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OXFORD

Lessons From a 10-yr Invasive Species Webinar Program: Emerald Ash Borer University

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Abstract

Information about invasive species needs to be spread rapidly across a wide geographic area following an invasion. However, in-person events can be time-consuming and costly for the participants, organizers, and presenters. Online programming like webinars can bridge this gap, but there is limited published data on how best to run these programs. We report on a 10-yr webinar program, Emerald Ash Borer University, and offer suggestions for improving their effectiveness as a communication tool. Webinar participants viewed the webinars positively and undertook recommended management actions. In addition, most of our survey respondents extended the reach of this program by widely sharing the information from the webinars. Posting the webinars on popular streaming platforms greatly extended their reach long after the live viewing event. Despite their longevity, viewers of recorded videos watched them differently than those viewing live events. We suggest modifying the format of future webinar presentations to accommodate these differences to improve information transfer.

Key words: webinars, asynchronous viewing pattern, science communication, impact assessment, invasive species

Invasive species can be devastating to human wellbeing (e.g., Jones 2016), cause economic (e.g., Hauer and Peterson 2017) and environmental damage (e.g., Vilà et al. 2011, van Hengstum et al. 2014). Information about the growing threat of invasive species (Lovett et al. 2013) must be disseminated quickly across large geographic areas early in the invasion process when its potential to mitigate negative impacts of these organisms is greatest (Epanchin-Niell and Liebhold 2015). Traditional methods of outreach and extension play an important role in this process (e.g., Diss-Torrance et al. 2018) but can be time-consuming and costly. Increased access and acceptance of digital communication tools have made them increasingly useful to meet information transfer needs (e.g., Newman et al. 2010, Silliman 2016, Benge and Sowcik 2018), particularly after many extension and outreach programs were forced online due to the COVID-19 pandemic. Here we report on an online extension program aimed at expanding the reach of invasive species education.

Land managers, arborists, and other stakeholders are essential in controlling invasive species, but there is often a disconnect between the information they want and the information they receive. This contributes to the knowing-doing gap where in the best management practices suggested by research and those implemented on the ground do not always align (Esler et al. 2010, Hulme 2014, Matzek et al. 2014). Stakeholders have expressed frustrations with the speed at which they receive information and its practicality for management tasks (Matzek et al. 2015). Informal presentations can bridge

this gap by allowing researchers to address specific practitioner issues by sharing early results of relevant studies. This exchange of preliminary information and casual observation by both researchers and practitioners can help guide early implementation of management efforts (e.g., Parra et al. 2017). In-person events have been an opportunity for informal presentations, but they are costly in terms of time and money to the audience and educator, and limited in reach to the audience present (Morse 2012). Clearly, a platform is needed to facilitate widespread sharing of this information in a timely fashion.

Providing the general public with up-to-date knowledge about invasive species may improve their personal ability to manage these organisms (Requier et al. 2020), help slow the spread of these organisms (Jacobi et al. 2012, Kearns and Tobin 2020), and inform development and adoption of local management plans (Hauer and Peterson 2017, Barney et al. 2019). This is most readily achieved when trusted, local stakeholders and community leaders, such as extension educators and local arborists, rather than outside experts are the ones who actively participate in the development of local management and outreach plans (Shackleton et al. 2019, Wald et al. 2019). However, Extension Specialists and other regional technical and policy experts have limited capacity to receive and provide training due to the requirement to cover a wide range of issues over large territories (Warner et al. 2014). Programming that is practical but not time intensive could improve the ability of these regional specialists

and educators to keep up-to-date on key topics that interest their stakeholders. Thus, greatly increasing the number of people receiving and disseminating information that is critical to local invasive species efforts.

Webinars, a portmanteau of web and seminars, offer a way to augment in-person programming (Stein et al. 2010) and have been found to be as effective, in some cases, as in-person events (Anderson 2018). Webinars are usually conducted through a platform that allows viewers across the world to watch a speaker present and interact with them by asking questions (Wang 2008, Stein et al. 2010, Bogdanou et al. 2013, Mihai 2014, Johnson and Schumacher 2016, Nagy and Bernschütz 2016, Wardynski et al. 2018). Webinars can be recorded for viewing at a later time (Young et al. 2012, Brady et al. 2016, Gaolach et al. 2018, Lobley et al. 2019) and many video platforms allow for comments to be posted below the video, providing a space for continued interaction after the initial live presentation. They are therefore not as limited by space or time as in-person events and instead are only restricted by the viewer's interest and access to the internet (Wyatt 2006). However, despite the benefits and their prevalence in extension, published information about webinar efficacy, especially of long-running series, is limited (Zoumenou et al. 2015).

We have hosted a webinar series called Emerald Ash Borer University (EABU) since 2009 (http://www.emeraldashborer.info/eabu.php) to address the need for easily accessible and up-to-date information about emerald ash borer (Nagle et al. 2014). The initial focus of the webinars was emerald ash borer but expanded to include other invasive forest insects and pathogens affecting the north-central and eastern United States. The longevity of our webinar series presents us with the unique opportunity to explore the efficacy of both live and recorded webinars. Here we seek to answer four primary questions: 1) Did our webinars have a wide geographic reach?, 2) Did the audience change their behavior based on the message of the webinars?, 3) Did the viewers share the information they learned in the webinars?, and 4) What is the longevity of recorded webinars hosted on streaming platforms?

Methods

The Emerald Ash Borer University webinar series is produced through the combined efforts of the United States Forest Service (USFS), Purdue University, Michigan State University, and Ohio State University. The webinars have been held since 2009 and a detailed discussion of the beginning of the program can be found in Nagle et al. (2014). We hold at least 10 free 60-min webinars per year (typically five in the fall and spring) relating to the biology and management of invasive insects and pathogens of concern in North Central and Eastern United States. Speakers are mostly university faculty and United States federal or state government workers in a field related to forestry or entomology. In addition, municipal officials and business operators who deal with the financial and management issues these invasive pests bring to infested areas have provided first-hand experiences and share valuable insights. Most speakers only present a single webinar, but some have presented more frequently. Our steering committee is comprised of USFS staff and university professionals.

We choose webinar topics that target tree management and care professionals (e.g., foresters, arborists, city planners, etc.), extension educators, members of the public with outdoor hobbies (e.g., Master Gardeners and Master Naturalists), and homeowners. We marketed the webinars using an e-mail list of past viewers, e-mails to key organization leaders (e.g., Master Gardeners), posting announcements on blogs, professional organization websites (e.g., International Society of Arboriculture), Extension educators, and paper flyers. In addition, we offered continuing education credits for professional societies (International Society of Arboriculture, Society of American Foresters), licenses (Pesticide applicator's license through the Indiana State Chemist), and certificates of attendance.

Attendees watch the webinars synchronously as livestreaming Zoom events (Zoom Video Communications, Inc.) or asynchronously as posted recordings. Zoom records the number of live attendees. We have a tally of the number of viewers of all but four of our 92 webinars due to technical issues. Attendees who viewed the live webinars had the opportunity to ask the speakers questions. Attendees watching the recorded videos could leave comments on the videos that were answered by the EABU program managers.

Most webinars were recorded and posted online for free public viewing within a week of the live webinar. From February 2010 to August 2015, recorded videos were hosted on Michigan State University's server and were available from the Emerald Ash Borer University website (http://www.emeraldashborer.info/eabu.php). Due to technological constraints, we have information on the number of views during this time-period but not traffic source or length of view. Starting in August 2015, we uploaded all webinars to the video streaming platform YouTube (https://www.youtube.com/) on the EAB University channel (Emerald Ash Borer University), unless otherwise requested by the presenter. Older videos were uploaded in bulk to YouTube in 2015 and newer videos were uploaded within 1 wk of their aired date with a few exceptions due to technical issues (one video posted 1 mo later and two videos posted 1 yr later).

We recorded the total number of YouTube views for the lifetime of each video on 27 June 2019 and recorded the traffic sources for all videos, number of minutes viewed, and number of views by month since posting for each video on 1 July 2019. For the traffic sources, we pooled the broad YouTube generated categories into larger categories (YouTube, external source, and direct link or unknown) and did the same for the external source subcategories (unknown, EABU website, search engine, .edu site, social media, e-mail, miscellaneous organization, or government site). To assess the longevity of videos, we recorded the weekly views and total minutes watched from 1 September 2015 to 30 June 2019 as recorded by YouTube Analytics. YouTube only records views that last for more than 30 s. We calculated the mean and standard error for the number of views. To assess video longevity, we compared the ratio of recorded views to live views for the life of the video and on a bi-monthly basis. Viewing intensity over time was estimated by calculating mean watch times per month. We used JMP (JMP Pro 14.0.0) for all of our analyses.

The verbiage of titles can influence the number and type of people consuming a piece of communication material (e.g., Murphy et al. 2019). We tested whether key phrases in the titles of our recorded webinars influenced the number viewers and the length of views on YouTube. Presentations were categorized post hoc in a binary fashion according to the information included in their title (mention of 'management' or 'treatment', the presence of the word update, and the presence of a name of a geographic location). We tested whether these categories had an impact on the number of views of the recorded webinars and on the length of views of the recorded webinars using an ANOVA with category as the independent variable and number or length of views as the dependent variable.

Initial Survey

Beginning in 2012, we surveyed attendees of the live webinars about their experience using an anonymous, optional Qualtrics survey (IRB # 1208012585; Qualtrics International Inc.). To participate in the survey, respondents had to acknowledge that they were over 18. This question was the only one that we required them to answer. If attendees completed the survey and provided their e-mail address, we mailed them a small goodie bag worth less than $10 USD containing a reusable 'Don't Move Firewood' bag and invasive species information. We designed the survey to answer five questions: 1) What are the demographics of our audience (questions 3 and 4)? 2) Did the content of the webinar align with the audience's expectations (questions 5 and 6)? 3) Did they learn something meaningful to them from the webinar (question 7 and 8)? 4) Did the webinar prompt them to take action (questions 9 and 10)?, and 5) What topics would they like to see covered in the future (questions 11 and 12; Supp Appendix 1 [online only]). The answers to category 5 were not included in our analysis because we used this information for program development purposes.

Two researchers independently coded the two open-ended questions. After coding was completed, we compared results and resolved any conflicts. Responses to the question that assessed plans to act on webinar information (question 9) were coded into the following action categories: share with friends, share with work, share but not specified, plan action but type not specified, monitor or do survey work, do further research, report invasive species, and treat for invasive species. Audiences with whom information was shared (question 10) was coded into the following audience categories: friends or family, work, government, outreach or extension, clients, Extension Master Gardener or Naturalist Volunteers, not specified, and other. Answers to both questions could be coded for more than one response code if the respondent's answer fell into more than one category. We calculated the percent of each category of response for both questions using JMP (JMP Pro 14.0.0).

Four questions used a Likert scale (questions 5, 6, 7, and 8). Respondents were asked to rank their experience on a scale (e.g., very satisfied, somewhat satisfied, neutral, somewhat unsatisfied, and very dissatisfied). To simplify the analysis, we grouped the responses into a negative (position 1–3) and a positive level of satisfaction (positions 4–5). The neutral response was included in the negative category to avoid biasing our results towards a positive response. We calculated the percent of each category of response for all three questions using JMP (JMP Pro 14.0.0).

Long-Term Survey

In order to test the impact of our webinars and see if viewers followed through on their intended actions, we conducted a long-term survey of our viewers from 27 January 2020 to 1 April 2020 (IRB-2019-433; (Supp Appendix 2 [online only]). We solicited responses by sending the survey to our Emerald Ash Borer University e-mail list, our promotional e-mail list, which includes relevant organizations like Extension Master Gardener Volunteers, and asking that the survey link be forwarded when appropriate. They were first asked if they were over 18 yr old and if they answered no they were sent to the end of the survey. We asked basic demographic information (profession [question 2] and location [question 3]), how they watched the webinars (live, recorded, or both; question 4), and if information from the webinar had been used for management (questions 5 and 6), invasive species reporting (questions 7 and 8), public policy (questions 9 and 10), or education (questions 11, 12, 13, and

14). We assessed the answers to the 'Other' option of multiple-choice questions and coded them into pre-existing categories as appropriate. The invasive species that respondents listed as ones they had reported since watching the webinars were categorized according to their general taxonomic group (plant, insect, or disease). In an open-ended question, we asked respondents to provide one way they felt better able to manage invasive species after watching our webinars. Responses were coded into seven categories: identification, biology, survey or monitoring, insecticidal or mechanical treatment, teaching or answering questions, planning, and other. Answers could be coded into more than one category. We calculated the percentage of respondents for all questions.

Results

Of the 92 live webinars presented over 10 yr, we had live viewership data on 88, which had a mean viewership of 51.4 ± 4.8. The data for four webinars (4.3%) was not recorded because of technical issues. The 92 recordings of the webinars had a mean of 509.0 ± 51.8 asynchronous views, which is a mean of 13.3 ± 1.3 times as many viewers as the live webinars. The majority of the 42 talks posted directly to YouTube had the high ratio of live to recorded views in the first 6 mo (mean of 2.4 ± 0.2 asynchronous views/live views). However, the majority of webinars continued to gain viewers (81.8% of the 22 webinars that had been on YouTube for at least 24 mo), and many of the webinars had at least as many new recorded viewers per 2-mo time-period as live viewers for 24 or more months after their release (27.3% of the 22 webinars that had been on YouTube for at least 24 mo; Fig. 1). We found no evidence that including a location name or the word 'update' in the title impacted the number of views of the webinars (Table 1). Using the word 'management' or 'treatment' was associated with significantly higher number of views (Table 1). The mean watch time of the recorded webinars was 12:04 ± 0:44 min (*n* = 92; Fig. 2). We found no evidence that including a location name, the word 'update', or 'management' or 'treatment' increased viewing times (Table 1).

Viewers accessed the recorded webinars through external sources (44.4%), YouTube (50.5%), and direct link or unknown (5.7%, Fig. 3A). Of those viewers that accessed the webinars from a source outside YouTube, the majority came from unknown sources, the website associated with Emerald Ash Borer University, search engines, or other invasive species sites (Fig. 3B).

Initial Survey

We had a mean of 45.2 ± 2.8% live webinar viewers respond to our surveys. Webinar attendees self-identified as a member of categories involved in invasive species management or outreach professionally (76.7%), non-professionally (18.9%), or other (4.4%; *n* = 1,119). Most respondents were from the Midwestern United States (55.7%) but viewers were also present from the southern, western, and eastern United States (41.1%), and eastern and central Canada (3.3%; *n* = 1,101).

The majority of viewers reported that the webinar they watched was relevant and useful across multiple metrics. Most of the viewers found the webinars highly relevant (92.5 ± 1.6%; *n* = 875) and of high quality (94.8 ± 0.8%; *n* = 882). The majority of attendees reported that the webinar they watched made them feel better able to manage the focal pest (70.6 ± 1.9%; *n* = 1,127) and improved their knowledge of the subject matter (73.2 ± 2.3%; *n* = 1,126). The majority of respondents planned to take action based on the webinar (97.6%, *n* = 707). Those people
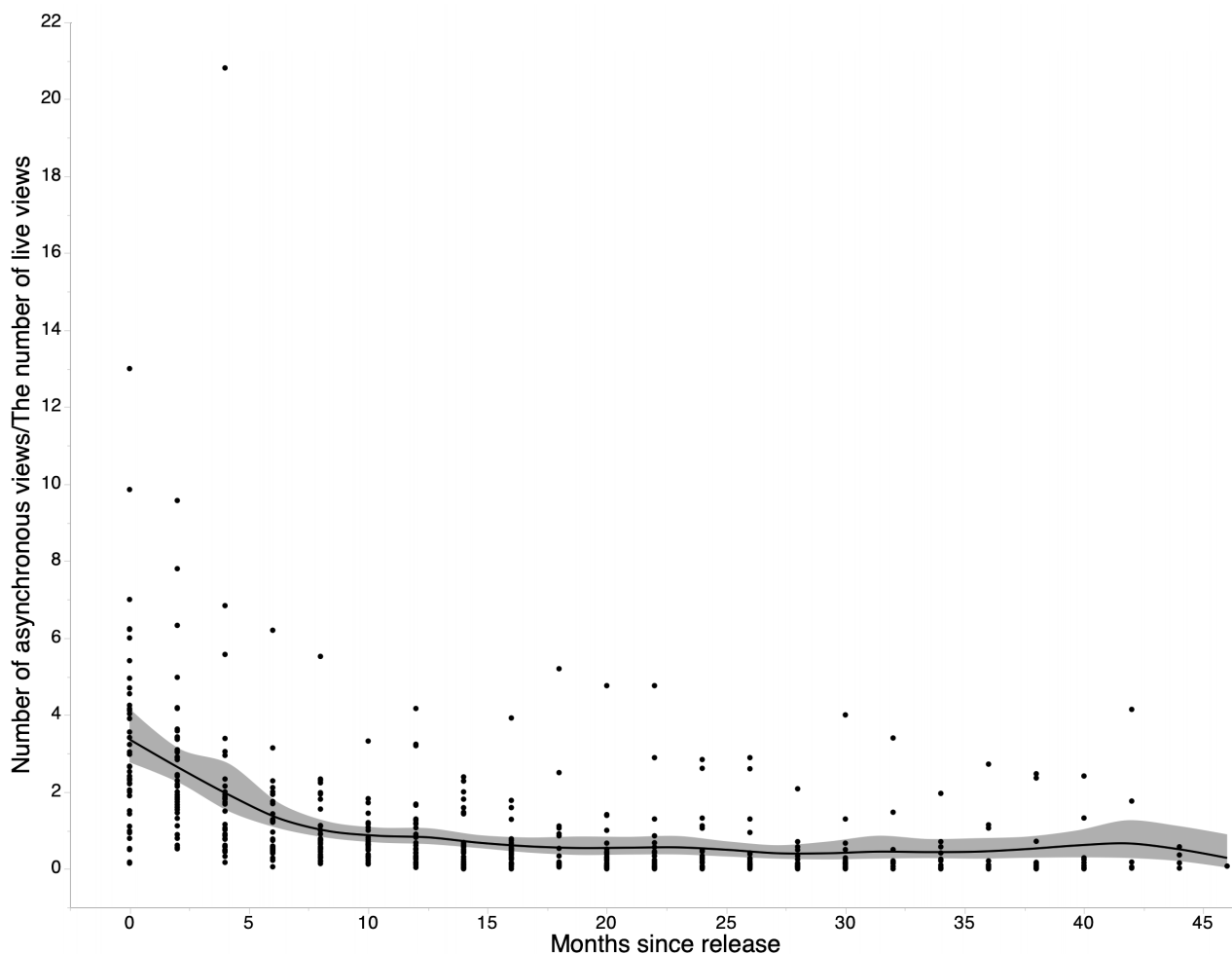
Fig. 1. The number of asynchronous views of the webinars divided by the number of live views in the months following their posting on YouTube. The shaded areas are the confidence of fit for each line.

that responded to the open-ended part of the question fell into the following categories: share the information (37.8%), conduct surveys or monitor (19.1%), treat for invasive species (16.9%), do further research (13.3%), and report invasive species (1.7%; $n = 707$). In a separate question, the majority of respondents planned to share the information in the webinars (mean=91.7 ± 1.4% $n = 1,114$; Table 2). Most did not specify how they would share the information ($n = 424$). Of those that did specify how they intended to share the information ($n = 217$), they reported that they would do so through outreach or extension work (35.0%), at their work (22.1%), with government officials (26.3%), with their clients (7.4%), with Master Gardeners (5.1%), or with family or friends (3.7%).

Long-Term Survey

Of those that responded to the long-term survey 15.8% watched only live webinars, 31.6% only recorded webinars, and 53.0% both live and recorded webinars (n= 57 respondents). Our sample size for the long-term survey is relatively low compared to our total number of viewers and we therefore acknowledge that our long-term survey may not be fully representative of our audience. The majority of survey respondents self-identified as a member of categories involved in invasive species management or outreach professionally (87.8%), non-professionally (10.3%), or other (1.7%; $n = 58$). Most of the survey respondents were from the midwestern United States (Indiana = 58.8%, Michigan = 11.8%, Minnesota = 9.8%, Wisconsin = 7.8%, Illinois = 2.0%, Ohio = 2.0%) but some also were from other sections of the United States (New Hampshire = 2.0%, Massachusetts = 2.0%) and Canada (Manitoba = 2.0%, Ontario = 2.0%; $n = 51$).

Respondents reported moderate to high levels of webinar utility. When asked if the webinar improved their ability to manage invasive species, the majority of respondents reported moderate to significant utility (60.3%). Of those self-identifying as better prepared to manage species and answered our open-ended question, 44.7% felt more prepared to teach or answer questions about invasive insects, 21.1% to identify the insect or signs of the insect, 21.1% to treat trees for the insect, 5.3% better understood the biology of the insect, 5.3% to survey or monitor, 5.3% to make a plan, and 10.5% other ($n = 37$). Some of the respondents (14.9%) also reported they used invasive species information from our webinars to shape public policy or were aware of the information being used in public policy (in revising existing rules= 7.4%, in creating new rules=1.9%, in another way= 5.6%; $n = 54$). Of those respondents that were directly involved in policy development 28.6% were on a planning committee, 14.3% as members of the public, and 42.9% reported other (as an urban forester, government regulatory scientist, and on a technical team; $n = 7$).

Table 1. ANOVA results of the number and length of asynchronous webinar views with a location name, the word 'update', or the words 'Management' or 'treatment' in the titles

Metric	Key word	Included	Not included	*F* value	Degrees of freedom	*P* value
Number of views	Location Name	164.9 ± 82.5	238.9 ± 34.9	0.68	1, 90	0.41
	The word 'update'	340.0 ± 102.5	215.5 ± 33.8	1.33	1, 90	0.25
	The words 'management' or 'Treatment'	355.1 ± 59.9	180.1 ± 36.6	6.2	1, 90	0.015*
View length (min)	Location Name	10.2 ± 1.2	10.1 ± 0.5	0.0083	1, 90	0.93
	The word 'update'	11.0 ± 1.4	10.0 ± 0.5	0.43	1, 90	0.51
	The words 'management' or 'Treatment'	10.5 ± 0.6	9.7 ± 0.6	0.86	1, 90	0.36

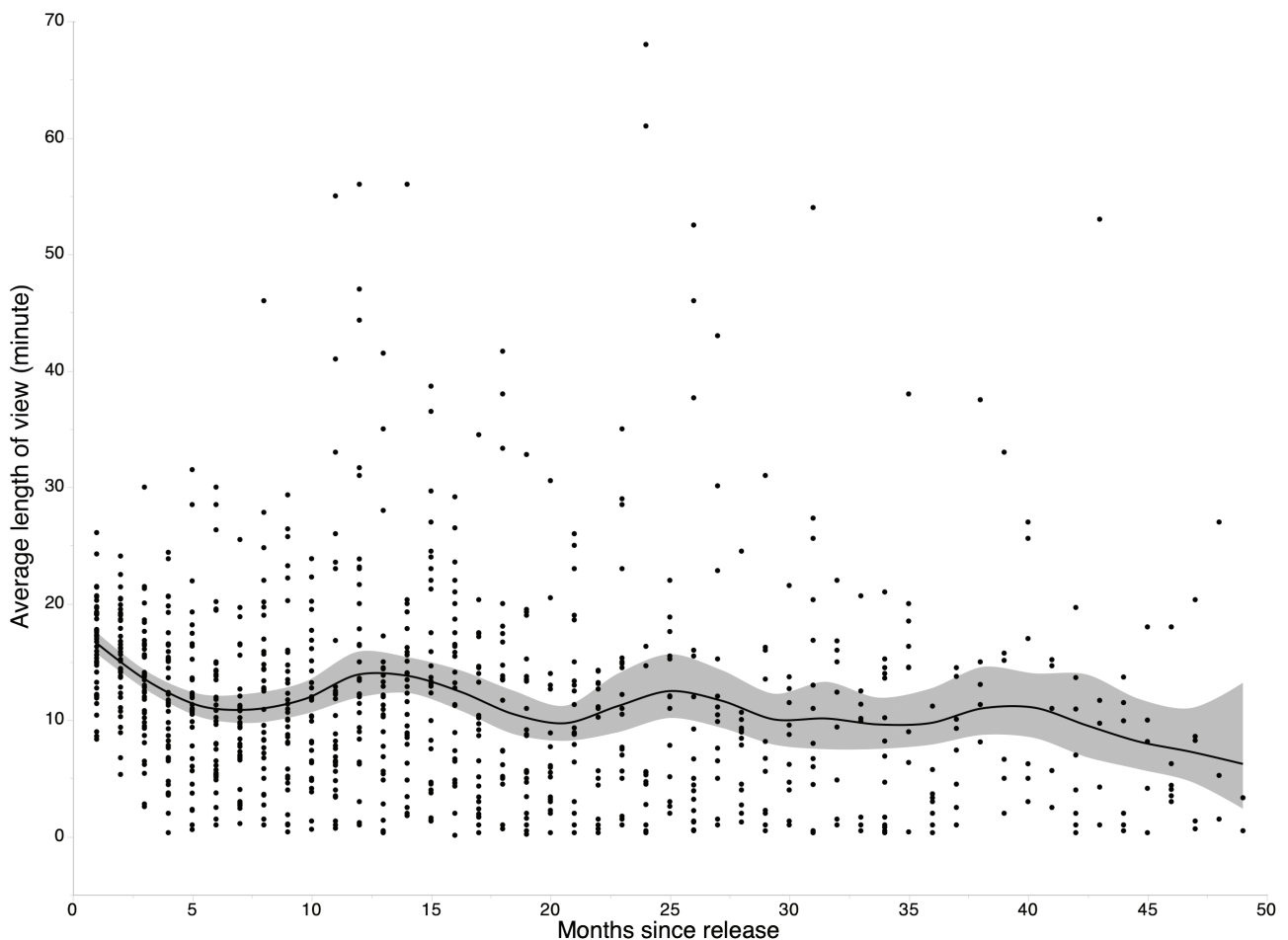Asterisks represent significant results.

Fig. 2. The average number of asynchronous views over the time since the webinars were posted on YouTube. The shaded areas are the confidence of fit for each line.

The majority of respondents used information contained in webinars for education (Yes = 80.4%, No = 19.6%; *n* = 56). Slightly more than 40% of respondents reported that they shared the information with more than 50 people (*n* = 44; Fig. 4A). Those respondents that shared the information reported sharing it with a wide range of members of the public (*n* = 44; Fig. 4B). They primarily shared information about management but also a range of other topics aimed at reducing invasive species spread (*n* = 44; Fig. 4C).

Most respondents indicated that the webinars either made them more likely to report invasive species (43.4%) or that they already were familiar with reporting procedures (54.7%) and a small percentage reported they were less likely to report (1.9%; *n* = 53). Of those that responded, 83.0% had not reported an invasive species since watching our webinars and 17.0% had (*n* = 53). Only seven of the people who had reported an invasive species listed which one(s) they had reported: two plants (*Rubus phoenicolasius* Maxim. (Rosales: Rosaceae) and *Phragmites* spp. (Cyperales: Poaceae)), six insects (*Agrilus planipennis* Fairmaire (Coleoptera: Buprestide), *Psyllopsis discrepans* Flor (Hemiptera: Liviidae), *Lymantria dispar* Linnaeus (Lepidoptera: Erebidae), and unspecified Pentatomidae (Hemiptera: Pentatomida)), and one plant disease (beech leaf disease).
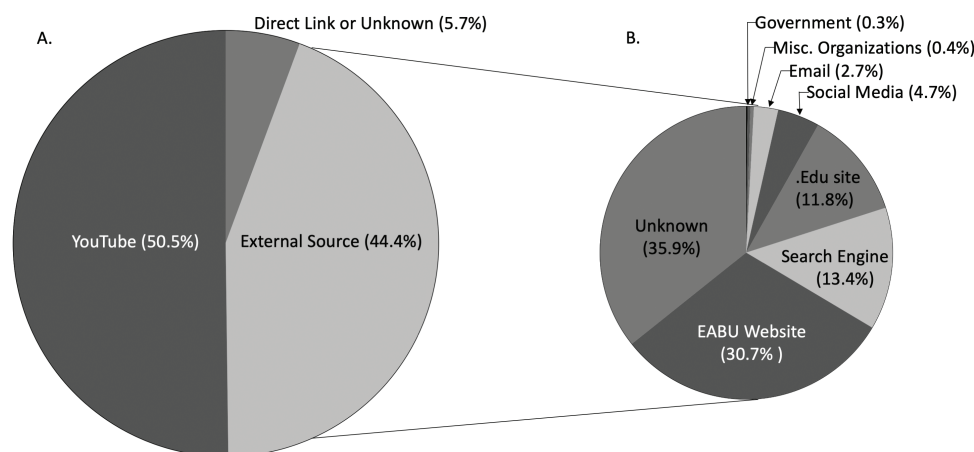
Fig. 3. Percentages of viewer sources for the recorded webinars posted on YouTube. Pie chart A shows the sources of views for all of the recorded webinar. Pie chart B shows a detailed breakdown of the origin of viewers from external sources.

Table 2. Table of responses to Likert scale questions in the survey given to viewers immediately after they watched the live webinar

Survey question	Positive response
Did you find the webinar relevant?	92.5 ± 1.6%
What was the quality of the webinar?	94.8 ± 0.8%
Did it improve your knowledge of the subject matter?	73.2 ± 2.3%
Do you feel better prepared to manage the pest?	70.6 ± 1.9%

Discussion

Webinars facilitate effective sharing of cutting-edge invasive species information across wide geographic areas. The vast majority of our viewers reported that they found the webinars relevant to their expectations and of high quality. They left the webinars with a deeper knowledge of the subject matter and felt better able to manage the invasive species under discussion. This baseline level of quality is important for our goals of connecting people across the country, having viewers widely share the information they learned, and having them act on that information.

Behavioral Change

In both the short and long term, attendees reported their intention to use the information from our webinars in activities that had a strong potential to have a real-world impact on the management and spread of invasive species. They reported a range of ways they were better able to manage these insects such as feeling more capable of answering questions about invasive insects and being better able to treat trees for invasive pests. Our results suggest that the type of information in our webinars was actionable and practical. Combined with the wide geographic distribution of our viewers, these results suggest that webinars effectively spread actionable information about invasive species quickly. Thus, selecting speakers who are able to give management advice and warning them that they may receive management questions could improve the webinar experience for both the viewers and the presenters.

Information Sharing

The demographics of the audience of an outreach program affects its final reach because some categories of viewers are more likely to share the message of the program. The majority of our viewers split into two categories: People who either professionally (i.e., extension educators) or for their hobby (i.e., Extension Master Gardener Volunteers) are obligated to engage in plant-health related outreach and people who interact with and advise the general public about tree health issues (i.e., arborists). As people already established in a community, these groups are likely to be more persuasive and more trusted than someone, even an expert, from the outside (Akin 2017, Suldovsky et al. 2017). Our surveys also showed that these viewers widely shared the webinar information with target audiences we were unlikely to reach. For example, tree care professionals may be called in to assess a sickly tree by homeowners who do not recognize the signs of an invasive species. Thus, the final reach of the webinars includes people who may not seek out invasive species information, but may be in the position to act on it and reduce the impact of these species. We strongly recommend advertising not only to audiences that are likely to directly use the information in webinars but also to the people who are incentivized to share it.

Longevity of Recordings

Recording webinars has the potential to expand the reach of presentations beyond the audience that watches the live program (e.g., Dunn et al. 2011, Mirando et al. 2012, Formiga et al. 2014, Johnson and Schumacher 2016, DePhelps et al. 2019). Our data demonstrate that our audience readily took advantage of the opportunities to view recorded webinars and underscores the value of making recordings readily available to the public. Webinars with 'management' or 'treatment' in the title had even higher numbers of views on YouTube, suggesting either greater interest in these topics than other webinars or higher use of these words as search terms. We suggest determining the keywords the program's target audiences are most likely to search and including them in the titles of videos so that they are prioritized by search engines.

Our webinar views tend to spike after their initial release, likely from people who registered for the webinar but were unable to watch live. However, many of the webinars did not drop to a consistent zero views after the initial 6 mo. Indeed, many of the recorded webinars had sudden spikes in viewership 20, 30, even 40 mo after their initial posting, which suggests that new viewers continue to find the webinars over time. None of these webinars were actively promoted by the organizers after they were first posted to YouTube, which means that gaining these additional viewers required no additional time or money for the organizers. Webinar organizers that fail to take advantage of this sharing option either by not recording
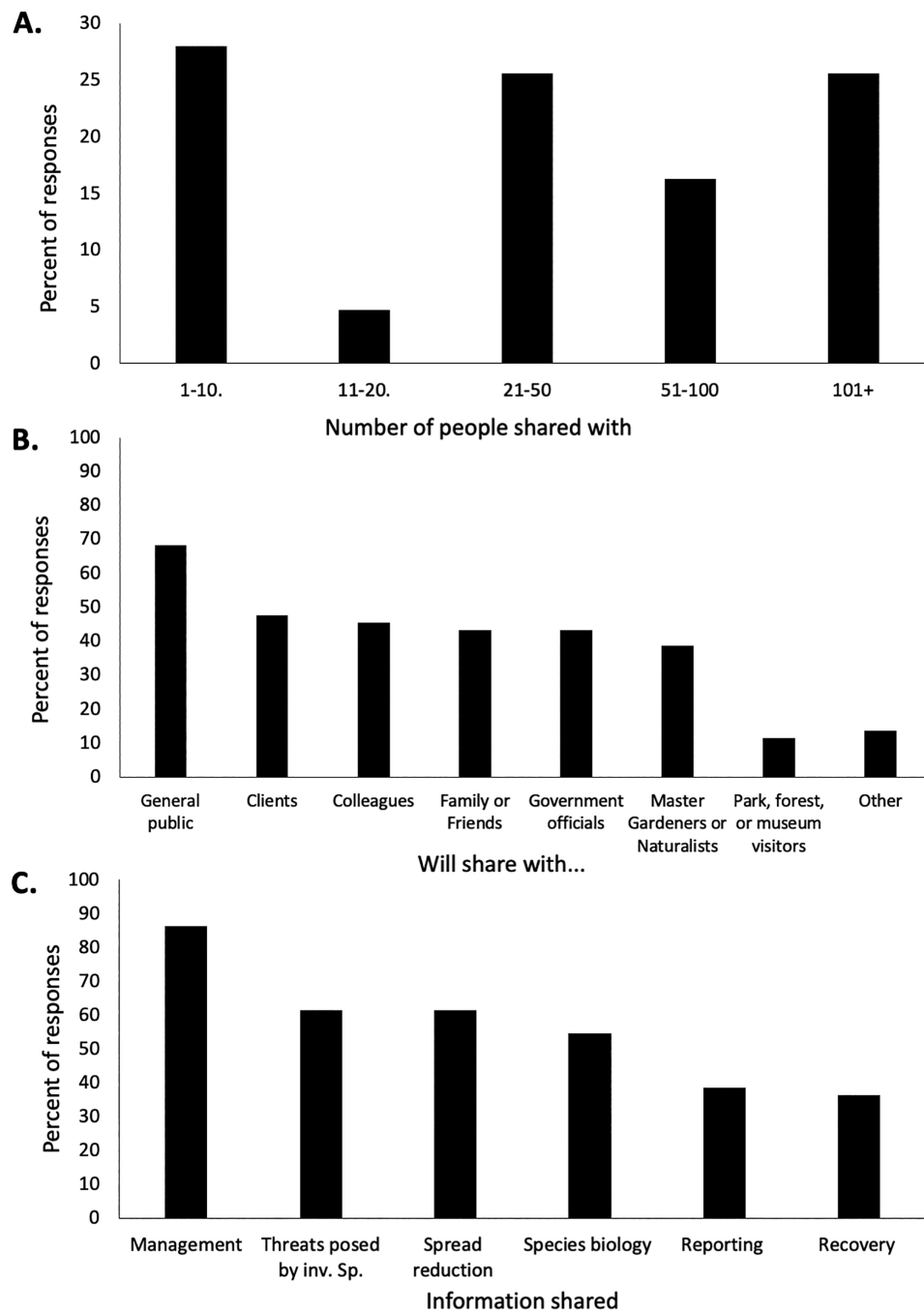
Fig. 4. Graphs depicting the number of people (A) and types of people (B) with whom our long-term survey respondents reported sharing Emerald Ash Borer University webinar information. Respondents reported sharing a wide range of types of information (C).

their videos or by only making the videos available to people who preregistered could be missing out on greatly expanding the reach of their message.

Although the total number of views is important, equally critical is the length of time that people watch each video. Our results showed that most viewers did not watch the full hour long video (a mean of 12:04 ± 0:44 min with some webinars having mean view times over 20 min), but still watched much longer than the typically recommended run time for online extension videos (Dev et al. 2018). This suggests sustained interest in our videos and is more in line with current trends in YouTube watching behavior and algorithm preferences (Ellis 2018, Smith 2018). For this reason, we

recommend that complete video postings be supplemented with a short 5–10 min summary to comply with viewer behavior. However, editing down videos can be a time-consuming process. A group of Minnesota extension agents found great success doing this with their old videos, but it cost them an additional 40–60 h of work per video because they had to cut and even reshoot parts of the old videos (Langworthy 2017). A simpler approach would be to ask each webinar speaker to create a video abstract of their talk by spending a few minutes summarizing their key points at the beginning or end of each webinar. The abstract could either be left at the beginning of the video or be copied from the webinar recording with readily available editing software and posted separately. These two

Table 3. Summary of recommendations for running a webinar series

1. Maintain an archive that is open to the public. Many webinars are viewed years after their initial posting.
2. Post your webinar recordings on popular streaming platforms but also link to them on specialized websites (e.g., for EABU, our emerald ash borer specific site).
3. Attracting an audience engaged in formal or informal outreach can dramatically increase your reach.
4. Ask your speakers to begin or end with a 10 min abstract of their talk. Post both the full version of the webinar and the 10-min abstract.
5. Determine the key words your audience is likely to search for and include them in your titles.

versions would potentially capture viewers pressed for time who only need the highlights of the video and those who want the full details.

Analysis of the source of our video traffic revealed clear trends that could be used to improve the reach of recorded webinars. Slightly more than half of our recorded viewers found our webinars directly through YouTube. This result points to one of the benefits of posting recorded webinars on popular streaming platforms. Posting videos to an information generalist website like YouTube can potentially bring in an entirely new group of interested viewers who are not already connected to the extension information network. The majority of our remaining viewers found the webinars through the website associated with Emerald Ash Borer University (emeraldashborer.info), which supports the importance of linking to recorded webinars on invasive species-specific pages. Search engine traffic and links from other invasive species websites made up the third-largest proportion of our traffic which, again, underlines the importance of understanding search engine optimization (Kritzinger and Weideman 2015) and strategically linking through relevant partner organizations. Overall, our results suggest the benefit of connecting recorded webinars both to general information repositories and specialized websites.

Conclusions and Future Directions

Our webinar series strongly suggests that webinars can be an impactful way to deliver invasive species messages to a wide audience. We suggest several ways to increase the impact of webinar programs by reaching key audiences and sharing recordings to increase longevity (Table 3). Small changes to the way that recorded webinars are shared can drastically expand the final reach of the webinars and increase their utility to other extension or outreach personnel. Using techniques like the ones we describe could increase webinar impact. We encourage other webinar organizers to publish their own experiences and to more systematically test some of our recommendations so that the efficacy of these techniques can be better understood.

Supplementary Data

Supplementary data are available at *Environmental Entomology* online.

Acknowledgments

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