

RESEARCH ARTICLE

## ASSESSMENT OF EXPERIENTIAL EDUCATION IN PRESCRIBED BURNING FOR CURRENT AND FUTURE NATURAL RESOURCE MANAGERS

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### ABSTRACT

Acquiring experiential prescribed fire education is difficult for college students. In order to evaluate the effects of instruction on students, we surveyed those who were taking or had completed Oklahoma State University's (OSU) prescribed fire courses since 2000. Of those surveyed, 32 were current students and 99 were former students. We assessed changes in their perception, knowledge, skills, abilities, the total area that they have prescribed burned since leaving OSU, their career trajectories, and how they rated the importance of different types of instruction. One third of the current students had never participated in a prescribed burn before the course; however, after the course, they had participated in seven burns on average. Current students had increased confidence in planning prescribed fire, operating a drip torch, and leading a prescribed fire program. Former students were employed in 20 US states and one Canadian province. Only one third of former students had participated in a prescribed burning association (or similar local cooperative), of which two thirds became federal government employees. Former students

### RESUMEN

Adquirir experiencia en educación en quemas prescritas es difícil para estudiantes universitarios. Con el objetivo de evaluar los efectos de la instrucción en los estudiantes, relevamos aquellos que estaban tomando o habían completado los cursos de quemas prescritas en la Oklahoma State University's (OSU) desde el año 2000. De aquellos relevados, 32 eran estudiantes actuales y 99 de cursos anteriores. Evaluamos cambios en sus percepciones, conocimientos, habilidades, destrezas, el área total que habían quemado a través de quemas prescritas desde su egreso de la OSU, la trayectoria de sus carreras, y cómo ellos evaluaban la importancia de los diferentes tipos de instrucción. Un tercio de los estudiantes actuales nunca había participado en una quema prescrita antes del curso; no obstante y después del curso, habían participado en siete quemas en promedio. Los estudiantes actuales habían incrementado su confianza en la planificación de una quema, en el uso de la antorcha, y liderado un programa de quema prescrita. Los estudiantes graduados en años anteriores fueron empleados en 20 estados de los EEUU y en una provincia de Canadá. Solo un tercio de los estudiantes ya graduados había participado de una asociación de quemas prescritas (o una cooperativa local de similares características), de los cuales dos tercios pasaron a ser empleados del gobierno federal. Estos estudiantes habían conducido o

had conducted or assisted with 6247 prescribed fires on a total of 803 252 ha after taking the courses, from 2000 to 2013. Experiential learning such as conducting prescribed burns, writing burn plans, and spot fire and equipment training ranked higher in utility than passive types of instruction such as lectures. Of the 37 universities assessed, only eight offer any courses explicitly focused on prescribed fire. Based on our results that demonstrate that both current and former students value experiential fire ecology educational training, we recommend that university curricula should increase the focus on prescribed fire, emphasize experiential learning, and facilitate greater interaction between student and instructor.

asistido a 6247 quemas prescritas sobre un total de 803 252 ha después de tomar los cursos y entre los años 2000 y 2013. La experiencia práctica de aprendizaje, tal como conducir quemas prescritas, escribir planes de quema, el manejo de focos secundarios y el entrenamiento en el uso de equipamiento fueron considerados como de mayor utilidad que el tipo de instrucción pasiva que implican las clases áulicas. De las 37 universidades examinadas, solo ocho ofrecen cursos explícitamente enfocados en quemas prescritas. Basados en nuestros resultados, que demuestran que tanto los estudiantes actuales como los ya egresados valoran el entrenamiento práctico en ecología del fuego, recomendamos que la currícula de las universidades debería incrementar el enfoque sobre las quemas prescritas, enfatizando el aprender haciendo y facilitando una mayor interacción entre el estudiante y su instructor.

**Keywords:** controlled burning, curriculum, experiential learning, prescribed fire, students

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## INTRODUCTION

Fire is a critical disturbance in most North American ecosystems, and the management of wildland fire and the application of prescribed fire has become increasingly complex (Radeloff *et al.* 2005, Keeley *et al.* 2009, Ryan *et al.* 2013). The complexity, risk, and public perception of fire have structured current fire-related policies and limited the implementation of effective fire management (Pyne 1982, Wise and Freitag 2002). Moreover, the rapid expansion of the wildland-urban interface has heightened the general public's concerns about wildland fire (Jacobson *et al.* 2001, Loomis *et al.* 2001). As the interaction between the public and wildland fire becomes increasingly frequent and complex, so does the need for competent fire management professionals.

According to Kobziar *et al.* (2009), only about 20 universities offer structured wildland fire ecology courses and, according to the Association for Fire Ecology (AFE) website, only seven are certified fire ecology academic programs (Association for Fire Ecology 2015). Subsequently, a recent survey of college students identified that the most needed training and education opportunity was access to local prescribed fires (Godwin and Ferrarese 2014). Furthermore, it is difficult for students to acquire the skill set that includes both classroom instruction and fire experience, especially as it relates to prescribed burning (Kobziar *et al.* 2009). This difficulty of acquiring prescribed fire experience hinders the development of competent wildland fire professionals (Sneeuwagt *et al.* 2013). The role of experiential learning is an effective approach to changing

the perceptions and knowledge of the general public about wildland fire (Jacobson *et al.* 2001, Loomis *et al.* 2001, Parkinson *et al.* 2003). Experiential learning is also important for decision making in high-stress environments when lives and property are at stake (Useem *et al.* 2005). However, none of these studies explicitly assessed how experiential learning should be integrated into university curricula to enhance student engagement and the development of wildland fire professionals.

Given the lack of data on experiential fire learning in university curricula and the desire of students for prescribed burning experience, we evaluated the prescribed fire courses of Oklahoma State University (OSU) by surveying current and former students. Our objectives were to:

- 1) assess how the OSU lecture and field-based prescribed fire courses affected current undergraduate and graduate students in three areas:
  - a) their perceptions about fire,
  - b) their knowledge, skills, and abilities (KSAs) related to prescribed fire, and
  - c) their potential for applying prescribed fire;
- 2) assess how former students had applied prescribed fire, their involvement with the public, and their perception of the value of different types of educational instruction; and
- 3) determine the extent to which university curricula explicitly include courses on prescribed fire.

Ultimately, we sought to enhance our understanding of effective instructional techniques of existing university prescribed fire programs and the implications for natural resource professionals, curricula development, and functional landscapes. These results will be of importance to educators, agencies, and technical trainers.

## MATERIALS AND METHODS

### *Description of the Prescribed Fire Courses*

The focus of this study was to assess how students perceived benefit from completing the prescribed fire courses within the Natural Resource Ecology and Management Department (NREM) at OSU. The OSU prescribed fire course of study is comprised of two semester courses. The fall semester is a classroom-based course that introduces students to prescribed fire and also requires field trips on which students observe the effects of prescribed fire in various ecosystems. The basis for the fall course is a comprehensive overview of all aspects of conducting prescribed fires and covers laws and regulations, liability, weather, fuels, ignition, fire behavior, suppression, safety, and public education (Weir 2009). The spring semester is a field-based course that builds on the knowledge gained in the pre-requisite classroom-based fall course with experiential learning. Experiential learning opportunities include operating a drip torch (including mixing fuel, filling with fuel, adjusting air flow, lighting, extinguishing, and effectively igniting fuels) in supervised teams (Figure 1a), training on how to operate suppression equipment and respond to spot fires (i.e., fire ignited outside the perimeter of the main fire by a firebrand) (Figure 1b), and active participation in all phases of conducting prescribed fires (Figure 1c). The institutional course descriptions are below:

***NREM 4783/5783 (Undergraduate/Graduate): Prescribed Fire—Lab 3 hours per week. Prerequisite NREM 3613 (Rangeland Management). When to use prescribed fire and how to use prescribe fire to accomplish specific land management objectives. Writing prescribed fire plans (burn plans), policy and laws, weather, equipment, conducting burns, and post-burn mop-up. Field trips required.***





**Figure 1.** A) Students learning how to operate a drip torch under supervision (i.e., training on ignition). B) Spot fire training and the experiential nature of group learning in a calm and controlled scenario (i.e., training on suppression). C) The deployment of teams of undergraduate and graduate students on prescribed fires (i.e., gaining real experience).

***NREM 4793/5793 (Undergraduate/Graduate): Advanced Prescribed Fire—Lab 3 hours per week. Prereq-***

*uisite NREM 4783 (Prescribed Fire) or consent of instructor. Preparing fire plans (burn plans) and executing prescribed fires as the fire boss.*

### **Administration of Surveys**

To assess student perceptions, we administered two surveys: one to current OSU students and one to former OSU students who had completed the OSU prescribed fire courses. Both surveys were anonymous with no identifiers. The current-student survey was a retrospective survey taken at the completion of the field-based prescribed fire course at OSU in May of 2012 and 2013 (<http://dx.doi.org/10.6084/m9.figshare.1284665>). Retrospective surveys ask participants to self-evaluate changes after an experience, a different survey approach than surveying participants before and after an experience. We assessed current students' major field of study, whether their background was urban or rural, their prescribed burning experience, and changes in three areas: a) their perceptions about prescribed fire; b) their knowledge, skills, and abilities (KSAs) in relation to prescribed fire; and c) their potential for applying prescribed fire. The survey used a five-point Likert scale, which is a psychometric index of equal negative and positive positions with an intermediate neutral option (i.e., 1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, 5 = strongly agree) (Boone and Boone 2012).

The second survey, using the Dillman method (Dillman 2000), was administered to former OSU students who had completed the prescribed fire courses between 2000 to 2013 (<http://dx.doi.org/10.6084/m9.figshare.1284666>). The sample of targeted former students was non-random because we only were able to send surveys to students for whom we had current contact information. From 2000 to 2013, 376 students completed NREM 4783/5783 and 154 students completed NREM 4793/5793. The former-student survey was

sent to 132 former students (representing 86% of students who completed both semesters). The former-student survey was an online reflective survey that assessed their current location of employment, their type of employer, the number of prescribed fires they assisted, and the total area burned on those fires. Former students were asked a series of binary yes-or-no questions regarding their role in wildland fire work, their primary use of fire in previous or current professional positions, and their involvement in prescribed burn associations or cooperatives (i.e., groups of landowners that share equipment, labor, and liability to conduct prescribed fires [see Taylor 2005]). Former students were then asked a series of six questions about the effectiveness of the OSU prescribed fire courses in terms of professional preparation, career trajectory, comparison to other fire training, and relevance. Lastly, former students were asked to rank the utility of the five types of instruction used in the OSU courses (lectures, case studies, writing burn plans, hands-on spot fire and equipment training, conducting prescribed fires).

### *Data Analyses*

For the current-student survey, we calculated the proportion of educational majors and whether the students had urban or rural backgrounds, their prescribed burning experience prior to the course, the mean number of prescribed fires on which students participated during the course, and the number of prescribed fires on which students had the opportunity to participate. For the former-student survey, we calculated the proportion of the types of their employers and the mean number of prescribed fires on which the former students participated. We calculated the percentage of job responsibilities related to prescribed fire and involvement with prescribed burn associations by employer.

Because our sample of former and current students was non-random and only included

students from a single program without a control, we considered this to be a case study and therefore did not make inferences about any category of former students. For both surveys, we assessed the median as a measure of central tendency, and frequency distributions as a measure of variability of the five-point Likert rankings. For the current-student retrospective survey, change of frequency distribution of Likert rankings was compared before the course (Pre) and after the course (Post). Medians and frequency distributions were used because the Likert data from our surveys is an ordinal measurement scale that indicates rankings of different magnitudes for responses. However, ordinal scale rankings do not imply how much less or greater different rankings are, as with an interval measurement scale, and the non-normally distributed data violate assumptions of parametric hypothesis testing (Boone and Boone 2012). Although non-parametric statistics would be appropriate, mean ordinal scale rankings and separation are less informative than the relative distribution of student responses for informing curriculum development.

### *Review of US Wildland Fire Curricula Relative to Prescribed Fire*

Based on the results of our study and results reported in Kobziar *et al.* (2009) and Godwin and Ferrarese (2014), we assessed the current wildland fire courses offered by universities relative to courses that focused explicitly on prescribed fire. We reviewed official course descriptions for the 22 universities assessed in Kobziar *et al.* (2009), and 15 other universities recommended by the editorial review. If a course was cross-listed between departments of education level, it was only counted once. We only counted courses available for academic credit towards a degree. We calculated summary statistics for wildland fire courses, the number of courses titled “prescribed fire” (or some similar phrase; i.e., pre-

scribed burning, controlled burn), and the number of official course descriptions that mentioned prescribed fire or similar phrases.

## RESULTS

### Current-Student Survey Results

Current students represented a wide range of academic interests and prescribed burning experience. Seven different majors were represented (Table 1) and half (50%) of the students indicated that their background was rural, 6% indicated that it was urban, and 38% indicated that it was a combination of rural and urban. The remainder of the students did not indicate their background type. Prior to the course, 38% of the students (12 of 32) had never participated on a prescribed burn. During the course, students participated on an average of seven prescribed burns out of a total of eight burns on 294 ha in 2011, and 11 burns on 236 ha in 2012.

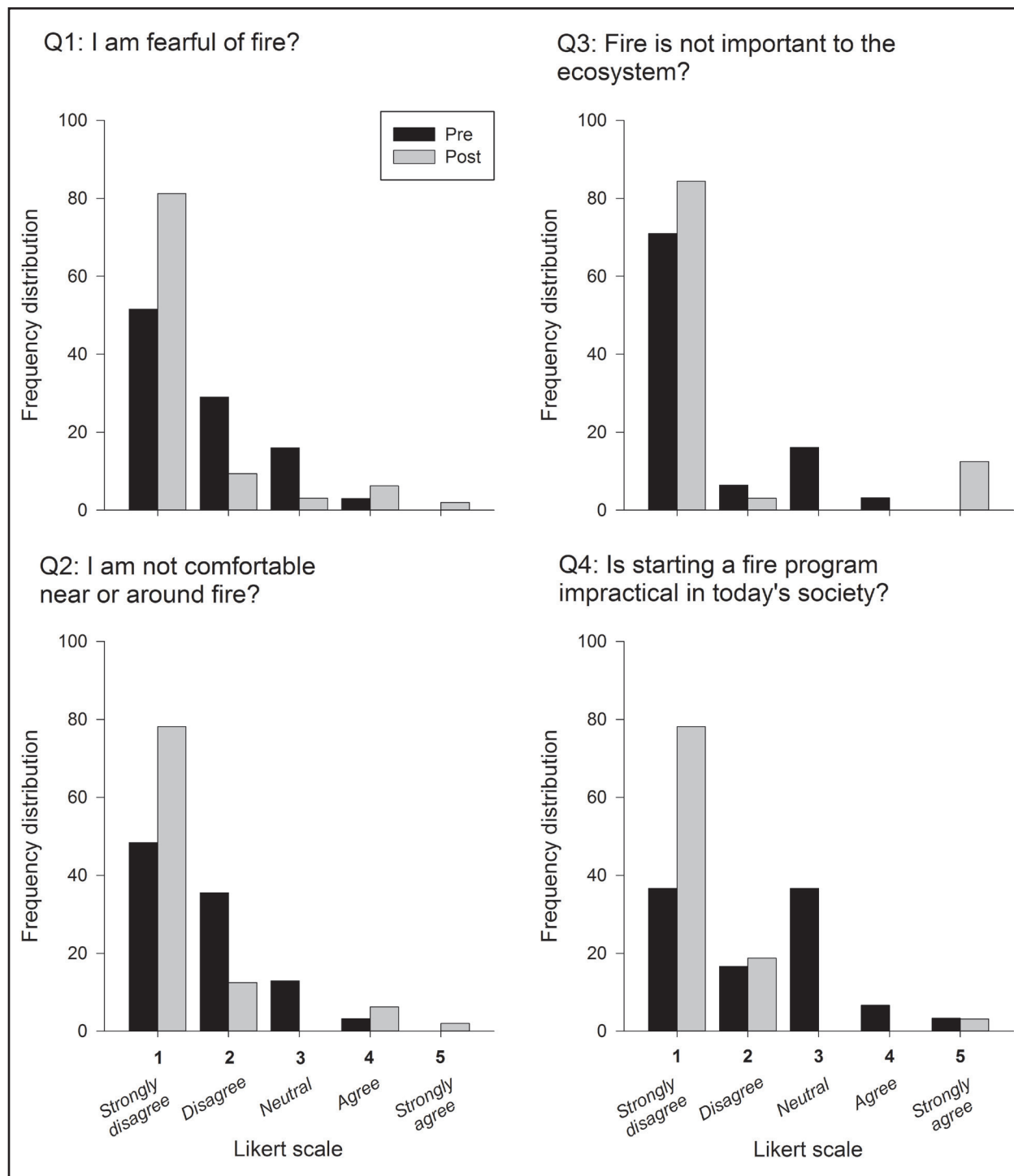
Frequency distributions on the first two questions (question 1, Q1; question 2, Q2) about fear or comfort (Figure 2) tended towards disagreement prior to the course and even more so after course completion. Prior to the course, 80% of students responded “strongly disagreed” or “disagreed” with state-

ments that suggested that they had a fear or lack of comfort with prescribed fire, a response that increased to 90% after the course. There was a highly perceived importance of fire to the ecosystem both before (71%) and after (84%) the course (Q3; Figure 2), and a more normally distributed frequency of perceptions about the practicality of starting a prescribed fire program in today’s society that shifted strongly after the course (from 37% before to 78% after the course strongly disagreed) (Q4; Figure 2). The median rankings for Q1 to Q4 (Figure 2) were 1, 2, 1, and 2 prior to the course, and 1 after the course.

Current-student responses to KSA questions were more evenly distributed or skewed towards “below average” prior to the course and demonstrated shifts in a positive direction after the course (Figure 2, Figure 3). When asked about their ability to plan prescribed fires, 90% reported “none” or “very little” prior to the course, but 97% reported “good” or “excellent” after the course (Q5; Figure 3). Similar patterns of strong shifts in the opposite direction emerged when asked about the role of fire in the ecosystem, their confidence and ability to operate a drip torch, and their confidence in their ability to lead a prescribed fire program (Q6, Q7, and Q8; Figure 3). After the course, 97% of student responses indicated

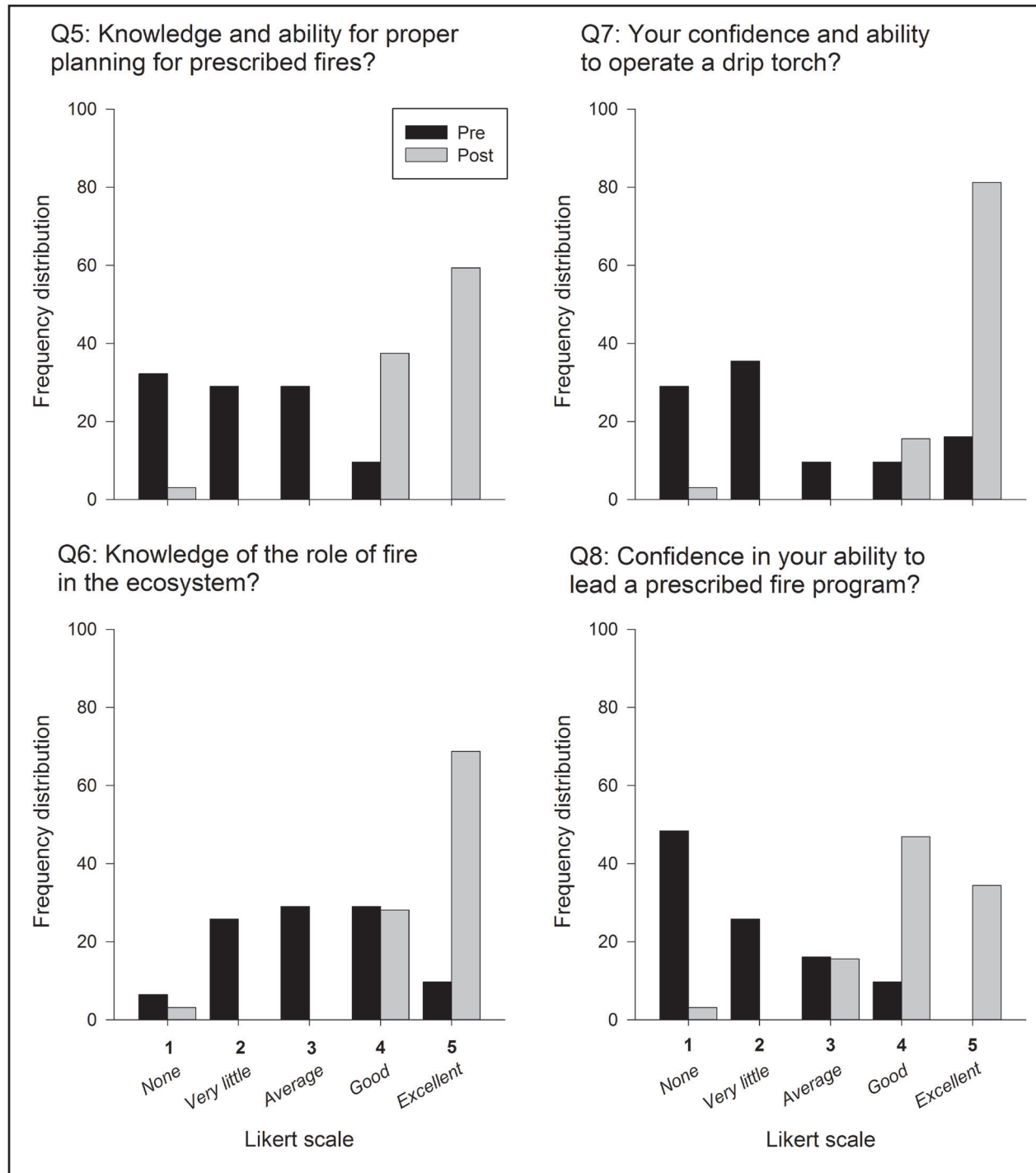
**Table 1.** Major fields of study at Oklahoma State University for current students completing the two-semester prescribed fire course sequence in the 2011 and 2012 academic years.

Major field of study	Number of students and percent of total
Animal Science	3 (9%)
Fire Ecology and Management	8 (25%)
Forest Ecology and Management	1 (3%)
International Agriculture	1 (3%)
Plant and Soil Science	1 (3%)
Rangeland Ecology and Management	7 (22%)
Wildlife Ecology and Management	8 (25%)
Fire and Range Ecology and Management (double major)	2 (6%)
Not reporting	1 (3%)
<b>Total current students evaluated</b>	<b>32 (100%)</b>



**Figure 2.** Histogram of frequency distribution of current-student rankings to questions assessing perceptions of prescribed fire before (Pre) and after (Post) completing the Oklahoma State University prescribed fire course.





**Figure 3.** Histogram of frequency distribution of current-student rankings to questions assessing knowledge, skills, and abilities (KSAs) of prescribed fire before (Pre) and after (Post) completing the Oklahoma State University prescribed fire course.



that they had “good” or “excellent” confidence and ability to operate a drip torch after the course. The median rankings for Q5 to Q8 (Figure 3) were 2, 2, 2, and 3 prior to the course, and 5, 5, 5, and 4 after the course.

Current-student responses to questions about applying prescribed fire were more evenly distributed prior to the course than were responses to perception or KSA questions, and demonstrated strong positive shifts after the course (Figure 2, Figure 3, Figure 4). For all questions assessing the potential for applying prescribed fire prior to the course, none of the frequency distributions was more than 36% for a single ranking, with at least 9% of responses for all rankings (Figure 4). After the course, 72% of student responses indicated that they “mostly” or “certainly” were interested in obtaining a fire-related job, compared to only 31% prior to the course (Q9; Figure 4). The frequency distributions of student rankings demonstrated a similar trend for the final three questions about their potential to explain prescribed fire to acquaintances and strangers, and their ability to apply fire on family land; ranking “mostly” or “certainly” shifted from 28% to 41% prior to the course to 96% to 97% after the course (Q10, Q11, and Q12; Figure 4). The median rankings for Q9 to Q12 (Figure 4) were 3, 3, 2, and 3 prior to the course, and 4, 5, 5, and 4 after the course.

#### *Former-Student Survey Results*

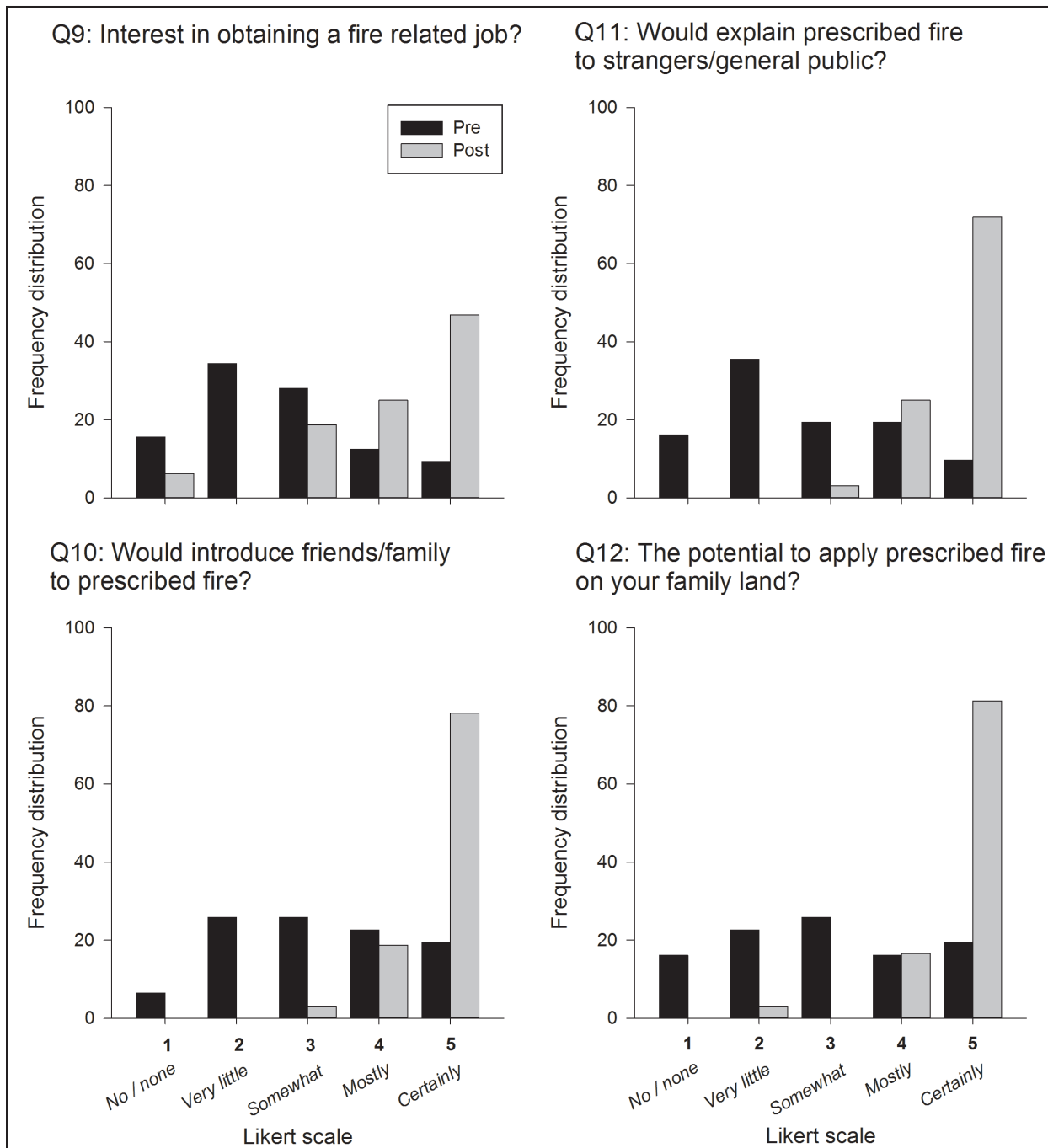
The response rate to the former-student survey was 75%, with 99 of the 132 invited former students completing the survey. Former students were currently employed in 20 US states, the US District of Columbia, and one Canadian province, with more than half residing in Oklahoma (Table 2). Approximately half (47) of the former students were employed by the federal government, one quarter (27) were employed by a state governmental agency, and the remainder were employed privately, by non-governmental organizations, by

Native American tribes, or did not specify an employer. In terms of professional responsibilities, 67% conducted prescribed burns, 60% did some type of preparation work for burning, 73% wrote burn plans, 30% worked on prescribed fire-related policy, 32% were involved in wildland fire prevention, and 26% conducted research related to prescribed fire. About one third (35) of the former students had started or participated in a prescribed burn association or some type of local cooperative that empowers private and public managers to burn by limiting liability and sharing equipment. Of those former students that had been actively involved with a prescribed burn association, about two thirds (20) were employed by a federal government agency.

Former students reported conducting or assisting with a total of 6247 prescribed fires on 803 252 ha across North America (Table 2), with Kansas and Oklahoma accounting for the majority of number of fires and area burned. The mean number of prescribed fires per former student was 63 fires, ranging from 0 fires to 2000 fires per former student. The mean area burned per former student was 8196 ha, ranging from 0 ha to 303 509 ha. The mean size of a prescribed burn per former student was 146 ha, ranging from 6 ha to 2023 ha.

The frequency distribution of the utility ranking of the five educational activities of “most important” and “least important” was 60% and 1% for conducting prescribed fires, 25% and 5% for writing burn plans, 11% and 9% for the spot fire and equipment training, 1% and 34% for case studies, and 4% and 50% for lectures. (Figure 5). Based on the median former-student rankings, conducting prescribed fires was ranked as the most useful instructional activity, writing burn plans was ranked second, the spot fire and equipment training was ranked third, case studies were ranked fourth, and lectures were ranked as the least useful.

When asked if the OSU courses had changed their career goals, 43 of 99 former



**Figure 4.** Histogram of frequency distribution of current-student rankings to questions assessing potential for adoption of prescribed fire before (Pre) and after (Post) completing the Oklahoma State University prescribed fire course.

students indicated some form of directional change or a reinforcement and enhancement of their desire to work in wildland fire. This indicates that the other students may have already desired to work in wildland fire irrespective of

the course. When asked for additional comments, 85 former students responded. The terms “experience”, “hands-on,” and “practical” were mentioned 25, 16, and 7 times, respectively. Several former students also sug-

**Table 2.** Current location and number of former students completing the Oklahoma State University prescribed fire courses. Fire data indicates the total number of prescribed fires, the total area burned by prescribed fire, and mean fire size of prescribed fires that students had conducted or participated in in some way, such as planning.

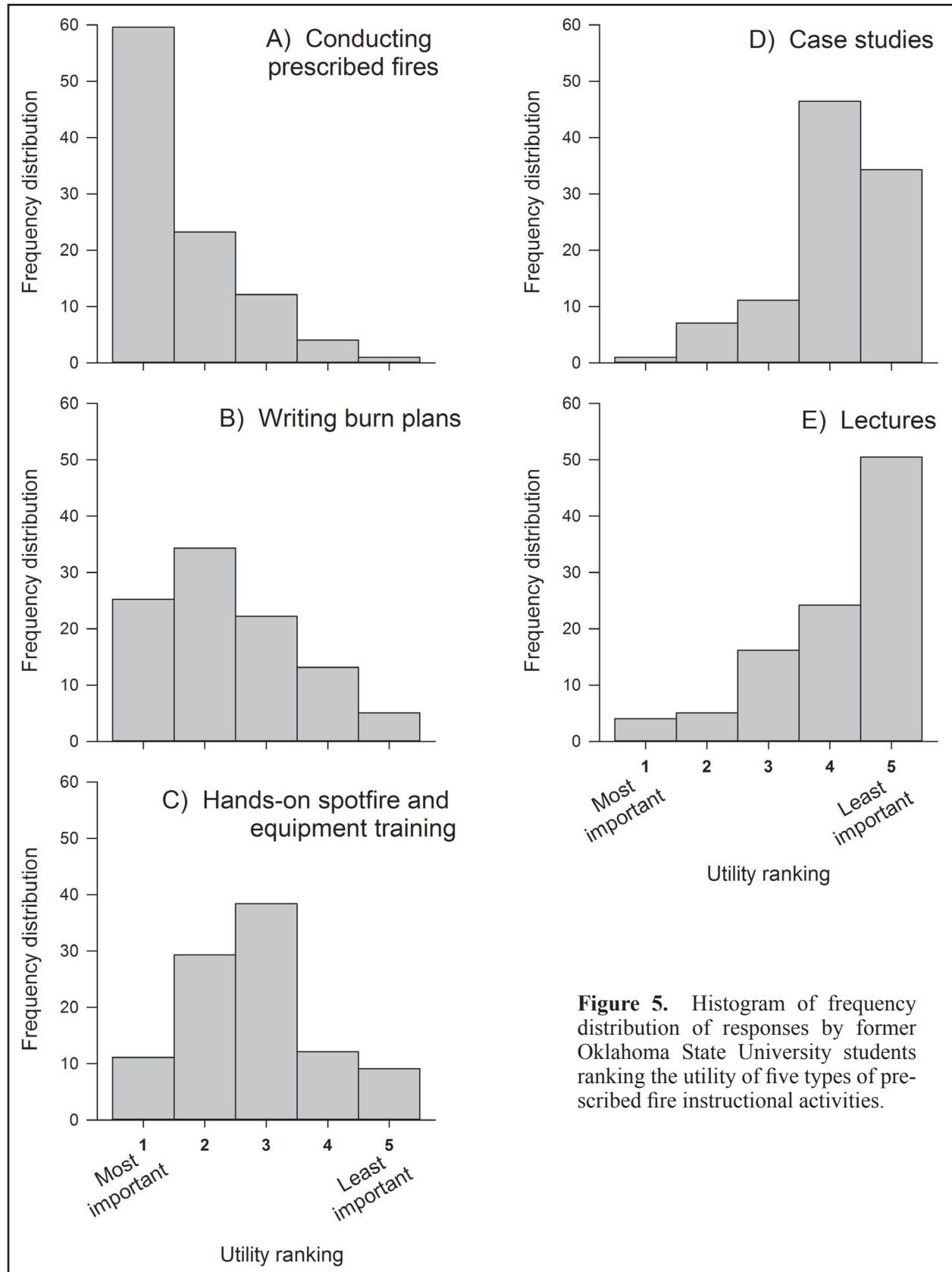
Location	Number of former students	Total fires	Total area burned (ha)	Mean fire size (ha)
Arizona, USA	1	0	0	0
Arkansas, USA	1	150	40 469	270
California, USA	2	650	45 325	35
District of Columbia, USA	1	60	2 023	34
Florida, USA	1	50	324	6
Indiana, USA	2	210	1 214	22
Kansas, USA	6	364	319 505	341
Michigan, USA	1	0	0	0
Minnesota, USA	3	74	1 299	20
Mississippi, USA	3	151	12 958	46
Missouri, USA	1	20	2 428	121
Montana, USA	1	50	8 094	162
Nebraska, USA	3	105	8 903	162
New Hampshire, USA	1	0	0	0
New Mexico, USA	2	43	30 655	453
North Dakota, USA	1	200	2 023	10
Oklahoma, USA	57	3 969	304 033	103
Oregon, USA	2	10	972	61
Tennessee, USA	1	8	1 012	126
Texas, USA	5	60	12 302	167
Wyoming, USA	3	72	7 689	392
British Columbia, Canada	1	1	2 023	2 023
<b>Summary</b>	<b>Total = 99</b>	<b>Total = 6 247</b>	<b>Total = 803 252</b>	<b>Mean = 146</b>

gested incorporating instruction on federal fire standards to assist students in entering federal wildland careers.

### Review of US Wildland Fire Curricula Results

Of the 37 universities that we assessed that offered wildland fire courses, on average, they offered three courses per institution for a total of 114 with a range of 1 to 14 (Table 3). About half (18) of the universities only had a single fire course, and three quarters (30) did not have a course with “prescribed fire” explicitly in the course title. Only nine courses that were

explicitly titled “prescribed fire” (or some form of the phrase) were offered and represented only 8% of wildland fire courses at the universities we assessed. Of those 37 universities, only eight offered courses explicitly focused on prescribed fire including Colorado Mesa University, New Mexico Highlands University, Oklahoma State University, Texas Tech University, the University of Georgia, the University of Idaho, the University of Montana, and the University of Tennessee. However, 35 of the 114 total wildland fire courses mention prescribed fire or some form of the term in their official course descriptions. Of



**Figure 5.** Histogram of frequency distribution of responses by former Oklahoma State University students ranking the utility of five types of prescribed fire instructional activities.

**Table 3.** Wildland fire curricula in United States universities in 2014 that offer wildland fire programs, courses, or Student Association for Fire Ecology chapters. Bold text indicates that the institution offers a fire ecology program certified by the Association for Fire Ecology.

<b>University</b>	<b>Total number of wildland fire courses<sup>a</sup></b>	<b>Number of courses with “prescribed fire” in title<sup>b</sup></b>	<b>Number of courses with “prescribed fire” in course description<sup>c</sup></b>
Auburn University	1	0	0
<b>California Polytechnic State University*</b>	<b>6</b>	<b>0</b>	<b>0</b>
California State University, Chico	1	0	0
Clark University*	1	0	0
Clemson University	2	0	Unknown
Colorado Mesa University	10	1	3
<b>Colorado State University*</b>	<b>4</b>	<b>0</b>	<b>2</b>
Duke University*	1	0	1
<b>Humboldt State University*</b>	<b>5</b>	<b>0</b>	<b>1</b>
Louisiana State University*	1	0	0
Mississippi State University*	1	0	1
New Mexico Highlands University	5	1	2
<b>Northern Arizona University*</b>	<b>4</b>	<b>0</b>	<b>0</b>
Northern Michigan University	6	0	1
Ohio State University*	2	0	1
Oklahoma State University*	5	2	4
Oregon State University*	4	0	0
<b>Stephen F. Austin State University*</b>	<b>3</b>	<b>0</b>	<b>1</b>
Texas Tech University*	3	1	1
University of California, Berkeley*	4	0	2
University of California, Davis*	1	0	0
University of Oregon*	1	0	1
University of Florida*	4	0	3
University of Georgia	1	1	1
<b>University of Idaho*</b>	<b>14</b>	<b>1</b>	<b>2</b>
University of Massachusetts	1	0	0
University of Missouri	1	0	0
<b>University of Montana*</b>	<b>5</b>	<b>1</b>	<b>1</b>
University of Nevada, Reno*	1	0	1
University of Nevada, Las Vegas	1	0	0
University of North Texas	1	0	1
University of Tennessee	3	1	1
University of Washington*	2	0	0
University of Wisconsin, Madison	1	0	0
University of Wisconsin, Stevens Point	5	0	2
Utah State University*	1	0	0
Virginia Tech University	2	0	2
<b>Total</b>	<b>114</b>	<b>9</b>	<b>35</b>
<b>Mean</b>	<b>3</b>	<b>0.2</b>	<b>1</b>
<b>Proportion of universities with prescribed fire curricula</b>	<b>8 of 37 (22 %)</b>		<b>22 of 37 (60 %)</b>

<sup>a</sup> Wildland fire course numbers are based on official university websites and course descriptions. We assessed both undergraduate and graduate courses; if a course was cross-listed, it was only counted once. We only counted courses available for academic credit towards a degree.

<sup>b</sup> Courses with “prescribed fire” in title or some variation (prescribed burning, controlled burning, ignition).

<sup>c</sup> Courses mentioning ‘prescribed fire’ in course description: total wildland fire courses = 35 of 114 (31 %).

\* Universities assessed in Kobziar *et al.* 2009; all others recommended by editorial reviewers.



the 37 universities assessed, 22 offered at least one course that mentioned prescribed fire in the official course description (Table 3). Of the seven AFE-certified academic programs, five did not have prescribed fire title courses, three did not have course descriptions with prescribed fire mentioned, but all seven universities offered the average number of fire courses or more (Table 3).

## DISCUSSION

The results from our evaluation of current and former students demonstrated positive changes in knowledge, skills, abilities, perceptions, and the application of prescribed fire resulting from the courses at OSU. One third of the students had zero prescribed fire experience before the course, but, through experiential opportunities, the course reduced negative perceptions associated with fire while increasing knowledge, skills, and abilities in conducting fires, especially in planning fires, leading a fire program, and operating a drip torch. Changes in perceptions were less than changes in knowledge, skills, and abilities, or potential for applying prescribed fire. This is not surprising because, based on their responses in the perceptions portion of the survey, students who chose to enroll in the OSU course already perceived fire as an essential natural process in the ecosystem. Many students reported that the course changed their career trajectories by stimulating their interest in obtaining fire-related jobs, and by communicating the critical role of fire in wildland ecosystems. Furthermore, our study also revealed a lack of university courses that explicitly focus on prescribed fire, a potential explanation for the problems that students have in acquiring the needed prescribed-fire education at the national level (Godwin and Ferrarese 2014).

The long-term effect of the OSU university curricula is that alumni have had a broad impact on North American wildland fire as measured by their participation in thousands of

prescribed fires on close to a million hectares from 2000 to 2013. The importance of federal and state government agencies in employing and conducting wildland fire operations is also demonstrated in the employment of approximately 75% of the former students who responded to the survey. Former students not only directly applied prescribed fire but potentially indirectly enhanced the ability of others to conduct fires through their involvement in planning, policy development, and education. Where alumni are employed and their interactions with the public are also critically important as personalized contact is a key component to changing public perception (McCaffrey 2004). Former students have been active in this role of transferring knowledge to the public, especially to private landowners involved in prescribed burn associations. Because the use of prescribed fire is complex, prescribed burn associations are essential to overcoming the social constraints on prescribed fire, and the participation in prescribed burn associations by competent wildland fire professionals is important (Taylor 2005, Scasta *et al.* 2011). Our results indicate that current students are more willing to interact with the public in communicating the importance of prescribed fire after completing the courses, and that former students have actively done so over the past decade. These short-term and long-term impacts will be essential to restoring the role of fire in fire-dependent ecosystems (Twidwell *et al.* 2013).

The key role of experiential learning is evident for both current and former students. The greatest impacts identified in the current-student survey were outcomes directly associated with active experiential learning such as proper planning for prescribed fires (i.e., writing burn plans) and operating a drip torch (i.e., igniting a prescribed fire). Current students also referenced the hands-on learning that was feasible only in the field-based portion of the course that is experientially based. Former students placed the highest value on

experiential learning as actually conducting prescribed fires had more utility than any other type of instruction and included all aspects of igniting and suppressing fires. Writing burn plans ranked second highest and involved physically assessing fuels, hazards, and appropriate techniques for each burn unit, and integrating classroom-based knowledge with active application of fire. The third most useful type of instruction was the hands-on spot fire and equipment training, which provided experience in using wildland fire hand tools to suppress and extinguish simulated escaped or spot fires. The least useful types of instruction were case studies and lectures—types of instruction that require little to no active learning, very little interaction with the instructor, and are largely passive. Therefore, experiential learning resonates with future and current wildland fire managers and should be included in curriculum development. However, it has to build on a foundation of basic subject matter. We therefore suggest that fire education be successional so that basic subject-matter knowledge in the classroom is integrated with field application (Tanaka *et al.* 2012).

## IMPLICATIONS AND RECOMMENDATIONS

Based on the short-term and long-term benefits of experiential education in prescribed fire at OSU and the low number of prescribed fire courses nationally, we provide the following recommendations to overcome the challenges reported by students (Godwin and Ferrarese 2014). To deal with the difficulty in accessing fire training and education, we recommend that universities develop field sites where burn units are small enough and simple enough (in terms of terrain, woody plant cover, and distance from campus) to be burned regularly. To address the limited access to equipment and lack of funding, we recommend that student groups petition both faculty and administrators for assistance in acquiring

external funding from fire-focused funding entities that have a history of providing equipment for prescribed fire associations. Lastly, given the stated lack of institutional support from universities and management agencies, we recommend that assessments such as this one and others (Kobziar *et al.* 2009, Godwin and Ferrarese 2014) be used to demonstrate the support of prescribed fire education and training. If universities are resistant to prescribed fire education due to perceived risks and liabilities, we suggest that they apply customary risk management strategies to prescribed burning.

An effective approach to enhancing prescribed fire knowledge and application has been the coupling of fire management with fire research by the Australian Department of Environment and Conservation, which has led to a large body of regionally specific research (Sneeuwjagt *et al.* 2013). Our experience at OSU suggests that research and management are highly synergistic, and that training students on both research fires and management fires enhances the research capacity while developing research-based prescribed fire guidelines that are specific to Oklahoma and the Great Plains. At OSU, the majority of the research fires were conducted by students with the supervision of only a few OSU employees. Assimilating an adequate fire crew can be very difficult and students have been an important part of the research process. This integration has led to research dealing with livestock parasites (Scasta *et al.* 2012, Polito *et al.* 2013), fuel combustion on grazed pastures (Scasta *et al.* 2014), invasive plant species (Cummings *et al.* 2007), and many more studies. Student experiences in the field can also be the impetus to additional types of fire research and inquiry that continue to address regional issues (for example, Weir and Scasta 2014). We recommend that universities encourage more integration of fire ecology research and experiential education to maximize benefits to both researchers and students.

## CONCLUSION

Our results, coupled with studies that demonstrate the desire for prescribed fire experience by students and engagement with the general public, suggest that prescribed fire is a point of reference for understanding wildland fire (Taylor and Daniel 1984, Jacobson *et al.* 2001, Loomis *et al.* 2001, Parkinson *et al.* 2003). If universities are going to continue to provide relevant programs in wildland fire, they must develop innovative approaches that

strike a balance between learning the concepts and then applying them through field experiences—a progression that leads to mastery of technical skills (Abbott *et al.* 2012). Ultimately, classroom instruction will never serve as an adequate proxy for experiential learning of prescribed fire. If we are to develop competent and effective wildland fire managers in an increasingly complex and hazardous wildland fire environment, constraints to experiential learning about prescribed fire must be overcome (Kobziar *et al.* 2009).

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