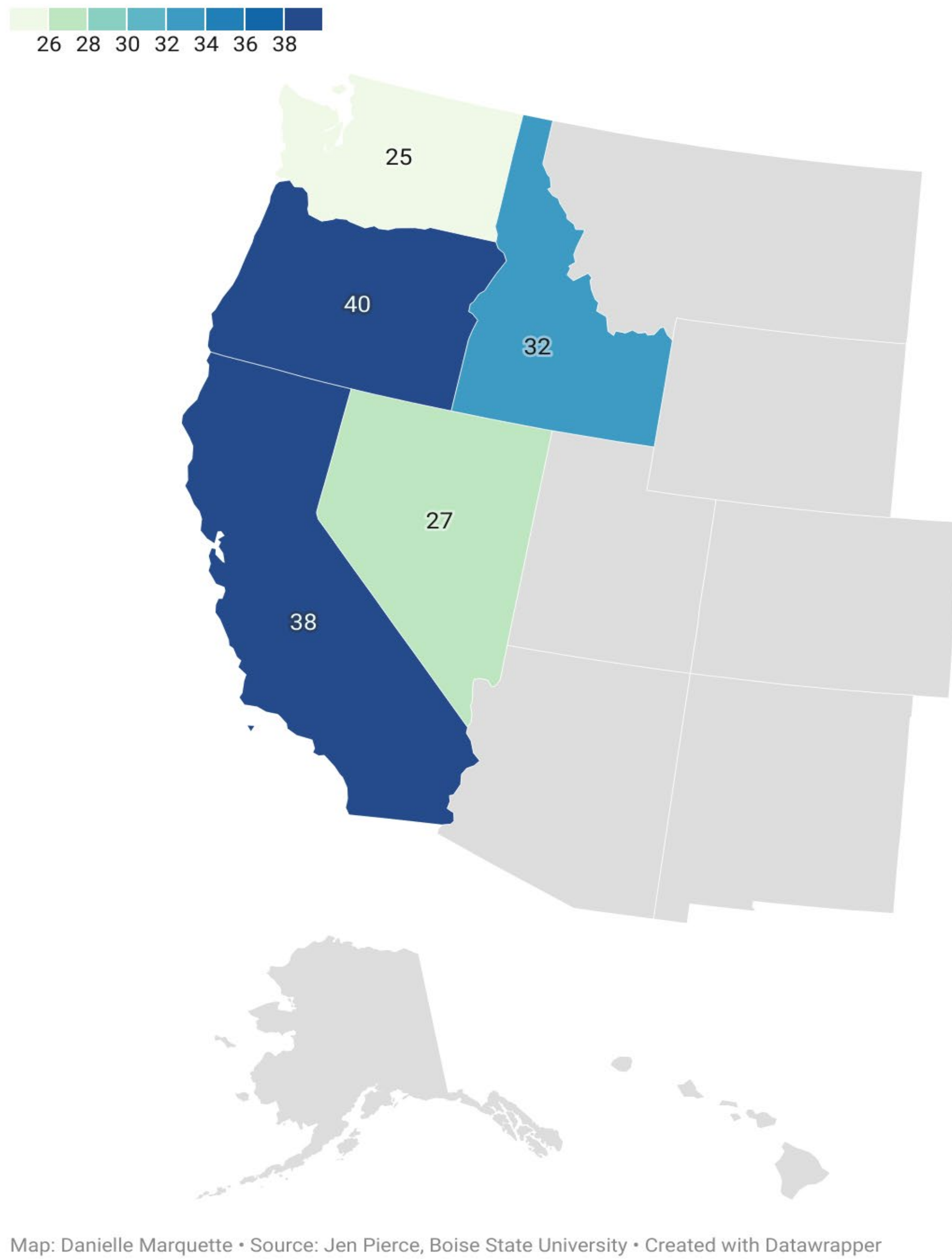

Figure 13 About a third of Boise State University students reported receiving at least some wildfire education at the K-12 level. Map showing the percentage of students from each state who reported covering at least one wildfire lesson in their K-12 education. n= 201

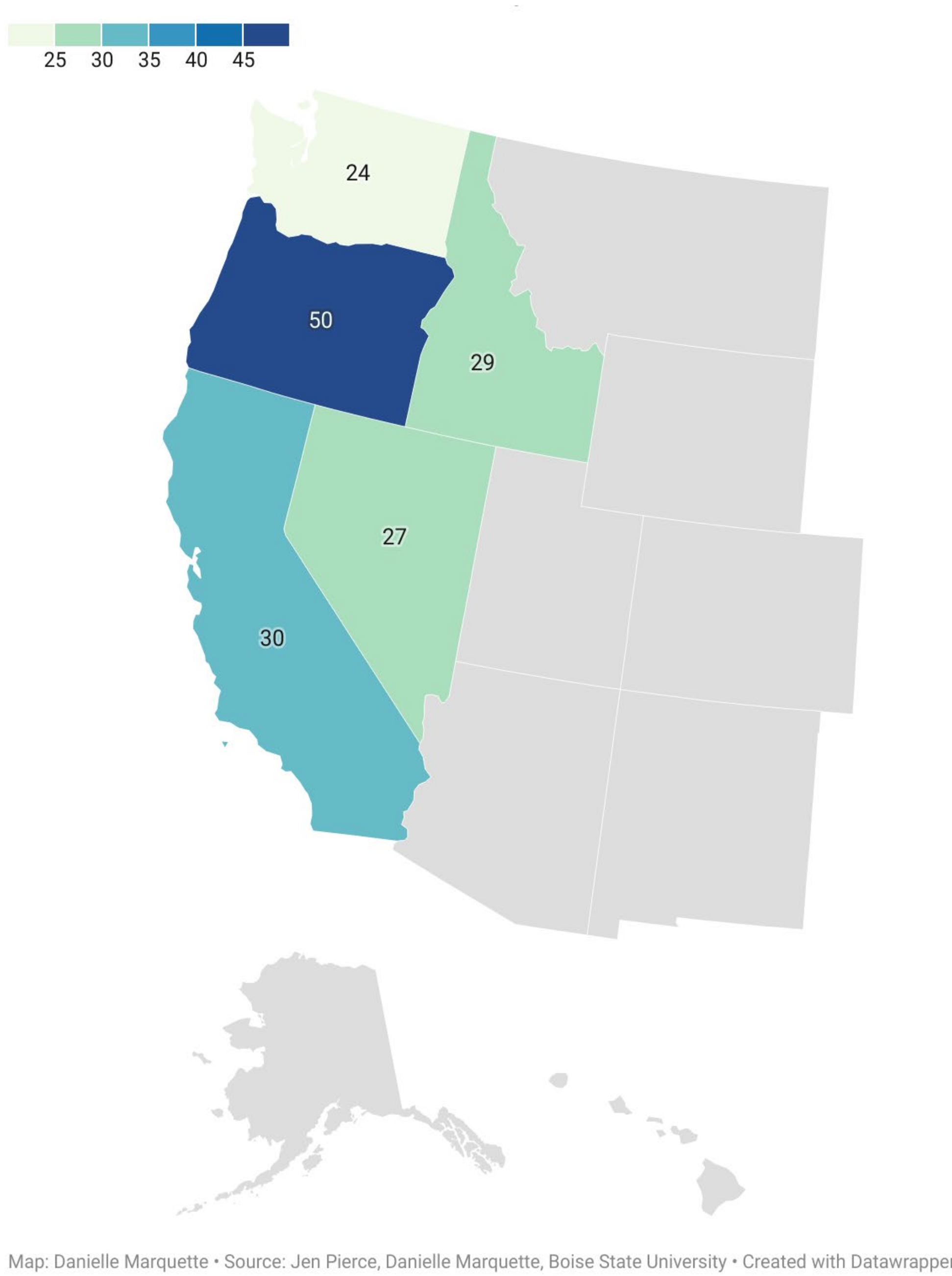

Figure 14 About a third of Boise State University students reported receiving at least some wildfire education at the K-12 level. Map showing the percentage of students from each state who reported receiving at least one wildfire lesson outside of a K-12 class, in a setting such as Scouts, a camp, or community event. n= 201

Responses to the open-ended question yielded common themes that were similar for both groups of students. We combined and analyzed the two years of responses in regards to the length, setting, and scope of the wildfire education. While we did not specifically ask about the educational setting in the question, more students identified the setting that the wildfire education had occurred than the scope of what was covered in the content. We identified *place of relevance* as a common theme in responses for setting. Numerous students reported gaining some wildfire knowledge due to visiting or living in a high wildfire risk area, or place that had recently experienced a wildfire. These responses were categorized as *place of relevance*. Of the 201 students surveyed in 2021 and 2022, 63 students provided a short answer response to question 4 describing the length and scope of the wildfire education that they had received. Not all of these responses were thorough enough to fit into one of the categories, and some fit into multiple categories (Table 5).

Table 5 Boise State University student responses to a short answer survey question regarding the length, setting, and scope of wildfire education received at the K-12 level. Sixty-three of the 201 students provided short answer responses.

Time spent on wildfire	**≤ 1 Day**	**2 Days-1 Week**	**≥ Week**	**Scope of curriculum**	**Safety & Prevention**	**Science of Wildfire**
Number of Student Responses	18	21	10	Number of Student Responses	20	6
Setting	**Classroom**	**Camp**	**Place of Relevance**	**Scouts**	**Family Member**	**Work**
Number of Student Responses	20	9	7	7	4	2

Several student responses stated that a positive experience with wildfire education had a lasting impact on them. Examples of some of these responses are: “At my 5th grade science camp I was taught about wildfires and still remember it to this day.” Another student responded, “I took a yearlong Environmental Science class my junior year of high school that covered all about climate change, wildfires, and the environment. The teacher was very well educated in the topic and used outside materials like textbooks, books, TED Talks and movies to help us understand more what was going on in the world and how humans were negatively affecting the environment. This class actually started my interest in Environmental Science and wildlife conservation. I am pretty lucky to have been exposed to this educational opportunity at the high school level.”

4th Grade Wildfire Unit Analysis

Each lesson’s assessments were analyzed for average scores in the pre and the post- assessments. These scores were then normalized (Table 6).

Table 6 The four lessons, the topic of each lesson, the pre assessment score for the total number of assessments collected, the post assessment score for the total number of assessments collected, the total number of assessments collected, and the normalized gain between those the pre and post assessment.

Lesson	Topic	Total Average Pre Assessment	Total Average Post Assessment	Number of Paired Assessments Collected	Normalized Gain
Lesson 1	Fire Triangle & The Big Burn of 1910	33%	73%	49	0.60
Lesson 2	Matchstick Forest and Campfire Fuels	56%	69%	48	0.30
Lesson 3	Fire Weather and Climate	57%	64%	46	0.16
Lesson 4	Post Fire Erosion and Revegetation	40%	63%	48	0.38

Table 7 Analysis of lessons 1 through 4 for the aggregated assessments.

Lesson	Pre-Assessment		Post-Assessment		*t*(n-1)	*p*	Cohen's *d*
	M	SD	M	SD			
Lesson 1 (n=44)	2.73	2.46	6.48	1.69	-9.574	<0.001	-1.443
Lesson 2 (n=48)	4.08	1.33	4.83	1.40	-4.060	<0.001	-0.586
Lesson 3 (n=44)	3.45	1.72	4.05	1.26	-1.945	0.058	-0.293
Lesson 4 (n=44)	2.43	0.98	3.96	1.28	-1.945	<0.001	-1.160

Lesson 1 Assessment Analysis- Fire Triangle & The Big Burn

Schools 1 (Figure 15) and 5 (Figure 17) showed substantial improvement for all questions in Assessment 1. Schools 2 and 3 were omitted from individual analysis due to their low sample size (n=1, and n=3). School 4 (Figure 16) had high pre-assessment scores and did not show any change in pre and post assessments for questions 1, 2, or 4, and a slight improvement for question 3. School 4 had recently completed the Boise School Districts' 4th grade fire unit prior to participating in this study, which explains the high pre-assessment scores and lack of improvement.

Analysis of all of the schools aggregated data (Table 7) yielded a value of $p<0.001$ and t (43) =-9.574. These results show a statistically significant improvement between the pre and post lesson assessment for lesson 1 with a large effect size (-1.443). The normalized gain for the urban schools was 0.66, and 0.72 for the rural schools.

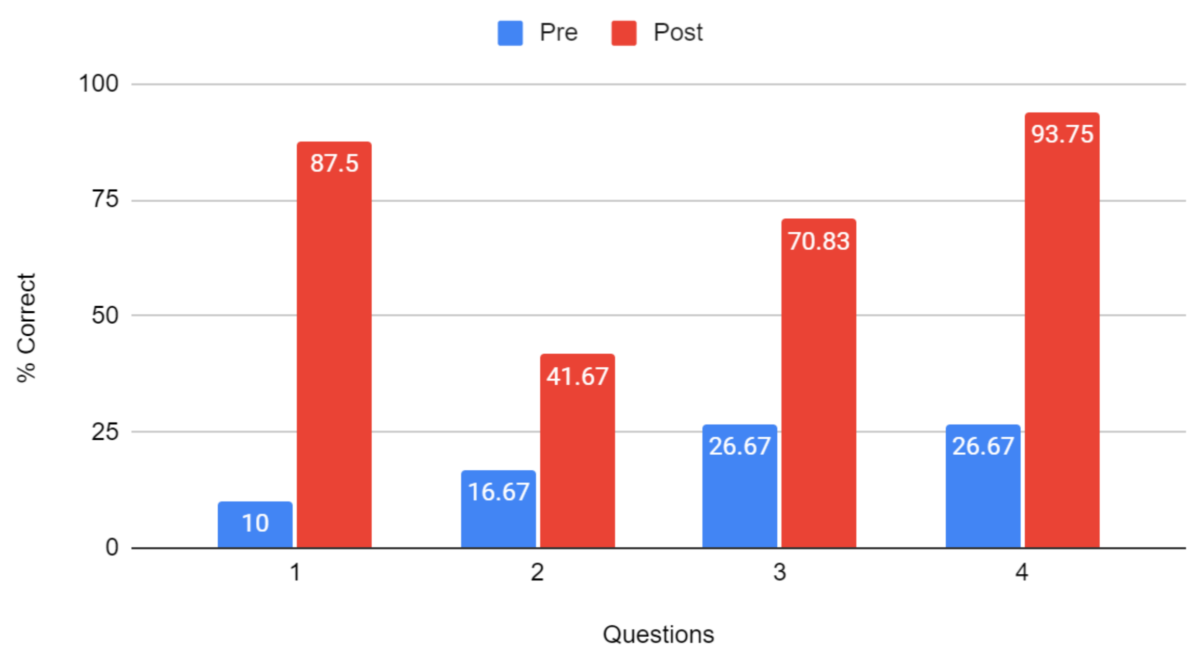

Figure 15 **The percent of correct responses for each of the four questions on Assessment 1 at School 1. n=15**

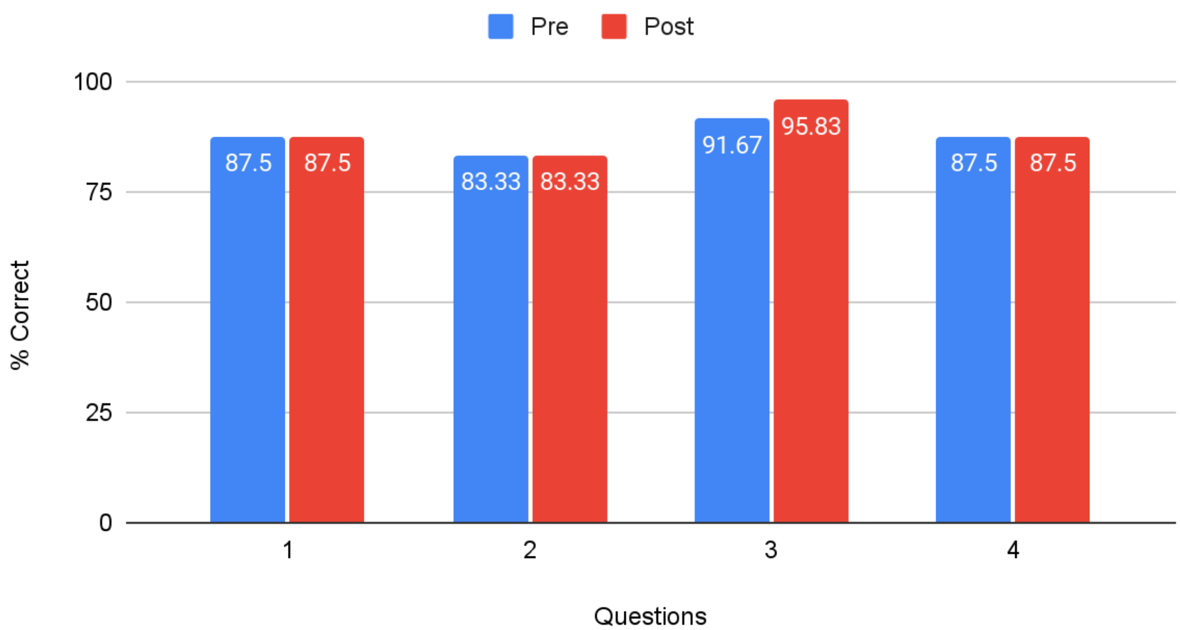

Figure 16 **The percent of correct responses for each of the four questions on Assessment 1 at School 4. n=8**

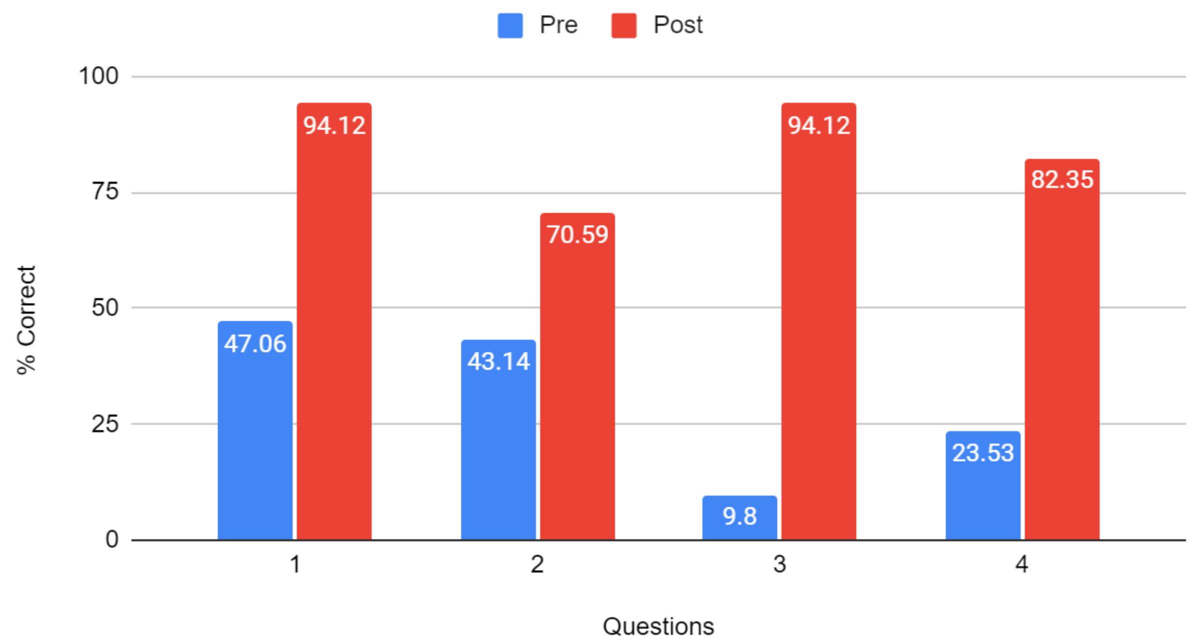

Figure 17 The percent of correct responses for each of the four questions on Assessment 1 at School 5. n=17

Lesson 2 Assessment Analysis

Schools 1 (Figure 18), 4 (Figure 19), and 5 (Figure 20) showed overall improvement in the post lesson 2 assessment. Schools 2 and 3 were omitted from individual analysis due to their low sample size (n=3).

The original design of this lesson included a wrap up discussion of steps to create a Firewise perimeter around homes. Due to the length of this lesson however, the concept of a Firewise setting was not covered in depth or at all at certain schools. Since this subject was not covered at depth, or at all, there was little improvement in question 4 at any of the schools, and sometimes a decrease.

Analysis of all schools aggregated data (Table 7) yielded a value of $p<0.001$ and t (47) =-4.060. These results show a statistically significant improvement between the pre and post lesson assessment for lesson 2 with a medium effect size (-0.586). The normalized gain for the urban schools was 0.22 and 0.30 for the rural schools.

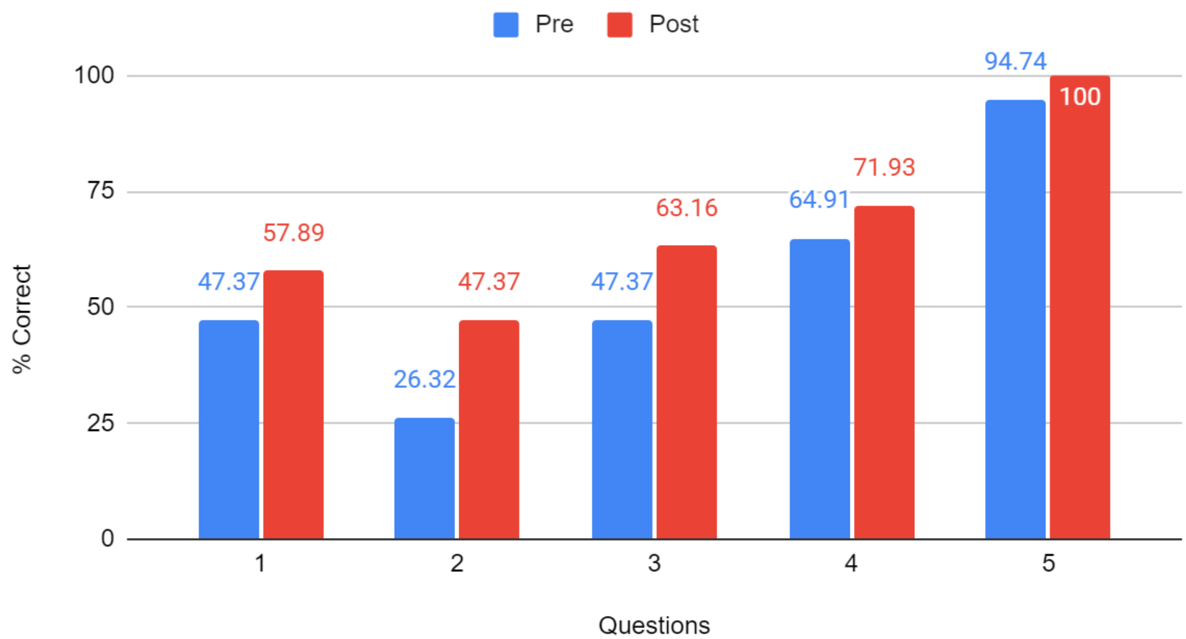

Figure 18 The percent of correct responses for each of the five questions on Assessment 2 at school 1. n=19

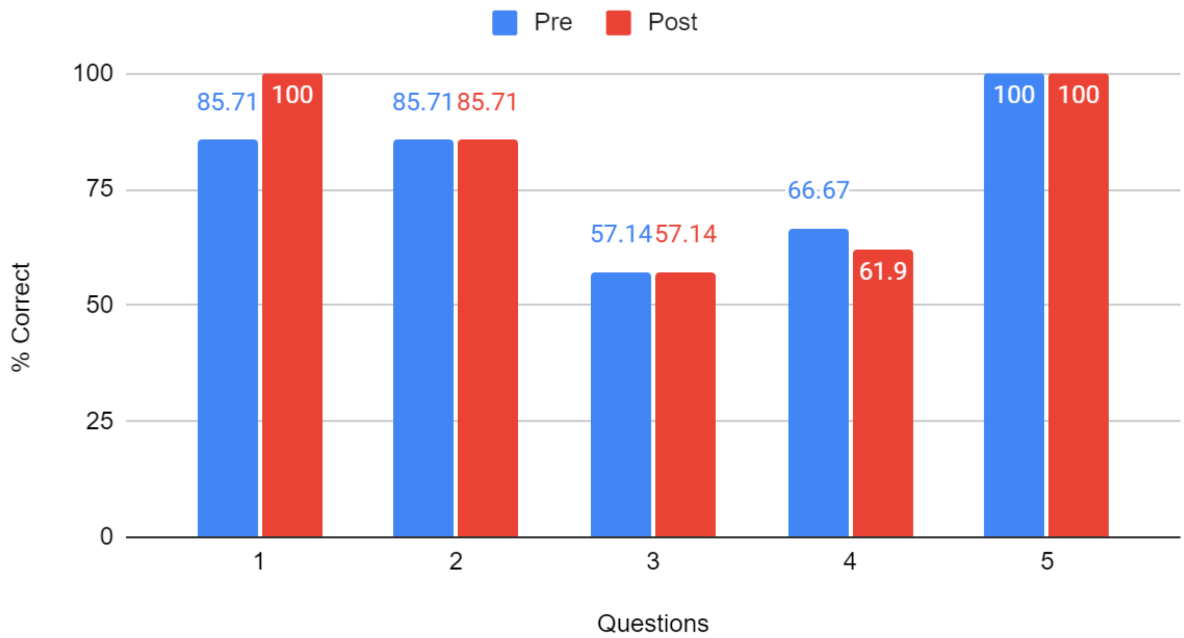

Figure 19 **The percent of correct responses for each of the five questions on Assessment 2 at school 4. n=7**

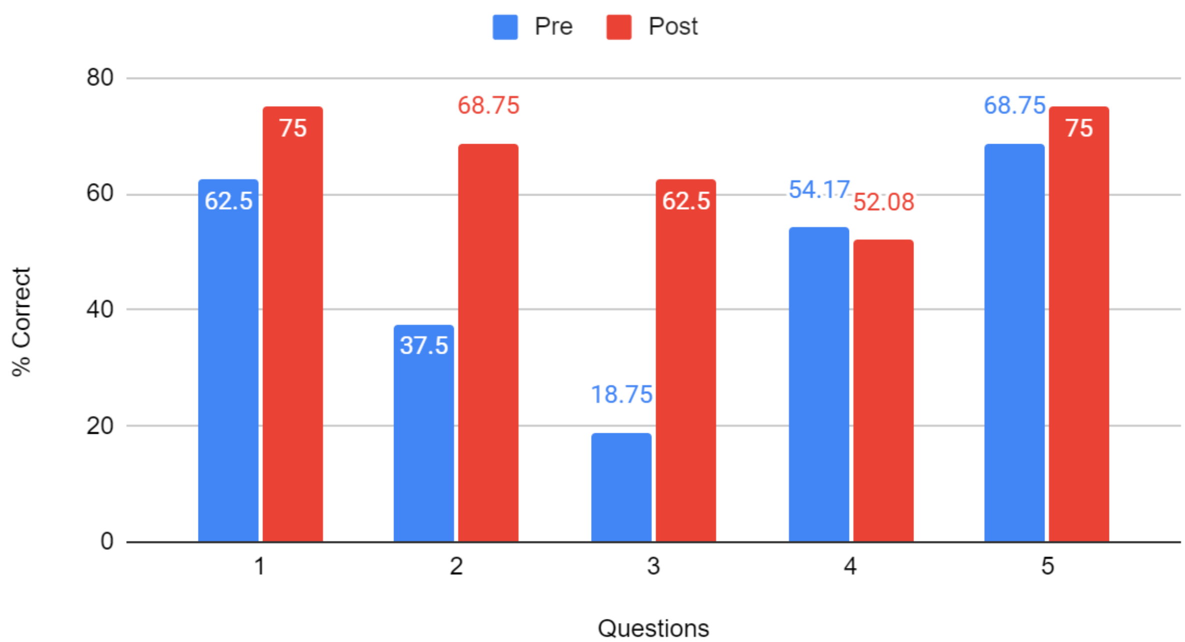

Figure 20 **Graph showing the percent of correct responses for each of the five questions on Assessment 2 at school 5. n=16**

Lesson 3 Assessment Analysis

Assessment 3 had mixed results, with some questions showing a decrease in correct responses (Figure 21; 22; 23).

Schools 2 and 3 were not included in the individual analysis by school due to their low sample size (n=4), (n=3).

Assessment 3 asks students to recall the trend of the graphed data that they were shown. The questions asking students to recall the trend of the graphed data (questions 1, 4, & 5) had mixed results, with some showing improvements and others a decrease in correct post lesson assessments. Question 1 asks students to recall the trend of the burned area since the 1980's. Question 2 asks students to list two variables that contribute to high fire danger. This is a concept that is covered during both lesson 1, with the account of the Big Burn, and lesson 2 with the fuel moisture demonstration and discussion of wind during the burnings. Therefore, this concept has been reinforced several times by the time it is covered at depth in lesson 3. All schools showed improvement in this question.

All schools showed a decrease in correct responses to question 5. Question 5 asks students to recall the graphed trend of snow water equivalent (SWE) at a local SNOTEL site over time.

Analysis of all schools aggregated data (Table 7) yielded a value of $p=0.058$ and $t(43)=-1.945$. These results are above the threshold of $p=0.05$, and therefore do not show a statistically significant improvement between the pre and post lesson assessment for lesson 3. The effect size is small (-0.293). The normalized gain for the urban schools was 0.16, and 0.29 for the rural schools.

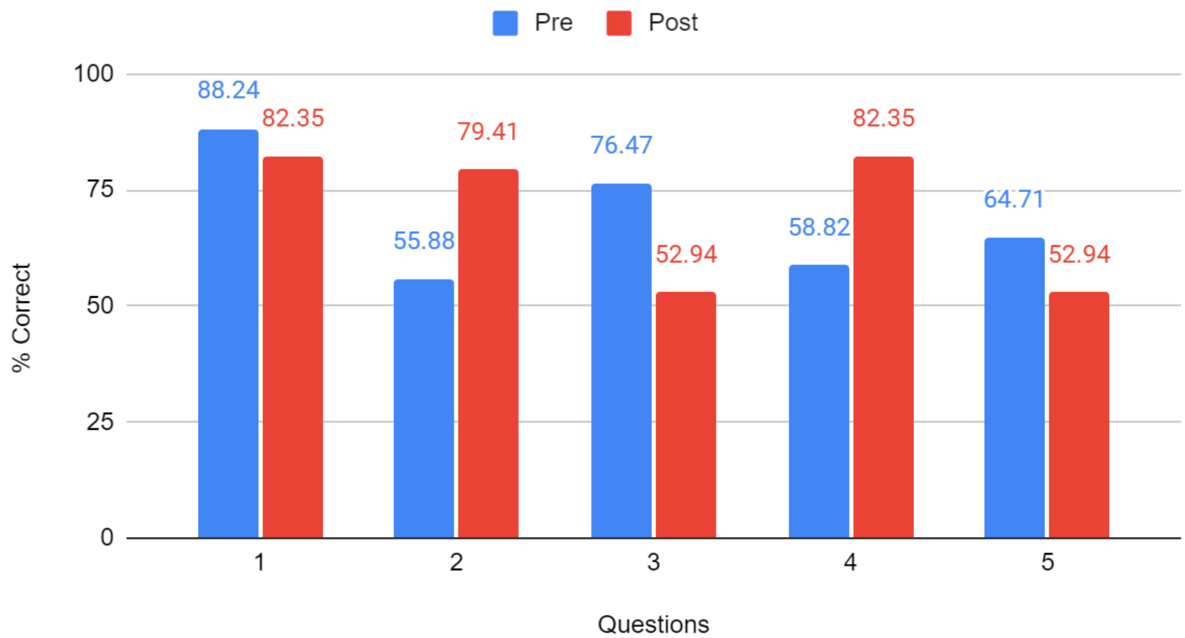

Figure 21 **The percent of correct responses for each of the five questions on Assessment 3 at school 1. n=17**

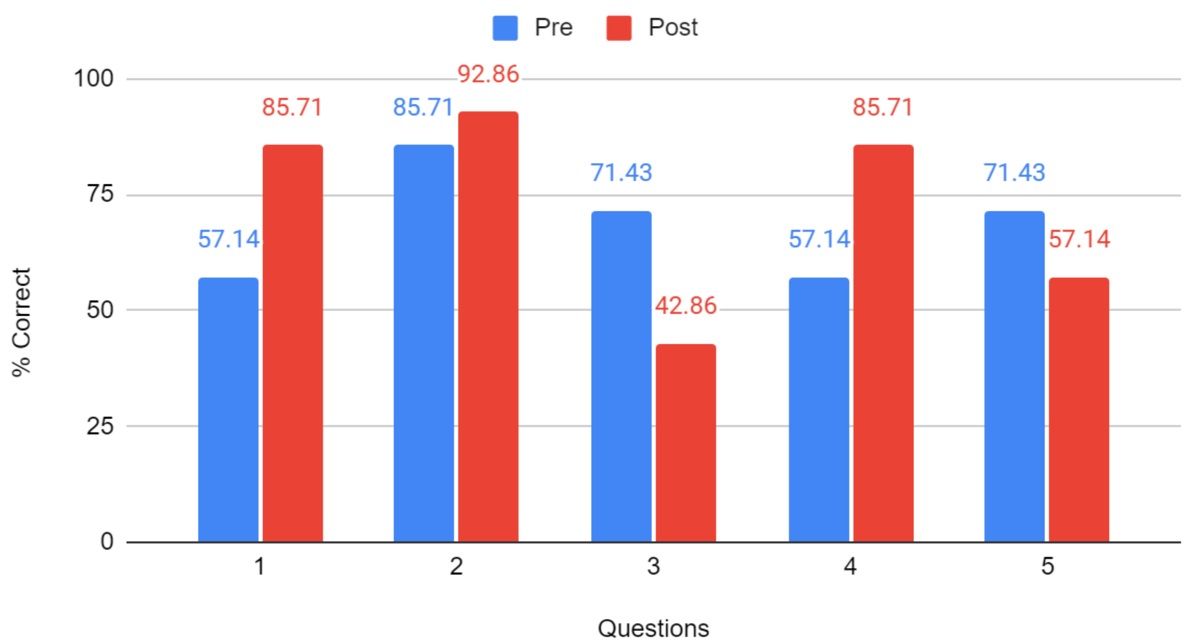

Figure 22 **The percent of correct responses for each of the five questions on Assessment 3 at school 4. n=7**

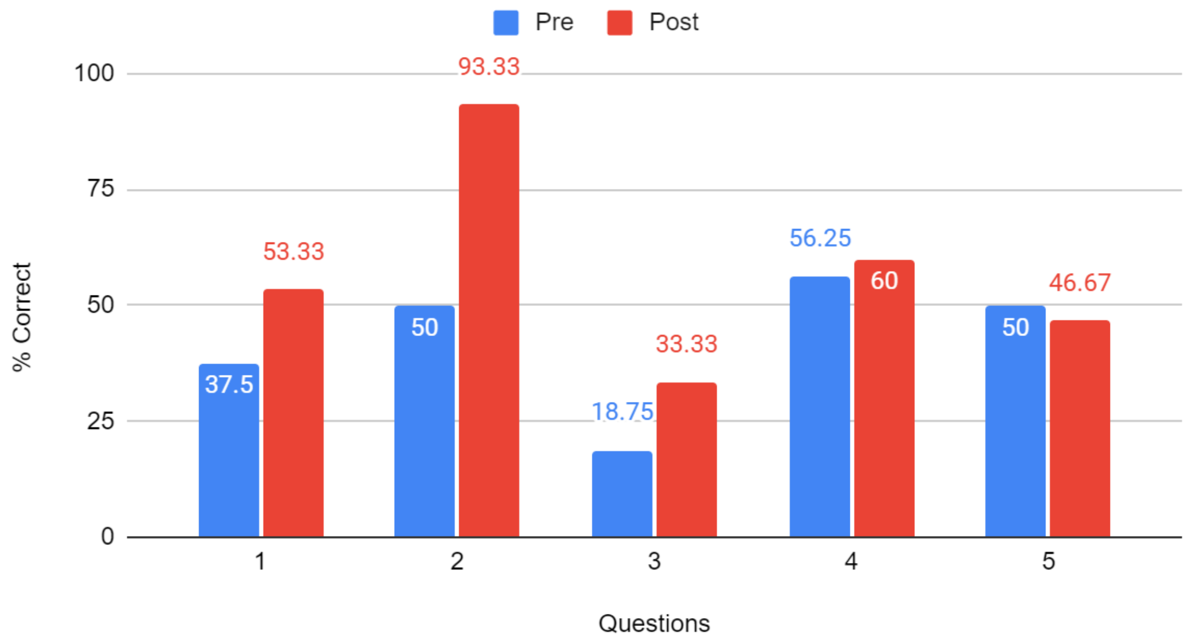

Figure 23 The percent of correct responses for each of the five questions on Assessment 3 at school 5. n=16

<u>Lesson 4 Assessment Analysis</u>

All schools showed substantial improvement in the lesson 4 assessments (Figure 24; 25; 26). Question 6 showed improvement in students' vocabulary. Responses such as “mudslide”, or “landslide” were counted as correct, though many students who used these terms in their pre assessment, changed their responses to the more accurate term, “debris flow”, in the post assessment. All schools showed the greatest improvement in question 2.

Analysis of all schools aggregated data (Table 7) yielded a value of $p<0.001$ and $t(45) = -7.866$. The results show a significant improvement in the post assessments with a large effect size (-1.160). The normalized gain for the urban schools was 0.51 and 0.34 for the rural schools.

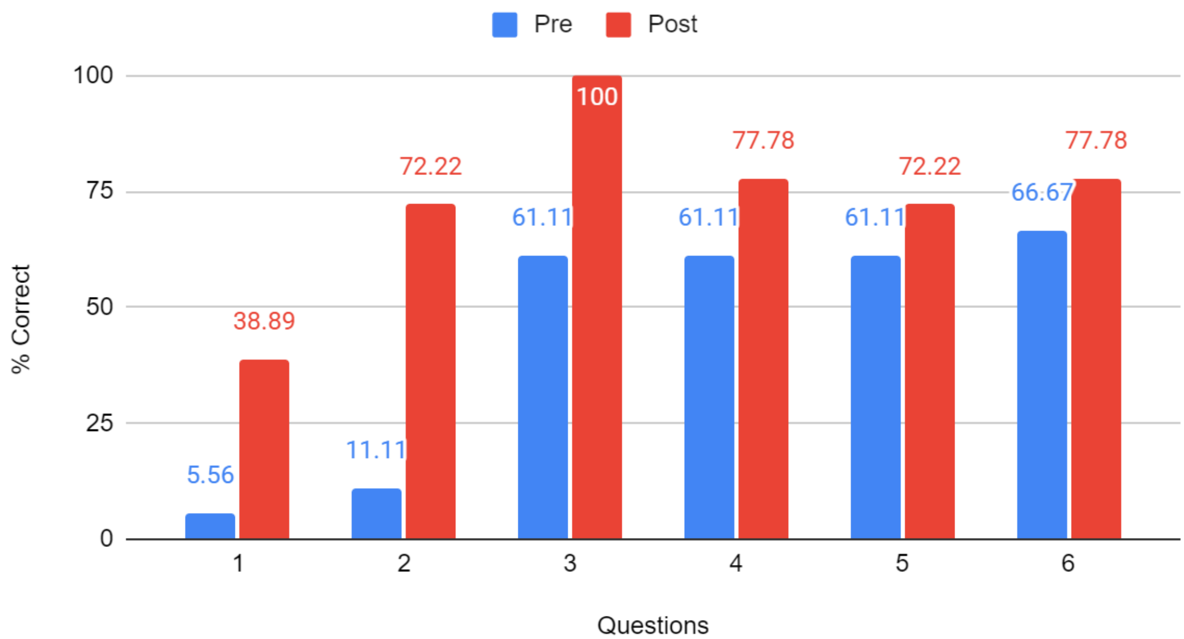

Figure 24 **The percent of correct responses for each of the five questions on Assessment 4 at school 1. n=18**

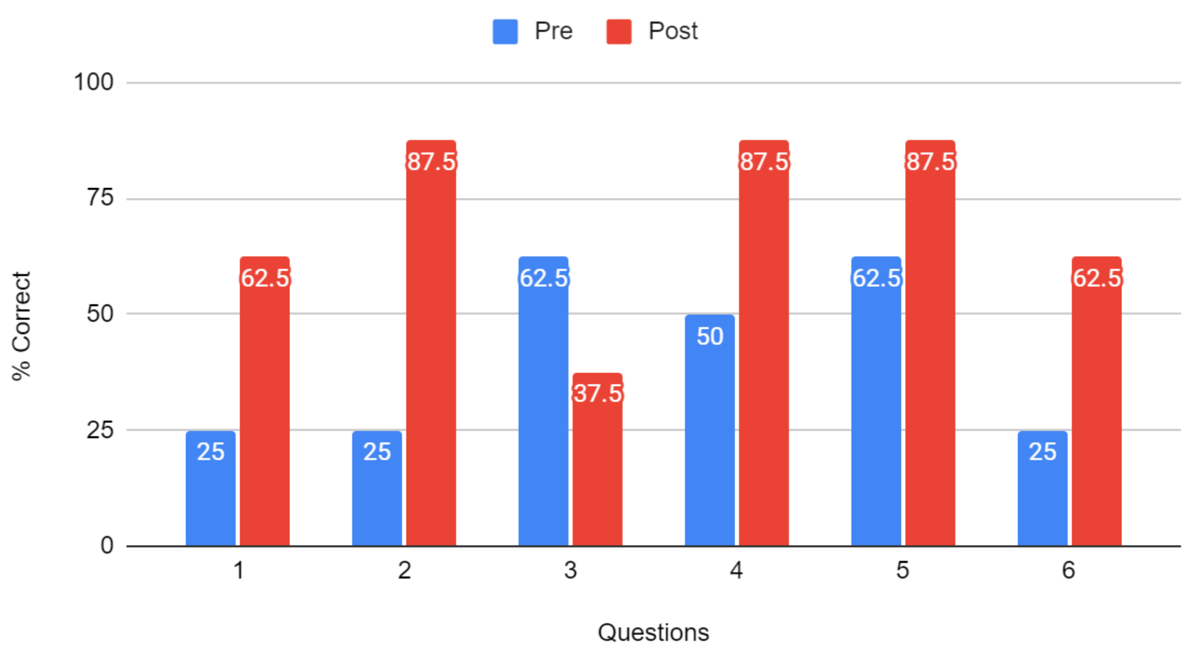

Figure 25 **The percent of correct responses for each of the five questions on Assessment 4 at school 4. n=8**

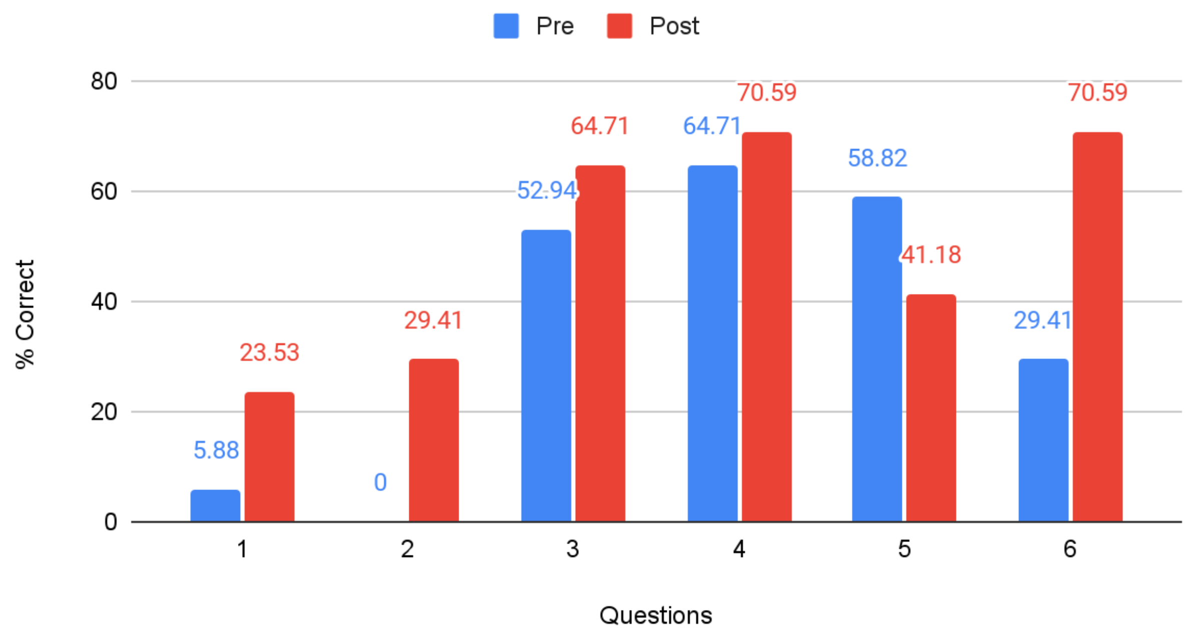

Figure 26 The percent of correct responses for each of the five questions on Assessment 4 at school 5. n=17

At the end of the wildfire unit, students were asked to vote for their favorite lesson. Sixty-one percent of the students stated that lesson 2 was their favorite. This was followed by 22% of students that preferred lesson 3, and 15% of students that preferred lesson 4.

Survey of Idaho Teachers Who Observed Instruction of the Wildfire Unit

The Idaho teachers' responses to the survey are reported in Figures 27, 28, 29, 30 & 31. While there are only seven paired responses, these paired responses show that teachers who observed the instruction of this unit increased in their perceived knowledge of wildfire and increased in their confidence to teach and communicate about wildfire (Figures 27, 28, 29). The majority of the paired responses did not show an increase in teacher's ability to incorporate wildfire into their subject matter or an understanding of where to acquire materials to teach about wildfire.

The short-answer responses regarding hesitations to teaching wildfire on their own produced two themes. These were the ability to fit the content into their existing curriculum and subject (including the constriction of time), and lack of knowledge and understanding of the subject matter. In the pre-instruction survey, three educators cited the ability to fit it into their curriculum as hesitations to teaching wildfire on their own. This decreased to one in the post-instruction survey. In the pre-instruction survey, four educators cited a lack of knowledge, understanding, and awareness of resources as hesitations to teaching wildfire on their own. This decreased to one in the post-instruction survey. One teacher stated in the pre-instruction survey that they were aware of some lessons, but found them scary. In the post-instruction survey two educators stated that the classroom environment would be a barrier, as lesson 2 is performed best with at least one other adult to assist in supervising.

Five of the total seven respondents who completed the post-instruction survey stated that they would use at least a part of the wildfire unit in their classrooms. In the post-instruction survey, two educators stated that they would use the whole four lesson unit in their classrooms. Two stated that they would use lesson 4. One stated that they would use lesson 2, and one stated that they would use part of lesson 1 to discuss the fire triangle.

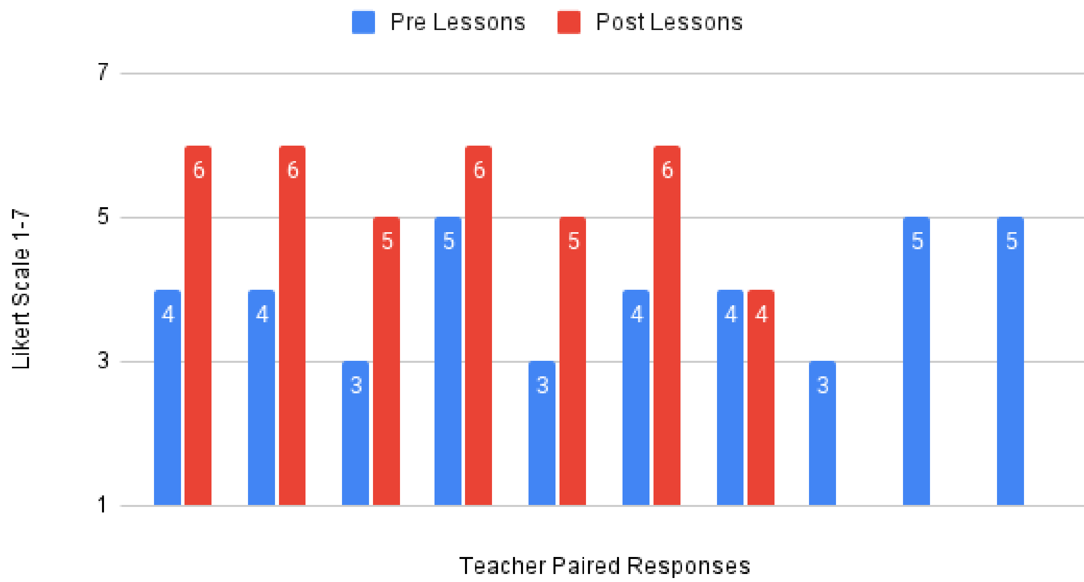

Figure 27 **Idaho 4th grade teachers and workshop participants perceived knowledge of wildfire prior to and after instruction of the wildfire unit (n=10). Teachers were asked, "Please rate your knowledge of wildfire."**

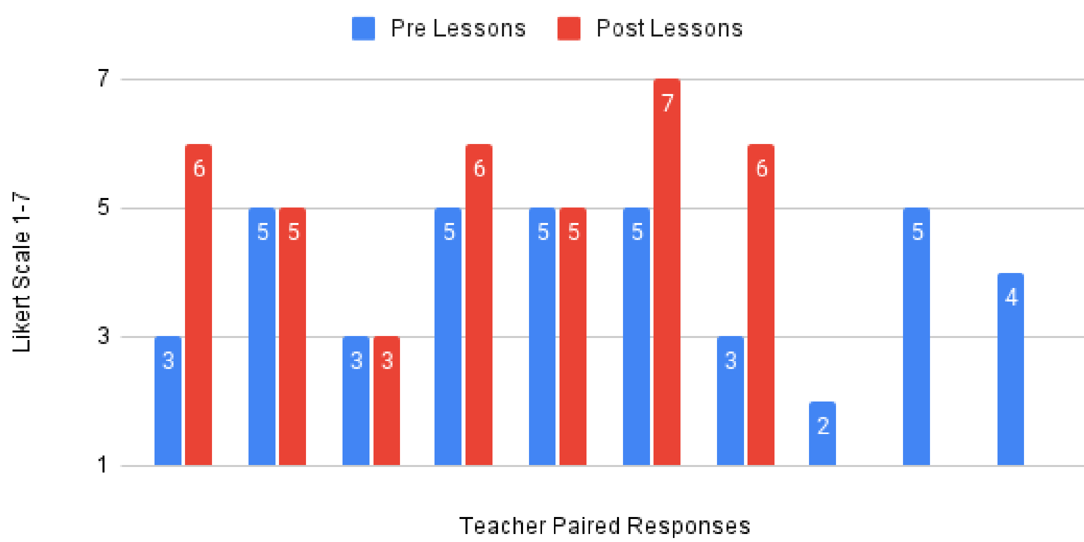

Figure 28 **Idaho 4th grade teachers and workshop participants perceived confidence to teach and communicate about wildfire prior to and after instruction of the wildfire unit (n=10). Teachers were asked, "How confident do you feel to teach or communicate about wildfire?**

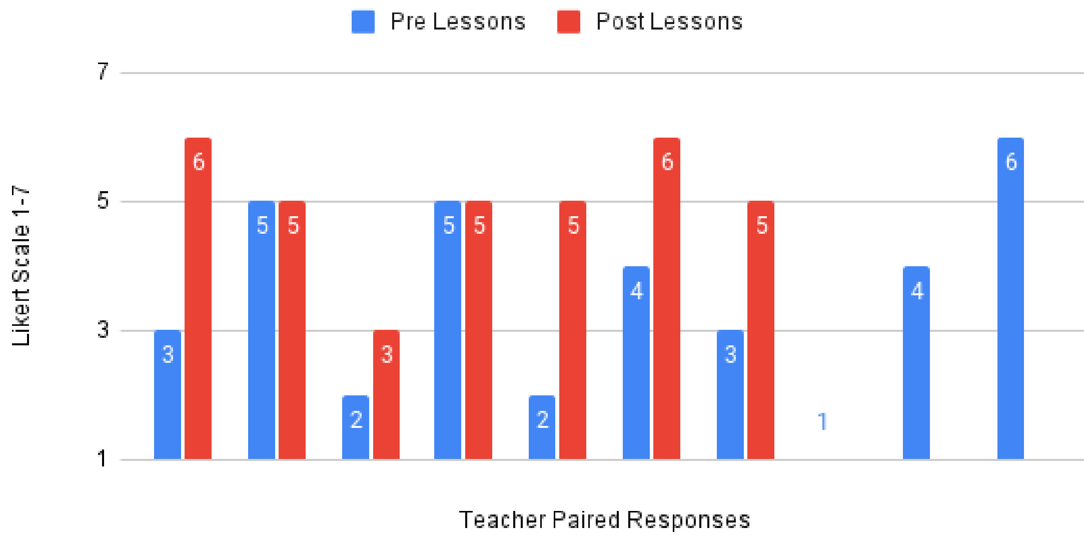

Figure 29 Idaho 4th grade teachers and workshop participants perceived content knowledge and understanding to answer questions about wildfire, prior to and after instruction of the wildfire unit (n=10). Teachers chose a response to the statement, "I believe that I have the content knowledge and understanding to be able to answer questions from my students regarding wildfire".

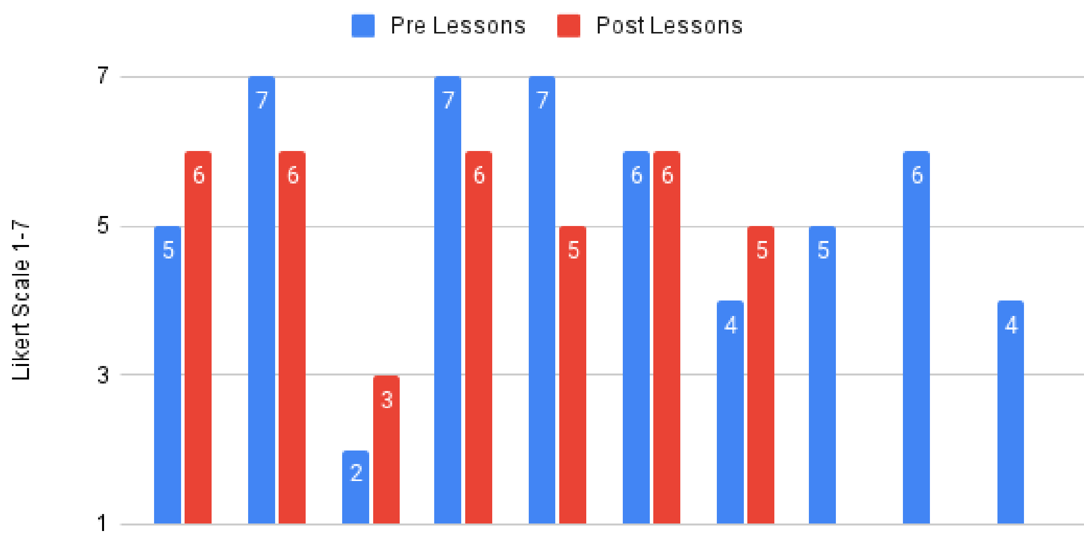

Figure 30 Idaho 4th grade teachers and workshop participants perceived ability to find ways to incorporate wildfire education into the subjects they teach (n=10). Teachers chose a response to the statement, "I can easily find ways to incorporate wildfire into the subjects that I teach".

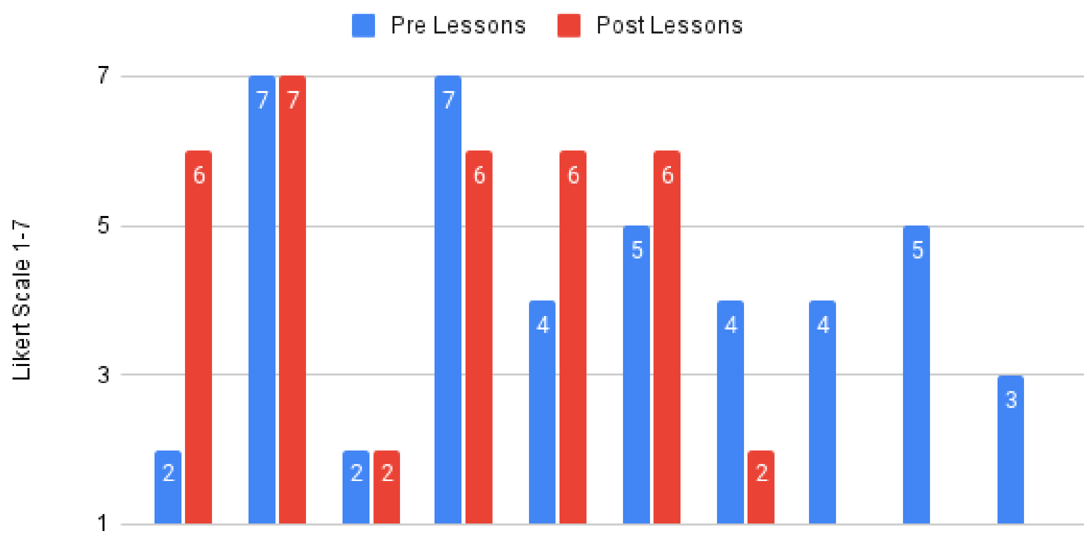

Figure 31 Idaho 4th grade teachers and workshop participants perceived understanding of where to obtain resources to teach wildfire (n=10). Teachers chose a response to the statement, "I know where to go to acquire materials and resources to teach wildfire, including a fire trunk".

Discussion

<u>Boise State Students K-12 Wildfire Education</u>

Despite most of the students attending high school in states with a high wildfire risk, only about one-third of the students reported receiving any form of wildfire education in their K-12 background. This survey shows that most of the K-12 wildfire education occurs in a classroom setting on a timeline of one day to one week. Some of the longer wildfire education units (greater than one week) occurred in Scouts, or in a semester-long class, such as AP Environmental Science. Students reported similar response rates for camps, Scouts, and *place of relevance* as educational settings.

The theme of the content that students reported most often was fire safety and prevention. This result was similar to a 2012 study of wildfire education, which found that 68% of youth wildfire education programs focused on safety, prevention, and suppression, with half of those solely focused on those topics, and half touching on some fire science, ecology, and management, but only as support for the topic of fire safety (Ballard et al., 2012). Ballard et al. also found that only 32% of youth wildfire education programs focused on wildfire science, ecology, and management. Wildfire safety and prevention are important areas of fire education, especially for students who reside or recreate in areas that are designated high risk for wildfires (Monroe at al., 2013). However, a more comprehensive coverage of wildfire education includes science and ecology. Focusing on fire science and ecology promotes a better understanding of wildfire behavior, and its impacts. In this way, students see scientific concepts introduced, reinforced, and connected to the real world. As wildfire burn area continues to increase in the United States, learning how to live with fire in fire prone communities is better supported through a more comprehensive wildfire education (Ballard et al., 2012). Comprehensive wildfire curriculum also naturally supports the pedagogical approach widely advocated by educators, that science should be taught by doing, within the real-world context, and where students can see how it is connected to their lives (NSSME, 2018).

Some student responses revealed a positive ‘student affect’ (positive learning outcome) from their wildfire education experience, as well as a long term positive impact. These student experiences highlight the positive impact that wildfire education has at the K-12 level, and support the findings that students who had completed a wildfire education program within their K-12 classroom perceived themselves as being more attentive and interested in the material, their classroom as a more positive environment, and their teachers as more invested and fostering of creative thinking than students who did not receive the instruction (Thomas et al., 2000).

<u>4th Grade Wildfire Unit</u>

Overall, students showed significant improvement in pre and post assessments for lessons 1, 2, and 4. Lesson 3 did not meet the threshold *p* value of less than 0.05. We believe that this is due to the design of the assessment, which required students to recall trends from graphs that were discussed in a slideshow presentation. Idaho students are introduced to graphs in the 4th grade. Since we conducted this study in the fall, students had not yet been taught how to graph or interpret graphed data. Therefore, instructions on how to read and interpret graphed data were covered in detail during this lesson. In addition to graphing, SWE was also a new concept that was introduced to students in this lesson. This may have compounded the confusion for students, resulting in decreased performance. Possible explanations for the poor results may be due to a lack of mastery in graph analysis, the grade level appropriateness of the content, or the design of the assessments. The written assessment that was used for the pre and post assessment statistical analysis included three questions that required students to recall the trend of three of the graphs. However, these graphs were not provided on the assessments for reference. It is possible that these assessments may have produced higher scores if they had shown the graphs, or if the answers were worded more simply (e.g., using the term "more area burned", instead of saying the trend is "increasing"). The repetitive wording of the three questions may have contributed to the poor outcome as well. Each of the three questions regarding the graphs asks students to select whether the trend was increasing or decreasing. Mixing up the vocabulary for these questions may have produced different results (e.g., using the select response "more area burned", instead of saying the trend is “increasing”). Formative, undocumented assessments during the lessons indicated that students were understanding how to interpret the graphed data, and as well as the content. After explaining how to read and interpret graphed data, we pointed out individual data points as examples and had students raise their hand to answer questions about that data point. We performed this exercise numerous times on each of the graphs to allow many students to answer the questions. During this activity, we observed that students were able to very quickly interpret information about a particular data point (e.g., We would say, “In 2010, the average July air temperature at Mores Creek Summit was______.” To which, a student would raise their hand and answer, “60°F”). The general trend of the data was discussed after this activity. It is also possible that, while the students were able to quickly learn how to interpret the data of an individual data point, the overall trend confused them due to the variability of the data set.

We observed that rural schools had greater improvements from the pre and post assessments in lessons 1, 2, and 3 than the urban schools. Lesson 4 showed similar levels of improvements between the rural and urban schools. We note however, that for lesson 1 these results are skewed by the results from School 4. School 4 (urban) had recently covered much of the material from that lesson, prior to this study. Therefore, the students performed well in the pre assessments and there was little change in the post assessments for School 4 in lesson 1. This fact may demonstrate that the content of that lesson was retained well by the students.

We found that, contrary to our hypothesis, students from urban areas scored higher on the pre assessments for each lesson, indicating greater wildfire knowledge than the students who resided in higher wildfire risk areas; however, students from rural areas showed greater improvement in their post assessments. It was our belief that students from the rural schools, which were all located in the WUI, may have more prior wildfire knowledge and experience with wildfire than students who attended schools in the urban areas. However, the students from the rural schools scored lower on their pre assessments. One possible explanation for this is access to resources. All of the rural schools in this study receive Title 1 funding, while neither of the urban schools do. The schools that receive Title 1 funding have a greater portion of students who come from lower income households. This may contribute to more limited access to educational resources and support than students who attend non-Title 1 schools. Due to the low number of responses for each of these samples, we are hesitant to make broad assertions regarding these demographics, however, these results indicate that wildfire education may be more beneficial in areas that are rural and at greater risk of wildfire.

We also found unsolicited messages from the students on the assessments. Some of these included random drawings and some included statements regarding their sentiments towards the wildfire unit. Some of these examples include; “I love fire”, “We love you Mrs. M”, “You are the best fire teacher ever! Thank you”, “I love this assignment” (found on assessment 3), “Stay! Teach more fire. Stay, don’t leave! Love you!” These examples demonstrate the positive student affect that this wildfire unit contributed to. This feedback provides insights into the value that this wildfire unit may provide beyond simply increasing content knowledge among the students. Since the elementary level is a critical point in attaining continued interest in science (Jarrett, 1999; Adams et al., 2014), these positive statements indicate considerable student interest and engagement was developed with this wildfire unit. This was an unplanned benefit that may be interesting to investigate further with a longitudinal study. These positive students' statements are also in concurrence with the results of the 7th grade FireWorks Educational Program study, which found that students who had received this education perceived themselves as more attentive and interested in the material, their classrooms as more positive environments, and their teachers as more invested in their learning (Thomas et al., 2000).

Students reported that lesson 2 was their favorite lesson in the unit. This is a fun and interactive lesson that allows students to observe fire behavior first hand. If teachers only have time to teach one lesson out of the unit, lesson 2 works well as a stand-alone lesson. While lesson 3 builds upon lesson 2 to make a better climate connection, if teaching lesson 2 alone, emphasis in discussion regarding climate changes impacts to fuel moisture may assist in supporting the climate change component that is better covered by also teaching lesson 3.

Teacher Surveys

While the survey response population is low for statistical analysis, the results of the teacher surveys indicate that teachers who had some form of instruction in the wildfire unit felt they had more knowledge on the subject matter, and had greater confidence in their ability to teach and communicate the subject matter. This was true for both the teachers who observed the lessons being taught in their own classrooms, where they were able to hear questions and comments elicited from their students, as well as the workshop setting, where the teachers acted as the students.

Prior to observing the lessons instruction, teachers most often reported that they were hesitant to teach about wildfire due to a lack of knowledge, understanding, and awareness of resources. Teachers also cited the ability to fit wildfire into their curriculum and class time as a hesitation. There were less hesitations reported in the post-instruction survey, indicating that the educators felt more comfortable teaching the subject on their own after observing the lessons being taught. Half of the teachers who had observed the instruction of the wildfire unit stated that they planned on teaching at least part of the unit on their own.

Survey results from teachers did not show any improvement in teachers' reported knowledge of where to acquire resources to teach about wildfire. This is likely due to the fact that these lessons were not available to teachers in the unit format that now exists on its own website at the time that this study was being conducted in classroom instruction. The material and site is now available to the public at the following website: https://sites.google.com/boisestate.edu/wildfire-unit/home

We expected that teachers who had observed these lessons being taught would report greater understanding of wildfire curriculum, confidence and willingness to teach wildfire on their own. These results confirm our hypothesis. This study was designed to allow teachers to observe the implementation of these lessons in their classroom, and to model to the workshop participants how to teach this material. These forms of instruction and professional development have been shown to be successful models for teacher training (Owens et al., 2018).

Of all five of the educators that we invited to participate in this study, everyone invited us to teach this unit in their classroom. The high rate of teacher acceptance to participate in this study is likely due to the design of this study, whereby teachers did not need to familiarize themselves with the content, but were learning alongside the students.

This removed the burden from the teachers to prepare new material and allowed them to turn over classroom instruction to a guest teacher. The benefit of this implementation design is similar to the wildfire education study by Jakes (2012), which attributed the success of its program to the presence of a coordinator who taught in the classrooms, instead of the teachers.

Future implementation of new K-12 curricular units may benefit from the introduction of a content expert to better prepare the educator and increase the literacy of both the teacher and students. While teachers expressed interest in teaching at least part of this unit on their own, we did not contact the teachers again to find out if they had used the material on their own. Because we had just taught this in their classrooms, it is unlikely that they chose to teach this material again during that same school year. Given the large amount of time between observing these lessons taught, and possibly teaching them on their own, a follow up professional development opportunity or training may have been beneficial to ensure that these teachers remained confident and competent to teach these lessons.

Conclusion

This study examines curricular gaps in K-12 wildfire education, and develops, implements and tests four new wildfire lessons. We surveyed Idaho STEM workshop teachers and incoming Boise State University students to assess their background in wildfire education. Surveys of university-wide 100 level climate change courses at Boise State University show that only about one third of students had some form of wildfire education in their K-12 experience, despite the majority of these students attending high school in high wildfire-risk states.

To address the minimal K-12 wildfire education and lack of curriculum connecting climate change to changing fire regimes, we developed a wildfire unit and evaluated its effectiveness in the classroom. We analyzed the effectiveness of this curriculum on students and taught it in the classrooms, where teachers could observe the instruction. We implemented it in this way to measure teacher confidence, efficacy, and willingness to teach the lessons on their own after observing the unit's instruction.

The wildfire unit was designed for the fourth grade level as a four lesson unit, using new and existing material. The material was selected and developed to address a lack of curriculum connecting wildfire to climate change. The purpose was to provide teachers and students with hands-on, interactive, place-based lessons to increase wildfire and climate literacy. The unit focused on wildfire in Idaho because it is a critical local climate change impact. Pre and post lesson assessments measured the effectiveness of these lessons. Three of the four lessons showed significant improvement in post lesson assessments. We believe that the lesson that did not show significant improvement may be due to the design of the assessment as well as the grade level appropriateness of the content. Students' understanding of basic fire science, including; the fire triangle, fire behavior based on fuel density, fuel moisture, topography, and weather showed significant improvement in post lesson assessments. We found that students from the rural demographics scored lower on their pre assessments but showed greater improvement in their post lesson assessments, in three of the four lessons, than students from urban areas. Surveys showed that the teachers who observed the lessons' instruction, reported an increase in content knowledge, confidence and willingness to teach these units after observing these lessons being taught.

Droughts, wildfire, and growing populations are transforming the western United States. Research, understanding, and education of these issues will be the foundation for building resilient communities in this changing world. More efforts to improve teacher climate literacy are vital to effectively educate youth on climate change. Professional development and teacher training provide the opportunity to better prepare K-12 teachers to educate youth on this grand challenge problem. Without widespread, consistent educational standards, implementing educational units using local and regional climate impacts is an effective means of increasing climate literacy and addressing local problems. There is a crucial need to create and develop material that connects climate change to real world issues and to equip educators with the understanding, confidence and resources to implement climate education in the classroom.

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APPENDIX

Idaho State Standards Discussing Climate Variability. From the Idaho State Department of Education, 2022.

MS-ESS-3.5 Students who demonstrate understanding can:

Ask questions to interpret evidence of the factors that cause climate variability throughout Earth's history.

Supporting Content ESS3.C: Human Influences on Earth Systems

• Current scientific models indicate that human activities, such as the release of greenhouse gases from fossil fuel combustion, can contribute to the present-day measured rise in Earth's mean surface temperature. Natural activities, such as changes in incoming solar radiation, also contribute to changing global temperatures. (MS-ESS-3.5)

Further Explanation: Examples of factors include human activities (such as fossil fuel combustion and changes in land use) and natural processes (such as changes in incoming solar radiation and volcanic activity). Examples of evidence can include tables, graphs, and maps of global and regional temperatures; atmospheric levels of gases such as carbon dioxide and methane; and natural resource use.

HS-ESS-2.4

Supporting Content ESS2.A: Earth Material and Systems

• The geological record shows that changes to global and regional climate can be caused by interactions among changes in the Sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (e.g., ice ages) to very long-term tectonic cycles. (HS-ESS-2.4)

Supporting Content ESS2.D: Weather and Climate

• The foundation for Earth's global climate systems is the electromagnetic radiation from the Sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space. (HS-ESS-2.2, HS-ESS-2.4)

• Changes in carbon dioxide concentrations in the atmosphere affect climate. (HS-ESS-2.6, HSESS-2.4)

Further Explanation: Examples of the causes of variations in climate differ by timescale: over 1–10 years: large volcanic eruption, ocean circulation; 10–100s of years: changes in human activity, ocean circulation, solar output; 10–100s of thousands of years: changes to Earth's orbit and the orientation of its axis; and 10–100s of millions of years: long-term changes in atmospheric composition.

Assessment Limit: Assessment of the results of changes in climate is limited to changes in surface temperatures, precipitation patterns, glacial ice volumes, sea levels, and biosphere distribution.

HS-ESS-2.6 Students who demonstrate understanding can:

Develop a model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.

Supporting Content ESS2.D: Weather and Climate

• Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. (HS-ESS-2.6, HS-ESS-2.7)

• Changes in carbon dioxide concentrations in the atmosphere affect climate. (HS-ESS-2.4, HSESS-2.6)

Further Explanation: Emphasis is on modeling biogeochemical cycles that include the cycling of carbon through the ocean, atmosphere, soil, and biosphere (including humans), providing the foundation for living organisms.

HS-ESS-2.7 Students who demonstrate understanding can:

Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth.

Supporting Content ESS2.D: Weather and Climate

• Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. (HS-ESS-2.6, HS-ESS-2.7)

Supporting Content ESS2.E: Biogeology

• The many dynamic and delicate feedbacks between the biosphere and other Earth systems cause a continual co-evolution of Earth's surface and the life that exists on it. (ESS2-HS-7) Further Explanation: Emphasis is on the dynamic causes, effects, and feedbacks between the biosphere and Earth's other systems, whereby geoscience factors control the evolution of life, which in turn continuously alters Earth's surface. Examples include how photosynthetic life altered the atmosphere through the production of oxygen, which in turn increased weathering rates and allowed for the evolution of animal life; how microbial life on land increased the formation of soil, which in turn allowed for the evolution of land plants; or how the evolution of corals created reefs that altered patterns of erosion and deposition along coastlines and provided habitats for the evolution of new life forms.

HS-ESS-3.6 Students who demonstrate understanding can:

Communicate how relationships among Earth systems are being influenced by human activity.

Supporting Content ESS2.D: Weather and Climate

• Current models project that average global temperatures will continue to rise. The outcomes projected by these models depend on the amounts of greenhouse gases added to the atmosphere each year and the ways these gases are stored by Earth's systems. (HS-ESS-3.6)

Supporting Content ESS3.C: Human Influences on Earth Systems

• Through computer simulations and scientific research, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are influenced by human activities. (HS-ESS-3.6)

Further Explanation: Examples of Earth systems are the hydrosphere, atmosphere, cryosphere, geosphere, and/or biosphere. An example is how an increase in atmospheric carbon dioxide results in an increase in photosynthetic biomass on land and an increase in ocean acidification, with resulting impacts on sea organism health and marine populations.

Assessment Limit: Assessment does not include running computational representations but is limited to using the published results of scientific computational models.

Chapter 2 Tables

Table 8 Boise State University Foundational Students Background in Wildfire Education- In your K-12 education did you ever receive wildfire education? (Wildfire education refers to uncontrolled fire spread through vegetation and while it may burn residential structures, it is different from education on home fire safety, such as how to prevent grease fires from starting on your stove).

Year- 2022			

	Yes	No	Maybe
California	12	15	2
Idaho	14	19	8
Nevada	0	1	1
Oregon	1	1	2
Washington	4	8	4
Year- 2021			
	Yes	No	Maybe
California	10	12	7
Idaho	13	22	8
Nevada	3	5	1
Oregon	1	0	0
Washington	3	5	4
Combined Years			
	Yes	No	Maybe
California	22	27	9
Idaho	27	41	16
Nevada	3	6	2
Oregon	2	1	2

Washington	7	13	8

Table 9 Boise State University Foundational Students Background in Wildfire Education- Outside of your K-12 education, did you ever receive wildfire education, as previously defined, in an environment such as a camp, club, community program, etc?

Year- 2022	Yes	No	Maybe
California	7	21	1
Idaho	11	27	3
Nevada	1	1	0
Oregon	1	2	1
Washington	1	12	3
Year- 2021			
	Yes	No	Maybe
California	8	19	2
Idaho	10	31	2
Nevada	2	7	0
Oregon	1	0	0
Washington	1	8	3
Combined Years			
	Yes	No	Maybe
California	18	40	3

Idaho	26	58	5
Nevada	3	8	0
Oregon	3	2	1
Washington	8	20	6

Wildfire Education Module

Wildfire Portfolio Instructions

Purpose: To assess student comprehension of a 4th grade wildfire curriculum unit and to have students reflect on some of the big ideas of this unit. Students will start and end the unit by answering the same question. Their answers are likely to change as they learn more about the complex nature of wildfires.

Curriculum Aims: The curriculum aims of this portfolio assessment are to both improve content knowledge of wildfire history, behavior, and impacts, as well as an understanding that fire is a necessary part of a healthy ecosystem.

Instructions: While we are working through our wildfire curriculum unit, you will keep a wildfire notebook. We will add activity worksheets to this as we go. In addition, you will keep a journal and reflect at the beginning and end of each lesson.

Lesson 1: The Fire Triangle and The Big Burn.

Pre Lesson Journal Question: Should we always try to put out wildfires? Why or why not?

Add to your notebook:

1. Students cut out and fold to create their own fire triangle.

2. Movie note catcher from The Big Burn of 1910.

Post Lesson Journal Question: Pretend that you live in Warren, ID in 1910 and have just survived the Big Burn fire. Write a letter to a relative or friend in another state telling them about how the fire impacted you and how you escaped it. This should be at least 6 sentences.

Lesson 2: Matchstick Forest and Campfire Fuels

Pre Lesson Journal Question: What are some ways that people accidentally start fires? What are some good practices to follow when recreating in the forests? Answer these questions in at least 3 complete sentences.

Add to your notebook:

1. Worksheet for Matchstick Forest activity.
2. Worksheet for Campfire Fuels activity.
3. Hot Discussion Questions Worksheet

Post Lesson Journal Question: We have explored how several variables affect fire behavior; fuel moisture, fuel density, and topography. Choose which of these three you think is most critical for a wildfire to spread and write one paragraph discussing why you think this is the most critical variable for wildfire. We have also repeatedly seen the effect of wind on fire. How can wind enhance or diminish what you chose to write about in your paragraph? Add at least 3 sentences discussing this.

Lesson 3: Fire Weather and Climate

Pre Lesson Journal Question: What is climate change? Why is this occurring? How might climate change impact wildfires? Answer each question in at least 3 complete sentences.

Add to your notebook:

1. Vocabulary worksheet.
2. Fire weather forecasting movie note catcher.
3. Post lesson assessment.

Post Lesson Journal Question: Pretend you are a 400 year old Ponderosa Pine tree in the mountains of central Idaho. What changes have you seen in your lifetime? How has the temperature changed? How has precipitation changed? Have you ever seen a wildfire? How many? Describe how that affected you. This should be at least two paragraphs. Get creative! In 400 years, you've seen a whole lot!!

Lesson 4: Post Fire Erosion and Revegetation

Pre Lesson Journal Question: Is fire good or bad? Why? Please write at least 6 sentences defending your point.

Add to your notebook:

1. Erosion observation worksheet.
2. Pony and Elk Complex Fire rehabilitation video note catcher.
3. Post lesson assessment

Post Lesson Journal Question: Should we always try to put out wildfires? Why or why not?

Post Unit Journal Question: Go back and read your first journal entry. Did your answer change? In what ways did your answer change? What things did you learn that made you change your answer? Please write at least 6 sentences.

Criteria	3	2	1
Worksheets	All required worksheets are included and complete.	Most of the required worksheets are included and usually complete.	Missing a substantial amount of the required worksheets or worksheets have not been completed.
Writing	Worksheets and journal entries are legible, include complete sentences when required, and are free of grammatical errors.	Worksheets and journal entries are usually legible, include complete sentences, and are mostly free of grammatical errors.	Worksheets and journal entries would benefit from writing more legibly, answering in complete sentences, and fixing grammatical errors.
Journal	Questions are answered completely and show a thoughtful response.	Most of the questions are answered and responses are acceptable.	Many of the questions are not answered. Some responses require further development.

Lesson 1- Fire Triangle & The Big Burn of 1910

This lesson is a combination of lessons #2 and #4 from the Boise School District 4th Grade Integrated Fire Curriculum, and uses materials provided in that unit.

Duration: 1 Hour

Idaho Standards: 4.SS.2.3.3

Learning Outcomes:

Part 1 Students are introduced to the fire triangle and learn the three necessary components of fire through a visual demonstration.

Part 2 Students learn about the 1910 Big Burn, an important event in Idaho history which shaped firefighting and management practices throughout the western U.S. for the rest of the century.

Lesson Plan:

Part 1- Fire Triangle - Start PowerPoint and go to the 2nd slide.

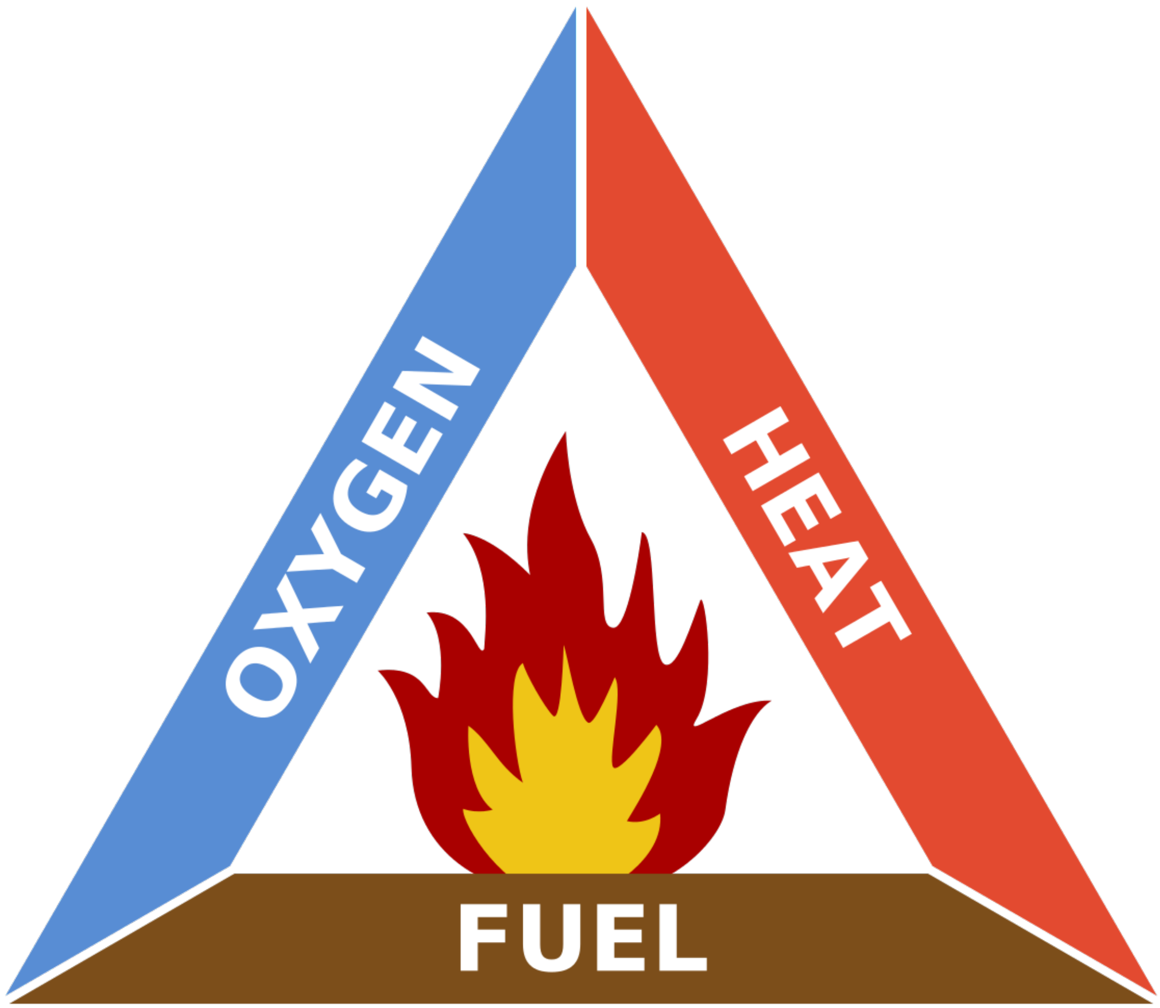
For further instruction, use this lesson plan as a guide: Fire Triangle

Begin with steps 1-3, demonstrate the candle in the jar, and lead students to realize that fire requires oxygen to burn. If any part of the triangle is removed, the fire will be extinguished.

Ask students what is happening? Why is the fire going out?

Tell students that there are 3 things necessary for a fire to burn. Have them discuss with the person to their right what they think the other 2 requirements are. Ask groups to share out.

Show the Fire Triangle and discuss the three variables. (**Slides 3-6**)



- Create fire triangle foldable in science notebook
- Use circle template to help create the foldable for students

  The second fold can be tricky for students, and must make a corner at the end of the first fold, creating something resembling an ice-cream cone, in order to create the triangle.

- Have students label their triangle

Part 2- 1910 Big Burn

Slide 7- Ask students to make observations about the photo. What is this picture showing?

What do you notice about this forest?

1910 Fire- How long ago was 1910? What was Idaho like back then?

Video Link: The Spokesman-Review: The Big Burn of 1910 (3 min 36 sec)

Use this map to show students what areas are discussed in the video.

This was one of several large fires that occurred during the early 20th century which led to a shift in how forest fires were fought. After these devastating fires, the Forest Service tried to extinguish every new fire by 10 a.m.of the following day.

Discussion questions:

How did they fight the fire? Did they have airplanes to help dump water and fire retardant? What did it mean when it said that they lit a backburn?

What did they mean by “the locomotives sprayed sparks”?

Fires sometimes started along the train routes. This is similar to fires often starting along our roads- why? Cars, atvs, cigarettes, campfires.

Lesson 2- Matchstick Forest & Campfire Fuels

This lesson uses materials from the Boise School District 4th Grade Integrated Fire Unit, Lesson #9.

Duration: 1 Hour

Idaho Standards:4-ESS3-2

Learning Outcomes:

Students will learn about how fire behavior is affected by topography and fuel density, through hands-on experiments. Students will form a hypothesis and test that hypothesis. A key takeaway of this lesson is the importance of creating a Firewise perimeter around your home.

Part 1 Fire Observations-

Use PowerPoint or open in google slides.

Have students look at photos of ponderosa vs lodgepole **Slides 1 & 2** fires.

Print and hand out Diagram observations.

Slide 1 Start with the ponderosa forest. Ask students to make observations about the image showing the fire. Where is the fire occurring? What are some observations about the forest post fire?

Slide 2 What are some observations about the image of a fire in a lodgepole pine forest? Where is the fire occurring in this image? What do you notice about this forest post fire?

What are some differences between these two forests? Go back to slide 1 and lead students to the observation that in ponderosa forests, trees are more spaced out than in lodgepole pine forests. How did this affect the fire's ability to spread?

The fire in the ponderosa forest was more confined to the ground and smaller vegetation (a **surface fire**). These trees will likely have fire scars on their lower trunks, but most of the larger trees survived this fire. The fire in the lodgepole pine forest spread through the canopy (a **crown fire**). This resulted in a **stand replacing fire**, as it killed the majority of those trees.

Extra fun facts: Ponderosa pine trees have thick bark that helps defend them from fires. Lodgepole pine trees have special serotinous cones, which are coated with wax. These cones build up on a forest floor. It actually takes a fire to melt this wax and release the seeds from these cones, which will lead to a new stand of trees. Both species tend to shed their lower limbs as they grow. These are adaptations that trees have developed to survive and reproduce after wildfires.

Have students quickly sketch where the fire would likely spread in both of these forests. A quick scribble along the lower portion of image A, and scribbles all over the trees in image B is all that is needed. Have students note some of those observations that were just discussed.

Part 2- Matchstick Forest

Before beginning, review these safety instructions.

Have students break into small groups of 3-5

Pass out peg boards and for more detailed instruction, see this lesson plan-

Pass out placement cards. Each group gets one placement card.

Pass out the recording sheets to each student.

Groups will fill their peg boards with matches and will fill out their recording sheet according to the placement card that their group received. After each group has filled out their recording sheet, start with group #1. Have all students observe. Ask group #1 to state the variables of their placement card. All other students will record this information on their recording sheet. Ask the group how they hypothesize the matchstick forest will burn. Nominate a student to be the timer and instruct them to begin timing when you have lit the first row. Use a lighter to light a row according to the instructions on the placement card. Remind the timer to stop when the last match has extinguished. Have students record this on their recording sheets. Do this for each group. Ask students what type of forest is represented by the boards with matches spread apart (ponderosa pine) and what forest is represented by the boards with trees closer together (lodgepole pine). Use some of the terminology from part 1- did any of the groups experience a **stand replacing fire**?

If time allows, these wrap up questions may be completed as group work, or assigned as homework.

Part 3- Campfire Fuels- You will need two pie tins for this.

Choose various fuels to demonstrate their ability to burn. Place these fuels in your “campfire” (pie tin).

Tray 1- One campfire should contain a fine, dry fuel, such as dry grass. (Cheatgrass is an excellent choice and provides a good opportunity to mention that it is an invasive species that has altered the fire regimes of our rangelands in the west.)

Tray 2- One should contain green and heavier, slow burning fuels such as small (<1 inch diameter) branches and green leaves.

Light the campfires one at a time. The dry grass should burn very quickly. Tray 2 will likely be difficult to ignite. If you are successful in lighting it, the larger pieces of fuel will burn slowly.

Discuss how fuel moisture and fuel size affect fire behavior.

Debrief- discuss steps to Firewise a home exterior

Fire Observation Handout

Boise School District 4th Grade Integrated Fire Unit

Name ____

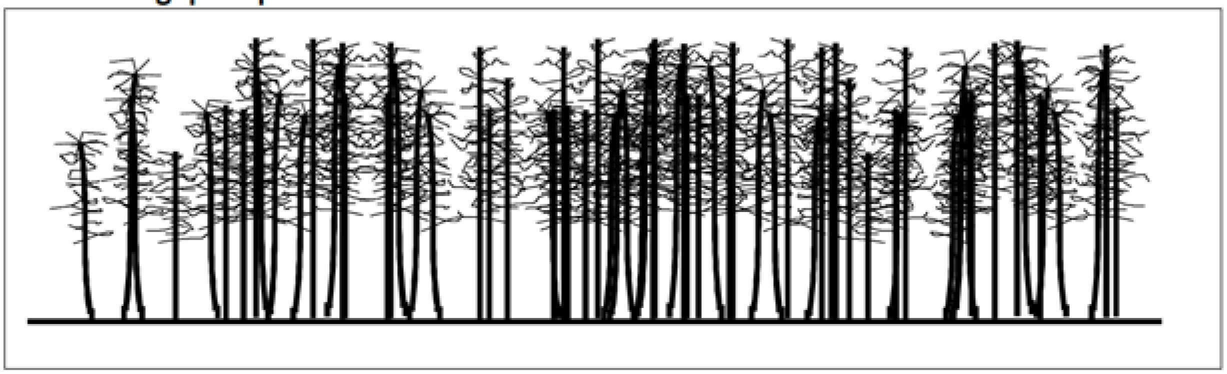
Color each sketch to show a typical fire in this type of forest.

Also write one “fire” observation from the photos.

A. Ponderosa pine:

Observation:

B. Lodgepole pine:



Observation:

Matchstick Forest Group Scenario

Boise School District 4th Grade Integrated Fire Unit

Group 1

On the **small** board, use 35 matches to build a matchstick forest on a **flat slope** with underbrush *tear 1 tissue into pieces. This group can light at any edge.

Group 2

On the **small** board, use 35 matches to build a matchstick forest on a **20 degree slope** (approximately 3-4 inches). This group will ***light the bottom edge*** of the slope.

Group 3

On the **<u>small</u>** board, use 35 matches to build a matchstick forest on a **<u>20 degree slope</u>** (approximately 3-4 inches). This group will ***light the top edge*** of the slope.

Group 4

On the **<u>small</u>** board, use 35 matches to build a matchstick forest on a **<u>40 degree slope</u>** (approximately 6 inches). This group will ***light the bottom edge*** of the slope.

Group 5

On the **<u>BIG</u>** board, use 35 matches to build a matchstick forest on a **<u>40 degree slope</u>** (approximately 6 inches). This group will ***light***

the top edge of the slope.

Group 6

On the **BIG** board, use 35 matches to build a matchstick forest on a **20 degree slope** (approximately 3-4 inches). This group will ***light the bottom edge*** of the slope.

Hot Discussion Questions Worksheet

Boise School District 4th Grade Integrated Fire Unit

Name: ______________________________________

1. How did the slope affect each fire's spread?

   How well did fire burn downhill?

   Did the slope affect how many trees (matches) burned? Explain.

2. What happened when the arrangement of matches was changed?

3. What happened when an understory layer (paper wads) was added to the matchstick forest?

4. How did other changes that you made in the matchstick forest affect the way it burned?

5. How does this experiment/ demonstration of fire behavior differ from fire behavior in a wildland setting?

Lesson 3 –Fire Weather and Climate

This lesson follows Lesson 1, where students learned about human and natural factors that contributed to the 1910 fires, as well as Lesson 2, the campfire fuels experiment, where students observed the difference in burning green vs. dry fuels. At this point students have also learned about the fire triangle. This lesson uses graphs, which students may not have covered yet. It is not necessary for students to have been introduced to graphs before to understand this lesson.

Learning outcomes- Understanding of fire weather, and ability to describe variables that contribute to high fire danger. Interpret graphs of local data to see long term trends in changing climate. Conclude that warming temperatures and less precipitation lead to longer fire seasons, and more opportunity for ignitions.

Standards- 4ESS3-2, MS-LS2-1,MS-LS2-4, MP2, MP4

Key vocabulary- Students will follow along with their worksheets. Vocabulary terms are highlighted (red in Powerpoint). Stop, define, and have students write the definition or term on their worksheet at each highlighted term.

Part 1. Fire Weather

Begin Powerpoint

Slide 1. Ask students if they have seen a sign like this before.

Ask students what kinds of things would make the fire danger high.

Have students try to list 3 things in groups. Encourage them to talk in their groups to discuss possibilities.

Call on several groups to share. Students will likely list things such as- high temperature, lack of rain, lightning storms, wind, etc.

Slide 2. List and discuss these fire weather variables and what part of the fire triangle each of these support. Ask students how each of these contribute to increased fire danger as you go down the list.

High temperature- Heat. High temperature dries out fuels.

Wind- Supplies oxygen and exerts a force on flames, pushing them towards fuels.

Lack of precipitation- Drier fuels have less fuel moisture. Remind students of the campfire fuels experiment in the previous lesson.

Fuel moisture- Drier fuels have less fuel moisture. Remind students of the campfire fuels experiment in the previous lesson.

Humidity- spend a little more time explaining this, as they will likely not be familiar with it. Water exists in 3 phases: solid, liquid and gas. Humidity is the amount of water vapor (gas) in the air.

(Link for information on these variables, just for instructors information, not necessary to show students- Weather Elements (auburn.edu))

Slides 3-5. Definitions of each term. Have students match the term to the definition on their worksheets. Slide 4- Ask students which forest would burn more easily. Ask why. Slide 5- Ask students if they think it would be difficult or easy to ignite a fire in these conditions.

Part 2. Climate Change

Slide 6. Ask students if they have ever seen a site like this in the mountains. Ask students if they know what this is used for. This is a SNOTEL site. SNOTEL stands for snow telemetry. This is just one type of station that we use to collect weather data like temperature, precipitation, and wind speeds. This information can help scientists and water managers to have a better understanding of how much water we have in our mountains, stored as snow, which will melt and flow into lakes and reservoirs in the spring and summer. Winter and spring precipitation, and the timing of the snowmelt are important factors for the fire season. We have 83 SNOTEL sites throughout the mountains in Idaho. Each of these blue dots is a different site, and they are all collecting weather and precipitation data every single day.

This one is located at Moores Creek Summit, about 10 miles up the highway from Idaho City. This site has been collecting data since 1982. We can look at the weather data over long periods of time to see changes that occur. Long term trends in weather are referred to as climate.

Let’s look at some of these long term trends from Mores Creek Summit.

Slide 7. Ask students if anyone can tell you what this is.

This is a graph. As scientists, we often graph our data as a way to better see and understand it. When we look at a graph, the first thing that we do is read the title, which should tell us what is being graphed. Ask someone to read the title of the graph.

Explain both of the axes, and provide a quick overview of how to interpret a graph.

The blue dots are data points. They tell us two things- what the average temperature was and the year that temperature was recorded. Point out a blue dot and show students how to read this data point. Looking straight down, this tells us what year, looking straight across, this tells us what the temperature was. Pick out a new dot and ask students to tell you what year this data point is for, followed by what the average temperature was that year. Repeat a number of times. Point out that in some years the average July temperature is high and other years it is low, so there is a lot of variability. That is why we use a trendline to help us see what the general trend is in the data. The red line is a trendline, which is created using a mathematical equation that looks at all of the data points. Ask students if the trendline is going up or down. Does that mean that the average July air temperature has been increasing or decreasing since the early 1980's?

Let's look at one more graph from this SNOTEL site.

Slide 8.

This graph is showing the amount of water that is stored in the snow, something that we refer to as SWE or Snow Water Equivalent, on April 1st over the same time as the previous graph. Not all snow contains the same amount of water. If you melted a bucket of snow from Bogus Basin and the same size bucket of snow from Sun Valley (use places students will know), and melted this snow, you may have different amounts of water in your bucket. This is why we measure SWE. This is an important thing to measure because it helps us to know how much water we will have in the summer for many things, including for farmers to be able to water their crops. Ask students to read the title on the axes. Point out data points, as before, and ask students to interpret them. Discuss what this trendline is showing.

Ask students what two trends were observed in the data at Mores Creek Summit- warming temperatures and less water stored as snow in the mountains. Unfortunately, we see these trends at SNOTEL sites all over Idaho, not just this one. Ask students what affect these two trends could have on wildfires. Would this lead to more fires or less fires? Have students show thumbs up or down.

Slide 9. Now let's look at how much area wildfires have burned over this same time period in the United States. Read the title and axes titles. Let's look at our red trendline again. Has the area that wildfires have burned gone up or down?

Additional fact- Approximately 85% of wildfires in the U.S. are caused by humans. If time permits, this is a good time to discuss how increased development and the number of people recreating in our forests contribute to this increase in wildfires.

Part 3. Fire Danger Today

Slide 10.

Students will work in the same groups from part 1. Start with Fire Forecasting Video.

Hand out Video Note catcher.

Stop video at 2:15 What three examples contribute to critical fire weather? Winds, Dry Lightening, Dry Fuels.

Play to 3:30 What 4 weather elements go into a fire weather forecast? Sky conditions, Temperature, Humidity, Winds.

Put students into groups of 3 or 4

Hand out a Fire Danger Today spinner to each group. Spinners may be found on Amazon.

Read the following role playing scenario to the students.

You work for the land management agency that takes care of ________. (Pick a location that the students in that particular school will be familiar with- Lucky Peak, Owyhee Front, Boise National Forest, etc.) I will read several scenarios to you and you will decide as a group what fire danger the signs in that area should be changed to.

Remind students to look at their notes regarding fire weather. After each situation ask students to hold up their signs and discuss. For high danger days, discuss what activities should be avoided/what precautions should be taken.

Situation 1.

It is February 6th. A snowstorm has recently dumped 6 inches of fresh snow on the ground. It is 30 degrees and windy. Relative humidity is low. What is the fire danger today?

Situation 2.

It is April 22nd. It is a warm 70 degree spring day. Relative humidity is moderate and there is a light breeze. Snow still covers the mountains, and grasses that cover the lower hills are still green. What is the fire danger today?

Situation 3.

It is June 1st. Storms during the past week have resulted in a total of 1.5 inches of rain. Relative humidity is high. The temperature will reach 78 today.

Situation 4.

It is July 26th. It has not rained in almost 2 months. The high temperature for the day is 100 degrees and temperatures have been above normal for the past month. Relative humidity is low. What is the fire danger today?

Situation 5.

It is August 17th. It has still not rained. Temperatures have remained above normal. The high temperature for the day is 102 degrees. Relative humidity is low. A dry thunderstorm with gusty winds is forecasted for this evening. What is the fire danger today?

Situation 6.

It is October 3rd. Smoke from nearby wildfires fills the air. A couple of rain showers resulted in a small amount of precipitation during September. Relative humidity is moderate. The high temperature for the day is 78 degrees. It is breezy and overcast. What is the fire danger today?

Lesson 3 Vocabulary Terms and Definitions

Match the vocabulary term with its definition.

______Precipitation

______Climate

______Fuel Moisture

______Snow water equivalent

______Humidity

______SNOTEL

A. Condensation of water in the atmosphere that falls to the ground as rain, snow, hail, etc.

B. How much water is in the air, as a gas.

C. The amount of liquid water in the snow.

D. Snow telemetry stations that record snow and climate data.

E. The amount of water in a fuel.

F. Weather conditions over a long period of time.

Fire Weather Forecasting Video

What are three examples that contribute to critical fire weather?

1.___________________________________

2.___________________________________

3.___________________________________

What are the four elements of a fire weather forecast?

1.______________________________________

2.______________________________________

3.______________________________________

4.______________________________________

Curricular Aims:

Students will gain an understanding of the weather variables that contribute to fire weather, long term trends in weather, and the ability to interpret graphed data.

Grade Level:

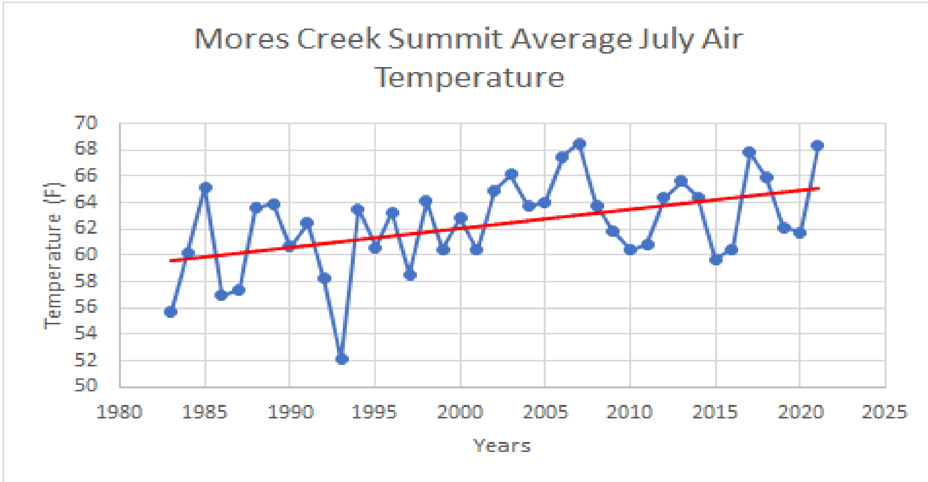
4th grade students, following a lesson on how climate affects wildfire regimes.

Directions: Answer each of the questions to the best of your ability. This should take approximately 15 minutes to complete.

1. Humidity is an example of water in which phase? _______________________

2. Weather conditions over a long period of time are referred to as (or called) _______________________.

Use the graph below to answer the following questions (3 & 4).

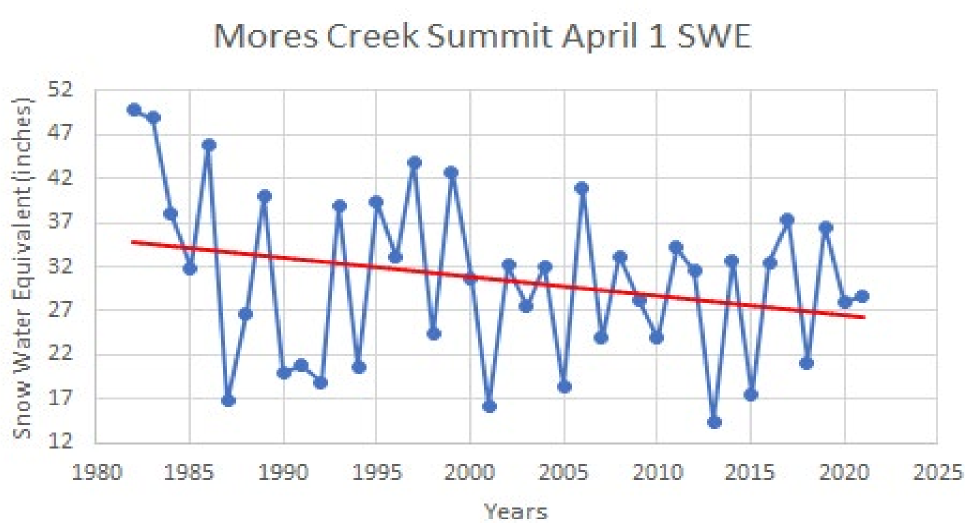


3. What was the average July air temperature at Mores Creek Summit in 2010?

____

4. The trend for the average July air temperature at Mores Creek Summit, since the early 1980's is ________________________. (Increasing or Decreasing)

Use the graph below to answer the following questions (5 & 6).



5. What was the Snow Water Equivalent (SWE), in inches, at Mores Creek Summit on April 1, 2015?

   ____

6. In one word, describe the trend in the amount of Snow Water Equivalent, at Mores Creek Summit, since the early 1980's.

   ____

Essay Question: How has the average July air temperature at Mores Creek Summit changed over time? How could this impact wildfires? What are some weather conditions that lead to fire weather, or a high fire danger? Answer in at least 6 sentences.

Lesson 4- Post Fire Erosion and Managed Revegetation

This lesson is an adaptation of the Fireworks Educational Program Northern Rocky Mountain and Cascades Curriculum, M10:Fire, Soil, and Water Interactions, which can be found here: www.frames.gov/fireworks/home.

Duration: 1 Hour

Standards: 4-ESS2-1, 4-ESS3.B

Learning Outcomes:

Students learn about post fire erosion through the observation of a soil and water demonstration and through learning about the Pony and Elk Complex Fires, which occurred in the Danskin Mountains of Idaho in 2013.

Slide 2- Have students look at the image of a burned forest and ask them to discuss in groups what happens to a forest after a fire. What are some good things that could happen next? What are some hazardous things that could happen next? Call on groups to share out. Ask students to make observations about the image. Try to lead students to the observation of the white lines in the lower right hand corner and ask what caused those linear features. This is where a fallen tree burned. The white ash indicates that the carbon was completely consumed in the fire. Ask students if they think the soil burn severity for the soil directly beneath these lines would be greater or less than the other areas. Make the connection back to the campfire fuels experiment. Light, quick burning fuels, such as grasses, likely will not result in high soil burn severity, however slow burning fuels will result in high soil burn severity.

Slide 3- Continues on with the explanation of soil burn severity. This depends on the amount and duration of the heat. Ask students which scenario they think would produce the highest burn severity and why.

Slide 4- Another image where this is visible. Ask students where they think the highest soil burn severity likely occurred. You may use the following discussion questions from the Fireworks Educational Program: **Discussion:** Can you find patches that show no evidence of fire? How about patches that are "lightly burned" – that is, the ground surface is black and some woody fuels remain? How about patches that are "severely burned" – that is, the ash is completely white (no carbon left) and woody fuels are nearly gone? The lines of thick white ash, where the logs were before the fire, are places where the soil probably experienced hotter temperatures for longer periods of time than most of the other areas in this photo. That is, the areas underneath the logs experienced very high soil burn severity.

Slide 5- There is a lot going on in this photo which does not need to be covered for the 4th grade level. What students should take away from this is that the burning of vegetation will result in a waxy layer being deposited just under the surface of the soil. This layer does not allow water to penetrate through it. Point out that water repellent layer after the fire (hydrophobic soils). This usually occurs anywhere from a few centimeters to a couple of inches under the soil. Diagram a hillslope on a white board with a line under the surface for the hydrophobic layer. Ask students what they think would occur if there is a rainstorm on this hillslope now? Students should be lead to the realization that the saturated material will begin to slide down. This is what forms a **debris flow**.

Perform the water in containers experiment or watch (1678) Erosion and Soil - YouTube

Discussion: Why did the example with the grass have the least amount of dirt wash out of it? Vegetation helps to hold the soil together. What do you think would happen on a hillslope if we had the combination of loss of vegetation from a fire, hydrophobic soils, and a rainstorm?

Slide 7- Play USGS video. Discuss the changes that occur during the video. If time permits start over for a moment to remind students of what it looked like at the beginning.

Slide 8- Discuss the images on slide 6. This debris flow occurred in Montecito, CA, which lies at the bottom of the hills, following a fire and a rainstorm event.

Slide 9- Show Video about Pony and Elk Complex Fires. Use this handout to follow along with. Play the first video to 6:00 (If time allows, play to end), then show the second video and fast forward to 5:45 and play to end, to see the more recent restoration results

Video 1- Restoring the land after the Pony and Elk wildfires – Focus on BLM and USFS rehab techniques – Idaho Rangeland Resource Commission (idrange.org)

Video 2-Restoring Rangelands in the Danskin Mountains of Idaho – Idaho Rangeland Resource Commission (idrange.org)

1. The Pony and Elk Complex fires began from ______________ and high heat.

2. Why did the ranchers have to remove their cattle for 2 years after the fire?

____

____.

3. The Emergency Response Strategy prioritized three things when crafting their recovery plan.
   1. ____ and safety.
   2. ____________________________________ stabilization.
   3. Threatened and endangered ______________________________________.

4. What was one way they tried to bring back plants to the area?

____

____.

5. How many inches of rain fell to produce a debris flow?_________________________

6. What type of groups volunteered to plant trees and shrubs along the South Fork of the Boise River?

____.

7. Were the recovery efforts successful?____

____.

Habitat- the natural home of an animal, plant or other living thing.

Lesson 4- Selected Response Assessment

Purpose- To determine whether 4th grade students have mastered the curricular aims at the end of Lesson 4.

Curricular Aims- Understanding of fuel properties and how these relate to natural hazard impacts.

1. Soil burn severity will likely be greatest (worst) when there is/are: (Circle correct answer)

   A. More fast burning fuels on the ground.

   B. More slow burning fuels on the ground.

   C. More fuel moisture.

   D. Less fuel moisture.

2. Burned soil that loses its vegetation can experience:

A. More fires

B. Better grazing areas for cattle

C. Flooding and erosion

D. All of the above

3. The top priority in an emergency response strategy plan is:

A. Stabilizing the soil

B. Human life and safety

C. Threatened and endangered species

4. If all of the fuel in both of these images were to be consumed in a fire, which would result in higher soil burn severity?

A.

B.

Photo’s from the Fireworks Educational Program, Northern Rocky Mountains and Northern Cascades- M10: Fire, Soil, and Water Interactions (Fireworks Educational Program, 2021)

5. Fuels burn more easily if they have ____________ fuel moisture.

   a. High

   b. Low

6. Soil burn severity depends on the amount and duration of heat.

   a. True

   b. False

7. Match the term on the left with the BEST description on the right.

A.	Fuel Moisture	Occurs on hillslopes following fires
B.	Precipitation	Caused by the burning of organic material
C.	Hydrophobic soils	Decreases during periods of heat and drought
D.	Debris Flow	Absorbed better by soils with vegetation
		Will increase soil burn severity

Lesson 1-4 Assessment Questions

Lesson 1

1. The 1910 Big Burn occurred in: (circle the correct answer)

    a. Canada

    b. Idaho

    c. California

    d. Oregon

2. List 3 weather (natural) factors that contributed to the spread of the 1910 fires. Wind, Lightening, Drought

3. What 3 things are needed to create fire? Oxygen, Heat, Fuel

4. 

The flame in this photo will continue to burn until all of the _________ has been consumed. Oxygen

Lesson 2

1. Circle the correct answer: In _________forests trees are more widely spaced.
    a. Lodgepole Pine
    b. Ponderosa

2. Fires usually spread more quickly _________.

a. Uphill

b. downhill

3. Fuels burn more easily if they have (low/high) fuel moisture.

4. An example of making your home Firewise is: Circle all that apply.

a. Taking out your trash

b. Removing dry and flammable fuels from around your home

c. Keeping your grass green and mowed

d. Trimming or thinning your trees

5. In which forest do you predict fire will spread more easily:

A. (Image of dense logepole pine forest)

B. (Image of ponderosa pine forest, with trees spaced further apart than in image A)

Lesson 3

1. Since the early 1980's. The amount of area burned by wildfires every year has:

   a. Decreased

   b. Increased

2. List two variables that contribute to high fire danger (fire weather).

1. ____Drought, high heat, dry lightning, high wind, other answers may be acceptable__

2. ___________________________________

3. The long term trend in weather is called:

a. Meteorology

b. Temperature

c. Climate

d. Precipitation

4. Data from local SNOTEL sites show that the average July air temperature has ___________, since the early 1980's.

a. Increased

b. Decreased

5. Data from local SNOTEL sites show that the amount of water in the snow has ____________, since the early 1980's.

a. Increased

b. Decreased

Lesson 4

1. Soil burn severity will likely be greatest (worst) when there is: (Circle correct answer)

   A. More fast burning fuels on the ground.

   B. More slow burning fuels on the ground.

   C. More water in the soil.

   D. Lightning caused fire.

2. Burned soil that loses its vegetation can experience:

   A. More fires

B. Better grazing areas for cattle

C. Flooding and erosion

D. All of the above

3. The top priority in an emergency response strategy plan is:

A. Stabilizing the soil

B. Human life and safety

C. Threatened and endangered species

4. Which of these pictures do you think would experience higher soil burn severity?

A.

B.

5. Precipitation is better absorbed by soil (with/without) vegetation. (Circle the correct answer)

6. After a fire, water can easily erode a slope, triggering a

__________debris flow__________________.