Mapping climate science needs and networks in the Pacific Northwest through evaluation of the Northwest Climate Science Center climate science digest

Authors: Diana R. Gergel¹, Lisa S. Hayward², Meghan Kearney³, John D. Mankowski³, Eric P. Salathé⁴

Author affiliations:
1. Department of Civil and Environmental Engineering, University of Washington, 201 More Hall, Box 352700, Seattle, WA 98195, USA
2. Center for Creative Conservation, University of Washington, Box 355674, Seattle, WA 98195, USA
3. North Pacific Landscape Conservation Cooperative, 510 Desmond Dr SE, Lacey, WA 98503, USA
4. Department of Physics, University of Washington at Bothell, Box 358500, 18115 Campus Way NE, Bothell, WA 98011, USA

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Corresponding author:
Diana R. Gergel
University of Washington
Department of Civil and Environmental Engineering
Box 352700
Seattle, WA 98195
E-mail: gergel@uw.edu

Abstract

Literature on the evaluation of boundary organizations and boundary management has pointed to the importance of boundary work being viewed as salient, credible and legitimate. However, little work has been done on the evaluation of boundary objects in the form of communications products that operate at the interface between scientific research and decision- and policy-making. This study evaluates the effectiveness of a boundary object, a monthly climate science newsletter, that is produced by two boundary organizations, the Northwest Climate Science Center (NW CSC) and the North Pacific Landscape Conservation Cooperative (NPLCC). This study came out of work by a third university-based boundary organization, the University of Washington’s Program on Climate Change. We take a three-pronged evaluation approach using a) in-depth interviews with constituents, b) survey-style poll questions, and c) quantitative analysis using distribution analytics. We find that the newsletter is widely used both within the Pacific Northwest (PNW) as well as in all 50 U.S. states and many parts of Canada. Topics of particular concern to natural resource managers in the PNW include hydrology, fire science and management, and climate adaptation. Furthermore, our respondents described a strong need for the dissemination of transferrable climate science—a role that the climate science newsletter helps fill. Our approach for evaluating the newsletter contributes to a growing body of literature
on the evaluation of boundary objects and helps establish a protocol for producing a climate science newsletter that can be used by other agencies.

**Practical Implications**

In the literature on communications programs in boundary organizations, there is a strong push to take an iterative approach—to strategize, evaluate, improve, and evaluate yet again. However, few studies provide guidance as to how to undertake this process. Our study combines in-depth interviews, survey-style poll questions, and quantitative analysis to provide a framework for the analysis of a communications product that operates at the interface between scientific research and decision- and policy-making. In addition, we have designed a protocol for creating and implementing a boundary object in the form of a climate science newsletter that can be used by other agencies that wish to design a similar product or to apply our protocol to the design and implementation of other products. Both our study framework and design protocol are transferrable to evaluating communications products outside of the realm of climate science and point to the importance of continuous evaluation of boundary objects.

1. **Introduction**

   Climate science, already highly interdisciplinary, is increasingly drawing upon more diverse academic fields, as the impacts of climate change are felt across disciplinary, spatial and geographic domains. With the increase in social and geo-political challenges due to climate change comes a heightened need for collaboration and cooperation among governments (federal, state, local and tribal), non-profit, academic and for-profit sectors that are all addressing—either directly or indirectly—issues relating to natural resources management, climate adaptation and resilience. It is in this space that the demand for boundary organizations addressing contemporary challenges related to climate arose.

   Boundary organizations are defined as formal organizations that exist at the interface of research and policy or management organizations and facilitate mutual knowledge transfer between them (Guston 2001). Generally, they share three criteria: 1) they create opportunities for creating or using boundary objects, 2) they enable participation by managers and researchers, and potentially practitioners that mediate between both entities, and 3) they exist at the interface
between science production and science use, but are not confined to either area. Boundary objects can be either models or products that facilitate interaction and coordination on both (or all) sides of the interface (Parker and Crona 2012). As a result, Sheila Jasanoff has termed boundary organizations sites of “co-production”, meaning that they simultaneously produce both knowledge and social order within the spheres in which they operate (Jasanoff 1996). In doing so, the primary goal of boundary organizations is to promote knowledge-to-action networks so that various stakeholders involved in decision making are both engaged with and contributing to scientific knowledge production (Clark et al 2011).

In this space, a number of boundary organizations have been established in recent years to fulfill the need for sites of co-production between researchers and managers working on climate-related issues. An example of this is the National Oceanic and Atmospheric Administration (NOAA) Regional Integrated Sciences and Assessments (RISA) program, which began in the 1990s to improve coordination between science and society by supporting interaction between universities and regional stakeholders (Stevenson et al 2016). Much of this work—and related work, such as that of the Cooperative Extension System established at Land Grant Universities across the US—can be termed “boundary management”. In the climate world, linking scientific knowledge with management often means bridging the gap between climate science and applications and management around climate adaptation. There is a strong basis for this link established by legal precedent; in the US, there are a number of laws and regulations that specifically direct natural resource managers to consider the “best available science” (BAS) in decision-making, including but not limited to the Endangered Species Act of 1973, the Marine Mammal Protection Act of 1972, and the Forest Service Planning Rule of 2012 (Charnley et al 2017). Cash et al (2003) identified four roles that they labeled as critical for boundary
management, the first role being communication. They defined communication as occurring both ways, both from science producers to users and back again in an iterative process (Stevenson et al 2016). Several boundary organizations in the Pacific Northwest are fulfilling these roles, which is discussed further in Section 2.

There is a growing body of literature on boundary organizations and how to evaluate the effectiveness of boundary work (White et al 2010). Several studies have found that boundary work is most likely to be viewed as influential if it is perceived by stakeholders to be salient, credible and legitimate (Clark et al 2011; Cash et al 2003). However, few studies focus on how to evaluate the effectiveness of boundary objects in the form of communications products that serve as boundary management tools. This form of evaluation, in effect, bridges the literatures of communications products evaluation and boundary organizations.

Our study aims to fill this gap by evaluating the effectiveness of a boundary object, a monthly climate science e-newsletter, that is produced by two boundary organizations, the Northwest Climate Science Center (NW CSC) and the North Pacific Landscape Conservation Cooperative (LCC). The study is supported by, and came out of, work by a third university-based boundary organization, the University of Washington’s Program on Climate Change (UW PCC). We aim to a) map the reach of the newsletter into varying domains and climate information networks across the Pacific Northwest, b) understand how effective the newsletter is at communicating climate science to diverse audiences, c) evaluate how useful the content of the newsletter is for diverse constituencies of natural resource managers, Tribes and First Nations, and scientists, d) glean knowledge and skills for future evaluations of boundary objects, and e) establish a protocol for designing a climate science digest that can be used by other agencies disseminating climate science information.
2. Background on the NW CSC, the NPLCC and the Climate Science Digest

The Northwest Climate Science Center (NW CSC) was originally established by the United States Department of the Interior (DOI) in 2010 with the goal of protecting natural resources by providing climate science information to natural resource managers and policymakers in the region. The NW CSC is one of eight regional DOI Climate Science Centers across the United States, under the umbrella of the National Climate Change and Wildlife Science Center of the United States Geological Survey (USGS), and serves Washington, Oregon, Idaho and Western Montana. For the duration of this study, the NW CSC was a consortium of three universities in the Northwest: Oregon State University, the University of Washington and the University of Idaho, managed with federal oversight from the US Geological Survey (USGS). Since July of 2017, the academic consortium of the NW CSC has been led by the University of Washington’s Climate Impacts Group in Seattle. The goals of the NW CSC, when first established, were twofold: to strengthen the region’s capacity to plan and implement climate science, and to enhance climate science literacy via development of resources and programs. Communication services are a key component of the NW CSC, serving to promote climate science information exchange between scientists and regional stakeholders. The NW CSC, thus, acts as a boundary organization between USGS, the university consortium, and regional resource managers and policymakers.

The North Pacific Landscape Conservation Cooperative (NPLCC) is also a boundary organization, but operates in the sphere between the US Tribes and Canadian First Nations, non-governmental organizations (NGOs), federal and state agencies and universities. Its focus lies in the realm of decision support and coordination of conservation efforts across entities and geographies, rather than solely on climate science resource development. The LCCs were
established by the DOI, also in 2010, to improve science capacity and technical expertise for meeting regional conservation priorities for natural and cultural resources. There are 22 LCCs in total in the United States (including Alaska) and Canada, and the NPLCC domain extends from the coast of Northern California through Oregon and Washington west of the Cascades, through coastal British Columbia to south-central Alaska. Two other LCCs overlap with the domain of the NW CSC, the Great Basin LCC (covering southeastern Oregon, southern Idaho, northeastern California, northwestern Utah and the majority of Nevada) and the Great Northern LCC (including eastern Washington, northeastern Utah, northwestern Colorado, part of Wyoming, much of British Columbia and western Montana). The NW CSC works closely with the three LCCs in its domain, but particularly with the NPLCC in coordinating communications products to disseminate climate science information.

As part of its communication services, the NW CSC and NPLCC began jointly producing the Northwest Climate Digest (CSD) in 2014. The CSD had been originally developed by U.S. Fish and Wildlife Service Region 1 under the oversight of David Patte. The goal of the digest was to synthesize, translate and distribute climate science research, news and events in the Pacific Northwest. Upon Patte’s retirement, the NW CSC took over production of the digest with support from the NPLCC. Each organization has a separate subscriber list representing varying constituencies of federal and state agencies, natural resource managers, policymakers, Tribes and First Nations, non-profit organizations, organizations in the private sector, and universities. Although there are some differences in content between the versions of the digest distributed by the two groups, primarily in terms of the geographic content of research articles, since the domains of NW CSC and NPLCC differ, the versions typically contain 70-90% of the same content, with the largest difference lying in the distribution interface. The NPLCC version
contains extensive graphics and pictures that accompany research articles, whereas the NW CSC version is streamlined and contains solely text. This is primarily due to the difference in audiences; the NW CSC version is disseminated to a primarily academic audience, whereas the NPLCC subscriber base is more diverse. Additionally, the goal of distributing the NW CSC version is to compile and translate climate science information (a “wholesale” version) with the expectation that the NPLCC version would tailor the content of the NW CSC version for their audience (a “retail” version). Both versions are now distributed via MailChimp to subscribers, which allows for monitoring distribution analytics.

3. Methods

3.1. Study background

This study began as part of a capstone project in climate science communication for the Graduate Certificate in Climate Science (GCeCS) offered by the University of Washington’s Program on Climate Change (PCC). The PCC is a university-based boundary organization that enables cross-disciplinary collaboration on climate science from the fields of oceanography, biology, atmospheric sciences, civil and environmental engineering, and a variety of other fields, including the social sciences and humanities. It promotes community outreach and has played an active role in middle and high school science education on climate change in the Puget Sound region. The program is intended to move beyond disciplinary constraints in climate research, and as such the GCeCS requires both graduate coursework in climate science (such as Climate Modeling and Carbon Cycle classes) as well as communications (science communication applications and theory). Culminating the GCeCS is a capstone project that incorporates communications and/or outreach into some aspect of climate science work. The NW CSC reached out to the UW PCC with the goal of finding a GCeCS student who could work on a
project to evaluate the NW CSC communications products, which was how this project was conceived. The original goals of the study were to expand circulation of the CSD, to better understand the climate science information needs and information networks of various constituents in the Pacific Northwest, and to ensure that the climate science content of the digest was meeting the needs of subscribers. Although project involvement from the first author of the study was limited to the NW CSC side of the CSD distribution in a direct capacity, the project entailed close collaboration with the NPLCC and analysis included the NPLCC version of the CSD.

3.2. Database

One of the first steps we took to expand distribution of the CSD was to streamline the distribution process. Production was somewhat of an archaic process, due to the legacy of the CSD, so we developed a searchable database of research articles using Drupal on the NW CSC website such that it would be easy to locate articles from past digests. We also began archiving all digests on the NW CSC site, with the goal that this would increase visibility and enable a higher degree of information sharing. To further streamline the distribution process, we shifted from distributing the digest as a simple rich text e-mail to using MailChimp, which enabled us to track distribution analytics.

3.3. Interviews

To better understand the climate science needs and information networks that the CSD was tapping into, we conducted six in-depth, targeted interviews with individuals who were actively using the digest. We defined “actively using the digest” as either forwarding to internal agency distribution lists or incorporating articles from the CSD into their own climate-related information products. Interviews were loosely structured around the following questions:
1) To whom do you forward the digest? What other digests do you forward?
2) Which aspects of the digest content do you find particularly useful?
3) How could the digest be more useful to you?
4) What is your primary field of interest and geographic domain? How does the geographic domain of the digest overlap with your own?
5) Do you know of anyone else who is forwarding the digest and/or using its content?

Our list of interviewees included individuals from the Bureau of Reclamation, Tribal Climate Change Project at the University of Oregon, Great Basin LCC, Association of Fish and Wildlife Agencies and the US Fish and Wildlife Service. This list was, however, by no means a comprehensive one of individuals on the subscriber list who would meet the “actively using the digest” criteria.

3.4. Poll questions

To more broadly sample the subscriber base of the CSD, we distributed a series of “poll-style” questions at the beginning of the CSD for several consecutive months. By distributing a series of short questions, we hoped to garner a higher response rate and thus information from a wider (and more representative) group of subscribers. Table 1 shows the list of poll questions distributed with the NW CSC version of the CSD.

**Table 1: List of Poll Questions**

<table>
<thead>
<tr>
<th>Poll Question</th>
<th>Response Options</th>
</tr>
</thead>
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| Which of the following categories is most useful to you? | 1) Natural resources management  
2) aquatic resources and/or hydrology  
3) ocean acidification  
4) Sea level rise  
5) Climate change policy and government  
6) Ecosystem change/ecosystem response  
7) Biodiversity  
8) Land use/land cover  
9) Forests  
10) Tribal issues  
11) Extreme events and hazards  
12) Climate change adaptation  
13) Fire science and management |
Which region is of the greatest interest to your work?
1) West of Cascades/Western WA/OR
2) East of Cascades/Eastern WA/OR/MT
3) Snake Basin/Southern Idaho/OR
4) Alaska
5) Western Canada/British Columbia
6) Great Plains/OR/Nevada

What type of articles do you find most useful?
1) Journal articles
2) News/media articles
3) Research reports

Do you forward the digest?
1) Yes
2) No

3.5. MailChimp analytics

In addition to a more qualitative understanding of climate science needs and information networks, we wanted to quantify the distribution of the CSD among natural resource managers, Tribes and First Nations, and university constituencies in the Pacific Northwest. We also wanted to understand what climate science content was most useful to each of these constituencies, in terms of article type as well as topic area. Consequently, the third phase of evaluation involved gleaning analytics from user interactions with the digest e-mails. The NPLCC digest had been using MailChimp for years to distribute the CSD, whereas for the NW CSC the switch occurred during this study (see Section 3.2). Thus, the analytics available to us were uneven between the two entities. Furthermore, the subscriber lists are separate, and due to government regulations and the nature of the first author’s affiliation, the NPLCC subscriber list was not distributed outside the NPLCC partnership. Thus, we partnered with the NPLCC staff to obtain distribution analytics for October – December, 2014-2016. We limited our collection of analytics to these months because they spanned a time period before and after the study began (to measure improvements made to the CSD during the time period of the study). MailChimp provides information in the form of “clicks”, so we collected click data on subscriber agency affiliation,
article topics and article categories from the NPLCC for those months. This data included both number of clicks for each featured article and article topic category as well as the agency affiliation for each click, allowing us to track both popularity of articles in total number of clicks but also to trace which articles were most relevant/useful to which constituencies of subscribers. Furthermore, for each of the articles that received more than ten clicks, we collated abstracts to be able to further understand which topics were most relevant to natural resource managers across the Northwest. We then conducted a text analysis of the abstracts using Python to understand which subtopics in climate science were most salient to CSD subscribers. For the NW CSC distribution of the CSD, we gleaned the same data from MailChimp for all months since February 2016 (when MailChimp distribution commenced).

4. Results

4.1. Interviews

4.1.1. Reach of digest

By questioning interviewees about how they were forwarding and using the digest, we hoped to gain more data on what networks the digest was tapping into. One of our major pitfalls in using MailChimp analytics for the quantitative analysis was that while click data does include clicks from forwarded digests, it does not provide demographic information from those clicks nor does it specify how many clicks came from forwards for each click, thus this was a major piece that we hoped to get at in our interviews. We were surprised at the extent and diversity of networks in which the CSD was being utilized. In our interviews with climate change coordinators for the Bureau of Land Management (BLM) and the Association of Fish and Wildlife Agencies, several themes emerged. Both interviewees were actively using content from the CSD for their own agency-specific climate science synthesis products, which they were then
sending out on various mailing lists, some outside of their respective agencies. We expected that the distribution lists of interviewees using the digest would be confined to the Pacific Northwest, given the geographic scope of the CSD. However, in our interview with the climate change coordinator for the Association of Fish and Wildlife Agencies, which is based in Washington, D.C., we found that their distribution list included all 50 U.S. states, several Canadian provincial agencies, as well as other partners.

### 4.1.2. Digest content

In questioning interviewees about digest content, their responses demonstrated that all sections of the CSD were useful to subscribers. Certain topic areas were, however, identified as being relevant to broader categories of scientists, namely hydrology and water resources and fire science/management. The latter is unsurprising given that the Pacific Northwest has seen increases in forest fire area and frequency in recent years. Our quantitative analysis using click data supported this (see Section 4.3). We were also able to identify gaps in coverage of climate science content in areas where interviewees suggested improvements. One particular area was climate research relevant to rangelands. This gap partly reflects broader funding issues affecting research relevant to rangelands, but likely also reveals a bias in our selection of science content more relevant to areas west versus east of the Cascades due to its larger population. Another problem for content was the dearth of articles on tribal and First Nation climate issues. In particular, traditional ecological knowledge (TEK) was called out as an area where it would be useful to include more related content.

### 4.1.3. Geographic relevance

Overall, our interviews uncovered a tension between science with local, sometimes even hyper-local, applications, and more transferrable or actionable science relevant to broader
constituencies. Thus far, the geographic scope of the CSD has been the US portion of the Pacific Northwest (excluding the Canadian headwaters of the Columbia River Basin), matching the scope of the NW CSC. The NPLCC has typically added additional articles relevant to Southeast Alaska and Coastal British Columbia. Federal leadership of the CSD has strongly pushed for confining the geographic scope to the Pacific Northwest. However, our interviews pointed to the importance of local science being transferrable, and even more useful due to the localized case study nature of many of the featured articles. They also pointed to the need for more articles on topics that transcend the regional level, such as hydrology and water resources and fire management. For example, in the Great Basin LCC (GBLCC), much of the CSD content is less relevant, since the GBLCC focuses less on climate science and more on management applications, particularly as they relate to bull trout. But studies that are of broad relevance to their work, such as water management and fire management, would still be useful, even if they are case study-based in the Pacific Northwest or other locations with similar ecosystems. Some of our interviews underscored the relevance and transferability of Pacific Northwest-specific climate science research, particularly research on freshwater habitats, to other regions of the country. Other interviews also echoed a need for more transferrable climate science in the CSD. However, our quantitative analysis did not consistently back this up.

4.2. Poll questions

Through our poll questions, we had hoped to gain an unbiased sample from the NW CSC subscriber list. The questions we distributed, shown in Table 1, were included at the header of each digest monthly over a period of four months. We had hoped that including a short question at the beginning of each digest would lead to a large response rate, but unfortunately, we found that this did not occur—the largest number of responses that we received for a single month was
22. Figure 1 shows the results from the poll questions for each month. As shown, we found that just over one third of respondents were either using or forwarding the digest. The geographic distribution of respondents strongly favored western Washington, which we expected, given the historical legacy of the CSD focus on areas west of the Cascades. Nearly a quarter of respondents, however, represented areas east of the Cascades, which demonstrated that the CSC has expanded its reach since its inception. The largest topics of interest were hydrology and natural resources management, which largely agreed with what we gathered from interviews. Respondents favored academic journal articles over other sources of climate science, which we expected, given that the NW CSC distribution list has strong academic and federal agency constituencies. Overall, we had hoped to gain much more data from distributing poll questions, but chose to shift to using MailChimp click data once we realized that the response rate would not allow us to make significant inferences about the nature of subscriber preferences. Additionally, using MailChimp data allowed us to include the NPLCC digest data in our analysis.

4.3. Quantitative Analysis

Our MailChimp click data for the NW CSC and NPLCC digests overlapped for the month of November 2016, which allowed for quantitative comparisons for this period of time.

4.3.1. Subscriber Distribution

One of the first areas we investigated was the distribution of subscribers based on agency affiliation and how this distribution differed between the NW CSC and NPLCC subscriber lists. We anticipated that the LCC would have a much higher representation from Tribes, based on their organizational focus. Figure 2 shows histograms of the number of subscribers based on agency, with subscribers grouped by categories for state, federal, for-profit, non-profit, university
or other organization. As is evident, the subscriber bases are distinct between the NPLCC and NW CSC digests. The NW CSC digest has approximately 275 subscribers, whereas the NPLCC digest has approximately 8,000 subscribers, hence the difference in magnitude between the two panels. For the NPLCC panel, state agencies comprise the largest constituency, whereas for the NW CSC panel, the DOI comprises the largest constituency. The DOI, universities and Tribes are also significant groups for LCC subscribers. The LCC has a much larger network of subscribers from Tribes, which reflects the mission and reach of the LCC. Note that the tribal category for the LCC encompasses both US Tribes and Canadian First Nations. Another key difference between subscriber bases is that the LCC has a strong Canadian component, whereas the NW CSC has a very small Canadian portion of subscribers. Overall, the distinct subscriber bases reflect the overall mission and scope of the respective organizations.

4.3.2. Climate Science Article Categories

To better understand what article categories were most useful to subscribers, we categorized articles with the most clicks by category for the November 2016 NW CSC and NPLCC digests. In the NW CSC digest, articles are grouped into the following categories: a) Aquatic Resources/Stream Flow/Hydrology, b) Biodiversity/Species and Ecosystem Response, c) Coastal/Marine Ecosystems, Ocean Acidification, Sea Level Rise, d) Arid Ecosystems, e) Fire, f) Forests, g) Land Use, h) Tribal and Indigenous Peoples Matters, and i) Taking Action. Figure 3 shows horizontal barplots of article categories for the most-clicked articles for each digest. It is evident from both the NPLCC (top) and NW CSC (bottom) figures that hydrology is the most important category for both digests, followed by coastal regions for the NPLCC and climate adaptation for the NW CSC, which is also important for NPLCC subscribers. Fire was a
significantly more important category (by percent of clicks) for NW CSC than NPLCC subscribers.

4.3.3. Climate Science Topics

To further understand what topics within these article categories were most useful, we chose the most salient topic from each article in the November 2016 NPLCC and NW CSC digests and created word clouds in Python showing these topics. Figure 4 is a word cloud of these topics for the NPLCC digest. The size of each word represents the relative importance of that subtopic in comparison to the other words (or subtopics) shown. From the figure, we can observe that streamflow, flooding, and changes in snow are the major topics of concern within hydrology to subscribers. In the coastal regions category, mussels, phytoplankton, and aquaculture (related topics) were most important, pointing to interest in ocean acidification and concerns of sea level rise.

Figure 5 shows the same for the NW CSC digest, and tells a similar story. Snow, flooding, and streamflow are again key areas of interest for subscribers, although snow is more important to NW CSC subscribers. This likely reflects the west-of-Cascades focus of NW CSC subscribers, where snowmelt is vital for water resources. Wildfire is also much more salient for NW CSC subscribers, and this result is harder to explain. Land adaptation represents another strong area of concern for the NW CSC subscribers. Both word clouds include ‘carbon flux data,’ which refers to a recent release of FluxNet site data, a nation-wide observation network where micrometeorological measurements are collected and recorded (data available through https://fluxnet.ornl.gov).

5. Discussion
Overall, despite key differences in the target audiences of the NPLCC and NW CSC digests, we found strong similarities in the science topical areas and subfields that were of greatest interest to subscribers. We identified a need for transferrable science, rather than hyperlocal case studies specific to the geographic domain of the subscriber lists. But, perhaps most importantly, we were able to synthesize oftentimes disparate modalities of research – combining targeted in-depth interviews, survey-style poll questions, and quantitative analysis that involved scripting techniques typical of computational data analysis in the geosciences. As a result, we compiled a unique dataset of both qualitative and quantitative data on the effectiveness of the NPLCC and NW CSC digests as communication tools and as disseminators of climate science knowledge in the Pacific Northwest.

Our results indicate a strong need for the digests—as boundary objects—to facilitate scientific knowledge exchange between academic research and natural resource managers at the federal, state and local level, as well as scientists working in the for-profit and non-profit sectors (although these latter groups were a minority of subscribers). Our interviews in particular showed that the digests were being actively used, both in terms of being shared directly with other members of the subscribers’ respective agencies as well as being absorbed into internal publications and/or used in natural resource decision-making. To enable other boundary organizations to develop similar communications products, we developed a protocol for designing a climate science newsletter, which we have included in the supplemental materials.

Our results also speak to a need for evaluating boundary objects. Prior to our evaluation study, we expected that subscribers would want more localized climate science studies, rather than articles that were transferrable to other geographic regions. Both the NW CSC and NPLCC typically included a large range of topics in climate science, rather than prioritizing topic areas of
particular interest to subscribers. Our study demonstrated the value of evaluating communications products—serving as boundary objects—in order to disseminate more applicable and relevant climate science to natural resource managers. Moreover, our work also underscores a strong need for the development of a methodology around evaluating communications products that serve as boundary objects, effectively bridges between producers of climate science research and those who use it to inform management and decision-making. Tailoring communications products that disseminate climate science would enable more well-informed natural resources decision-making at the federal, state, and local levels. We hope that our study might provide a template for future evaluations of communications materials produced by boundary organizations.

6. Conclusions

In our study, we have mapped climate science information networks across the Pacific Northwest using two communications products functioning as boundary objects—the NPLCC and NW CSC climate science digests. We found that subscribers across diverse constituencies—including university-based scientists, federal, state and local natural resource managers, Tribes and First Nations and for-profit and non-profit organizations—were actively using the digests both for their own individual work as well as internal organizational publications. Certain topic areas within climate science were of particular interest to subscribers, with hydrology identified as one of the most salient research areas. Fire science and management and climate adaptation were also of key concern. Our interviews pointed to a strong demand for transferrable science, which included case studies specific to habitats found in the Pacific Northwest. In sum, our study indicates that a wholesale, integrated evaluation of communications materials can be extremely
significant for a boundary organization to effectively tailor materials in order to optimize their relevance for interfacing with diverse constituencies.

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Declarations of Interest

There are none.

7. References


Figure Captions

Figure 1: Results from poll questions for each month, showing a) which type of articles are most important, b) whether subscribers forward the digest, c) which geographic areas are most important, and d) which topical areas of the digest are most important. Abbreviations for geographic areas: Western Washington (W Wa), Eastern Washington/Oregon/Montana (E Wa/OR/MT), Snake River Basin (Snake), Western Canada/British Columbia (W Canada/BC), Great Plains/Oregon/Nevada (GP/OR/Nevada). Abbreviations for article categories: Natural Resources Management (NRM), Ocean acidification (OA), Sea Level Rise (SLR), Climate Change Policy (CC Policy), Land Use Land Cover changes (LULC). See Table 1 for the exact poll questions distributed.

Figure 2: Numbers of subscribers based on agency for the North Pacific Landscape Conservation Cooperative (top) and Northwest Climate Science Center (bottom). Abbreviations: Environmental Protection Agency (EPA), Private Organizations (Orgs), Department of the Interior (DOI), Department of Energy (DOE), United States Department of Agriculture (USDA), Department of Commerce (DOC) and Department of Homeland Security (DHS).

Figure 3: Article categories for the most popular articles for each digest for the North Pacific Landscape Conservation Cooperative (top) and the Northwest Climate Science Center (bottom).

Figure 4: Word cloud of the most salient topics from each article in the November 2016 North Pacific Landscape Conservation Cooperative digest. The size of each word represents the importance of that subtopic relative to the other subtopics shown in the figure.

Figure 5: Word cloud of the most salient topics from each article in the November 2016 Northwest Climate Science Center digest. The size of each word represents the importance of that subtopic relative to the other subtopics shown in the figure.