

Innovating Approaches to Drought Communications with North Carolina Decision Makers

“Project Nighthawk”

Final Project Report

Team Members

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Table of Contents

Section 1. Introduction	3
1.1. Overview	3
1.2 Approach	4
1.3 Project Highlights	4
1.4 Key Takeaways	6
Section 2 Decision Maker Needs and Priorities	8
2.1 Approach and Methods	8
2.2 Phase 1 Results	9
Section 3 Product Development, Feedback Processes, and Usability Findings	11
3.1 Approach to engagement and data collection	11
3.2 Analyzing Participant Feedback Data	12
Section 4. Product Descriptions	15
4.1 Priority 1: Narratives to Accompany the NC Drought Map	15
4.2 Priority 2: Resources that relate short- and long-range conditions	19
4.3 Priority 3: Contextualized and tailored sector-specific information to support the understanding and use of drought information	23
4.4 Priority 4: Resources about the NC DMAC	26
Section 5. Evaluation	27
5.1 Participant Feedback: Data Collection and Analysis	27
5.2 Findings and Results: Product and Information Use	28
5.3 Final Thoughts and Lessons Learned	34
Section 6. References	37
Appendix.	38

Section 1. Introduction

1.1. Overview

This project, a collaboration between the State Climate Office of North Carolina (SCONC) and the Carolinas Integrated Sciences and Assessments (CISA) program, focused on improving the usability of drought-relevant information for North Carolina decision makers based on needs identified by the NC Drought Management Advisory Council (DMAC) and constituents such as NC Cooperative Extension agents and public water supply system managers. These needs included a better understanding of how drought is monitored, the climatic and environmental conditions (e.g., ENSO and other seasonal differences) that can cause or worsen drought conditions, and drought impacts on various sectors including agriculture, forestry, and water resources. The project objectives were to:

- Develop tailored, sector-specific information relevant for drought decisions
- Deliver information in accessible and actionable formats
- Improve the transparency of the drought monitoring process through enhanced engagement and communications with decision makers

The project was conducted from September 2018 to August 2020. During this time we identified decision makers' needs related to drought communications, piloted new informational resources, and obtained feedback from users to iteratively refine and improve the products developed through the project. Overall, we conducted and/or attended over 17 engagements with decision makers and other project stakeholders. While conditions were generally wet during the project period, the flash drought that hit North Carolina in fall of 2019 gave users an opportunity to apply some of the new products to a drought situation.

This report documents the activities and outcomes generated through the project. It is organized as follows:

- Section 1 highlights key accomplishments and takeaways.
- Section 2 summarizes results from the Phase 1 assessment to identify priority needs for drought information.
- Section 3 details the product development, feedback, and evaluation processes.
- Section 4 provides an overview of the project's outputs and relevant usability findings.
- Section 5 discusses findings from the final project evaluation to assess use of the new products and overall effectiveness of the engagement process.
- The appendix provides a comprehensive list of engagements conducted through the project.

“Project Nighthawk”

Our project's name is inspired by nature. The common nighthawk, *Chordeiles minor*, is a bird species native to North Carolina that is one of nature's best examples of drought resilience. Just as these iconic birds have learned to live with and recover from drought, our goal in Project Nighthawk was to help decision makers across North Carolina become better informed about and prepared to respond to drought and the weather and climate patterns that can cause and alleviate it.



Common nighthawk. Photo by Andy Reago and Chrissy McClarren, shared under CC BY

1.2 Approach

The project was designed as an iterative process and engaged three key sectors affected by drought: agriculture, forestry, water resources (Figure 1). We employed the “decision support principles” proposed by the National Research Council (2009) as a framework to design the research and engagement activities in this project. This framework includes beginning with users’ needs, prioritizing process over product, linking producers and users of information, building connections, seeking institutional stability, and designing for learning. Throughout the project, SCONC and CISA interacted with a variety of decision makers to identify and prioritize drought information needs, develop new informational resources and prototypes, and obtain feedback on the usability and usefulness of those new products. Collaborating with partners and involving stakeholders in the early stages of information and product development can lead to greater usability and usage of those products (Dilling & Lemos, 2011; Mase & Prokopy, 2014). Our engagements with stakeholders included in-person and virtual meetings and workshops, focus group discussions, online surveys, and eye-tracking usability studies.

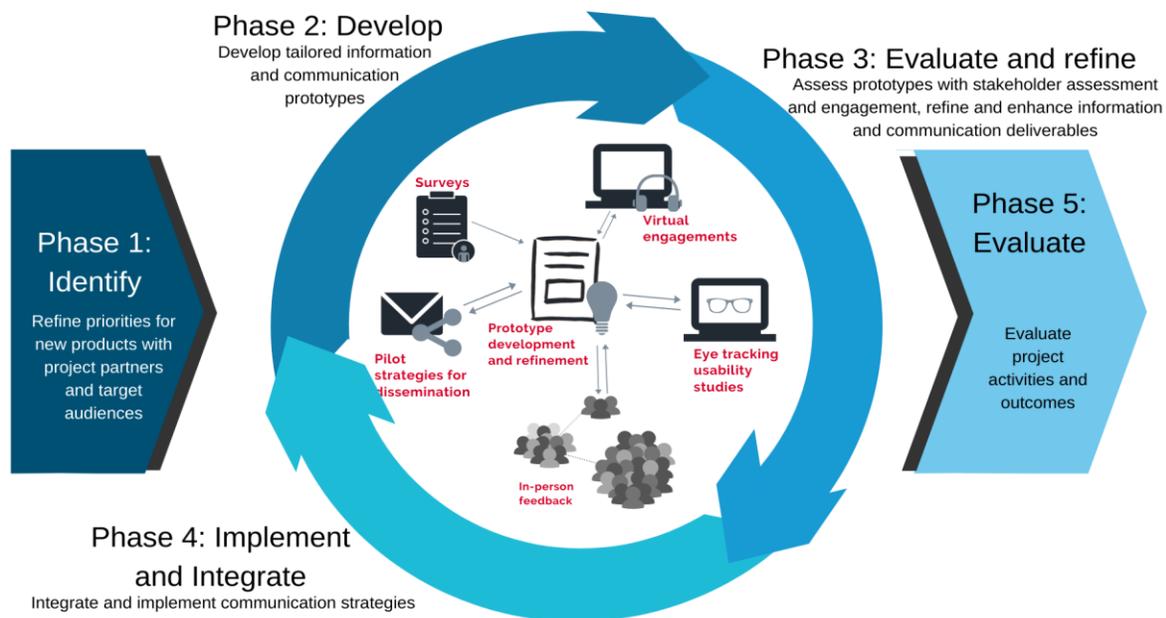


Figure 1. The project was divided into five phases. Phase 1 began with engagements with sector representatives to identify priorities for information resources and strategies to develop under the project. Phases 2, 3, and 4 were iterative and is where the majority of the project time was spent. Phase 5 consisted of a holistic evaluation of the project’s activities and outcomes.

1.3 Project Highlights

Integral components of the project design were regular interactions with decision makers and systematic evaluation of new products and the processes through which we engaged drought information users. The project design enabled us to convene researchers, agencies, stakeholders, and decision makers through systematic engagement in order to develop solutions that address drought information needs and challenges (Table 1).

- **Tailored resources** added value to currently available ones by addressing user needs for drought information. New products answered questions about different types of drought (e.g., seasonal v. flash v. multi-year; statewide v. regional) and provided

information about sector-specific impacts at decision-relevant temporal and spatial scales.

- We employed **communication strategies and designs** that resonate with decision makers from different sectors and who are impacted by all forms of drought in the state. Participant feedback indicated that Extension agents, National Weather Service (NWS) Forecast Offices, and water utilities are using the new products to facilitate drought communications and outreach with homeowners, growers, and their communities. Products have also been used by NC DMAC members to answer media questions, to provide valuable situational awareness, and inform operational decision making, such as to justify overtime and hazard pay for firefighting.
- We leveraged existing networks and partnerships to **enhance drought communications** and will continue to incorporate and apply lessons learned through this project to SCONC's future outreach and trainings with and for partners such as N.C. Cooperative Extension, the NC Fire Environment Committee, and water systems throughout the State. Throughout the project, we sought to develop strategies for communication and dissemination that would last beyond the project's end date. By collaborating with the NC Division of Water Resources (DWR), new drought information resources are available on the NC DMAC's website, <https://ncdrought.org>. Additionally, as capacity allows, the SCONC is incorporating development of the Weekly Drought Update Infographic into its regular activities on the NC DMAC technical committee and is exploring funding for continued development of the Short Range Outlook Infographic.

Table 1. Final products and resources developed for each of the identified priorities.

Priority	Developed Resource(s)
1. Narratives to accompany the NC Drought Map and synthesize the weekly drought status in North Carolina	Weekly Drought Update Infographics
2. Resources that relate anticipated short- and long-range conditions to drought conditions and local- and sector-specific effects in North Carolina	Short-Range Outlook infographics
3. Contextualized and sector-specific information to support use and understanding of drought information	Workshops and Trainings
	Historical drought factsheets
	Collaboration with the Internet of Water to develop a Water Supply Dashboard
4. Resources that describe the NC Drought Management Advisory Council, its purpose, its weekly drought monitoring process, and how this relates to the US Drought Monitor	Story map and factsheets about the NC DMAC and its weekly drought monitoring process
	Recommendations to improve the NC DMAC's website to increase the accessibility and discoverability of information.

1.4 Key Takeaways

Our project uncovered a number of **key takeaways** that be valuable to other organizations or groups who similarly communicate drought information to diverse stakeholder and user groups.

Place drought information in context

Information is used and valued if it **ties to a specific decision or action to be taken**. Through engagement with various participants and sectors, we learned more about the seasonality and timing of their decisions and how drought's varying effects on the different sectors influence when and how they want to interact with drought information.

Drought is important to all our target sectors, but at different times and in different ways. While some preferences are universal, such as the importance of emphasizing impacts rather than objective indicators when communicating drought status, **the exact type and extent of use is related to the drought severity and specific sector**, for example:

- Agricultural extension agents are likely to use these products year-round, regardless of drought conditions.
- Water managers indicate that they follow their own metrics for drought monitoring but would appreciate additional information resources during drought events to help communicate information about causes and future conditions.

Understand and use your audience's preferred communication channels

It is important to **disseminate new information through channels that target users are already tuned into, rather than creating a new channel**. The NC DMAC's website (ncdrought.org) was revealed early on to be a trusted, go-to resource for drought information, but one that needed updates to allow information to be uncovered more readily and to deliver that information in more digestible pieces. While working with NC DWR to create and update information resources for this website, we considered different types of resources and formats that our target sectors indicated preferences for (e.g., story map, factsheets).

The project's stakeholders indicated **preferences for combinations of web-based and emailed information**. While social media is a growing medium, our target sectors indicated varying preferences; water resources and NWS offices, for example, preferred Twitter, while Extension agents preferred Facebook. Understanding **how information is used and shared** is important, as this may vary based on the sector or stakeholder group. For example, Extension agents and NC Forest Service personnel indicated they did (or would) use information resources to inform themselves and their clients or constituents by directly sharing them. Water utility staff indicated they do (or may) use information for their own situational awareness, but that they prefer to use their own "branding" when sharing information with their clients or constituents.

Translate technical information – but know when to stop

Creating and producing explanatory infographics assumes a baseline level of knowledge among consumers. Our engagements with project stakeholders revealed that this assumption may not hold true, particularly among the diverse set of users who consume weather, climate, and drought information to inform various activities and decisions. **We therefore prioritized producing and providing information that explains how to access, interpret, and apply technical types of information to fill in knowledge gaps among our target audiences.**

Participant feedback indicated preferences for **partially translated technical and scientific information**, but that some technical information was still preferred, particularly if it could be used as a learning opportunity for themselves or others. Users also relayed **the importance of connecting information to the original data source or information creator** in the product and using reputable and **trusted sources**, such as the SCONC or NWS.

Don't just create, evaluate

By integrating evaluation through systematic user engagement throughout our project, we sought to ensure that the final products would not only be useful but also used by our target audiences.

Informational products, especially the Weekly Drought Update and Short Range Outlook Infographics, received multiple rounds of evaluation with participants from our target sectors and other groups involved in drought monitoring (e.g., NWS). Through quantitative and qualitative data collection and analysis, we learned which **standardized formats and design elements help users read and consume the information on a week-to-week basis**.

Feedback from participants revealed that **the use of informational resources is influenced by their perceived credibility and legitimacy**. To foster these characteristics in the information prototypes, we tried to convey decision-relevant information and elucidate the “behind the scenes” process to make information more transparent to the end-user.

Project participants reported their main use (real or potential) of the informational resources was to **maintain situational awareness of current or emerging conditions**, suggesting that **the resources we developed could serve as an alert or early warning of changing conditions**. Some participants also indicated using project outputs to justify or inform specific decisions, such as for fire response and management or agricultural decisions.

Work toward sustained engagement and long-term learning

This project's success is partly owed to our **ability to leverage existing networks and partnerships**, as well as related activities at the SCONC, for example:

- We partnered with the NC DMAC to ensure project outputs are available on the ncdrought.org website. This includes the story map describing the NC DMAC and Weekly Drought Update and Short Range Outlook Infographics.
- Through ongoing projects and activities with N.C. Cooperative Extension and the NC Fire Environment Committee, we have been able to expand the reach of the project outputs and findings, such as through educational training sessions.
- An outcome of the project is a new collaboration with the [Internet of Water](#), which is leading an effort to pilot a “Water Supply Dashboard” with the Triangle Water Supply Partnership, downstream utilities, and NC DWR. This is a direct outgrowth of a priority identified and refined through our project's activities. The Water Supply Dashboard will enable users to discover real-time water supply information and help water resource managers monitor and communicate water supply status and risk reduction measures.

Finally, it is imperative to highlight that **ongoing engagement and sustained dialogue** with information users **requires devoted or leveraged resources, such as through a grant or other budget allocation**. Do not underestimate what is required: staff time, science translation skills, and an ability to build relationships.

Section 2. Decision Maker Needs and Priorities

The purpose of Phase 1 of the project (Figure 1) was to identify and refine priorities for enhancing existing, or developing new, resources and products with project partners and target audiences. The focus was on providing relevant and actionable information for decision makers who have responsibility for their own or their organization's decisions, and a communications role in translating drought information to their constituents, customers, and colleagues. This included members of the North Carolina Drought Management Advisory Council (DMAC) and representatives of the agriculture, forestry/fire management, and water resources sectors.

2.1 Approach and Methods

- Initial surveys focused on clarifying the existing context of drought information use and needs.
- Follow-up webinars focused on eliciting feedback on the survey results and identifying specific priorities for the development of new information and products.

2.1.1 Surveys

In October 2018 we sent online surveys to extension agents (in agriculture and forestry), water resources managers, and DMAC members to collect initial information about decision makers' current uses of and needs for drought information. The survey was open for three weeks and had a 28.1% response rate for those recipients who either partially or fully completed the survey (Table 2); the response rate for completed surveys was 14.8%. Several factors may have contributed to this low response rate, including the lingering effects of Hurricane Florence, which caused us to disseminate the survey in October rather than in September as originally planned. In addition, Hurricane Michael hit the state on October 11, causing widespread power outages in the central part of the state, and the North Carolina State Fair, held from October 11-21, may have occupied many Extension agents during the time when the survey invitations were first disseminated. The project team generated summary statistics and graphs and reviewed open-ended responses to identify common themes or specific recommendations regarding drought information needs or priorities.

Table 2. Online Survey #1 - Response Rates

	Agriculture & Forestry	Water Resources
Invitations sent	316	183
Surveys opened	100 (31% of invitees)	40 (22% of invitees)
Surveys completed	52 (16% of invitees)	22 (12% of invitees)
Surveys partially completed	48 (2-81% completion rate)	18 (5-81% completion rate)

2.1.2 Follow-Up Webinars

Webinars were designed to share results from the initial survey, discuss preliminary ideas for resources and tools to develop as part of the project, and obtain feedback from participants to refine and prioritize the list of ideas. Invited participants included NC DMAC members, other drought information providers who wrote letters of support for the project (e.g., USDA Southeast Regional Climate Hub, NWS offices), and key sector representatives (e.g., Extension, water systems). We conducted two webinars, with a total of 31 participants, one for the agriculture and forestry sectors and one for the water resources sector.

The webinars were organized around three themes: (1) communication channels and formats; (2) drought information use, preferences, and potential gaps in existing resources; and (3) the NC and US drought monitoring processes. For each theme, we presented survey results; shared examples of existing resources currently available in NC or other states through national-, regional-, or state-level agencies; and posed discussion questions to attendees. During the final part of the webinar, we asked participants to discuss priorities for new products to be developed as part of Project Nighthawk. Webinar participants also received a link to a brief follow-up survey that provided them an opportunity to voice their opinions anonymously. Seven attendees (total from both webinars) responded to the follow-up survey.

2.2 Phase 1 Results

Key findings from Phase 1 are summarized here and in Table 3. For more detailed information and analysis, see the detailed Phase 1 report, accessible from the project's [archival website](#).

Communication formats and channels

Participants indicated a desire for products that are easily understandable and accessible to the various audiences with whom they interact. They indicated preferences for:

- Translated or synthesized information that is clear and concise;
- Information available in a variety of formats, ranging from alerts to factsheets to infographics that are easily shareable through a variety of media; and
- A balance of pushed and web-based content.

Drought monitoring processes

A key finding from the surveys and follow-up webinars was the need for a better understanding and awareness of the NC drought monitoring process, how drought designations are determined, and where to find information. Survey results revealed that:

- Respondents were almost evenly split between those who are aware of the NC drought monitoring process and use the NC Drought Map and/or the US Drought Monitor (USDM) and those who are unaware of these processes and products; and
- Over half of the respondents indicated that they consider the NC and USDM maps only moderately accurate or are unsure about their accuracy.

Drought information use and needs

Current drought maps and indicators are often retrospective, showing past conditions, and not always presented at a meaningful scale for decision making. Participants indicated needs for:

- Information that better conveys forecasts, what those forecasts mean for going into (or out) of drought, and what to expect; and
- Information that places drought into a geographic and water management context, while also conveying the “bigger picture”.

Table 3. Summary of Phase 1 key findings and takeaways by sector and participant group.

		Agriculture	Water Resources
Decision Makers	NC DMAC	Extension agents	Water system managers
Primary drought-related decisions and actions	Determine drought status (D0-D4)	Provide guidance to farmers, agricultural producers, and land managers regarding drought and other weather-climate conditions for planting, harvesting, irrigation, and land management decisions	Water system operations Communicate to customers, staff, boards, and elected officials about drought conditions and conservation actions
Timescale(s) of interest	Weekly, preceding 7 days Past conditions	Daily to seasonal Current and anticipated conditions	Weekly to seasonal Current and anticipated conditions
Geographic scale(s) of interest	State, county, river basin	County, region	Water system area (county-municipal level), river basin
Current information use	Technical information, from a variety of federal and state agencies	Technical information, from a variety of federal and state agencies, primarily precipitation and temperature data	Water system-specific information Technical information, from a variety of federal and state agencies, primarily water level data
Preferred communication formats and channels	ncdrought.org website NC Drought Map	Preferences for concise maps, graphs, narratives Communicated through social media, one-on-one consultation	Preferences for concise maps, graphs, narratives Communicated through news media, emails, social media, websites

Through this process we identified the following project priorities to address the needs articulated by the survey and webinar participants. These priorities were the basis for the new products and resources described in Section 3.

1. Information in narrative form to accompany the NC Drought Map, with the purpose of synthesizing the weekly drought status in North Carolina, any recent changes in drought status or outlooks, and the data and information was used in determining the drought status.
2. Resources that relate anticipated short- and long-range conditions, such as those provided by national-scale forecasts and outlooks, to drought conditions and local- and sector-specific effects in North Carolina.
3. Contextualized and tailored sector-specific information to support the understanding and use of drought information.
4. Resources that describe the NC Drought Management Advisory Council, its purpose, its weekly drought monitoring process, and how this relates to the US Drought Monitor.

Section 3. Product Development, Feedback Processes, and Usability Findings

3.1 Approach to engagement and data collection

A key component of the project was the deployment of an iterative feedback process to develop, communicate, and evaluate new drought resources, dissemination mechanisms, and engagement strategies. Beginning in January 2019 we created drought resource prototypes, based on priorities identified during Phase 1. We simultaneously mapped out a strategy to share and test the prototypes with extension agents, water resource managers and other stakeholders. Their feedback was used to improve the prototypes in an iterative manner. As such, participants at each successive engagement session were likely to receive a modified version of any given product, depending on the feedback received on earlier versions.

The Appendix shows the full list of engagements and methods used throughout the project, broken down by project phase. We used a variety of methods to assess the usefulness and usability of existing drought information resources as well as the resources developed under this project. These include focus group discussions (in-person and virtual), eye-tracking studies, and online surveys. By employing complementary methods, our aim was to explore each product from multiple perspectives, and thus triangulate findings.

In-person feedback

The team targeted conferences and meetings at which sector stakeholders would be present, for example, annual conferences sponsored by North Carolina's Cooperative Extension Service and Water Resources Research Institute (WRRRI) and semi-annual meetings of the NC Fire Environment Committee. We also attended drought-focused meetings, such as the annual meetings of the NC DMAC and Catawba Water Drought Management Advisory Group. Between February 2019 to February 2020, team members conducted engagements at 9 different events, with additional feedback solicited through surveys and project-specific feedback sessions.

We modified our engagements to fit the audience and conference format. For example, at the WRRRI conference, we gave an oral presentation as part of the regular conference program and conducted a 2-hour workshop. At other meetings, we were provided a shorter time block on the agenda, such as 30 minutes for a presentation and discussion. We typically started an engagement with a brief presentation to share the project motivation, findings from Phase 1 (and other phases, depending on when the presentation took place within the project), and priorities for new products. Depending on the audience and available time, we shared prototypes as part of the presentation, as handouts, or poster-sized displays. For each engagement, we asked questions designed to elicit feedback on the understandability of the content and formatting and design elements. We used focus group-style discussions as well as activities where participants could provide written comments. For example, "sticky note exercises" allowed participants to place sticky notes with feedback directly onto poster-size printouts of prototypes (Figure 2). At least two team members attended each engagement, with one person leading the discussion and one taking notes or assisting with follow-up questions.

Virtual engagements

While we aimed to conduct primarily in-person engagements, we also employed webinars and conference calls to convene or interact with groups when it was not practicable or efficient to travel. For example, we conducted a webinar with water utility communications staff based across the state in September 2019. In addition, several "final" in-person engagements planned

for spring 2020 with our target audiences were cancelled or postponed indefinitely due to the COVID-19 pandemic. We adapted by conducting webinars with smaller groups of participants. Similar to in-person meetings, at least two team members attended each engagement, with one person leading the discussion and another taking notes.

Eye-tracking usability studies

We conducted two eye-tracking studies during this project: one in March 2019 at the NC WRRRI Annual Conference and one in October 2019 at the NC State Extension Annual Conference. For each conference, we developed complementary eye-tracking tests to explore different facets of information resources and prototypes. During the March 2019 tests, we collected information about the usefulness and usability of existing resources from sources such as the US Drought Monitor, NOAA, and the NWS, as well as preliminary prototypes for resources we had developed under this project. During the October 2019 tests, we narrowed our focus to two infographics developed under this project — the Weekly Drought Update Infographic and the Short Range Outlook Infographic. All test questions were designed to assess whether users could locate or interpret information on the resources correctly, their perceptions about the ease of locating or interpreting the information, the extent to which the products aided their understanding of drought conditions, and how they would consider using these products in their work.

Pilot strategies for dissemination

In summer 2019, we started a distribution list to pilot the dissemination of prototype infographics, primarily the Weekly Drought Update and Short Range Outlook Infographics. We invited NC DMAC members as well as conference, meeting, and webinar attendees to sign up if they were interested in receiving the infographics. The final distribution list included 74 individuals, representing extension, fire monitoring and management, and water utilities. We periodically asked participants for feedback via emails, and occasionally recipients would send us unsolicited comments and suggestions via email. We maintained these comments in a Google document, with other notes from in-person and virtual engagements.

Online survey

In May 2020 we developed and sent an online survey to all individuals on our **infographic dissemination list** to obtain feedback on the Short Range Outlook Infographics. The survey was open for two weeks, and 26 of the 74 invitees completed the survey for a 35% response rate. Survey questions focused on (1) if, when, and for what purposes respondents had used the infographics; (2) eliciting feedback on the infographics' content and formatting; and (3) preferred methods of receiving, viewing, and sharing the infographics.

3.2 Analyzing Participant Feedback Data

Quantitative data from the eye-tracking usability studies and online survey were used to generate summary statistics and to help us identify product elements that conveyed drought information well and those that needed modification. The online survey also included open-ended questions that yielded text responses. We took detailed notes during participant discussions at each in-person and virtual engagement. For the engagements where participants had the opportunity to provide written comments, either by writing directly on prototype handouts or through “sticky note exercises” (Figure 2), we compiled all notes from these activities into a single MS-Word or Google document.

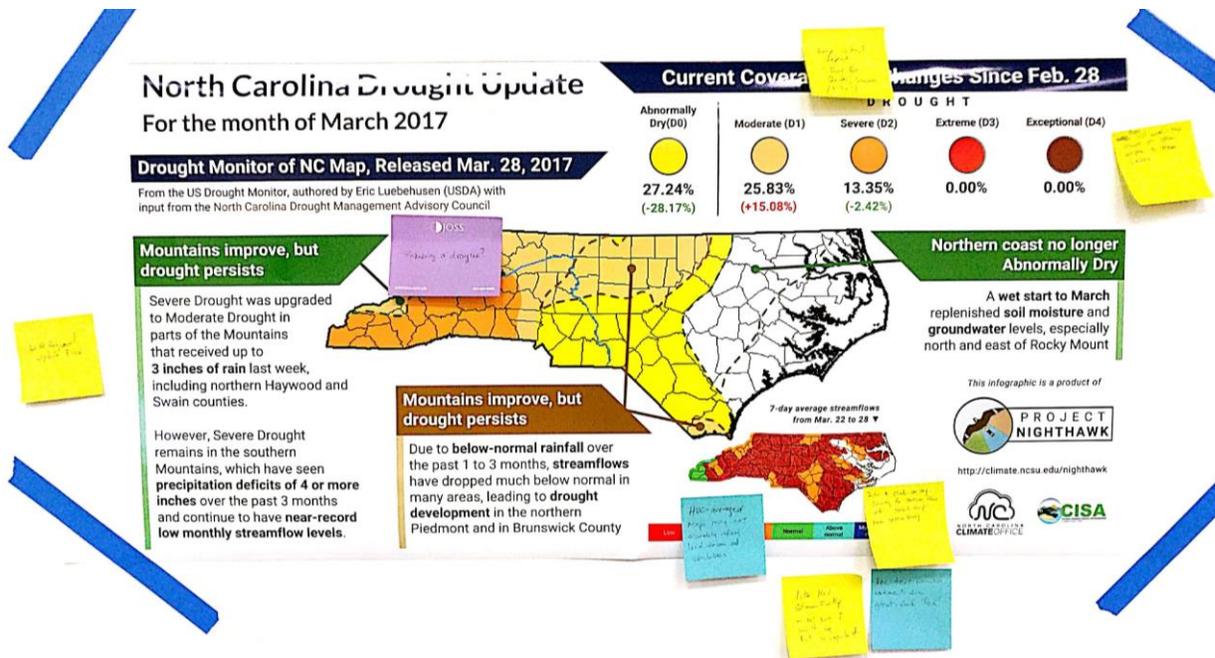


Figure 2. Feedback from “sticky note exercise” during a participatory session during the 2019 WRI Annual Conference. Participants wrote comments and suggestions on sticky notes and placed these on poster-size printouts of prototype infographics.

As we developed and sought feedback on the information prototypes, an important task was to find a balance between users’ desire for short and visually appealing messages and the difficulty in translating and synthesizing complex information in a simple manner for non-technical audiences. Table 4 demonstrates this challenge: two-thirds of participants in the fall 2019 eye-tracking usability study indicated that the Weekly Drought Update Infographic prototypes were only “somewhat effective” or “not effective” in communicating drought information. While we were pleased that most participants found the infographics to be “very” or “somewhat” effective, these results also revealed that there was room for improvement.

Table 4. Effectiveness of the Weekly Drought Update Infographic.

Overall, how effective is this infographic in communicating information about the weekly status?		
Very effective	Somewhat effective	Not effective
33%	62%	5%

Note. Table of participant responses about the effectiveness of the Weekly Drought Update Infographic in communicating drought information, from the eye-tracking usability study conducted at the North Carolina State Extension Conference, October 2019 (n = 21).

We used the qualitative and quantitative data collected throughout the project to improve the prototypes in an iterative manner. At weekly project meetings, we reviewed what we learned from each successive engagement and identified priorities for modifications. We additionally conducted qualitative analysis at the end of the project to assess, in a more holistic manner, the usability and usefulness of the newly developed products, as well as to glean insights into the effectiveness of the engagement process (see Section 5). We considered the following elements in our evaluation, based on previous research (e.g., Bruno Soares et al., 2018; Dilling

& Lemos, 2011; Oakley & Daudert, 2016; Swart et al., 2017), and as they related to our project goals and identified priorities from Phase 1:

- **Accessibility:** New resources should be as, or more, accessible and discoverable than existing drought information resources by connecting with end users' dissemination networks and preferred communication channels.
- **Compatibility:** New information prototypes should fit with existing information, tools, and processes for communicating and sharing information about drought.
- **Content and context:** New information prototypes should provide informative and useful content and be contextualized in a meaningful way for end-users.
- **Understandability:** A goal for new communication products is broad dissemination, requiring attention to use of language that is non-technical, jargon-free, simple, and straightforward, as well as employing appropriate visualizations.

Section 4. Product Descriptions

To address each of the priorities identified during Phase 1 of the project, we developed informational products and resources, and explored dissemination methods including website links, social media, and email. These were systematically evaluated (see Section 3) and results collected from participant feedback informed refinements to informational products and resources. As we completed this process, we noted several key findings related to design, content, and language of informational resources. These include that **having a standardized format and design helps users read and consume information on a week-to-week basis** (Weekly Drought Update Infographics [Priority 1]); and that **it is important to present forecast confidence in a clear and understandable manner** (Short Range Outlook Infographics [Priority 2]). A balance of text and visual elements is also important when designing informational resources. Qualitative feedback revealed that **some users appreciated the amount of detail included in these products, but we also received some comments that these products included too much text**. This section describes the various products developed under this project, the feedback processes employed to evaluate and refine them, and strategies we employed and assessed to disseminate them.

4.1 Priority 1: Narratives to Accompany the NC Drought Map

Creation Process

Initial project surveys and feedback collected prior to the start of the project and during initial webinars with stakeholders indicated the need for narratives to accompany the NC Drought Map to add context and explanation to the map. Finding more effective and proactive ways to share the reasoning behind the weekly drought map could both increase the awareness of the drought monitoring process and answer any anticipated questions about why changes did or did not occur across the state. Initial project survey results and webinars with stakeholders also indicated that shorter and more digestible formats were preferred for receiving and consuming information. Because of this and the mixed-media nature — both maps and text — of communicating the drought status, we chose to use infographics as a delivery format for these weekly drought updates, with a horizontal 2:1 aspect ratio so that graphics shared via Twitter would not be cropped or cut off when viewed within a tweet. The content of each infographic came directly from the data and information discussed during the weekly NC DMAC discussions.

Evaluation Process and Results

Initial versions of these infographics were developed in winter-spring 2019. We created poster-size versions of these and collected feedback from workshop and conference attendees (e.g., Figure 2). In summer 2019, we began to create these more regularly and piloted an email-based dissemination strategy to a list of interested individuals (see Section 3.1, under “Pilot strategies for dissemination”). Periodically, we asked for feedback on the infographics from this listserv, and some individuals sent unprompted feedback. Finally, we collected data on the usability and usefulness of these infographics with an eye-tracking study in fall 2019 (see Section 3.1, under “Eye-tracking usability studies”).

The overall response to these infographics was extremely positive. Pilot testers noted that their use of less-technical language makes them useful for explaining the drought status to the media, citizen scientists, and public audiences. In addition, because these were produced by contributors to the NC DMAC, they were viewed as credible, which makes them valuable for justifying decisions, such as mobilizing staff and resources to respond in times of developing

drought. Through our evaluation methods, we identified several elements and formatting conventions that seemed to work best for effectively and efficiently communicating information about the current week's drought status, and we have highlighted them here.

Change from the previous week

Stakeholders requested to see how the current week's map had changed from the previous week. Initial versions of this infographic used circles or dashed lines to annotate the current week's map to highlight where changes had occurred (Figure 3), but forestry stakeholders at a 2019 meeting suggested that these were distracting. Subsequent conversations and feedback about the best methods to assess changes led to the removal of these annotations and the use of the previous week's map or statistics on the infographic (Figure 4).

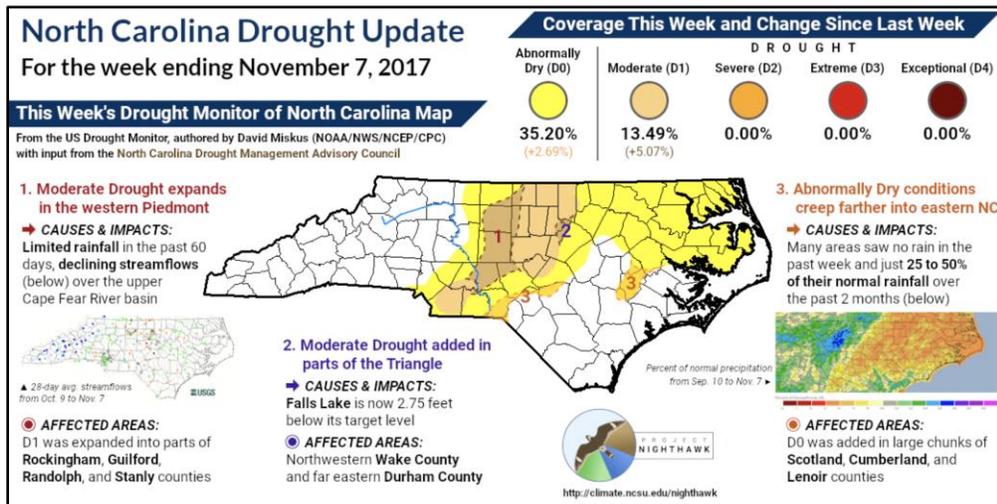


Figure 3. Initial prototype for the Weekly Drought Update Infographic utilized dashed lines and annotated areas on the current week's map to indicate changes from the previous week.

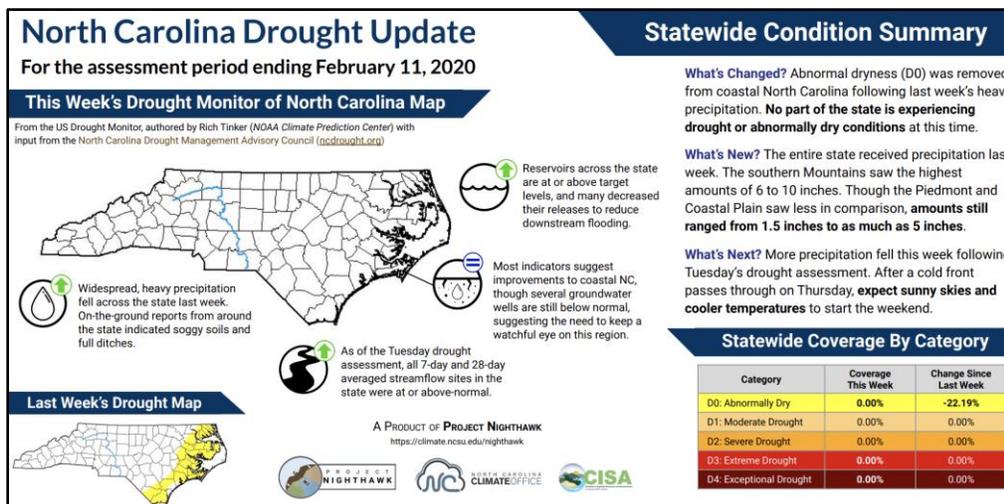


Figure 4. In the final version of the Weekly Drought Update Infographic, the past week's drought map is inset in the lower left of the infographic to allow users to quickly compare maps and examine changes.

Preferences for icons over text-only descriptions

Three to four brief text blurbs surround the current week’s map and describe the indicators and impacts important for determining or understanding that week’s drought status. Early versions of the infographic included only text, but we later incorporated icons (Figure 5) such as a tree to represent forestry impacts and a raindrop to represent precipitation reports. Up/down arrows and equal signs indicate the tendency of that indicator to show improving, worsening, or consistent conditions from the previous week. We compared infographics with and without icons in an eye-tracking study in fall 2019 during the State Extension Conference. Overall, participants receiving the infographic with icons spent more time viewing the infographic compared to the participants who received the text-only version. When asked to indicate how easy it was to find information about precipitation amounts, agriculture impacts, burn bans, streamflow levels, and soil moisture impacts, participant responses suggest that the version featuring icons may be easier to use than the text-only version. While the sample size is small, these results indicated that the icons can help direct users to key information and text in the infographic. Subsequent, qualitative feedback from stakeholders also indicated preferences for the version with icons.

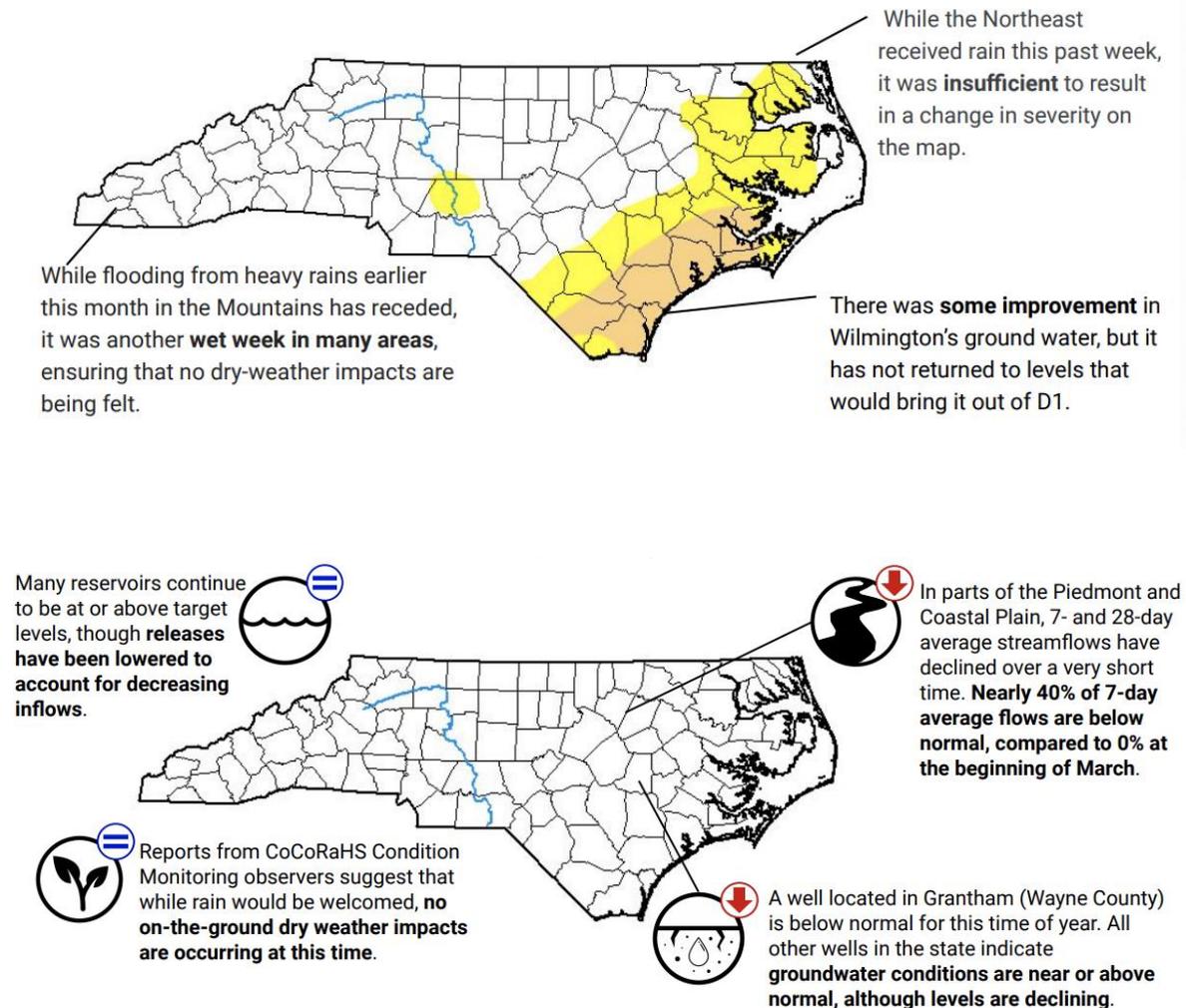


Figure 5. Later versions of the Weekly Drought Update Infographic combined icons with text to highlight changes visually (bottom), whereas earlier versions used only text (top).

Summary descriptions

The right side of the graphic is used to provide additional context about drought conditions (e.g., Figure 6). The “What’s Changed?” section briefly describes changes to the State’s drought status and “What’s New?” summarizes the reasoning behind the changes (or lack thereof). The “What’s Next?” section provides a one- to two-sentence weather forecast for the coming week, added after we received feedback that combining current and anticipated conditions in one product was useful. If we anticipated specific questions or confusion about a given week’s drought map, the right side of the graphic could also be used to address those. For example, when multiple drought categories were present in the state, we used this space to explain the difference between them, such as how D2 (Severe Drought) was more intense than D1 (Moderate Drought) ([view example online](#)). In another example we incorporated an explanation about the reasons for the drawdown of some reservoirs in a fall 2019; this was based on feedback we received from the water resources sector that decreasing lake levels could be seen by some as a sign of drought rather than typical seasonal operations. The project’s archival website, https://climate.ncsu.edu/drought_comm, provides access to all Weekly Drought Update Infographics developed during the project.

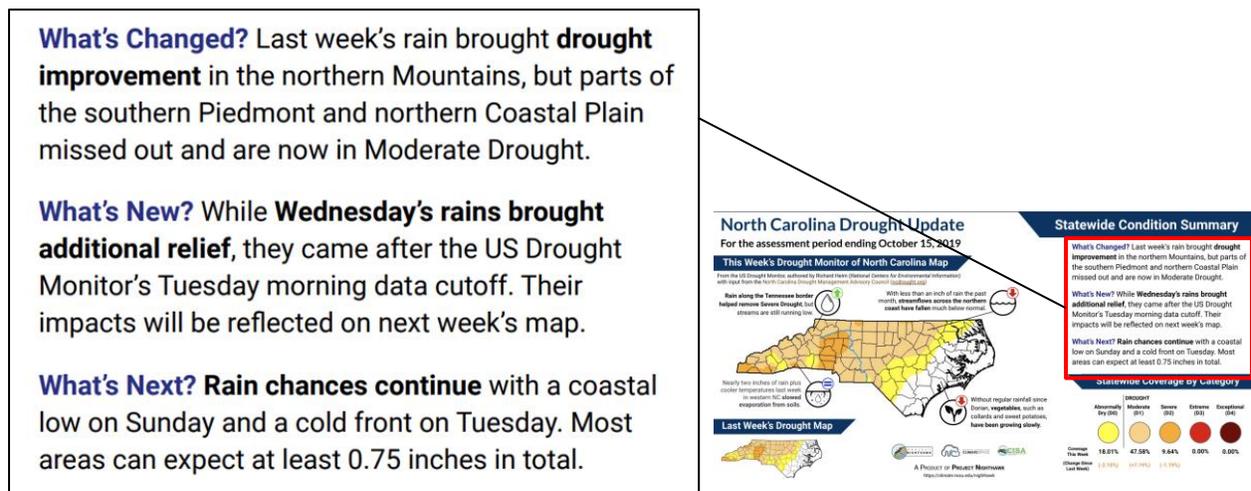


Figure 6. Summary descriptions on the right side of the Weekly Drought Update Infographic provide additional context for users on the current drought status, how it changed from the previous week, and what the forecast may bring over the next week. The Weekly Drought Update shown here is from October 15, 2019.

Preference for fewer elements and a streamlined design

Early iterations of the Weekly Drought Update Infographic (examples in Figures 2 and 3) included maps to show streamflow conditions, in addition to the NC drought map. Qualitative feedback, combined with quantitative results from the March 2019 eye-tracking study, suggested that these made the overall infographic too complex and difficult to navigate, particularly when the maps used different color schemes to represent similar concepts (e.g., dry or wet conditions). We ultimately decided to convey this type of information through brief text and icons. Based on eye-tracking analysis and qualitative data, we also refined the balance and use of colors, icons, and text to convey information.

Dissemination and Long-term Sustainability

Because of stakeholders' positive responses to the Weekly Drought Update, SCONC plans to continue creating these infographics after the Project Nighthawk grant period ends so long as it is feasible within the office's current capacity and is consistent with its present role in the DMAC.

At the time of this report, we continue to work with the NC Department of Environmental Quality's Division of Water Resources (DWR), which hosts the NC DMAC's website, to make ncdrought.org the go-to place for accessing these infographics. Each week's infographic, when created, is linked from the website, but the process is cumbersome and involves substantial human intervention to upload and link these resources. The SCONC and NC DWR are exploring pathways to make this process more automated and to allow site visitors to access an archive of infographics for previous weeks.

4.2 Priority 2: Resources that Translate Short- and Long-Range Forecasts

Creation Process

Past training sessions conducted by the SCONC with the agricultural and forestry sectors revealed that users who were aware of existing forecast and outlook resources frequently misinterpreted them. For example, when presented with a NWS Climate Prediction Center (CPC) outlook showing North Carolina in a 33% to 40% chance of above-normal temperatures, some users interpreted that to mean that warmer weather was likely, even though it represented only a small change from the background odds, i.e., a one-in-three chance of above-normal, below-normal, or near-normal conditions. This observation was consistent with research findings (e.g., Gigerenzer et al., 2005) and encouraged us to prioritize presenting this forecast information in a more easily understandable and actionable format.

In spring 2019, we developed a prototype for a one-page Short-Range Outlook infographic (Figure 7). This infographic has three panels covering time periods that align with those used by the CPC. Week 1 shows the next 7 days from the date on which the outlook was issued, Week 2 shows days 8 to 14 after the issuance date, and the combined Weeks 3 and 4 presents days 15 to 28. The content for these outlooks are created from numerical forecasts and area forecast discussions from local NWS offices across North Carolina, as well as computer model guidance (e.g., the GFS, CMC, and ECMWF models for weeks 1 and 2, and CFS weekly forecasts for weeks 3-4) and the CPC's 6-10 day, 8-14 day, and week 3-4 outlooks.¹

¹ NWS area forecast discussions for offices that cover North Carolina: [Raleigh](#), [Wilmington](#), [Newport/Morehead City](#), [Wakefield](#), [Greenville-Spartanburg](#), [Blacksburg](#), and [Knoxville/Tri Cities](#). Climate Prediction Center outlooks: <https://www.cpc.ncep.noaa.gov/>. Details on computer models: [GFS](#), [CMC](#), [ECMWF](#), and [CFS](#). More details on how the Short Range Outlook Infographic is made can be found in our ["How it's Made" explainer](#).

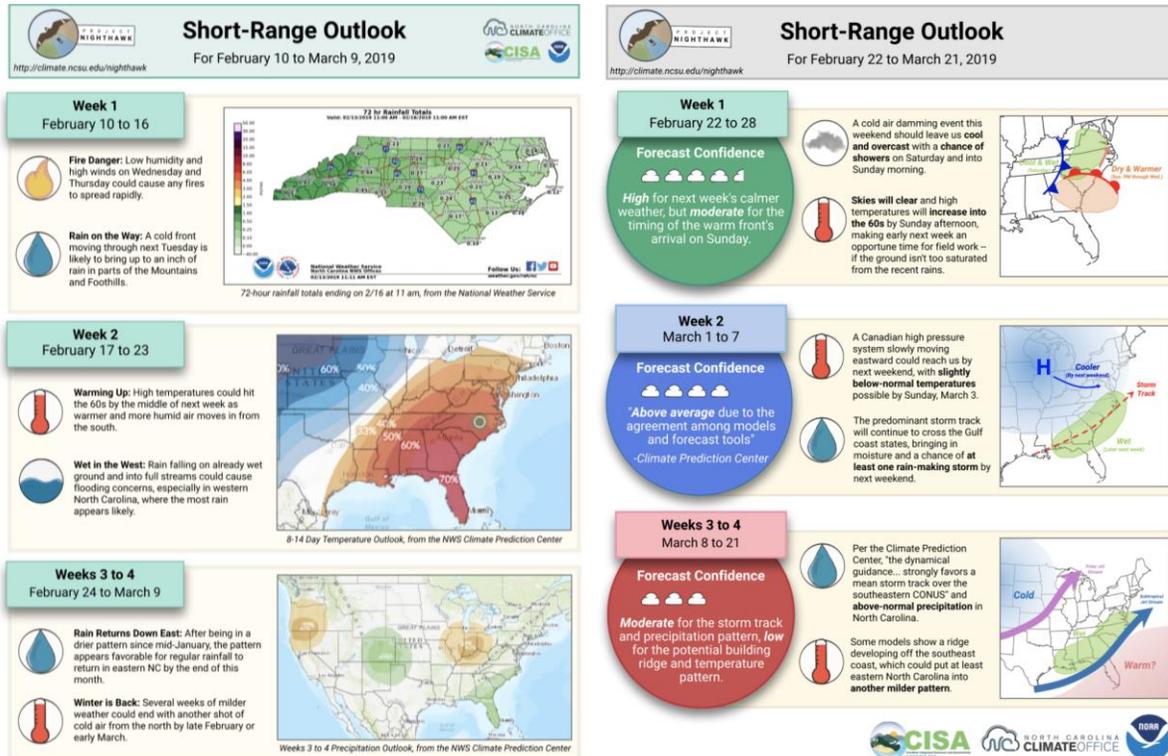


Figure 7. Two subtly different initial versions of the Short Range Outlook Infographic that were shared with project stakeholders for feedback in February 2019. While many elements of these were ultimately altered based on feedback throughout the project, including altering the horizontal layout for a vertical layout, the 3-period format has remained.

Evaluation Process and Results

Like the Weekly Drought Update Infographic, we used a combination of surveys, in-person or virtual feedback sessions, and eye-tracking studies to evaluate the Short Range Outlook Infographic in terms of its usability and usefulness, and specific elements were subsequently refined throughout the project. Below we describe findings related to the design and content of these infographics, as well as how this intersects with their usability and use.

Text translations of forecast information

We sought to avoid perpetuating known challenges with interpreting probabilistic forecast information while developing the Short Range Outlook Infographic. First, key weather features likely to affect North Carolina, such as cold fronts, high pressure areas, and moisture or rain, were displayed on a map of the eastern US. Initial versions of this infographic showed the entire contiguous US (Figure 7), but this was later altered to focus on the southeastern region following feedback requests for a state-level or regional perspective (Figure 8). Brief summaries describing the outlooks for temperature and precipitation over the given period accompany these maps. They include any events that could initiate or worsen drought conditions and impacts (e.g., heat waves, dry spells, or low-humidity windy days that might increase fire risk).

Short-Range Outlook for North Carolina

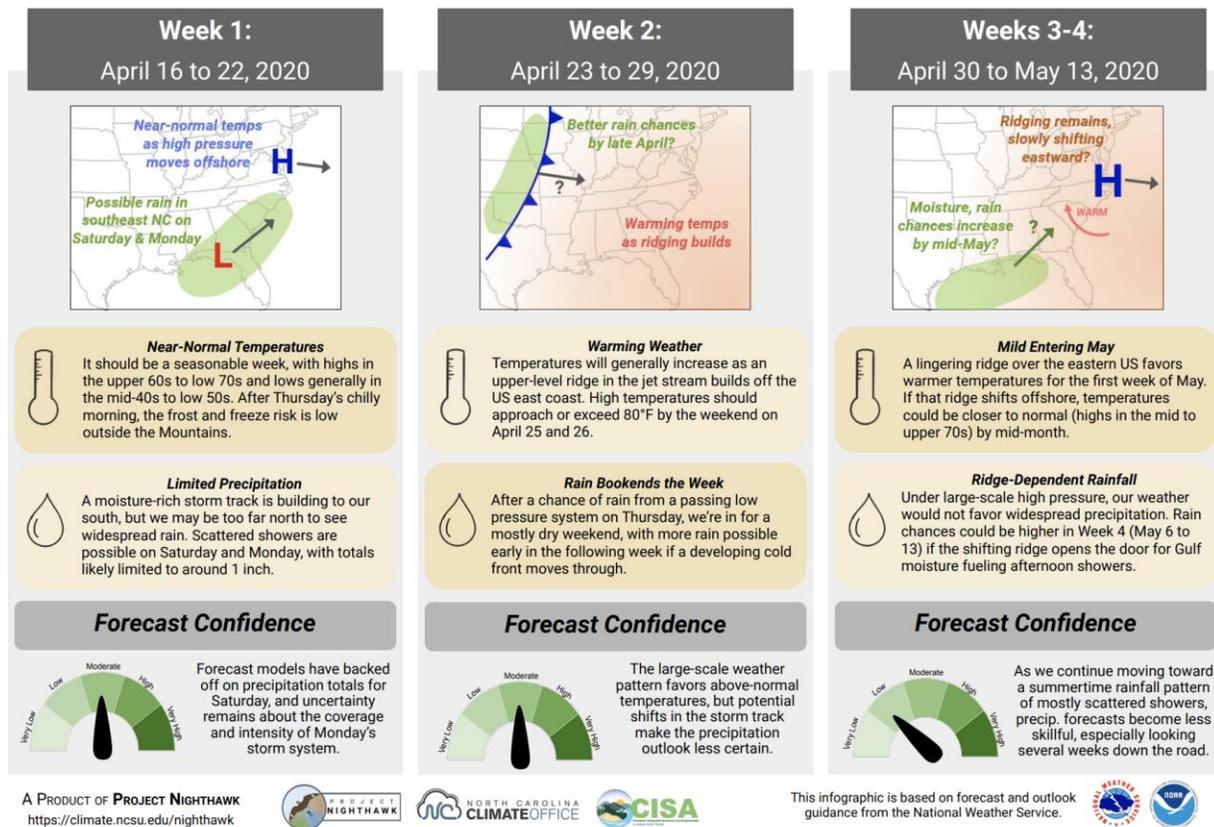


Figure 8. Example Short Range Outlook Infographic from April 2020 is more zoomed-in to the region surrounding North Carolina and uses a mixture of icons and text headings to organize content. Scales depicting forecast confidence are located in the bottom of each panel.

Forecast confidence measures

A measure of the forecast confidence is included for each of the periods displayed in the infographic (Figure 8, bottom). We display forecast confidence both on a five-point metered scale ranging from Very Low to Very High and as a short text summary that describes sources of uncertainty or confidence. We went through several iterations to refine how the infographic displays this information by collecting feedback on interpretations and preferences between numeric and text-only scales, as well as how colors helped or hindered using the graphics. In a feedback survey sent to users in spring 2020, respondents indicated that even when the forecast confidence was low, it was useful information since it served as a reminder to continue following their local forecast.

Preferences for clearer and more intuitive visual representations of information

In general, results from the spring 2019 eye-tracking study indicated that participants found the first iteration of forecast uncertainty icons (which featured color with the aim of making a more visually appealing product; e.g., Figure 7) and forecast confidence graphics confusing and difficult to interpret. The qualitative feedback we received during the in-person, participatory workshop held at the 2019 WRRRI conference supported results from the eye-tracking study. We subsequently altered some of the design elements based on this feedback.

- For example, a thermometer icon was filled with red (e.g., Figure 7), but participants were confused when this icon was used to indicate both warmer-than-normal and “normal” temperatures in the same infographic. We altered the icons to a monochromatic scale (e.g., Figure 8).
- To communicate forecast confidence, we initially used pictures or a number value to communicate a scale of 1 (low confidence) to 5 (high confidence) (Figure 7). We found that usability study participants were less likely to view forecast confidence information when it was embedded in the infographic text. Participants providing in-person feedback also indicated that the 1-to-5 scale was unclear and suggested a more intuitive representation would show confidence as very low, low, moderate, high, and very high, with a corresponding color scheme to symbolize confidence levels (Figures 8 and 9). Based on subsequent feedback, we eventually changed the multi-colored graphic (Figure 9, left) to a monochromatic visual (Figure 9, right).

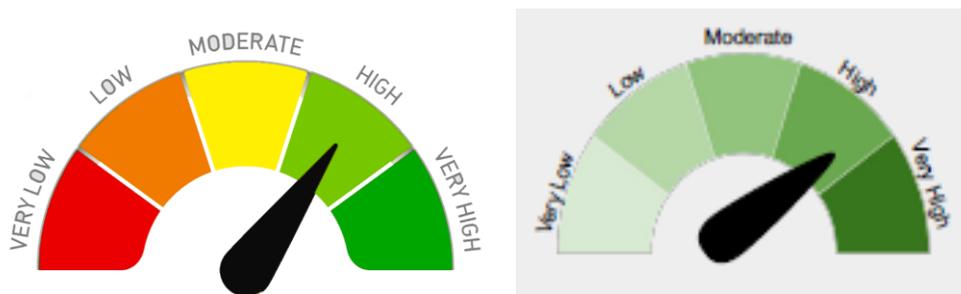


Figure 9. Earlier version of forecast confidence scale (left) and final, monochromatic version (right).

Preference for a vertical-oriented layout

Participants in the NC State Extension Conference (October 2019) eye-tracking study were divided into two groups; one group viewed the Short Range Outlook Infographic in a horizontal layout and the second group viewed a vertical layout. Each infographic included the same content (map, explanatory text, and forecast confidence meter). Overall, participants receiving the vertical layout spent more time viewing the infographic. When asked to answer questions about specific content in the infographic, participants with the vertical layout appeared to focus on the intended infographic element(s) (e.g., text about potential impacts, forecast confidence) more than the participants with the horizontal layout. The vertical layout was rated as “very effective” by more of the participants receiving that layout, when compared to the rating of the horizontal layout. While the sample size is small, these results suggested that the vertical layout provided a better format for communicating the intended information.

Dissemination and Long-term Sustainability

While the SCONC is not the originator of the forecast guidance in the Short Range Outlook Infographics, discussions with local NWS offices during feedback webinars in summer 2020

indicated that local NWS offices may lack the capacity to routinely create these infographics themselves. Participants in these webinars offered their support for the SCONC to continue producing these, provided their content links to and credits the NWS as the originator for the forecast information. At the time of this project's conclusion, we are in the process of pursuing long-term support for the creation and dissemination of these infographics, potentially from within one of the sectors or agencies that has been receiving them.

4.3 Priority 3: Contextualized information to support the understanding and use of drought information

For this priority, it was necessary for us to consider the varying capacities of drought information users and the multiple contexts in which they use drought information, and we recognized that a “one-size-fits-all” approach was unworkable for all the drought products we sought to create. Based on our interactions with participants in Phase 1, we identified sector-specific needs and preferences to pursue. Agriculture and forestry participants indicated needs for resources that explain how to access, interpret, and apply technical types of information. Participants from the water resources sector were most interested in tools that would aggregate statewide or basinwide conditions to support drought monitoring at those broader geographic scales. In this section we describe our efforts to provide tailored information, resources, and educational opportunities for these audiences.

Creation Process

Agriculture and forestry sectors

Creating and producing explanatory infographics assumes a baseline level of knowledge among consumers. Our engagements with users and project stakeholders revealed that this assumption may not hold true, particularly among the diverse set of users who consume weather, climate, and drought information to inform various activities and decisions. For example, master gardeners may be extremely comfortable with botany and some of the weather factors that influence it, such as spring freezes and extreme precipitation, but they may lack training or skills in using weather outlooks for planting decisions or in discriminating between validated and untrustworthy sources of information. Liaisons such as extension agents and district foresters are responsible for finding and translating technical information for the “boots on the ground”, such as farmers, master gardeners, and firefighting teams who then use it for their own decisions. To support these user groups, we prioritized producing and providing information that explains how to access, interpret, and apply technical types of drought information to fill in knowledge gaps.

1. By leveraging other activities and projects at the SCONC, we delivered workshops and training sessions on weather, climate, and drought information and concepts.
2. We developed a set of factsheets describing historic droughts, their meteorological and climatological contexts, and their impacts, to be used as quick references during current or developing drought events.

Water resources sector

One of the priorities identified early in the project was a resource to aggregate statewide and basinwide water supply conditions. Because of North Carolina’s diverse topography and geology, several types of water supply resources exist in the state (e.g., groundwater, surface reservoirs, and rivers). The time period at which drought impacts emerge in these different

water supply resources varies, and, when combined with the variety of management activities, can make it challenging to compute and communicate the state's water supply status in a single visual. This challenge has been noted as early as 2005 when the NC DMAC explored the development of an experimental water supply index (e.g., 2005 DMAC Activities Report, http://www.ncdrought.org/files/documents/2005_annual_report.pdf).

Developing a new web-based tool to deliver this information was beyond this project's scope. The project team therefore approached this priority from the perspective of understanding how water supply information informs drought decision making, specifically decisions by utilities to communicate about emerging or existing water supply concerns or restrictions. We also worked with a graduate-level design class at NC State University to explore innovative ways to package and translate this information. Students in this class designed mock-ups for websites to display this information. We shared the students' designs with stakeholders in winter 2020 and collected feedback on their perceived usefulness and use in communicating and translating drought information.

Working with this graduate design class and water utilities allowed us to collect information about user preferences for a web-based platform if the resources could be located to develop it. This led to a collaboration with the Internet of Water and water utilities in the Triangle region to pilot a "water supply dashboard" that would integrate information about drought, water supplies, utilities' water shortage response plans, and water conservation measures and available from a variety of sources (i.e., federal, state, and local agencies) into one web-based tool. The Internet of Water, located within the Nicholas Institute at Duke University, focuses on facilitating the opening, sharing, and integration of water data and information (<https://internetofwater.org/>). The goal of the dashboard is to assist water resource managers monitor regional water supply conditions and provide information to their water utility staff, Boards, and customers about drought conditions and any measures or decisions (e.g., water conservation) that might be necessary due to drought. Internet of Water staff are leading the technical and data management aspects of the project, including data collection, integration of relevant datasets, and development of the dashboard. The project team is assisting with the ongoing engagements with the water utilities, outreach to other relevant partners (e.g., NC DMAC), and incorporation of products and findings from this project into the dashboard product.

Evaluation Process and Findings

Workshops and training sessions

In spring-summer 2019, we held four different workshops for North Carolina Cooperative Extension personnel to provide training on weather, climate, and drought information and resources. The content for these workshops included an overview of large-scale factors that influence our seasonal climate (e.g., ENSO, the Bermuda high, and tropical activity), along with an overview of how weather forecasts are created and how to correctly interpret CPC outlooks. Several of these workshops also included focus group-type discussions in which participants were given the chance to review prototypes of the weekly drought updates and short-range outlook infographics and provide feedback about their usefulness to themselves and the constituents they serve.

SCONC, which is a member of North Carolina's Fire Environment Committee, organized by the NC Forest Service, has also used the biannual committee meetings to provide weather training to that audience, which includes representatives from state and federal agencies and non-profit organizations that conduct prescribed burns and respond to wildfire events across the state. Training topics have similarly included ENSO impacts on seasonal weather and fire danger and

weather outlooks geared toward forestry and fire. During the spring 2019 and spring 2020 FEC meetings, we also conducted brief feedback sessions about Nighthawk resources. This user response helped shape these products to be more useful for this sector, such as creating a set of fire-focused historical drought factsheets (see next section, below) or anticipating the number of days with more than a quarter-inch of rainfall since this amount is generally sufficient to moisten ground-level dead fuels and prevent immediate ignition.

Drought factsheets

Based on feedback collected throughout the project, and from water resource managers specifically during a winter 2020 meeting, we developed a series of prototype, one-page factsheets describing historic events tailored to the agricultural, forestry, or water resources sectors. Project stakeholders have shared that they are often asked how a current event compares to a memorable historic event. For example, water supply managers are often asked this by their boards or constituents, and NC DMAC members receive these questions from the media. Creating a factsheet for every sector and drought the state has experienced in recent years was not feasible in this project. We instead focused our attention to specific events that have strong impressions in the state (i.e., the 2007-08 drought of record), on a specific sector (e.g., the 2016-17 drought and associated wildfires that impacted western NC), or that were unique in some way (e.g., the 2019 “flash” droughts, and how this type of drought differs from “traditional” droughts). We collected feedback and refined the content and layout of these in summer 2020 using surveys and email exchanges with stakeholders.

Dissemination and Long-term Sustainability

By leveraging this project with other efforts at the SCONC to deliver workshops, we were able to more fully develop educational content about drought and the weather and climate factors that influence it that we have used in subsequent workshops and training sessions. For example, the curriculum for these workshops has since been recycled for other training sessions held by the SCONC, including a workshop on drought in June 2020 for Extension agents (80 attendees) and a webinar on North Carolina’s climate for interested members of the public in September 2020 (275 attendees). We are additionally working on a permanent home for the drought factsheets on either the State Climate Office or NC DMAC websites. These are currently available from the project’s archival website (https://climate.ncsu.edu/drought_comm) and have been provided to NC DWR for the ncdrought.org website.

4.4 Priority 4: Resources about the NC DMAC

Creation Process

Though the NC DMAC members have readily shared information about the drought monitoring process, and information did exist on the DMAC's website about the state's drought map and the process by which it is developed, early engagements with stakeholders suggested that a lack of transparency and accessibility to this information persisted. We collected information about preferred communication formats and channels of our target sectors and used this to guide the development of "static" information resources. We initially created a four-page factsheet that describes the history, membership, and function of the NC DMAC. This information resource also includes descriptions of the types of information that the NC DMAC uses in its weekly assessments, including how that information is interpreted.

Evaluation Process and Results

We collected feedback on this four-page factsheet from NC DMAC members during the 2019 annual DMAC in-person meeting. Among the feedback received was that an even shorter, two-page version could facilitate communication and sharing. Based on this, we generated a shorter version that contained more synthesized information and shared it with members of the DMAC and attendees at the February 2020 Southeast USDM Workshop.

In 2019, we also worked with NC DWR to redesign the DMAC's website, <https://ncdrought.org>. The project team provided recommendations for the reorganization of information on the website, based on feedback collected from stakeholders throughout the project. As part of this process, we also developed a story map to describe the DMAC's drought monitoring process in an immersive way that combined text-based narration with visual elements.

Dissemination and Long-term Sustainability

One of the most apparent long-lasting impacts of this project is a redesigned ncdrought.org website that contains or links to content created by the project team (e.g., story map describing the DMAC's process; Weekly Drought Update and Short Range Outlook Infographics). At the time of this project's end, we are continuing to work with NC DWR to add additional factsheets developed under this project to the website.

Section 5. Evaluation

This section describes how we approached evaluating the project’s final outputs (i.e., informational products), effectiveness of our engagement processes, and progress toward project goals. For brevity, we have avoided repeating data collection or analysis methods for individual products listed elsewhere in this report and instead focus on findings pertaining to the project as a whole.

5.1 Participant Feedback: Data Collection and Analysis

At the end of the project and as part of Phase 5 (Figure 1), we assessed in a holistic manner the *usability and usefulness of the newly developed products* in order to glean insights into the *effectiveness of the engagement process*. We used NVivo, a software program for qualitative data analysis, to analyze all notes from focus group discussions (both in-person and virtual), meeting notes, survey responses, and email comments. We developed an initial set of coding categories from literature on climate information use and usability, knowledge exchange, and co-production processes (Table 5). We coded documents and notes according to this initial set of categories (Protocol Coding), then followed this with a second round of coding and review during which we added new codes and sub-codes as we identified additional themes and patterns in the data (Saldaña, 2013).

Table 5. Coding categories used to examine product use and overall project outcomes.

Actual or potential use of information and products		References
Types of decisions and activities	<p><i>Communications</i>: product is used to communicate with others about drought conditions</p> <p><i>Education</i>: product is used to educate others about drought, drought conditions, and the drought monitoring process</p> <p><i>Monitoring</i>: product is consulted to check the status and evolution of drought conditions</p> <p><i>Planning and management</i>: product informs specific decisions or activities to respond to or prepare for drought</p>	<p><i>Derived from review of Phase 1 results and other references</i></p> <p>Corringham et al. (2008) Haigh et al. (2015) Ray and Webb (2016)</p>
Project and process outcomes		References
Credible	Users perceive information and new products to be accurate, valid, and of high quality	McNie (2007) Wall et al. (2017)
Legitimate	Users indicate trust in the information producer and/or the process through which the information is generated and communicated	
Salient	Information is relevant to the context in which it will be used and responds to specific decision-maker needs	

5.2 Findings and Results: Product and Information Use

The fundamental motivation for this project was to develop and deliver actionable drought information. As such, an important component of the product evaluation was to assess if and how our target audiences were using, or would potentially use, the new products and information created through the project. For this project, we considered “actionable information” to be information that (1) addressed stakeholder needs for greater understanding of how droughts form and evolve, their impacts, and drought monitoring processes (Colavito et al. 2019; McNie 2013) and (2) could inform or be applied to drought-related decisions.

To examine and learn how users were using, or might use, the new products, we drew from responses to Likert scale questions in the eye-tracking studies and the Short Range Outlook Infographic survey conducted in May 2020, responses to open-ended questions in the Short Range Outlook Infographic survey, and discussion notes from webinars, in-person meetings, and email exchanges. Analyses focused on identifying examples of actual use, as well as potential use and usefulness, of new information and communications resources. Due to the short-term nature of this project, and since North Carolina did not experience a severe or long-lasting drought during the project, we did not expect to record many examples of actual use.

Project participants reported using the new products and informational resources primarily for communicating to and educating constituents/customers, colleagues, and supervisors about drought conditions. While not as prevalent, we also discovered examples where users consulted the products to monitor and maintain situational awareness about changing conditions and to inform or justify management decisions.

Quantitative Data Analysis and Results

Eye-Tracking Studies

We asked participants in the fall 2019 eye-tracking studies to indicate how likely they were to use the Weekly Drought Update (Table 6) and Short Range Outlooks (Table 7) for a variety of purposes. Responses for those participants viewing the different infographic formats (i.e., icons v. no icons, horizontal v. vertical layout) did not vary significantly, so they are combined here. In general, participants indicated that they were more likely to use these infographics to inform themselves, followed by constituents, customers, and colleagues. They were less likely to use the infographic to inform decisions at seasonal to long-term term timescales. Given the timescales for which the infographics are produced (approximately 1-2 weeks for the Weekly Drought Updates, 1-4 weeks for the Short Range Outlooks), that result is not unexpected.

Table 6. Weekly Drought Update infographic potential use, eye-tracking study.

Likelihood of using the <i>Weekly Drought Update</i> infographic:	Percentage of respondents			
	Very likely	Somewhat likely	Not likely	Unsure
To inform myself	67%	29%	4%	0%
To inform colleagues	43%	29%	29%	0%
To inform constituents and customers	43%	33%	24%	0%
To inform seasonal decisions (e.g., planting, purchasing, irrigation)	29%	43%	24%	4%
To inform longer-term decisions (e.g., development of infrastructure)	14%	24%	57%	4%

Note. Responses to the question “In your professional capacity, how likely are you to use this infographic for the following purposes?” about the likelihood of using the information in the Weekly Drought Update infographic, from the eye-tracking usability study conducted at the North Carolina State Extension Conference, October 2019. (n=21)

Table 7. Short Range Outlook Infographic potential use, eye-tracking study.

Likelihood of using the <i>Short Range Outlook</i> Infographic:	Percentage of respondents			
	Very likely	Somewhat likely	Not likely	Unsure
To inform myself (n=20)	80%	20%	0%	0%
To inform colleagues (n=19)	47%	37%	16%	0%
To inform constituents and customers (n=20)	50%	35%	15%	0%
To inform seasonal decisions (e.g., planting, purchasing, irrigation) (n=20)	35%	50%	15%	0%
To inform longer-term decisions (e.g., develop infrastructure) (n=18)	22%	11%	56%	11%

Note. Responses to the question “In your professional capacity, how likely are you to use this infographic for the following purposes?” about the likelihood of using the information in the Short Range Outlook Infographic, from the eye-tracking usability study conducted at the North Carolina State Extension Conference, October 2019. The number of responses per question (n) varied due to one response being left blank by at least one participant.

Short Range Outlook Survey to Email Distribution List

In May 2020 we developed and sent an online survey to the 74 individuals on our infographic dissemination email list to obtain feedback on the Short Range Outlook Infographics. Many of the individuals on this list began receiving the infographics starting in summer 2019. We were interested in learning if they had opportunities to use them and characterizing their use to date.

A majority (21/22) of survey respondents who had seen the infographic previously indicated they used it to maintain situational awareness about the weather (Table 8). More than half of the respondents also indicated using these to plan for potential drought or dry periods, to inform or answer questions from colleagues, and to inform or answer questions from supervisors or superiors.

The use for “planning for potential drought/dry periods” (62% of total respondents) was higher than expected, given that the responses from the eye-tracking study suggested that use of the infographics for seasonal and long-term decisions was unlikely or only somewhat likely.

Few participants indicated they used these to answer questions from the public or to allocate resources for the coming weeks. No participants indicated they used these to answer questions from the media. These responses are not unexpected as drought conditions were neither extensive nor long-lived during the project period; consequently, most users would not have received many questions from the public or the media. Responses from participants who had either not seen the infographic before or were unsure (n=4) were similar.

Table 8. Short Range Outlook Infographic use and potential use, online survey.

Answer	Percentage of respondents		
	Group 1: How have you used the SRO infographics? (n =22)	Group 2: How might you consider using the SRO infographics? (n = 4)	Combined groups (n=26)
Maintaining situational awareness about the weather	95%	50%	88%
Allocating resources for the coming weeks	9%	0%	8%
Planning for potential drought/dry periods	64%	50%	62%
Planning for potential wet periods	45%	50%	46%
Informing or answering questions from the media	0%	50%	8%
Informing or answering questions from the public	14%	50%	19%
Informing or answering questions from colleagues	59%	50%	58%
Information or answering questions from supervisors/superiors	59%	25%	54%
I have not used the Short-Range Outlook infographics	5%	0%	4%

Note. Results from the Short Range Outlook Infographic Online Survey, May 2020. Participants were prompted to “check all that apply”, depending on which question they received, to indicate their use of the Short Range Outlook Infographic. Group 1 consisted of those participants who indicated having seen the infographic prior to the survey; they were asked how they have used the infographics (i.e., actual use). Group 2 consisted of those participants who indicated they had not seen the infographic prior to the survey; they were asked how they might consider using the infographic (i.e., potential use).

Qualitative Data Analysis and Results

Here we describe key ways participants are using (or considering using) the resources, based on feedback from group discussions, responses to open-ended survey questions, and other exchanges. We also include illustrative quotes obtained during our project's multiple engagements and feedback mechanisms (see Appendix).

General Communications and Information Sharing

Participants shared examples of how they have discussed, referenced, or shared the infographics with colleagues, stakeholders, and public audiences, with the purpose of communicating drought conditions and/or increasing awareness of the products themselves. Extension agents reported using Facebook and monthly newsletters to provide information to their constituents, including growers, industry associations, homeowners, and others in their communities. Water utilities may be more likely to use or share the products with colleagues for general awareness or potentially with customers to meet increased demand for information during an actual drought. Several respondents to the May 2020 survey about the Short Range Outlook Infographic also reported sharing this specific resource with colleagues. Federal agencies (e.g., National Weather Service) and state agencies (e.g., DMAC members) noted that the products would be useful for communicating with the public and the media (see exemplary quote in box to right).

"I think it [Short Range Outlook Infographic] will be useful for us, not only on a social media level but [also] ... dealing with partner calls or media calls and pointing them to these resources. I think [it] will help a lot to make sure the messaging is consistent and accurate." [NWS webinar participant]

Education and Training

Beyond the dissemination of drought information, project participants reported using the infographics to educate a variety of audiences about drought and drought monitoring processes and to explain the NC Drought Map and why certain actions, such as water restrictions and State Park beach closures, are being taken (or not being taken). One testimonial we received from a Listserv respondent referenced how these infographics are useful for educational purposes: "I use these to explain why the Drought Map looks like it does to those unfamiliar with the NC DMAC/USDM procedures for determining drought" [Short Range Outlook survey respondent]. We also heard from several stakeholders about the potential usefulness of the information for professional training for Extension and other state agency personnel, as well as for community-based educational programs.

Monitoring Conditions and Maintaining Situational Awareness

We heard from many participants that the Weekly Drought Update infographic aids in the monitoring of overall conditions and their evolution from week to week. **It can serve as an "alert" or "early warning" of changing conditions**, highlighting which locations or indicators to monitor more closely and indicating if worsening conditions warrant additional planning or preparedness. For example, one respondent to the Short Range Outlook survey stated "I paid particularly close attention to them during March when our precipitation was really low, and I was certain we were entering drought."

We also received a few examples where participants used the products not only to monitor conditions but also to convey that information to their supervisors or higher levels of management to increase their awareness and potentially inform decisions. As one water system representative noted, they receive questions from Boards of Directors on "how bad is it going to be" or "where is it going" and this regional perspective will be helpful.

In some examples, we learned how the infographics can augment other information, or even substitute in-person monitoring:

“I consult the outlook [Short Range Outlook Infographic] every month. One thing I like about it is that you provide an indication of forecast confidence. I feel like your outlook, combined with the NWS 3-month outlook, and the 3-day QPF gives me the best crystal ball available.” [Short Range Outlook survey respondent]

“I like the weekly [Weekly Drought Update Infographic] to keep an eye on potential for short term flash drought conditions that the USDM might not catch.” [Fire Environment Committee Meeting]

“Since the pandemic, I have been unable to get out to the rest of the state. The [Weekly Drought Update] graphic helps me understand where areas of abnormal dryness are appearing without having to see it for myself or ask local sources.” [Short Range Outlook survey respondent]

Response and Planning

We received examples where the information helped supervisors, administrators, and others understand evolving conditions and has been used to justify or inform specific decisions, primarily those related to prescribed burns, fire response, and crop management. As one Forestry stakeholder noted, “My higher level superiors are not natural resource professionals. I use the Drought Infographic/Assessment as a communications tool (via email) to inform them so they might have a better understanding as to why we are having high fire danger/fire occurrence and subsequent overtime and hazard pay. Having the information coming from an outside Subject Matter Expert (SME) carries more weight than me telling people ‘it’s the driest it has been since 2011’! This product has been an excellent communication tool!” We received additional examples of potential use. Respondents to the Short Range Outlook survey indicated that the forecast confidence information included in these infographics could be of value for planting as well as water conservation decisions (see exemplary quotes in box to right).

“When it indicates moderate to very high, it provided confidence that rain will occur and planting can occur.” [Short Range Outlook survey respondent]

“We have not had drought since these became available. But I could see us using the information to determine whether to enter voluntary/mandatory water use restrictions early. Knowing the information in this graphic along with other regional information is helpful.” [Short Range Outlook survey respondent]

Participants provided a few additional examples of how the information in the infographics could inform response and planning for hazards other than drought. For example, one stakeholder responded that “Knowing the forecast confidence may help us decide whether to warn our partners about a potential impending hazard, or whether to put it in our Hazardous Weather Outlook” [Short Range Outlook survey].

Use Case Example

Throughout the project period, North Carolina’s weather conditions were generally wet. The project began two weeks before the landfall of Hurricane Florence, the wettest tropical storm in

the state's recorded history, and continued through 2019, which ranked as the state's 46th-wettest year dating back to 1895. The prevailing wetter-than-normal conditions allowed the project team and project stakeholders opportunities to be reflective and think about long-term improvements, rather than short-term gains, in drought communications. These wet conditions were punctuated by a flash drought that developed across western North Carolina in September and October 2019, and by emerging dryness in early summer 2020, which allowed the project team to discuss and assess the project outputs in the context of actual drought or dry conditions. These two events served as brief case studies demonstrating how our developed resources could be used, both in tandem with each other and with external information from NOAA and other providers.

Before, during, and after a drought event, the Short-Range Outlook infographics were used by our target sectors to maintain situational awareness. During periods with lower forecast confidence, especially during the warm season or in times with the potential for drought development, users told us they paid closer attention to their local forecasts from the National Weather Service to be more weather-ready and drought-prepared.

Users reported employing the Weekly Drought Update infographics to monitor an event as it developed, and to stay informed on any downward-trending indicators. For example, the Weekly Drought Update infographic for September 10, 2019, noted increasing rainfall deficits, declining streamflows, and short-term agricultural impacts developing across western North Carolina in response to recent dry weather. Two weeks later, Moderate Drought had emerged in these same areas. Some users reported using the information in these infographics to justify specific decisions. In feedback collected during the project, a fire manager shared that these infographics were used to explain increases in fire danger to supervisors and justify overtime or hazard pay during those events.

We also designed the Weekly Drought Update infographics as educational resources and used them to share information about the nuances of drought measurement and monitoring. As one example, after several weeks of hot, dry weather in July 2020, the North Carolina drought map remained blank largely because soil moisture and surface water levels were still at or above normal following a wet spring. In addition to highlighting the conditions of drought indicators across the state in the July 21, 2020 Weekly Drought Update infographic, we included text and graphics to explain the tipping point between typical summer heat and dryness and abnormal dryness. This was well-received by other DMAC members and shared within their organizations. One DMAC member noted: "I really like your explanation of 'So when does a summer weather pattern become abnormal dryness, or even drought?' This should provide a great reference for the public."

The products developed under this project have also been designed to be used in concert to support drought communication and transparency. For example, the Weekly Drought Update infographics can be used alongside resources such as the Drought Story Map (<http://www.ncdrought.org/about>) and historical factsheets to understand which indicators are being used to monitor conditions, how the NC DMAC incorporates these into their assessment, and an event compares to historical droughts. Based on our interactions with project stakeholders, we anticipate the project outputs may be used in this combined manner in the future. In 2019, the NC Forest Service and other fire management organizations began growing concerned that the drought could continue and have similar impacts as the 2016 fall fire season, which included multiple large wildfires burning in the southern Mountains. Having a historical fact sheet for that event (which was not developed until summer 2020) might have provided a useful reference for its timeline and evolution.

5.3 Final Thoughts and Lessons Learned

We purposefully designed this project as a process that brought together researchers, agencies, stakeholders, and decision makers through systematic engagement to ensure that solutions fully address drought information needs and challenges. Here we discuss our overall findings related to the project; key takeaways on the usability, usefulness, and actual use of the drought resources and information produced through the project; and the long-term sustainability of the project outputs and outcomes.

Transparency

One challenge with using a static state- or national-level map to **communicate drought conditions** is that it is practically impossible to capture local conditions. Users, and potential users, thus **perceive the map to be inaccurate**, when they are most concerned about “what’s going on in their backyard.” To address this challenge, **we developed the Weekly Drought Updates to clearly portray the reasoning behind the drought status levels as shown in the NC Drought Map** and provide supporting examples from affected areas and sectors.

Findings from our project also suggest that the perceived inaccuracy of the NC Drought Map may be due to a lack of understanding of how the monitoring process works. We therefore created products with the goal of improving the understanding of, and by extension the transparency of, the NC DMAC and processes to develop the NC Drought Map and USDM. In addition to the information contained in the Weekly Drought Update infographics, we created a **NC DMAC story map** that details the DMAC membership and the data and information they use to assess and determine drought status across the state, and an accompanying information sheet that summarizes the story map content in a different (pdf) format.

Trust and Confidence in Information Resources

While users favored translated and non-technical language in the new products developed under this project, they also relayed the importance of the products containing explicit **connections between information and its original data source** or information creator. They similarly expressed the importance of this originator being a **reputable and trusted source**, such as the SCONC or NWS. We heard from several participants that being able to share drought information (i.e., the Weekly Drought Update and Short Range Outlook Infographics) generated by an outside subject-matter expert such as the SCONC carried more weight with their customers, colleagues, and supervisors, and consequently helped them to communicate that information more effectively. Based on this feedback, relevant references, links and/or logos that point to the originating source of information are included in the products we created.

Participants acknowledged the considerable uncertainties associated with **forecasts and outlooks**. However, this was one area where users could lose confidence in these products, if interpretation of these products is too difficult or not intuitive and/or if they do not convey the information that is most useful for decisions. To the extent possible, we tried to **convey decision-relevant information** from forecast products in the Short Range Outlook Infographics and dedicated effort to experimenting with different ways to communicate forecast confidence through these infographics.

Contextualized Climate Information

Participants requested information about both historical drought events, present trends and patterns, and forecasted conditions to help inform their decisions and communications with others. We developed a series of **1-pagers about specific, past drought events**, Weekly Drought Update Infographics to communicate **current drought status** (i.e., the NC drought

map), Short Range Outlooks to convey **forecast information**, respectively, to meet these needs. Drought is easier to understand if impacts are emphasized, rather than the objective indicators and measurements typically used by technical experts and committees. Icons used in the Weekly Drought Update, and visuals such as the photos and maps used in other products, help to draw attention to the types and locations of observed impacts, contextualizing the drought information.

We additionally heard repeated needs for information that not only provides climatological context (i.e., how are weather and climate patterns contributing to drought conditions and impacts) but also **accounts for the various decision-making contexts in which our target audiences work**. Decision makers and information users in each of the target sectors were fairly uniform in how they expressed preferences for products that explain how droughts form, worsen, and end; describe and illustrate impacts; and provide a range of geographic perspectives. However, we also found that the different sector participants (agriculture, forestry/fire, water) need information to fit the decisions, decision time scales, and other concerns that are unique to their sector.

Temporal and Geographic Scales of Decisions

Many of our project participants described the need for information depicting drought conditions at multiple scales. These decision makers recognize that local drought status at any given time may not reflect broader conditions. However, knowing the status of state, regional, and local-level conditions can help them monitor potential drought risks and water shortages and then tailor communications to their audiences, many of which may only be interested in local effects.

Information is used and valued if it ties to a specific decision or action to be taken. Through our engagement with various participants and sectors, we learned more about the seasonality and timing of their decisions and how drought's varying effects on the different sectors affected when and how they want to interact with drought information. Because the seasonality and time frames of decisions and impacts are different, **drought information needs to be placed “in decision context” for it to be relevant and actionable by the different sectors.**

Overall, we found that drought information and products would be useful for monitoring, general awareness, and communications at all times of the year and during varying levels of drought, including when there is no drought. The exact type and extent of use does appear to be related to sector and drought severity. Many of our project stakeholders, particularly from the agriculture and forestry/fire sectors, would like to receive information on a regular basis (weekly to biweekly) for their use. At the same time, many of our participants also acknowledged that public audiences, the media, and higher decision-making levels are unlikely to ask questions or seek information unless there is a drought. We also heard from water systems that they would not use the drought information products, particularly for communications purposes, unless their area was in a drought.

Sustainability

Throughout this project we have been able to leverage existing networks and partnerships to make this a successful project. We plan to apply lessons learned to ongoing and future work that aims to support drought monitoring, communications, and learning processes. The information and products generated through the project will continue through ongoing and future efforts. In addition to these tangible products, the SCONC has used findings from this project to inform how they engage with different audiences about drought and what information to provide about the drought monitoring process in formal presentations, climate training sessions, and

informal engagements. Specific ways that the project components will be sustained into the future are described here.

Online Availability of Informational Resources

- As capacity allows, the SCONC will continue to produce the Weekly Drought Update infographics as part of their role on the NC DMAC and share these with the NCDMAC Chair to be posted to the **ncdrought.org** website.
- Other products created through this project, such as the story map and fact sheet about the NC DMAC, will be housed on the **DMAC website**. These products provide more reader-friendly information about the DMAC that aligns with stakeholders' preferences for information formats and helped to update website text that had focused primarily on the legal authority and history of the DMAC.

Training Sessions and Workshops

- The drought information content and best practices for communication will continue to inform the SCONC's education and extension activities into the future.
- Over the course of the project, the SCONC leveraged related other activities funded by and conducted in partnership with **North Carolina's Cooperative Extension** program, including to deliver a series of "Weather + Climate Workshops" at various locations across the State in 2019. In June 2020, the SCONC hosted a virtual drought-specific training; 80 Cooperative Extension agents attended this training.
- The SCONC is a member of the **NC Fire Environment Committee**, an interagency group consisting of representatives from the NC Forest Service, NC Division of Air Quality, NC State Parks, National Weather Service, The Nature Conservancy and other groups with a role in fire monitoring and management. Their semi-annual meetings, and other interactions, have provided an opportunity to share project information and products with these organizations and their extended networks.

Collaboration with Internet of Water and Triangle Water Supply Partnership

- In March 2020, we initiated a partnership with the Internet of Water (IoW), located at Duke University. The IoW is now leading an effort to pilot a "water supply dashboard" with the Triangle Water Supply Partnership, downstream utilities, and the NC Division of Water Resources. The dashboard will help water resource managers monitor water supplies and provide information to staff, boards, and customers about drought conditions and any risk reduction measures or decisions (e.g., water conservation). We continue to assist with ongoing engagements and will help incorporate the products and findings developed through this project into the dashboard (see Section 3.4.4 for more details on this partnership).

Section 6. References

- Bruno Soares, M., M. Alexander, and S. Dessai (2018). Sectoral use of climate information in Europe: A synoptic overview. *Climate Services*, 9, 5-20. <https://doi.org/10.1016/j.cliser.2017.06.001>
- Corringham, T. W., A. L. Westerling, and B. Morehouse (2008). Exploring Use of Climate Information in Wildland Fire Management: A Decision Calendar Study. *Journal of Forestry*, 106(2), 71-77. <https://doi.org/10.1093/jof/106.2.71>
- Dilling, L., and M. C. Lemos (2011). Creating Usable Science: Opportunities and Constraints for Climate Knowledge Use and Their Implications for Science Policy. *Global Environmental Change*, 21, 680-689. <https://doi.org/10.1016/j.gloenvcha.2010.11.006>
- Gigerenzer, G., Hertwig, R., Van Den Broek, E., Fasofo, B., & Katsikopoulos, K. V. (2005). "A 30% chance of rain tomorrow": How does the public understand probabilistic weather forecasts?. *Risk Analysis: An International Journal*, 25(3), 623-629.
- Haigh, T., E. Tackle, J. Andresen, M. Widhalm, J. S. Carlton, and J. Angel (2015). Mapping the decision points and climate information use of agricultural producers across the U.S. Corn Belt. *Climate Risk Management*, 7, 20-30. <https://doi.org/10.1016/j.crm.2015.01.004>
- Mase, A. S., & Prokopy, L. S. (2013). Unrealized potential: A review of perceptions and use of weather and climate information in agricultural decision make. *Weather, Climate, and Society*, 6(1), 47-61. doi:10.1175/wcas-d-12-00062.1
- McNie, E. C. (2007). Reconciling the supply of scientific information with user demands: an analysis of the problem and review of the literature. *Environmental Science & Policy*, 10(1), 17-38. <https://doi.org/10.1016/j.envsci.2006.10.004>
- National Research Council (2009). *Informing Decisions in a Changing Climate*. Washington, DC: The National Academies Press. doi:10.17226/12626
- Oakley, N. S. and B. Daudert (2016). Establishing Best Practices To Improve Usefulness and Usability of Web Interfaces Providing Atmospheric Data. *Bulletin of the American Meteorological Society*, 97(2), 263-274. <https://doi.org/10.1175/BAMS-D-14-00121.1>
- Ray, A. J. and Webb, R. S. (2016). Understanding the user context: decision calendars as frameworks for linking climate to policy, planning, and decision-making. In *Climate in Context* (eds A.S. Parris, G.M. Garfin, K. Dow, R. Meyer and S.L. Close). doi:10.1002/9781118474785.ch2
- Saldaña, J. (2013). *The Coding Manual for Qualitative Researchers*. 2nd edition. Thousand Oaks, CA: SAGE Publications Inc.
- Swart, R. J., K. de Bruin, S. Dhenain, G. Dubois, A. Groot, and E. von der Forst (2017). Developing climate information portals with users: Promises and pitfalls. *Climate Services*, 6, 12-22. doi:10.1016/j.cliser.2017.06.008
- Wall, T. U., A. M. Meadow, and A. Organic (2017). Developing Evaluation Indicators to Improve the Process of Coproducing Usable Climate Science. *Weather, Climate, and Society*, 9(1), 95-107. <https://doi.org/10.1175/WCAS-D-16-0008.1>

Appendix A. Engagements with Decision Makers and Project Stakeholders

Phase 1

Initial Project Surveys

In October 2018, online surveys were sent to extension agents, water resource managers, and DMAC members (499 total) to collect initial information about decision makers' current uses of and needs for drought information. We developed two slightly different surveys, tailoring some wording and answer options to the different groups (i.e., agriculture and forestry extension agents and water resource managers). NC Cooperative Extension provided contact information for 307 agents and specialists who work directly with constituents in agriculture or forestry fields. A NC Forest Service representative (and DMAC member) provided contact information for 9 individuals within the NC Forest Service. NC DEQ provided a list of all public water supply systems within the state. Based on their guidance, we sent the survey to systems who served populations of 5,000 or more, which resulted in 183 unique emails sent to public water system representatives. We invited email recipients to forward the survey link to other colleagues, so the number of actual recipients may be higher than those indicated in Table A-1.

The survey opened on October 12, 2018, and invitation emails were sent out on this date. We sent out three additional reminders and extended the deadline by one week to November 2, 2018. Several factors may have contributed to the low response rate (Table A-1). This includes the lingering effects of Hurricane Florence (which caused us to disseminate the survey in October rather than in September as originally planned); Hurricane Michael, which hit the state on October 11, causing widespread power outages in the central part of the state; and the North Carolina State Fair, held from October 11-21, which may have occupied many extension agents during the time when the survey invitations were first disseminated. The survey consisted of 36 multiple choice and open-ended questions.

Table A-1. Online Survey #1 - Response Rates

	Agriculture & Forestry		Water Resources	
Invitations sent	316		183	
Surveys opened	100	31% of invitees	40	22% of invitees
Surveys completed	52	16% of invitees	22	12% of invitees
Surveys partially completed	48	2-81% completion rate	18	5-81% completion rate

Webinars with Sector Representatives

Participating organizations

Agriculture & Forestry	Water Resources
November 28, 2018	December 10, 2018
8 participating organizations 14 total participants	14 participating organizations 17 total participants
CISA (2) National Weather Service (4; Raleigh, Blacksburg, Wakefield) NC DEQ, Division of Water Resources NC Forest Service NC State Cooperative Extension (3) SCONC (2) USDA Southeast Regional Climate Hub	CISA (2) City of Durham (2) Cube-Hydro Duke Energy Fayetteville Public Works Commission National Weather Service (Raleigh) NC DEQ, Division of Water Resources (2) Orange Water and Sewer Authority (OWASA) SCONC (2) Southeast Regional Climate Center Town of Cary US Army Corps of Engineers US Geological Survey

Phase 3

Date	Event or Engagement	Participating Groups or Organizations	Sectors Engaged	Number of Participants	Engagement Type
February 2019	Chatham County NC Cooperative Extension Weather+Climate Workshop	N.C. Cooperative Extension	Agriculture	5	Weather+Climate Workshop, participatory session (in-person)
March 2019	NC Water Resources Research Institute (WRI) Annual Conference	Water systems (Durham, OWASA), USGS, state NC DEQ/DWR), research (RTI); Conference attendees	Water Resources	7	Participatory Session (in-person)
				21	Eye-Tracking Study
April 2019	NC Drought Management Advisory Council Annual In-Person Meeting	NC DMAC Technical Team: NWS, NC DWR, Water Systems, NC Forest Service (NC FS), NC Wildlife Resources Commission (NC WRC), USGS, SCONC, Extension	Agriculture, Forestry, Water Resources	14	Participatory Session (in-person)
May 2019	NC Fire Environment Committee	NC FS, NC Prescribed Fire Council (NC PFC), NC State Parks, NC WRC, NC Division of Air Quality (NC DAQ), NWS, The Nature Conservancy (TNC), US Fish & Wildlife Service (USFWS), US Forest Service (USFS)	Forestry	15	Participatory Session (in-person)
May 2019	Union County NC Cooperative Extension Weather+Climate Workshop	N.C. Cooperative Extension	Agriculture	5	Weather+Climate Workshop participatory session (in-person)
June 2019	Catawba Wateree Drought Management Advisory Group (DMAG) Annual Meeting	DMAG members: Duke Energy, consultants, water systems, federal and state agencies	Water Resources	20-25	Participatory Session (in-person)
June 2019	2019 NC Association of County Agricultural Agents State Meeting	University (NC State and NC A&T) faculty and field agents with Extension responsibilities in agriculture/natural resources	Agriculture	40	Weather+Climate Workshop, participatory session (in-person)
April, July, & September 2019	Conference calls and webinars with state agencies and local water utilities	NC DWR; Duke Energy; water systems (Durham, Fayetteville, Greensboro, Charlotte, OWASA)	Water Resources	10	Participatory Session (virtual)
October 2019	N.C. Cooperative Extension Annual Conference	N.C. Cooperative Extension, NC State Extension, NC A&T Extension	Agriculture, Forestry	24	Eye-Tracking Study

May 2020	Survey to Infographic Email Distribution List	Extension; water systems from across NC; NC FS; USFWS; NC DAQ; NWS; NC DWR; SC State Climatology Office (SC SCO); NIDIS	Agriculture, Forestry, Water Resources	74 (invited); 26 (responded)	Survey
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Phase 4

Date	Event or Engagement	Participating Groups or Organizations	Sectors Engaged	Number of Participants	Engagement Type
December 2019	Year-end testimonials	US Marine Corps Camp Lejeune, NWS, N.C. Cooperative Extension	Agriculture, Forestry	3	Online Survey
February 2020	Triangle Water Supply Partnership Meeting	Triangle J COG and Triangle water systems	Water Resources	16	Participatory Session (in-person)
June 2019-August 2020	Infographic Email Distribution List	N.C. Cooperative Extension; water systems from across NC; NC FS, USFWS; ND DAQ; NWS; NC DWR; SC SCO; NIDIS	Agriculture, Forestry, Water Resources	79	Online Survey

Phase 5

Date	Event or Engagement	Participating Groups or Organizations	Sectors Engaged	Number of Participants	Engagement Type
May 2020	Fire Environment Committee virtual meeting	Representatives from the NC FS, NC PFC, NC State Parks, NC WRC, NC DAQ, NWS, TNC, USFWS, USFS	Forestry	23	Participatory session (virtual)
July 2020	Webinars with NWS Offices and regional partners	NWS; SC SCO; NIDIS	Partner organizations	11	Participatory session (virtual)
October 2020	Final project presentation during NC DMAC Technical Team Meeting	NC DMAC Technical Team: NWS, NC DWR, Water Systems from across the state, NC FS, NC WRC, USGS, Extension, SCONC	Agriculture, Forestry, Water Resources, Partner organizations	15	Presentation (virtual)