

AN ABSTRACT OF THE THESIS OF

Sylvan Pritchett for the degree of Master of Science in Forest Ecosystems and Society presented on June 1, 2020

Title: Defensible Space Development: Exploring The Role of Arborists in Wildfire Risk Mitigation for Communities of the Pacific Northwest

Abstract approved: _____

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Every year in North America homes in the Wildland-Urban interface (WUI) are destroyed by wildfires. The creation of defensible space around homes in the WUI, through the management of vegetation can help mitigate some of the risk posed by fire. While many homeowners recognize the need for defensible space around their homes, oftentimes work to manage vegetation goes undone. Homeowners cite a variety of reasons for this including a lack of capacity, expertise and equipment necessary to perform defensible space development (DSD) work. Green industry professionals such as arborists have the potential to help homeowners in the development of defensible space around homes in the communities they serve. This research uses an exploratory quantitative approach to determine to what extent commercial arborists in the Pacific Northwest (PNW) (Alaska, BC, Washington, Idaho, Oregon) are currently working to develop defensible space in their community, how they see a need or value for wildfire risk mitigation in their community, and if training or education related to DSD work would be of value to their business. The results of 229 valid responses to an online survey distributed to 3994 e-mail addresses through the PNW International Society of Arboriculture (PNW-ISA) chapter

listserv indicate that there is a small contingency of arborists working in the PNW who regularly work to mitigate wildfire risk in their community and are interested in continuing education and training related to DSD work. There is a nearly equal population of arborists who are not currently working to create defensible space around homes, but are none-the-less interested in learning more about wildfire risk mitigation and wildfire science. Professional organizations such as the PNW-ISA have an opportunity to fill an educational need for arborists working in the PNW by providing training and education related to wildfire risk mitigation which will support the growing need for defensible space development and help to protect homes from wildfire.

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Defensible Space Development: Exploring The Role of Arborists in Wildfire Risk Mitigation
for Communities of the Pacific Northwest

by
Sylvan Pritchett

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I understand that my thesis will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my thesis to any reader upon request.

Sylvan Pritchett, Author

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Chapter 1: Introduction

Every year in North America, hundreds of homes in the wildland-urban interface (WUI) are consumed by wildfires (Calkin et al. 2014). A legacy of fire exclusion and the growth of the WUI, coupled with climatic shifts in many parts of the continent will increase the likelihood of home loss due to wildfire (Cohen 2008). Defensible space development (DSD), the management of vegetation around homes and communities, can significantly reduce the severity and intensity of flames, thereby mitigating some of the risks posed by wildfire and saving homes from destruction (Bright and Burtz 2004). The work to manage vegetation for defensible space around homes goes undone for a variety of reasons, leaving property exposed to potential loss (Absher et al. 2013). This research, focused on the Pacific Northwest (PNW) region of North America (Oregon, Washington, Idaho, British Columbia, Alaska) will explore if and how arborists are working in their communities to mitigate wildfire, how arborists perceive their role in vegetation management for fuels reduction, and the potential benefit they may receive from education or training related to defensible space development and wildfire science.

1.1 Fire in the Pacific Northwest

Fire is one of the primary landscape-level disturbances that impact the forest ecosystems of the Northwest, resulting in a dynamic mosaic of forest structure and species composition across the region (Agee 1993; Lertzman et al. 1998, Taylor and Skinner 1998, Everett et al. 2000). The widespread suppression of fires in the Northwest coupled with changes in forest structure from timber harvest over the past century has resulted in the loss of a significant force of ecological change and precipitated shifts in forest structure and composition. This shift in the forest mosaic

has prompted an increase in exceptionally severe wildfires in dry forest ecosystems when they escape suppression (Hessburg et al. 2000). In addition to alterations of forest composition, the fuel for wildfires, changes in climatic conditions in the Northwest are leading to more extreme wildfires (Gedalof et al. 2005) and altered fire regimes in many high fire frequency landscapes of the western U.S. The changes in severity and intensity of fires in combination with an expanding wildland-urban interface in the Northwest contribute to more home loss from wildfires, an issue that is likely to continue growing for homeowners (Radeloff et al. 2018). Alterations in forest structure through fuels management can contribute to changes in forest fire behavior on a landscape scale potentially saving homes from destruction (Ager et al. 2014). A comparison of burn probability following investments in fuel treatments on National forest land and fuels management in the urban interface indicates forest management in the wildlands close to homes can influence fire behavior (Ager et al. 2010). Other perspectives indicate that fuel treatment on National Forest land does little to mitigate wildfire risk to homeowners but indicates that vegetation modification in the WUI, immediately adjacent to and within 100 feet of structures had the greatest impact on survivability of a building following a wildfire event (Scott et al. 2016; Syphard et al. 2014).

1.2 Firewise & The Home Ignition Zone

In 1985, after an especially destructive fire year, the WUI fire problem was identified and recognized on a national level (Cohen 2008). The response to the WUI fires resulted in a collaborative conference between the US Forest Service (USFS) and the National Fire Protection Association (NFPA) (Cohen 2008). The conference, *Wildfire Strikes Home*, was organized to

confront the issues surrounding wildfire and the loss of property. The conference resulted in an initiative that led to the development of the Firewise USA program.

The NFPA Firewise USA® is a national program aimed at teaching people how to adapt to living with wildfire (NFPA 2019). Firewise USA®, and its Canadian counterpart FireSmart guides homeowners about ways to reduce the risk of property loss from wildfire. The program covers a variety of topics relating to ways in which wildfire might impact a home or community. Wildfire risk reduction steps outlined by the Firewise program are divided into two primary sections: fire resistive home construction and vegetation management, also, referred to as defensible space. Firewise activities, such as debris removal and vegetation management, are common approaches to reducing wildfire risk within the home ignition zone (HIZ), the area typically within 100 ft. (~30m) of the home (Cohen, 2001). It is worth noting that fire-resistant home construction is just as important as landscape fuel vegetation management to the survival outcome of a home during a wildfire (Syphard et al. 2017). Additionally, it is often embers blown in ahead of a wildfire flaming front that ignite debris in and around the home resulting the loss of a structure (Koo et al. 2010). The combination of fire-resistive construction and defensible space development around the home contribute to making a home and community Firewise®.

Vegetation management for wildfire risk reduction involves maintaining landscaping within the home ignition zone (HIZ) in a way that alters potential fire behavior and facilitates firefighting efforts. The home ignition zone, generally the area within 30 meters of a building, often has landscaping and ignitable debris that could transmit flames to a structure and make fire

suppression efforts costlier and difficult (Calkin et al. 2014). Creation of a *defensible space* within 30 meters of the home through vegetation and debris management has a significant impact on fire behavior, home ignition, and firefighter safety (Syphard et al. 2014). The National Fire Protection Agency (NFPA) provides guidelines on how a homeowner can develop defensible space around their home by reducing the flammable vegetation that could expose a home to fire (NFPA 2019). The Firewise program merely provides suggestions for actions to take to reduce wildfire risk, it is ultimately the homeowner's responsibility to apply the Firewise program recommendations to their property and create defensible space to reduce exposure to wildfire. Research has shown that residents in fire-prone communities understand the importance of creating defensible space and are willing to engage in activities to reduce the risk of home loss due to wildfire (Brenkert-Smith et al. 2006; Bright and Burtz 2004).

Although there are many homeowners who understand and engage in Firewise activities, there are sometimes limitations on the ability and willingness of some individuals to perform vegetation management on their property; for instance, techniques involved in tree removal often require specialized skills and equipment. A survey distributed to Colorado residents aimed at understanding the barriers to adopting Firewise actions found that; time commitment (to perform the work), impact on aesthetics, and lack of specialized equipment were significant barriers to creating defensible space around homes (Brenkert-Smith et al. 2006). Household Income of residents is a significant predictor in the adoption of some defensible practices like the removal of dead limbs, leaves, and debris. Respondents in the \$50,000 or lower household income categories were more likely to engage in these activities (Absher et al. 2013). A study of residents following the destructive Four-Mile Canyon fire in Colorado indicate that residents

understand the need for defensible space development (Brenkert-Smith and Champ 2011); However, it seems that it is time, not money, that is the limiting factor in mitigating wildfire risk on their property (Brenkert-Smith and Champ 2011). Even when homeowners in the WUI understand the risk that wildfire poses to property, they decide not to engage in vegetation management around their homes for fear of losing other essential values like privacy, wildlife, and aesthetics (Absher et al. 2009; Bright and Burtz 2006). The barriers to engaging in the defensible space activities, as well as the homeowners' understanding of the importance of wildfire risk management, indicates there may be a market for arborists to provide wildfire risk reduction education and services to homeowners living in the WUI.

1.3 WUI Entrepreneurs

As forests become increasingly fragmented and the WUI continues to expand around the cities, towns and rural areas in the Northwest (Radeloff et al. 2018), opportunities for entrepreneurs to conduct work for property owners in the WUI will increase. Despite motivational barriers to the adoption of wildfire risk mitigation actions by homeowners, research has shown that homeowners are willing to hire contractors to engage in defensible space development on their property (Fried et al. 1999). Homeowner cost-share programs for chipping and hauling services have proven effective in getting homeowners to participate in vegetation management on their property (McCaffery 2004). Community policies encouraging defensible space management through financial incentives can help offset the direct cost to homeowners for adopting measures to reduce their risk (Winter et al. 2009). The adoption of local ordinances for wildfire risk reduction around homes enforced with fees or penalization for non-compliance can prompt homeowners to conform to standards for vegetation management (Vogt et al. 2005).

Homeowners who are willing, or compelled through local mandates, to perform vegetation management on their property still have various barriers to completing the work, namely time and capacity. Professionals working in the WUI have the opportunity to fill the gap in demand for the defensible space development work on properties in the WUI.

Entrepreneurs working on private forested WUI properties are often from scaled-down forestry operations or scaling up from the landscaping industry to fill a niche market of forest management for homeowners. Landscaping professionals, have the appropriately scaled equipment, people skills, and business plans necessary to conduct work for homeowners in the WUI but lack some of the technical skills relating to silviculture and ecosystem management that professional foresters are likely to have (Hull and Nelson 2010). Professional organizations that support the landscape industry can provide the necessary training to entrepreneurs working in the WUI.

1.4 Education and Training

Landscape industry professional organizations like the International Society of Arboriculture (ISA) provide the opportunity to fill the education gap and improve the skills of arborists interested in expanding their business operations in the WUI. The ISA is a non-governmental, fee-based membership organization operating worldwide that promotes the professional practice of arboriculture through research, technology, and education. It has developed a variety of certifications and qualifications for tree care professionals (ISA 2020). To stay current in the field and maintain an ISA certification or qualification, individuals must obtain continuing education credits through ISA approved workshops, online modules, and conferences. The ISA

is divided into smaller regional chapters; each chapter is responsible for providing localized region-specific training and conference opportunities for the members in the area. The Pacific Northwest Chapter of the International Society of Arboriculture (PNW-ISA) covers the Pacific Northwest region of North America and includes Alaska, British Columbia, Washington, Idaho, and Oregon. The PNW-ISA chapter hosts numerous in-person and online training workshops and continuing education credit opportunities covering a wide variety of subjects on issues that arborists face in the PNW. As of yet, like most ISA chapters, the PNW-ISA does not provide any formal recommendations or training to arborists working in wildfire-prone communities in the Northwest, specifically defensible space development. A pilot program for wildfire risk education in Texas, was developed by the Texas ISA Chapter and the Texas A&M Forest Service with the goal of training ISA certified arborists to identify wildfire risk for homeowners (ISA Texas 2020). The resulting Texas Wildfire Risk Reduction Qualification (WRRQ) was developed in response to an especially destructive fire season in 2011 when nearly 3,000 homes were destroyed in Texas (Jones et al. 2011). The course intends to inform arborists about ways they might help homeowners to mitigate the risk by creating defensible space around their homes. The curriculum was developed for the WRRQ course, and it was beta-tested in December of 2017. There was no pre-course development survey used to assess the needs of arborists in Texas or to identify the potential extent of the risk assessment program before the launch of the WRRQ program. There is an opportunity in the PNW to assess the needs of arborists working in wildfire-prone communities and to determine if a similar Wildfire Risk Reduction curriculum would be fitting for implementation in the PNW-ISA chapter.

1.5 Hypothesis

As the communities of the PNW grow, the wildfire issue in the wildland-urban interface will continue to expand, and more homes will be a risk of loss from wildfire (Radeloff et al. 2018). Defensible space development in the landscape around homes can mitigate wildfire risk and is a key tool in an adaptive approach to dealing with inevitable wildfires (Schoennagel et al. 2017). However, homeowners are not always capable of implementing the various vegetation management techniques necessary to create defensible space on their property. Arborists have an opportunity to provide a service to homeowners in the WUI and use their training and equipment to help prepare properties for potential wildfires. Currently, little is understood of how commercial arborists are contributing to wildfire risk mitigation in communities and if they would benefit from education or training about defensible space development. Assessing the wildfire risk mitigation perceptions, values, and educational needs of arborists in the PNW is the first step in determining if they are capable of or have the desire to work to develop defensible space in their community.

The research was designed to test two hypotheses:

- H1: Arborists currently working to mitigate wildfire risk in their communities will be more likely to value and see a need for defensible space development work, and
- H2: Arborists currently working to develop defensible space will more likely support educational opportunities relating to defensible space development

The research assesses the type and extent of wildfire-related educational programming that would be of value to arborists working the PNW and act as a needs assessment for arborists

operating in the PNW. The study attempts to capture two main components of a needs assessment model, the explanation and prioritization of needs, and the analysis of possible resources and solutions to fill the gap (Kaufman et al. 1981). The data identifies to what extent arborists are working to develop defensible space in their community, and if educational programming related to Firewise programs or wildfire risk mitigation around homes are of value. Potential resources and solutions to the knowledge gap are offered in the survey instrument.

Chapter 2: Methods

This research utilizes an exploratory quantitative method to determine to what extent arborists in the PNW-ISA chapter (Alaska, B.C., Washington, Idaho, Oregon) are working to develop defensible space in their communities and what continuing education related to wildfire science would be of value. A qualitative method of data collection through interviews and focus groups may have produced more in-depth detail about what arborists may need in terms of DSD work. However, the geographic scale of the PNW-ISA Chapter made this impractical. Subsequently, this research used a quantitative survey because of its ease of distribution and ability to assess a larger population across the broad and geographically diverse PNW region. According to the U.S. Bureau of Labor Statistics and Statistics Canada, there are 56,000 people employed in the landscaping and groundskeeping industry between the four states and province of the PNW (U.S. Bureau of Labor Statistics 2020; WorkBC,2020). Tree trimmers and pruners, which include arborists, is a sub-category of the landscapers and groundskeepers sector. Data for employment numbers of tree trimmers and pruners was only available for Washington and Oregon, each of which has 1070 and 700 tree trimmers and pruners, respectively (USBLS 2020). The data collection instrument will assess just a small portion of the total population of arborists and landscapers in this region. The initial survey assessment will determine if continued investment in a wildfire science or defensible space development curriculum would be justified.

2.1 Survey Development & Design

The survey "Arborists and wildfire risk mitigation in the Pacific Northwest" has 32 response items organized into three sections: 1) *Work and knowledge of wildfire risk reduction*, 2) *Education and training for wildfire risk reduction*, and 3) *Demographics*. (Appendix A)

Section 1) *Work and knowledge of wildfire risk reduction* include questions about actions taken to reduce wildfire risk around homes and the perceptions of wildfire risk in the community, questions in this section were adapted from surveys designed for homeowners living in wildfire prone areas (Brenkert-Smith et al. 2006; Absher et al. 2013; Brenkert-Smith and Champ 2011; Absher et al. 2009; Bright and Burtz 2006) and include inquiry into tasks related to defensible space development as outlined in the Firewise USA® program (NFPA 2020). Survey questions in following section; 2) *Education and training for wildfire risk reduction* are framed around primary topics in the Fire Science Core Curriculum, an existing wildfire risk reduction curriculum designed for homeowners living wildfire prone communities in Oregon (Berger et al. 2017) additional arborist-specific questions were borrowed from the the Texas ISA wildfire risk qualification course curriculum (ISA Texas 2020). The final section, 3) *Demographics*, gathers details on business size, location, and credentials represented in the arborists business; information about individual arborists that the PNW-ISA chapter does not collect.

Prior to distribution, the survey questions were reviewed and edited by representatives from the ISA, Texas ISA chapter, and an arborist working in defensible space development for homeowners outside of the PNW-ISA region. The survey was approved by the OSU Institutional Review Board (IRB) to ensure the instrument met the standards of ethical human subjects research set forth by Oregon State University. The survey participants were given a consent notice (Appendix A) before the survey. The survey device attempts to capture the population of commercial arborists that are working for individual homeowners, as opposed to municipal arborists working for a city urban forestry or parks and recreation department. Municipal arborists are excluded from data collection primarily due to the focus of Firewise programmatic

material, which is primarily focused on the homeowner. A municipal forester, for whom wildfire science and defensible space development course work may be of value, but whose work is directed on a city level via an urban forest management plan. This exclusion of municipal foresters from data collection will also help in further identifying how homeowners living in the WUI or commercial arborists themselves might be promoting defensible space management.

2.2 Work and knowledge of wildfire risk reduction

This section contains questions designed to assess survey participants' familiarity and perceptions about wildfire risk-related concepts and the tasks they perform related to defensible space development. The questions are organized into two primary types; multiple choice and text entry. The multiple-choice questions had a single answer and multiple answer selection options. The single answer questions are further divided into bi-variate and Likert-type scales. Of the four text entry questions in the survey section, two are attached as "other" categories in multiple answer responses, and two are open-ended qualitative questions.

The survey participants' familiarity and perceptions about wildfire risk issues are measured in the first section of the survey. Respondents were asked questions relating to the WUI, defensible space development, funding opportunities for wildfire risk mitigation, and how DSD relates to their business, and how they view wildfire issues in their community. The multiple-choice questions are further divided into single answer Likert-type scales, bi-variate responses, and multiple answer questions. The single answer questions related to perceptions and familiarity with wildfire risk reduction are Likert-type scales, from "strongly disagree" to "strongly agree". In addition to familiarity with wildfire risk-related concepts, the first section gathered

information about the tasks and frequency of work arborists perform directly related to defensible space development.

The second portion of the survey quantifies what educational programming about defensible space development would be of value to arborists and how they perceive the benefits of a potential credential related to wildfire risk mitigation. Additional questions about when and what format a training event would be best for the participant are identified, and finally, an open-ended question assessing the perceived needs of the arborists working in the WUI is included at the end of the section.

2.3 Potential Educational Coursework

In addition to assessing the potential value and desire for training related to defensible space development, the survey collected information on the preferred format and duration of a potential workshop or training module. Continuing education credits are a necessary part of maintaining an ISA certification, and identifying the most appropriate mechanism for delivering training materials will ensure the courses developed will satisfy the training needs of the tree care professionals. The PNW-ISA currently offers continuing education (C.E.) credit qualifying courses through the ISA website via online modules and offers in-person workshops throughout the PNW-ISA region or attending the annual PNW-ISA conference. The PNW-ISA chapter has offered courses related to wildfire science and defensible space development in the past in partnership with OSU extension. However, at this time, there are no classes offered on a regular basis.

2.4 Demographics

The third and final section of the questionnaire collects demographic information about the survey participants. Details about business size, number of employees, ISA credentials represented in the business, and the size of the community they service are collected on single and multiple answer options. The final part of the last section includes a text box where the respondent has the option to write in any thoughts about the survey - offering a quantitative data collection in an otherwise predominantly qualitative survey.

2.5 Geolocation of Survey Participants

The PNW-ISA chapter covers a broad geographic region, from the inland and semi-arid Idaho, through the coastal rainforests of British Columbia and into Alaska. Variability in the climate results in many different forest types, subsequently impacting the needs of arborists working across the diverse PNW-ISA region. Collecting information on the location of survey participants will be useful in identifying concentrations of arborists involved with defensible space development, inform the creation of inter-regional programming for arborists, and help identify areas of need within the PNW. Qualtrics collects the latitude and longitude of the I.P. address for the survey participants; I.P. address information does not give the precise location of each survey respondent. However, it will provide a general location of the arborists at the city level. This geolocation information will help determine the course content design and the appropriate method of delivery of region-specific defensible space development content.

2.6 Survey Distribution

The survey was created using Qualtrics™ and was distributed through a .html link to PNW-ISA chapter members via e-mail. The PNW-ISA chapter database is the primary means of e-mail communication that the chapter uses to contact arborists. The database contains e-mail addresses for current and former chapter members, current and former certified arborists, allied professionals, and both commercial and non-commercial arborists. The PNW-ISA does not maintain a separate database of commercial arborists. In order to narrow down the list of potential survey respondents, the PNW-ISA staff filtered the e-mail list and excluded e-mails with a .gov, .ca, and .edu suffix. Using the resulting e-mail list, the survey link was first distributed to 3994 e-mail addresses along with a brief statement of intent on November 1, 2019, and a second reminder e-mail with the attached link and statement was sent on November 18, 2019. The link to the Qualtrics™ survey and the data collection period was active from the 1st to the 30th of November.

2.7 Statistical Analysis

The statistical software platform SPSS was used to re-code and organize survey response data, assess descriptive statistics, and evaluate relationships between response variables. The system and user-missing or unfinished surveys were excluded, retaining 229 of the 276 surveys collected out of the 3994 distributed. The categorical question "How often do you work around homes to develop defensible space" was re-coded into a new dichotomous variable "workforDSD", 1 = any work performed (1-100%) and 0 = rarely or never (0% or no work performed). The development of a new dichotomous variable allows for a t-test comparison between arborists who conduct defensible space development as a component of their work and those who do not

The text responses to the two primary open-ended survey questions, "What do you think are your 3 main needs as an arborist when it comes to working in the wildland-urban interface?" and "Are there any thoughts you have about this survey you would like to include?" were analyzed with the qualitative analysis software program, NVivo. The responses to each question were individually coded with NVivo and organized into groups based on shared themes and related concepts.

2.8 Value in Defensible Space Development

Each part of question 9 and question 10 in the survey assesses how the participant perceives the need for or value of defensible space development work in their community and how their business can fill the need gap. Perceptions about wildfire risk and how work and training related to defensible space development might benefit their business will help identify in what ways participants might be motivated to reduce wildfire risk in their community. As no single variable on a survey is a good measure of a complex concept such as perceived benefit of DSD work, a composite index of multiple survey items related to wildfire risk mitigation will give a more comprehensive view on how survey respondents view the value of the work. Reliability between the last four parts of question 9 and question 10 (inverse coded) will be measured and combined into an additional continuous variable "valueneedDSDwork". The Cronbach alpha (α), the average correlation of survey questions associated with the concept, will be used to determine if the survey responses are sufficiently related in order to justify combining the variable into a new composite index. An acceptable Cronbach alpha ($\alpha \geq 0.65$) from the reliability test indicates a new variable "valueneedDSDwork" can be developed and used for further analysis, specifically

a comparison between arborists who conduct DSD work and those who do not. This new variable (scale 1-5) is used in assessing how arborists perceive the value and need for defensible space development work in their community.

2.9 Course Material

Question 17 of the survey is a collection of multiple-choice questions aimed at determining which wildfire science courses would be of interest to arborists. Four of the five categories in question 17 are written based on content in modules in the Fire Science Core Curriculum developed by OSU Extension (OSU, 2017) and the ISA Texas wildfire risk reduction qualification course (WRRQ, 2020). The last part of question 17 aims at determining if the respondent would be interested in a credential or qualification as a component of the wildfire science course, similar to that offered by the Texas chapter of the ISA. A reliability analysis between each part of question 17 identifies how the components are related in any part of question 17 that might not belong with the others. A Cronbach alpha ($\alpha \geq 0.65$) indicates an acceptable level of inter-item correlation and will allow the five separate elements of question 17 to be combined into a new continuous variable "*FireScienceCurriculum*".

2.10 One-Way ANOVA of arborists who perform DSD work

A One-way ANOVA was used to test the hypothesis(s) (H1) that arborists who perform defensible space development work will value work related to DSD and (H2) arborists who perform DSD work will support education related to DSD development. The dichotomous independent variable *workforDSD* (n=229) divides the survey participants into two groups of those who perform DSD work as a part of their job (n=129) and those who do not (n=100). The

grouping variable *workforDSD* tests differences and the effect size between the two new continuous dependent variables, *FireScienceCurriculum*, and *valueneedDSDwork*.

2.11 Survey Response

The online survey was open for a month from November 1 to November 31, 2019. The first e-mail link to the Qualtrics™ survey was delivered to 3994 individual PNW-ISA listserv e-mail addresses. Of the 3994 individuals that received the e-mail, 1582 (39.6%) were opened and 179 (4.5%) of the recipients clicked on the link to the survey. For the reminder e-mail delivered to the same listserv, 1293 (32.4%) of the recipients opened and 143 (3.6%) clicked on the link to the survey. Both the total recipient numbers and the number of e-mails opened are displayed above. In order to retain anonymity with the data collection device, personal identification information was not collected. There is no way to determine if e-mail recipients that clicked on the initial e-mail or filled out the survey also clicked on the second e-mail or filled out the survey more than once. After filtering out unfinished surveys where respondents failed to complete a majority of the questions, there were 229 valid responses.

The survey respondents were asked to state which state or province within the PNW-ISA chapter region they conducted most of their business. This question allows arborists who might live in one state and do a majority of their work in another to list their primary work location. Oregon had the highest response rate with 84 (36%) arborists submitting complete surveys, Washington represented 81 (35%) of the 229 valid responses, followed by British Columbia with 49 (21%), Idaho with 23 (10%), and Alaska with 7(3%). While there is a definitive number of survey e-

mails distributed to the PNW-ISA listserv (3994), the PNW-ISA does not keep records of the proportion of arborists working in each region of the chapter.

2.12 Justification for Research Design and Approach

This research follows an extensive needs assessment model, as outlined by Roger Kaufman (Kaufman et al. 1981). It is worth noting that the questions used in the survey instrument borrow heavily from theory-based quantitative and qualitative research. Concepts from studies on homeowner behavior, motivation, and perceptions about wildfire-related issues (Wolters et al. 2017; Miller et al. 2013; Brenkert-Smith et al. 2006; Nelson et al. 2004) and entrepreneurial opportunity identification (Ardichvili et al. 2003) and entrepreneurs (Hull and Nelson 2001) were adapted to study arborists and wildfire risk mitigation around homes for this study.

Established theory often forms the basis of social science research. It guides the development and design of studies (Creswell 2009). This project does not test a single theoretical construct and has no theoretical construct validity. Elements of the research methods and analysis, such as the development of new variables through reliability analysis, imitate methods often used in ensuring construct validity in theory-based social science research. In this analysis, this approach serves to consolidate related wildfire risk mitigation related concepts. Grouping the dependent survey response items into *FireScienceCurriculum* and *valueneedDSDwork* streamlines comparison to the dependent *workforDSD* variable.

The convergent validity between variables is tested through correlations between response variables. The results show a positive inter-item correlation between concepts related to wildfire risk mitigation work, likelihood to support related training opportunities, and the arborists that

are actively working to develop defensible space. This relationship is in contrast to arborists who never perform DSD work. They are likely to perceive that there is little wildfire risk in their community and, therefore, unlikely to be performing wildfire risk mitigation work. Similarly, and arborist that does not value or see a need for DSD work is not likely to identify a need for continuing education on the subject.

Chapter 3: Results

The results of the data analysis are organized into four sections, frequencies, hypothesis testing, independent samples t-test, and qualitative analysis. Frequencies for perceptions, demographic information, and education format preferences are included with accompanying figures and tables to facilitate interpretation of data. ANOVA is used to test hypotheses one and two using the variables *valueneedDSDwork* and *FireScienceCurriculum*. An independent samples t-test identifies differences of individual survey responses about wildfire risk mitigation work between arborists who perform DSD work and those who do not (*workforDSD*). The final section includes data collected from the open-ended qualitative survey responses organized into thematic groups.

3.1 Perceptions of Wildfire Issues

A predominant portion of survey respondents recognize that wildfire is an issue in and around the community where they live. Of the 223 individuals that answered the question "would you agree or disagree that wildfires are an issue in or around the community you work in?", 89 (40%) "strongly agreed" and 65 (28%) somewhat agreed. Seventeen (7%) neither agreed nor disagreed,

while 35 (15%) somewhat disagreed, and 17 (7%) strongly disagreed that wildfires were an issue in their community (Figure 1). The following survey question, "How familiar are you with creating defensible space around homes for wildfire risk reduction?" 184 (81%) people responded that they were at least moderately familiar with defensible space development. In comparison, the remaining 41 (19%) of individuals were only slightly or not at all familiar with DSD for wildfire risk reduction.

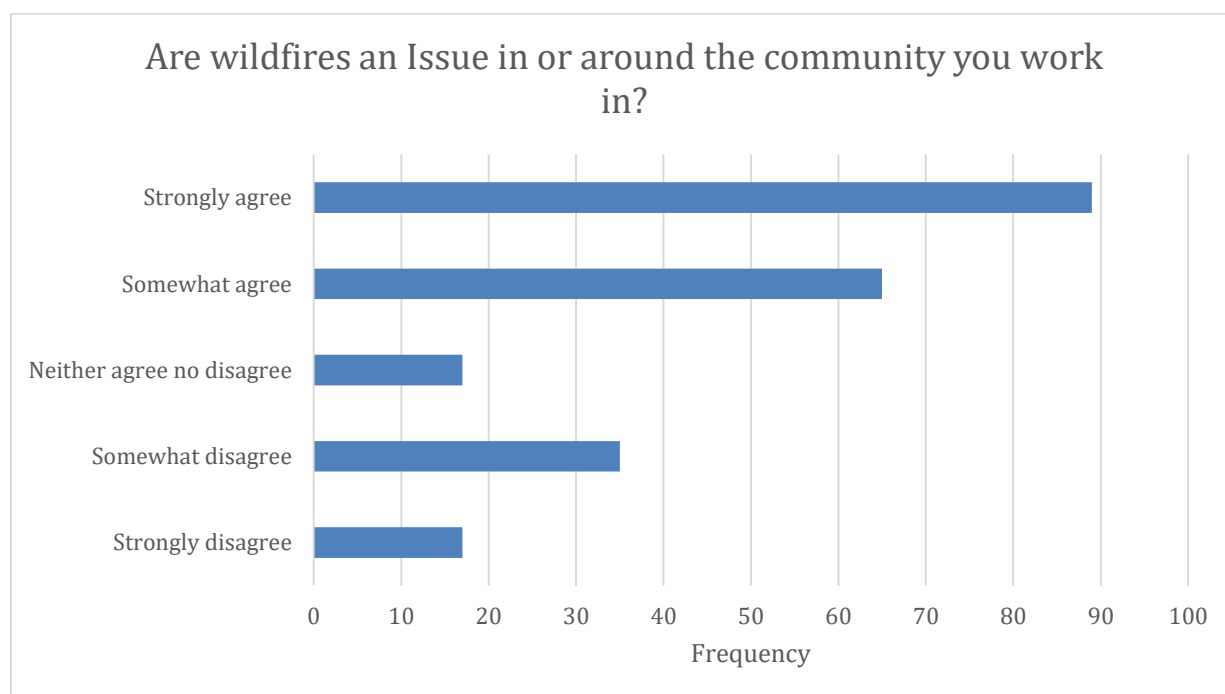


FIGURE 1: PERCEPTION OF WILDFIRE RISK

Frequency of survey respondent's perceptions of wildfire risk in their community.

To distinguish between survey participants that regularly do defensible space development work and those who do not, the survey question "How often do you work around homes with the purpose of developing defensible space for wildfire risk reduction?" was divided into five response categories. Four of the respondents (2%) reported dedicating more than 75% of their work time to defensible space development, followed by 9 (4%) who spent between 50-75% of

their time in DSD, 32 (14%) had 25-50% of their work in DSD and 84 (37%) only occasionally worked 1-25% of their time to mitigate wildfire risk. The largest proportion of the responses, 94 (42%) individuals listed rarely or never working to develop defensible space around homes. The variable groups were consolidated into a new dichotomous variable *workforDSD*, consisting of one group of respondents that rarely or never developed defensible space n=94 and those who at least occasionally worked to mitigate wildfire risk around homes n=129 (Figure 2).

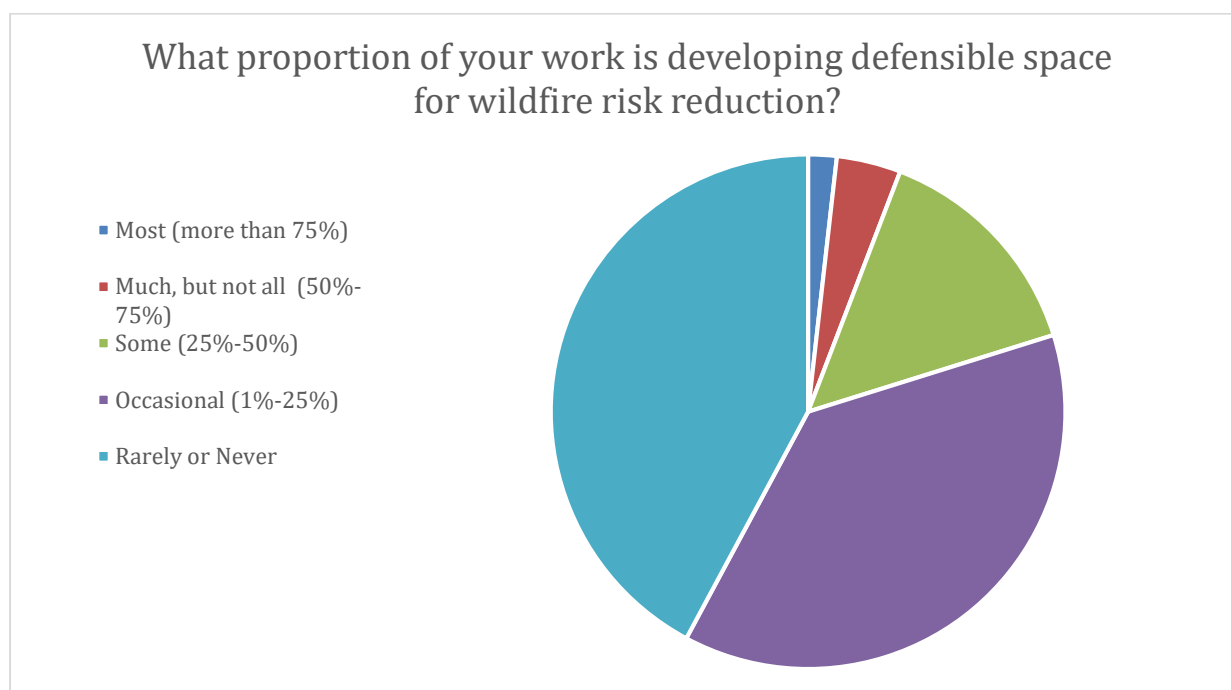


FIGURE 2: PROPORTION OF ARBORISTS CREATING DEFENSIBLE SPACE

Proportion of work time dedicated to mitigating wildfire risk for residents

The survey question, "What sort of tasks do you perform in an effort to develop defensible space?" was divided into various activities related to defensible space development. The work categories are based on the recommended vegetation management activities listed in the wildfire preparedness strategy of the Firewise program website (NFPA, 2020) an "other" category was provided for fill-in answers to the question. Survey respondents were able to select multiple

activities. In addition to the categories listed in the questionnaire, the top five fill-in responses of the "other" option are listed in Table 1. Almost a quarter of respondents (24%) did not do any of the listed tasks, but over half (55%) selected at least two or more of the defensible space development tasks listed as a component of their work.

TABLE 1: TASKS

Distribution of Firewise® fuels management tasks arborists conduct for homeowners

<i>"What sort of tasks do you perform in an effort to develop defensible space"</i>	Frequency	Percentage
Canopy raising/deadwood removal	145	63%
Debris Removal	134	58%
Thinning stands of trees	102	55%
Chipping	99	43%
Land clearing	53	25%
Other ¹	58	23%
<i>Consulting</i>	<i>10</i>	<i>17%</i>
<i>Prescribed fire</i>	<i>9</i>	<i>15%</i>
<i>Planning/design services</i>	<i>9</i>	<i>15%</i>
<i>Removal of trees</i>	<i>7</i>	<i>12%</i>
<i>None</i>	<i>6</i>	<i>10%</i>

¹percentages listed in the "other" survey items are based on the total of 58 responses in that category.

3.2 Arborist and Business Demographics

The respondents were asked about the population of the community where they primarily work. The options were divided into 5 categories; Rural (pop. Less than 2500), Small City (pop. 2500 – 30,000), Medium City (pop. 30,000 – 75,000), Large City (pop. 75,000 – 150,000), and Metro

area (150,000+). The lower bound of the population category, population less than 2,500, is based on the U.S. Census definition of a rural area (U.S. Census, 2020). The upper bound “Metro area” (150,000+) captures at least one of the major cities in each state and province of the study area. Of the 217 valid responses for this survey item, 99 responses or 43% of the arborists listed metro areas with populations above 150,000 people as the population of their primary work community. The second and third response rates were for Medium Cities 25,000 – 75,000 (17%) and Small Cities 2,500 – 25,000 (16%), respectively. Large Cities accounted for 14% of the responses, and rural communities were the lowest at 3.5% (Figure 3).

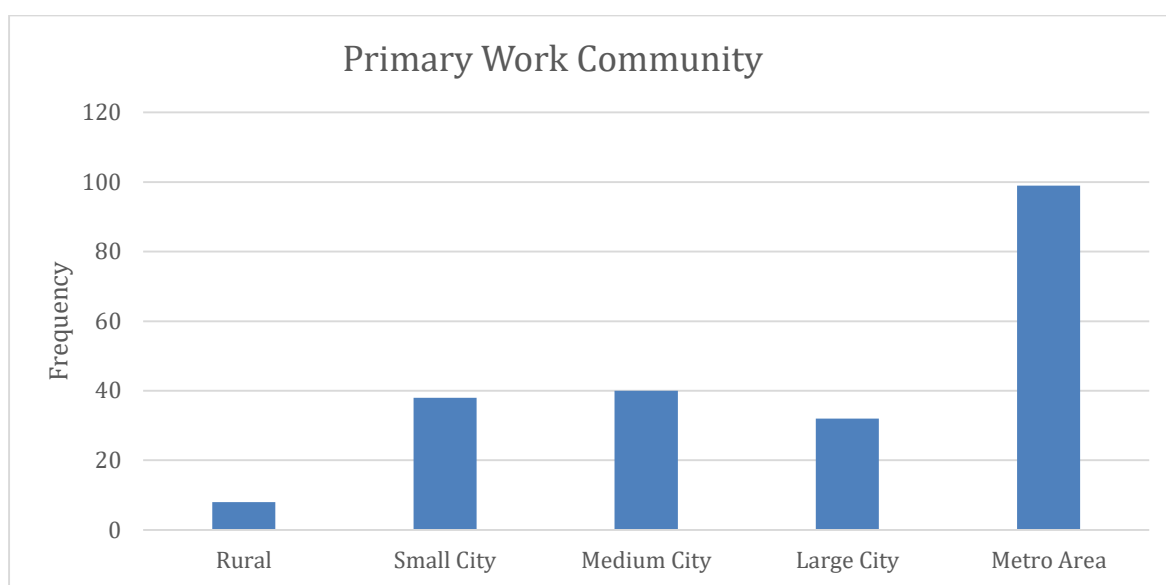


FIGURE 3: PRIMARY WORK COMMUNITY POPULATION

Survey respondent service area population; Rural (>2500), Small City (2,500-25,000), Medium City (25,000-75,000), Large City (75,000-150,000) and Metro Area (<150,000).

The follow-up question to the primary work community asked how long the individual had been working as an arborist in the region. Of the 221 responses to the four categories, the largest proportion of respondents had worked in the region for 10-20 years (30%) followed by 4-10 years (28%), over 20 years (26%) and finally 1-3 years (14%) (Figure 4).

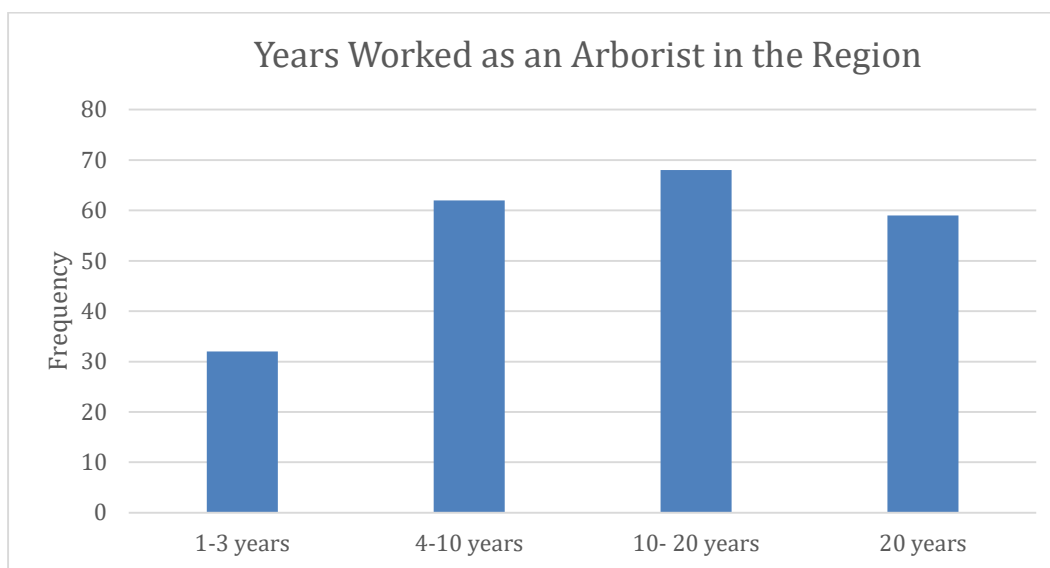


FIGURE 4: YEARS WORKED IN REGION

Number of years individual respondents have worked in the region

Of the 229 total responses, 201 (87%) had an ISA certified arborist represented in their business (Figure 5). The second-highest rate of representation were 136 (59%) Tree Risk Assessment Qualified individuals followed by; 30 (13%) Tree Worker Climber Specialists, 25 (11%) Board Certified Master Arborists, 24 (10%) Utility Specialists, 16 (7%) Municipal Specialists, and 10 (4%) Aerial Lift Specialists. The numbers and percentages listed are a proportion of the total 229 responses as multiple credentials can be represented in a single business.

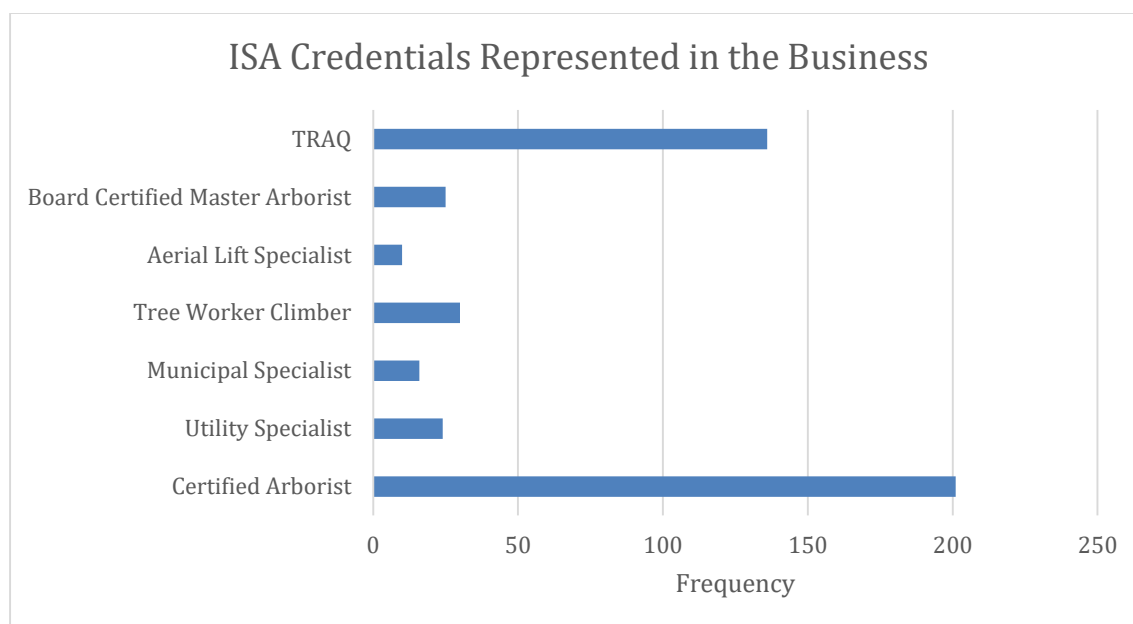


FIGURE 5: ISA CREDENTIALS HELD

Frequency of ISA credentials held by survey respondents and represented in the business

There were varied responses to the structure and organization of the respondent businesses. One-hundred and forty (63%) of the 221 individuals that responded were the owners of their business. Over 54% of the 213 total business employed 1-3 full-time people, followed by 16+ (17%) individuals, 4-8 people (16 %) and 8-16 people (11%). One-hundred and ten (50%) respondents reported that they hired no part-time and seasonal employees, 72 (33%) hired between 1-3 individuals, 16 (7.4%) respondents had 4-8 part-timers on staff, followed by 14 (6%) with more than 16 people, and 2% with between 8-16 on the crew (Figure 6).

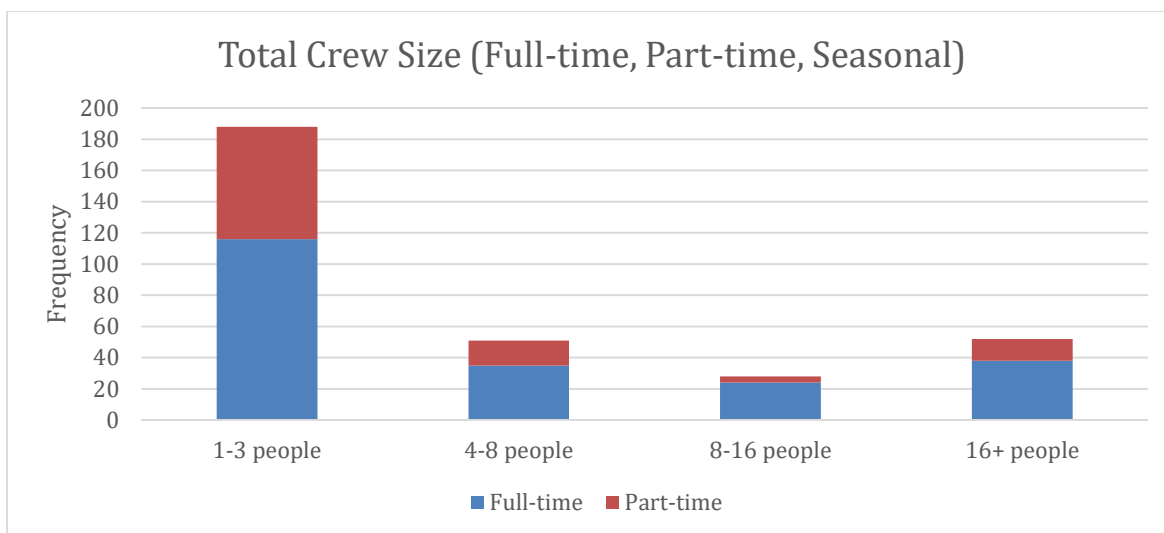


FIGURE 6: CREW SIZE FULL-TIME & PART-TIME

Total crew size of survey respondents both full-time and part-time/seasonal employees

ISA certified arborists represent 202 (91%) of respondents (Figure 7), while PNW-ISA chapter members make up 170 (77%) of the individuals that took the survey. Of the ISA certified arborists, 161 (73%) are chapter PNW-ISA chapter members, and 39 (17%) are not. The remaining 9 (4%) non-certified arborists maintain PNW-ISA membership without certification, and 10 (4%) of survey respondents are neither certified arborists or PNW-ISA members.

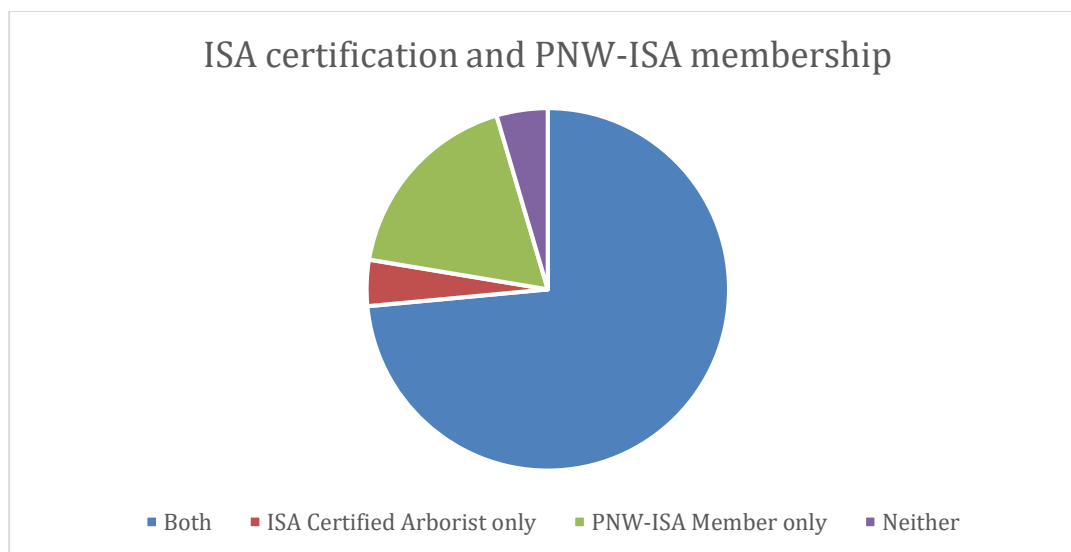


FIGURE 7: ISA CERTIFICATION AND MEMBERSHIP

Frequency of ISA certification and PNW-ISA chapter membership representation among respondents

3.3 Wildfire Risk Mitigation Curriculum

Three consecutive questions in the survey asked about the preferred format and length of a potential wildfire science course if one were to be developed and offered to arborists. The first question in the set, 'would you like education material deliver by online modules or a classroom setting' is based on the two formats, online and in-person workshops, that the ISA offers arborists to gain continuing education credits for certification. 119 (56%) of the respondents prefer educational material to be delivered both online and in-person, 41 (19%) would like online modules made available, while 27 (12%) would like an in-person classroom setting. 26 (12.2%) had no preference for a specific delivery method.

The second question in the set inquires about the potential length of a training event and the time the individual would be able to commit to a training event. Similar to the previous question, these categories are based on the workshop lengths that the ISA offers to arborists regularly.

Most of the respondents, 103 (45%) were willing to commit a full day to a training event, while 62 (27%) could offer two days, 52 (22%) would be willing to commit a few hours to a workshop, and 4 (1%) were willing to commit no time to wildfire risk mitigation education.

Many ISA sponsored in-person workshops are offered throughout the year; the final question of the set was regarding the preferred time of year for a potential in-person workshop event. The question was divided into the four seasons; 144 (65%) people preferred winter (January-March) for the training, 32 (14.5%) would like Spring (April-June), 25 (11%) in the Summer, and 12 (5%) preferred the fall (Table 2).

TABLE 2: FIRE SCIENCE CURRICULUM

Survey respondent preferences for educational material delivery method, duration, and time of year.

Wildfire Science Curriculum	Frequency	Percentage
<i>Educational Material Delivery Method</i>		
Both	119	55.90%
Online modules	41	19.20%
In-person classroom setting	27	12.70%
No preference	26	11.40%
Total	213	
<i>Hours for Training Event</i>		
Full day	103	46.6%
Two days	62	28.1%
A few hours	52	23.5%
None	4	1.8%
Total	221	
<i>Preferred Season for in Person Training Event</i>		
Winter (January-March)	144	65.5%
Spring (April-June)	32	14.5%
Summer (July-September)	25	11.4%
Fall (October-December)	12	5.5%
None	7	3.2%
Total	213	

3.4 Defensible Space Development Work Variable

Questions 9 and 10 of the survey test how arborists perceive the value and necessity of defensible space development work in their community, mainly concerning their business pursuits as arborists. Responses such as "I would be interested in pursuing opportunities in

defensible space development in my area" and "do you feel your business would benefit from providing tree work related to defensible space development..." are ways to directly assess perceptions of how arborists see defensible space development work in their community potentially benefiting their business. The other questions in this section, "Education relating to wildfire and defensible space development would be valuable" and "Training related to wildfire risk reduction would be beneficial to my business" are designed to gauge how they perceive the benefit of education related to DSD work. Question 10 was reverse coded for analysis to ensure a positive correlation between response variables. While different, each question is related to the potential value of increased defensible space development work and the potential benefit from wildfire risk mitigation training.

The combination of the multiple question responses into a single variable that measures perceptions about the value and need for DSD work is used to determine differences between groups of arborists in the PNW-ISA region. Reliability analysis of the four question responses (n=229) resulted in a Cronbach alpha of .853 (Table 3) indicating that the four questions are sufficiently related to justify combining into a new variable, *valueneedDSDwork*.

TABLE 3: VALUE DSD WORK VARIABLE

Survey variables relating to respondent's perceptions of wildfire risk and potential benefit of wildfire risk mitigation work.

	Item Total Correlation	Alpha if Item Deleted	Cronbach Alpha
Value Defensible Space Development Work (<i>valueneedDSDwork</i>)			.853
"Do you feel your business would benefit from providing tree work related to defensible space development (consulting, tree thinning...)?"	.652	.834	
"I would be interested in pursuing opportunities in defensible space development"	.711	.806	
"I feel like training relating to wildfire risk reduction would be beneficial to my business"	.798	.767	
"Education relating to wildfire and defensible space development would be valuable"	.633	.840	

3.5 Fire Science Curriculum Variable

In a fashion similar to the development of the *valueneedDSDwork* variable, a new variable for interest a fire science curriculum was developed from the five parts of question 17. The first four parts of question 17 are used to gauge interest in potential classes related to wildfire science and are based on modules of the Oregon State University Extension Publication *Fire Science Core Curriculum* and the ISA Texas Wildfire Risk Reduction Qualification curriculum; Defensible Space, Wildfire Science, Firewise, and Wildfire Risk Monitoring. The last part of question 17 is related to a potential professional credential or qualification that could result from taking a course in wildfire science. While measuring differences in interest between each wildfire science related modules helps develop a customized class suitable for arborists, each module could be presented collectively as a wildfire science curriculum. Reliability analysis of the responses (n=229) to the five elements in question 17 resulted in a Cronbach alpha of .933, indicating a

significant correlation between each of the questions and justifying the development of a new variable that combines the separate potential course modules and qualification. The new variable *FireScienceCurriculum* (Table 4) is used to determine differences in the population of survey respondents.

TABLE 4: FIRESCIENCE CURRICULUM VARIABLE

Survey variables relating to a potential wildfire science curriculum and credential.

	Item Total Correlation	Alpha if Item Deleted	Cronbach Alpha
Interest in Wildfire Science Curriculum (<i>FireScienceCurriculum</i>)			.933
"Are you interested in an educational or credential program for continuing education...?"			
Defensible space	.825	.917	
Wildfire science	.755	.929	
Firewise or FireSmart programs	.853	.911	
Wildfire risk monitoring	.879	.906	
Wildfire risk credential	.908	.922	

3.6 T-test test of H1

The results of the t-test test comparing the new variable *valueneedDSDwork* between the two groups of arborists, *workforDSD* those who perform defensible space development work (n=129) and those who do not (n=94), indicates that there is a significant ($p < .001$) difference between the two groups (Table 5). This result shows that survey respondents who are actively working to develop defensible space in their community for wildfire risk mitigation are more likely to see

the value or a need for the work they do, providing sufficient evidence to reject the null hypothesis.

Despite the significant difference between the two groups, arborists who do not do DSD work as a component of their job still identify wildfire risk mitigation as important. The variable *valueneedDSDwork* is on a scale of 1 – 5, a score of 1, translating to little importance to arborists and 5 indicating high importance to their work. Interestingly, the alternative group of arborists who do not perform DSD work still rated the value and need for DSD work at above average (3.72), perhaps indicating an understanding of the general importance of performing wildfire risk mitigation work.

TABLE 5: T-TEST OF H1

T-test comparison of how arborists who work to develop defensible space and those who do not value work related to wildfire risk mitigation.

	workforDSD		t-Value	p-value	ETA (n) effect size
	Yes	No			
<i>valueneedDSDwork</i>	4.22 ^a	3.72 ^a	18.85	>.001	.282

¹Means on a scale of 1 "little importance" to 5 "very important".

^aindicates significance at the $p < 0.05$ level.

3.7 T-test test of H2

The results of an t-test between the same independent dichotomous variable *workforDSD* and the new continuous variable *FireScienceCurriculum* (Table 6) shows that there is a non-significant difference between the two groups of arborists ($p = .058$) value selected based on Levene's test for equality of variances between groups and a point biserial correlation used to estimate effect

size. The *FireScienceCurriculum* variable is on a scale of 1 – 4; a score of 1 reflects no interest in *FireScienceCurriculum*, 2 is somewhat interested, 3 is interested, and 4 is very interested. The average interest response for the two groups of arborists was 2.97 for those who perform DSD work and 2.75 those who do not. Even though there is a non-significant difference between the responses of the *workforDSD* variable groups, there is still "some interest" in a fire science curriculum in both groups.

TABLE 6: T-TEST OF H2

T-test comparison of respondent interest in a fire science curriculum between two groups; arborists who work to develop defensible space and those who do not.

	workforDSD		t-Value	p-value	ETA (n) effect size
	Yes	No			
FireScienceCurriculum	2.97 ^b	2.75 ^b	3.62	.058	.128

¹Means on a scale of 1 "not interested" to 4 "very interested".

^bnot significant at the $p < 0.05$ level.

3.8 Geographic Distribution of Arborists

The geographic distribution of survey respondents (figure 8) show areas of high concentration of arborists in the PNW region in and around metropolitan areas; Portland, Seattle, and Vancouver. Arborists working in less populated areas (pop. less than 150,000) have are more likely to have performed wildfire risk mitigation work for homeowners.



FIGURE 8: DISTRIBUTION OF ARBORISTS

3.9 Independent Samples t-test

The results of an independent samples t-test (table 7) indicates there are differences in responses between the two arborist groups in individual survey variables. Values in the table are selected based on Levene's test for equality of variances between groups, point biserial correlation used to estimate effect size.

TABLE 7: INDEPENDENT SAMPLES T-TEST

Comparison of individual survey response items between arborists who conduct defensible space work and those who do not.

	WorkforDSD		t- value	p- value	Effect size (r _{pb})
	Yes (58%)	No (42%)			
Wildfire and trees in the landscapes around homes in your community... ¹					
Wildfire is a concern for the city/community I work in	4.2	3.11	7.01	.000	.438
I am familiar with the development of defensible space around homes for wildfire risk reduction	4.48	3.66	5.84	.000	.395
I am already working to reduce wildfire risk for people in my community	3.93	2.41	9.83	.000	.566
I would be interested in pursuing opportunities in defensible space development in my area	4.22	3.73	3.38	.001	.227
I feel like training relating to wildfire risk reduction would be beneficial to my business	4.06	3.59	3.09	.002	.210
Education relating to wildfire and defensible space development would be valuable	4.44	4.07	3.02	.003	.201
Wildfire risk training would be of value to all arborists	4.41	4.21	1.63	.101	.110
Do you feel your business would benefit from providing tree work related to defensible space development (consulting, tree thinning, pruning branches, debris removal, chipping, etc.)? ²	4.16	3.48	4.44	.000	.296
Do you think giving recommendations about defensible space development would be an unnecessary risk for your business? ²	2.09	2.31	1.69	.092	.029
Do you think other tree services companies in your area would be better suited for work related to defensible space development? ³	1.91	1.87	.43	.67	.113

¹On a scale of 1 "strongly disagree" to 5 "strongly agree"; ²On a scale of 1 "Definitely not" to 5 "Definitely yes"; ³On a scale of 1 "Yes" to 3 "No"

3.10 Qualitative data

The qualitative data collected in the open-ended survey questions were analyzed and coded into thematic groups using NVivo™ software. One-hundred and thirty-five responses to the first open-ended question, "What do you think are your 3 main needs as an arborist when it comes to working in the wildland-urban interface?" were divided into 176 distinct references. Each reference allocated to one of nine items; three primary groups and six subgroups (table 8).

TABLE 8: THREE MAIN NEEDS AS AN ARBORIST

Responses to the open-ended survey question organized into thematic groups

<i>"What do you think are your 3 main needs as an arborist when it Comes to working in the wildland-urban interface"</i>	Frequency	Percentage
Capacity		
Equipment and Personnel	17	10%
Funding/Grant opportunities	11	6%
Credential/Certification	7	4%
Knowledge/Education		
Personal (arborist) training/education	87	49%
Public/Client education	25	14%
Marketing/Outreach materials	12	7%
Policy/Code/Governmental Changes	17	10%
Total	176	

The second of the two qualitative questions, "Are there any thoughts you have about this survey you would like to include?" had 81 responses, divided into 100 references, and organized into four primary thematic groups and eight subgroups (table 9).

TABLE 9: SURVEY THOUGHTS

Responses to the final open-ended survey question organized into thematic groups.

<i>"Are there any thoughts you have about this survey you would like to include?"</i>	Frequency	Percentage
Work in Defensible Space Development		
Currently/interested in working for DSD	20	20%
Concerns about Ecological and Aesthetic Impact of work	17	17%
No need, no work, or no incentive in my area for DSD	11	11%
Knowledge/Education		
Professional and Public Education	17	17%
No support for certification/qualification	7	7%
Support for certification qualification	3	3%
Regulation and Policy		
Government regulation or policy in place for DSD	7	7%
B.C. - Professional Foresters	5	5%
Survey Instrument Critique	13	13%
Total	100	

Chapter 4 Discussion

This research of arborists working in the PNW-ISA chapter region indicates that there is a group of arborists in the Pacific Northwest region who are currently working to develop defensible space for homeowners and a nearly equal sized group of arborists who are not currently performing wildfire risk mitigation work, but are interested in providing services to homeowners. In addition to exploring to what extent arborists in the PNW are conducting wildfire risk mitigation for homeowners, this research shows that there is a need for and interest in arborist specific continuing education course work related to wildfire science. The 229 arborists that completed the online survey are likely a small and non-representative portion of tree workers in the PNW and a still smaller portion of all the people in the landscaping and groundskeeping industry in the region.

In addition to the difficulty of identifying a representative sample of arborists in the PNW region, it is difficult to tell what proportion of people doing tree work in the area are ISA certified arborists. While experience working in some facet of the landscaping industry is a prerequisite to becoming an ISA certified arborist, certification is voluntary and not required for contractor licensing, performing tree work, or other landscaping tasks in the PNW region. Membership to either the ISA or the PNW-ISA chapter is separate from one another, and both are unassociated with ISA arborist certification. Membership to the ISA is not a prerequisite for the certification process 39 of the survey participants were non-member ISA certified arborists. Additionally, subscription to the PNW-ISA chapter e-mail listserv requires neither a membership to the organization nor a certification, as evidenced by the 10 of the 229 survey respondents that are neither ISA certified or chapter members. The PNW-ISA chapter has 2,200 members and nearly

double that amount of 3,994 e-mail accounts on the listserv (PNW-ISA 2020). The International Society of Arboriculture has 31,400 current certified arborists and 23,805 due paying members, from this we might assume that there are some ISA certified arborists in the PNW region that do not maintain either an ISA or chapter membership (ISA 2017).

The distinction between certified arborists and chapter membership gives some insight into how arborists are obtaining CEUs. The PNW-ISA hosts and advertises many of the courses and workshops offered to arborists for continuing education credits that count towards the maintenance of their certification. The maintenance of an ISA arborist certification requires 30 credit hours of approved course work over three years or the alternative of re-taking the certification exam; other certifications offered through the ISA such as; tree climber, utility, and aerial lift specialist require additional CEUs. As a result of the CEU requirement to maintain ISA certification, arborists seek out and attend qualifying continuing education courses. Interestingly, despite having nothing to gain through collecting continuing education credits through the ISA, every one of the 19 (100%) non-ISA-certified arborists that filled out the survey were interested in seeing educational programming related to wildfire science and defensible space development.

4.1 Perceptions About Wildfire Risk & Defensible Space Development Work

One of the initial survey questions, "would you agree that wildfires are an issue in or around the community you work in?" was designed to elicit a response based on the respondent's perception of wildfire risk. Of the response group, 164 (68%) thought wildfires were an issue, perhaps as a future threat or the result of a past wildfire occurrence. Conversely, 52 (22%) did not agree that wildfire was an issue, 17 (7%) were equivocal and neither agreed or disagreed that fire was a

problem for their community. It is essential to distinguish in this case, that although respondents live in an area that carries a predicted wildfire risk as divined through models and post-fire data (Kramer et al. 2019; Ager et al. 2014; Ager et al. 2010), the survey measurements are about the arborist perception of wildfire issues in their community. Unlike a homeowner whose beliefs of wildfire risk to their property is mostly a function of their proximity to potential danger (Meldrum et al., 2018), arborists may have a different idea of wildfire issues in their community. They often have a wide service area that covers a range of potential wildfire risks, from properties in the middle of an urban area to homes on the edge of the wildland-urban interface. One survey respondent from British Columbia remarks on the variability they see throughout their service area:

"I work in a vast area with 0 population to 1 million +. Wildfire training is mandatory with some customers while homeowners are mostly ignorant. It is an important topic and education is key."

In addition to understanding how arborists perceive wildfire issues in their community, this study explores to what extent they are already working to develop defensible space for wildfire risk mitigation. Aside from an occasional mention of "contractor" in research related to wildfire risk mitigation, the people hired to implement Firewise or defensible space development activities on behalf of homeowners are not often studied (Howard, 2015; Stockmann et al., 2010). Many homeowners living in wildfire-prone areas implement defensible space development activities on their property (Calkin et al., 2014), but some encounter several barriers like the lack of specialized equipment and knowledge, that keep them from doing wildfire risk reduction activities (Brenkert-Smith, 2006). Arborists are well situated to serve the needs of homeowners that are unable to manage the trees and vegetation around their property. Both groups of arborists, those who conduct DSD work and those who do not, both shared an interest in

pursuing more work related to DSD and both groups felt they were the capable giving recommendations about and conducting wildfire risk mitigation work for homeowners (table 7).

4.2 The Value of Defensible Space Development Work & Education

Four survey questions related to how the respondent values and perceives opportunities for defensible space development work in their community were combined into a single variable *valueneedDSDwork* and used to compare the two groups of arborists' *workforDSD*. Arborists who do DSD work, even as a small component of their job, value opportunities related to wildfire risk reduction more than those who do not (table 5). The likelihood of an arborist working to develop defensible space around homes is correlated to how they perceive the issue of wildfire in their community. This connection shows that arborists working in the PNW understand they have a role to play in preparing homeowners for a potential wildfire around their home. The other component of this exploratory research centers on the needs of arborists, specifically if training or educational programming will support wildfire risk reduction work in the PNW.

The two groups of arborists (*workforDSD*) were asked if education on wildfire science and defensible space development would be valuable. The responses on a scale of 1 "strongly disagree" and 5 "strongly agree" were 4.44 for arborists who work in DSD and 4.07 for those who do not. The difference between the two groups was significant ($p=.003$), but the effect size was small ($r_{pb}=.201$). When the same comparison was tested between the two groups with the combined *FireScienceCurriculum* variable, the significant difference between the two groups disappeared ($p=.58$). Both groups agreed that wildfire risk training would be valuable to all

arborists, which suggests that even arborists who do not perform wildfire risk mitigation work as a component of their job, still understand the importance of education for others within the industry. This sentiment is echoed in some the responses to the survey item "What do you think are your three main needs as an arborist when it comes to working in the wildland-urban interface?" of which 87 (49%) of the responses cited some sort of desire for personal education or training on wildfire (table 6). For many of the arborists, the desire for wildfire-related training extends beyond mitigating wildfire risk. Training should involve many of the other critical ecological factors to consider when altering a landscape to be fire-adapted. An arborist from Oregon wrote:

"I would love to see more education for arborists about wildland-urban interface areas in general. Especially how to navigate municipal zoning rules and opportunities for grants for things like fire abatement, habitat improvement, and ecosystem services."

Some of the survey respondents raised concerns about the methods used to create fire-adapted landscapes and its potential impact on other environmental aspects such as biodiversity, slope stability, and aesthetics. This consideration speaks to the potential benefit of having trained landscape professionals help homeowners make wildfire risk mitigation decisions around their property as they also value many of the ecological functions of landscapes around homes (Wolters et al. 2017; Absher et al. 2009). Considering that over 80% of the survey respondents agreed that wildfire risk mitigation education would benefit themselves and their fellow arborists, the PNW-ISA should consider developing training focused on the needs of their members.

4.3 Revisiting the Study Hypotheses

A test of the first hypothesis, that arborists currently working to mitigate wildfire risk in their communities will be more likely to value and see a need for defensible space development work, indicates a significant difference between groups of arborists who perform defensible space development work and those who do not. Arborists who perform DSD work tend to perceive wildfire as being more of a risk for their community and they tend to place a higher value on the benefits of wildfire risk mitigation work. The geographic distribution of arborists (figure 8) shows that A higher proportion of arborists working in smaller cities and rural areas tend to be more likely to perform DSD work, in the major metropolitan areas of the PNW there the division is fairly equal between the two groups. Which indicates that even in the largest cities, perceptions about wildfire risk in their community differ between arborists. This difference in wildfire risk perceptions between arborists serving the same community could be rooted in past experiences with wildfire (McGee et al. 2009). Further investigation into how past experiences with fire shape risk perceptions and subsequently affect business decisions, such as providing DSD work to homeowners, might provide some insight into the differences identified between arborists in the same community.

Analysis of the second hypothesis, that arborists currently working to develop defensible space will more likely support educational opportunities relating to defensible space development, yielded non-significant results. The two populations of arborists seem to both support continuing education related to wildfire risk mitigation work. The equal support for fire science education by both groups of arborists might be explained by entrepreneurial opportunity identification (Ardichvili et al. 2003), where arborists who are not currently performing DSD work may see a

workshop or continuing education as a way of exploring future business opportunities in wildfire risk mitigation work. Despite the non-significant difference between the arborists the result provides support for the future development of workshops or training for arborists working in the PNW region.

4.4 Validity Within the Research Design and Approach

The lack of a theoretical foundation for this research makes it difficult to determine the face validity of some of the variables. The *FireScienceCurriculum* is a combination of multiple fire-related concepts based on the wildfire curriculum developed for the Wildfire Risk Reduction Qualification (WRRQ) developed by the ISA Texas chapter (ISA Texas 2020) and OSU extension. While the curriculum variable falls short of covering all aspects of the field of wildfire science, the components of the *FireScienceCurriculum* variable are correlated and closely aligns with those represented in the WRRQ, indicating content validity of the variable. The content validity of other variables, including those relating to perceptions about wildfire risk, are closely tied to similar research about homeowners and wildfire risk perception (Wolters et al. 2017). Arborists and homeowners share some elements of risk perception and the related behaviors; i.e., if they value defensible space development work, they are more likely to be conducting DSD work. Arborists and homeowners have sufficiently different motivations for conducting DSD work, so direct comparisons about the face validity of variables are inappropriate.

The survey results parallels conclusions from research on motivations for homeowners in DSD work around their homes. Homeowner risk reduction behaviors are primarily determined by how they perceive their level of risk and the efficacy of the DSD activities (Martin et al. 2009). The

results of a comparison between arborists who perform DSD work and those who do not indicate that their perception of wildfire risk in their community is closely associated with their likelihood of working to mitigate wildfire risk. Additionally, among the group of respondents who do not do DSD work, there is still a desire for education related to wildfire risk mitigation and a perception that work related to defensible space development would be beneficial. This result points to how entrepreneurial opportunity identification and development could reasonably account for the potential benefit of DSD work for arborists that do not currently perform any.

4.5 Representativeness

Arborists working in the Pacific Northwest is the population of interest for this research. The precise number of arborists working in the PNW is unknown. The results are not a true representation of the total population of arborists working in the region, in addition to the fact that a non-response check was not conducted for this survey, the group of respondents is a small subset of individuals in among a variable and undefined population. Unlike homeowners, whose tax lot numbers and ownership are fixed and can be accounted for in survey research, the definition of "arborist" varies and can encompass many elements of the landscape profession to varying degrees. While each state and province in the region requires contractors who provide tree services to be licensed, an ISA-certification is not required to conduct tree work (Oregon LCB, 2020; Washington L&I, 2020; Idaho DOPL, 2020; Alaska DCCED, 2020; BC ITA, 2020). There are other contractors, such as forestry professionals and non-arborist landscapers, working in the WUI that contribute to wildfire risk mitigation (Hull and Nelson, 2001). In addition to non-ISA certified arborists, the sampling method also could exclude arborists who may be certified non-ISA members, which accounts for nearly one out of every four certified arborists

(ISA, 2017). Additionally, the initial PNW-ISA listserv e-mail was distributed to 3994 individuals, while current PNW-ISA membership is just over 2,200, this discrepancy implies that nearly half of all e-mail recipients are not active members of the chapter (PNW-ISA, 2020).

4.6 Study and Measurement Reliability

It is reasonable to expect that this study can be reliably replicated, but likely to garner different results over time. The changes in responses could result from the development of an educational program related to wildfire risk mitigation, resulting in increased awareness and subsequent changes in behavior (Monroe et al., 2013). A significant fire event in the PNW shifting homeowners' perceptions of wildfire risk could influence arborists working in the WUI for defensible space development. (Champ & Brenkert-Smith, 2016). The measurement reliability between concepts can be recognized through the strong correlation between related response variables. The variables used to create the *FireScienceCurriculum* showed a high degree of correlation (table 3), indicating strong internal consistency in response patterns over the set of items. Similarly, the variables relating to the value and need for defensible space development work, *workforDSD*, also showed a high degree of correlation (table 4).

4.8 Generalizability

Inferences made from the survey respondents are dependent on its representativeness of the population. As stated above, the survey respondents are unlikely to be a characteristic sample of all the arborists working in the PNW. However, the results of the survey can help us make conjectures about the population of arborists working to mitigate wildfire risk for homeowners in this region. The state with the highest response was Oregon (n=84) followed by Washington

(n=81), the difference might be a result of Oregon having a higher relative proportion of housing units in the high-wildfire exposure zone (Scott, 2018) and differences in land use regulations. Some portions of the survey design were developed on the assumption that ISA certified arborists working in DSD would be supportive of education relating to wildfire risk mitigation if the course offered an opportunity to earn continuing education credits. The 19 non-ISA certified respondents unanimously supported wildfire risk mitigation training, which indicates there are motivators beyond CEUs that compel people to want to participate in education opportunities. There were numerous non-significant differences between demographic categories between arborists working to develop defensible space and those who do not, such as; crew size, years worked in the region, ownership of the business, certification status, and PNW-ISA membership.

4.9 Future Research

Although we might not be able to infer any general beliefs or behaviors about the total population of arborists in the region with this survey device, there is an opportunity to investigate further the subgroup of arborists that work to develop defensible space. Future research identifying arborist attitudes and motivations for conducting wildfire risk mitigation work might provide an alternative perspective and compliment similar research about homeowners. The consistency of responses in support of education in the region and the wildfire risk program offered by ISA Texas, it would be reasonable to assume there are arborists in other parts of North America conducting wildfire risk mitigation work. Adapting the current survey to fit the needs of other ISA associations in the region, like the Western or Rocky Mountain chapters, would be a matter of altering a few questions and distributing the device through their member e-mail database. Beyond applying the same study to other locations and ISA chapters, the scope of the

study could be broadened to include other populations of potential contractors working with homeowners. The National Association of Landscape Professionals could provide an avenue for identifying professionals within other parts of the landscape industry that could benefit from wildfire risk mitigation training.

Chapter 5 Conclusion

The expansion of the wildland-urban interface in the fire-adapted landscapes of the Pacific Northwest points to a growing need for wildfire risk mitigation around homes now and in the future as we thinking about our shifting landscapes. While it is essential to empower communities to implement defensible space activities around their property, it is presumptuous to think that all residents of the WUI are capable of implementing some of the necessary tasks to secure their homes from a potential wildfire. This research identified a knowledgeable workforce of arborists that are assisting homeowners in the Pacific Northwest to implement Firewise and Firesmart methods on their property. Additionally, arborists who are not currently working to develop defensible space for clients are eager to learn more about what is required to mitigate fire risk for residents living in the WUI. This research has also shown a desire among most of the respondents to expand wildfire risk mitigation training and fire preparedness education opportunities.

Arborists compelled by business needs, operate on different motivations for implementing fire risk mitigation work for homeowners. Despite this, arborist survey responses raise concerns about ecological and visual impacts of defensible space development, and in some cases even mirror sentiments of homeowners, indicating parallels between attitudes about wildfire risk

mitigation work around homes. Further investigation into arborist motivations and values related to defensible space development would contribute to our understanding of barriers to wildfire risk mitigation.

Education and training classes offered to arborists would not only impact those attending but likely transfer defensible space development awareness to the crews they work with and the work they provide to clients. A knowledgeable Firewise savvy workforce will help ensure that vegetation management around a home will be carried out in an educated manner, preserving the vital ecological and aesthetic functions that our landscapes provide while reducing the potential of home loss from a wildfire.

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APPENDIX

Appendix A: Participant Letter of Consent and Qualtrics™ Survey

Letter of Consent

Arborists and wildfire risk mitigation in the Pacific Northwest

Consent Notice

Welcome.

With the help of the PNW-ISA you have been identified as an arborist in the Pacific Northwest. The purpose of this study is to better understand how you perceive your role in wildfire risk mitigation and the development of defensible space in your community. After reading and agreeing to this consent notice, please provide responses to the following survey questions.

Confidentiality.

Your participation in this study is completely voluntary and confidential. There are no risks to your involvement and while there are no direct benefits for completing the survey, your participation is important and will contribute to the field of urban forestry. The survey will take about 10-15 minutes to complete. Information collected from you for this research will not be used or distributed for future use beyond the scope of this study.

Study contacts.

If you have any questions about this research project, please contact the principal investigator at paul.ries@oregonstate.edu. If you have questions about your rights or welfare as a participant, please contact the OSU Human Research Protection Program office, at (541) 737-8008 or by email at IRB@oregonstate.edu.

- ☐ I have read the consent notice and agree (take survey)
- ☐ I do not want to take the survey (leave survey)

Working to reduce wildfire risk around homes

Would you consider the area around the city you work in to be heavily forested?

- ☐ Strongly disagree
- ☐ Somewhat disagree
- ☐ Neither agree nor disagree
- ☐ Somewhat agree
- ☐ Strongly agree

Are you familiar with the term Wild-land Urban (WUI) Interface?

- ☐ Yes
- ☐ Somewhat
- ☐ No

Would you agree or disagree that wildfires are an issue in or around the community you work in?

- ☐ Strongly disagree
- ☐ Somewhat disagree
- ☐ Neither agree nor disagree
- ☐ Somewhat agree
- ☐ Strongly agree

Are you familiar with the Firewise USA program?

- ☐ Yes
- ☐ Somewhat
- ☐ No

How familiar are you with creating defensible space around homes for wildfire risk reduction?

- ☐ Not familiar at all
☐ Slightly familiar
☐ Moderately familiar
☐ Very familiar
☐ Extremely familiar

How often do you work around homes with the purpose of developing defensible space for wildfire risk reduction for homeowners?

- ☐ Most of my work is for defensible space development (more than 75%)
☐ Much, but not all of my work is for defensible space development (50%-75%)
☐ Some of my work is defensible space development (25%-50%)
☐ Occasionally work is related to defensible space development (0-25%)
☐ Rarely or Never

What sort of tasks do you perform in an effort to develop defensible space? (check all that apply)

- ☐ Thinning stands of trees
☐ Canopy raising/dead wood removal
☐ Debris removal
☐ Chipping
☐ Land Clearing
☐ Other

Are you familiar with any government grant or community funding opportunities available to landowners in your area relating to...

- ☐ defensible space development
☐ fuels management
☐ wildfire risk reduction
☐ I have not heard of any funding opportunities

The following statements relate to wildfire and trees in the landscapes around homes in your community

	Strongly disagree	Somewhat disagree	Neither agree nor disagree	Somewhat agree	Strongly agree
The area around the city I work in is heavily forested	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Wildfire is a concern for the city/community I work in	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I am familiar with the development of defensible space around homes for wildfire risk reduction	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I am already working to reduce wildfire risk for people in my community	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I would be interested in pursuing opportunities in defensible space development in my area	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
I feel like training relating to wildfire risk reduction would be beneficial to my business	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Education relating to wildfire and defensible space development would be valuable	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Wildfire risk training would be of value to all arborists	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Educational and or credentialing program

Do you feel your business would benefit from providing tree work related to defensible space development (consulting, tree thinning, pruning branches, debris removal, chipping, etc.)?

- ☐ Definitely not
- ☐ Probably not
- ☐ Might or might not
- ☐ Probably yes
- ☐ Definitely yes

Do you think other tree services companies in your area would be better suited for work related to defensible space development?

- ☐ Yes
- ☐ Maybe
- ☐ No

Which defensible space related programs do you work with?

- ☐ Firewise USA
- ☐ FireSafe Canada
- ☐ Fire adapted communities (FAC)
- ☐ None
- ☐ Other

Would you be interested in earning continuing education credits through the ISA for courses related reducing wildfire risk around homes?

- ☐ Yes
- ☐ No

Do you think giving recommendations about defensible space development would be a unnecessary risk for your business?

- ☐ Definitely not
- ☐ Probably not
- ☐ Might or might not
- ☐ Probably yes
- ☐ Definitely yes

Would you like to see educational programming related the development of defensible space?

- ☐ Yes
- ☐ Maybe
- ☐ No

Would you be interested in educational programming related to wildfire science?

- ☐ not interested
☐ Somewhat interested
☐ Interested
☐ Very interested

Are you interested in an educational or credentialing program for continuing education?

	not interested	somewhat interested	interested	very interested
Defensible space	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Wildfire science	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Firewise or FireSmart programs	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Wildfire risk monitoring	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Wildfire risk credential	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

Would you like the educational material delivered by online modules or in a classroom setting

- ☐ Online modules
☐ In person classroom setting
☐ Both (online/in person)
☐ No preference

How many hours would you be able to commit to a training event

- ☐ A few hours
☐ Full day
☐ Two-days
☐ None

What time of the year would be best for an in person training event

- ☐ Summer (July-September)
☐ Fall (October-December)
☐ Winter (January-March)
☐ Spring (April-June)
☐ none

What do you think are your 3 main needs as an arborist when it comes to working in the wildland-urban Interface?

General Location/Business Information

What State/Provinces of the PNW-ISA chapter region do you do most of your business?

- ☐ Washington
- ☐ Oregon
- ☐ Idaho
- ☐ Alaska
- ☐ British Columbia

What is the zip code for the city or town do you do most of your tree work?

What is the population of the community where you primarily work?

- ☐ Rural - population less than 2,500
- ☐ Small city - population 2,500 - 30,000
- ☐ Medium City - population 30,000 - 75,000
- ☐ Large City - population 75,000 - 150,000
- ☐ Metro area - population 150,000 +

How long have you been working as an arborist in this region?

- ☐ 1 - 3 years
- ☐ 4 - 10 years
- ☐ 10 - 20 years
- ☐ 20+ years

What ISA credentials are represented in your business

- ☐ Certified Arborist
- ☐ Utility Specialist
- ☐ Municipal Specialist
- ☐ Tree Worker Climber Specialist
- ☐ Aerial Lift Specialist
- ☐ Board Certified Master Arborist
- ☐ Tree Risk Assessment Qualification

Are you the owner of the business?

- ☐ Yes
- ☐ No

How many full-time people are employed by your business (including yourself & non-certified arborists)?

- ☐ 1-3
- ☐ 4-8
- ☐ 8-16
- ☐ 16+

How many part-time or seasonal people are employed by your business?

- ☐ none
- ☐ 1-3
- ☐ 4-8
- ☐ 8-16
- ☐ 16+

Are you currently a PNW-ISA chapter member?

- ☐ Yes
- ☐ No

Are you currently an ISA certified arborist?

- ☐ Yes
- ☐ No

Are there any thoughts you have about this survey you would like to include?

End of Survey