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Understanding barriers and opportunities for diffusion of an agricultural decision-support tool: An organizational perspective

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ABSTRACT

Decision-support tools (DSTs) are a type of innovation that can facilitate science-based decision-making, including nonpoint source pollution management in agricultural watersheds. However, organizational readiness for adopting innovations is a topic that has received limited attention in the literature. With the goal of filling this knowledge gap, we draw upon the diffusion of innovations (DOI) theory and literature around use of science by agency staff to assess United States Department of Agriculture Natural Resources Conservation Services' (USDA-NRCS) readiness towards using the Agricultural Conservation Planning Framework (ACPF) – a type of DST. To that end, we conducted 23 semi-structured, in-depth interviews with 27 NRCS staff holding leadership positions to explore how they perceive and use the ACPF, and their perceptions of organizational and structural elements that could enable or hinder NRCS' readiness to adopt the ACPF. Results suggest that NRCS' readiness was an outcome of both organizational- and individual-level factors. Factors such as perceived scientific credibility and the influential role of leaders positively influenced NRCS' readiness; however, factors such as low levels of ACPF knowledge and perceived complexity negatively influenced NRCS' readiness. Overall, our findings suggest that NRCS is in the initial stages of getting ready to adopt the ACPF, and that there is a need for the agency to pilot ACPF in different watersheds and measure social and bio-physical outcomes.

1. Introduction

The agriculture sector is replete with innovations ranging from those that were developed in the 1940 s (e.g., hybrid corn) to those that are relatively more recent (e.g., precision agricultural technologies). A hybrid corn study conducted several decades ago laid down the foundations for the diffusion of innovations (DOI) theory, and also established that diffusion is fundamentally a social process wherein innovations are adopted through subjective evaluations (e.g., perceived norms) rather than solely by economic, rational decision-making (Valente and Rogers 1995). Subsequently, the scholarship around, and applications of, the DOI theory has burgeoned to examine many elements of the diffusion process, including the adopter (i.e., the individual or decision-making unit), the change agent (i.e., an individual who influences the adopter), and the attributes of the innovation itself (e.g., complexity of the innovation) (Ranjan and Witter 2020; Rogers 1995). However, an aspect of diffusion of innovations that has received limited attention in the literature is organizational readiness for innovation (Lokuge et al. 2019). In particular, scholars have identified the need for research around, "the steps that organizations can take to assess and anticipate the impacts of an innovation" (Greenhalgh et al. 2004, 619). The innovation-decision process is considered to be much more complex when the unit of adoption is an organization versus an individual (Rogers 1995). Therefore, as pointed out by Rogers (1995, 402), "once an organization has made a decision to adopt, implementation does not follow directly." In a similar vein, the fact that "approximately 90% of new ideas never convert to new product or service deliveries because of the lack of organizational readiness" further underscores the complexity

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of the innovation-decision process when the unit of adoption is an organization (Lokuge et al. 2019, 445).

The complexity of understanding organizational readiness to adopt an innovation motivated us to assess the United States Department of Agriculture – Natural Resources Conservation Services' (USDA-NRCS; henceforth NRCS) readiness towards using the Agricultural Conservation Planning Framework (ACPF). NRCS provided the context (see section 3.1 for further details) to assess organizational readiness to adopt, whereas the ACPF – a scientific ArcGIS based decision-support tool (DST) that helps semi-automate the process of identifying field-specific locations for placement of agricultural best management practices (BMPs) within Hydrologic Unit Code 12 (HUC 12) watersheds (Tomer et al. 2015a; Ranjan et al. 2019), was the innovation of interest (see section 3.2 for further details). Whereas understanding organizational readiness provided a theoretical rationale for our study, it was also motivated by an increasing level of interest within the NRCS to use tools like the ACPF to spatially prioritize conservation planning efforts and redefine how resources are allocated. Indeed, owing to the fairly recent availability of LiDAR-based elevation data, ACPF can foster a 'small watershed approach', wherein the hydrology of a HUC 12 watershed can be analyzed as a whole to identify and prioritize hydrologic flow paths and critical source areas (Konopacky and Ristino 2017).

At a HUC 12 watershed scale, ACPF marks the first time that the NRCS could easily and cost effectively prioritize their conservation efforts, and therefore move away from the currently dominant approach of "random acts of conservation" (Knight 2005, 137A). However, this perhaps fundamental shift is contingent upon NRCS' readiness to change. DSTs, such as the ACPF, are designed to facilitate effective, science-based decision-making by intended users, who in the context of our study are the managers and staff working for the NRCS. However, understanding and subsequently promoting the use of science by civil servants in government agencies (hereafter agency staff) is a complex endeavor. Agency staff's decision to adopt or reject a scientific innovation can be influenced by both organizational-level factors (e.g., agency research infrastructure and push for recruitment and skill development) and individual-level factors (e.g., agency staff's prior knowledge and their perceptions of attributes of the innovation – relative advantage, compatibility, complexity, trialability, observability, and credibility) (Ouimet et al. 2009; Rogers 1995). Whereas organizational-level factors can help gauge NRCS' readiness towards using the ACPF, individual-level factors can help reveal pathways that enable agency staff to overcome real and perceived barriers to using the ACPF. Taken together, these factors help unravel the organizational context within which an innovation can be adopted.

As such, use of science has been studied in myriad contexts, including the use of climate science by USDA field staff and their readiness, willingness, and ability to act as climate advisors for farmers (Prokopy et al. 2013; Wiener et al. 2020), and use of science in collaborative governance processes to inform ecosystem recovery planning efforts (Koontz 2019). In a similar vein, the DOI theory has been applied in many contexts, including adoption of innovations by both individuals and organizations (Rogers 1995), and the development of the Consolidated Framework for Implementation Research – a framework that includes DOI constructs, to help guide effective implementation of innovations in organizations (Keith et al. 2017; "Consolidated Framework for Implementation Research" n.d.). However, what is missing in the current scholarship is using DOI and use of science theories together to holistically examine organizational- and individual-level factors that can enable or hinder organizational innovation.

With the goal of using theory to assess NRCS' readiness towards a fundamental shift in conservation planning, we present findings from semi-structured interviews conducted with NRCS staff holding leadership positions. Owing to technical advancements in conservation science, including the use of computer simulations to develop agricultural models, and USDA supported collaborative initiatives such as the Conservation Effects Assessment Project, agricultural DSTs are increasingly becoming the norm rather than exception in conservation planning (Mason et al. 2021; Ranjan et al. 2020a). Therefore, there is an urgent need to understand and assess organizational readiness to embrace innovations such as the ACPF, which has the potential to encourage watershed thinking among agricultural stakeholders, and expedite the process of conservation planning (Ranjan et al. 2019; Ranjan et al. 2020b).

2. Study conceptualization

There are three key components in our study: 1). ACPF – the scientific innovation under consideration, 2). NRCS – the multi-level organization within which the ACPF is intended to be adopted, and 3). Agency staff – the intended users of the ACPF who work for the NRCS. In order to theoretically contextualize our data, we draw upon Ouimet et al.'s (2009) conceptual framework on absorption of research knowledge by civil servants (see figure 1, 337), and Rogers' (1995) model of five stages in the innovation-decision process (see figure 5–1, 170) and variables related to organizational innovativeness (see figure 10–2, 411)[1]. By integrating elements of two theoretical perspectives – DOI and use of science, we are able to holistically examine organizational- and individual-level factors that can help us assess NRCS' readiness for adopting the ACPF. Drawing upon the influential work by Weiner (2009), we conceptualize organizational readiness to be an outcome of agency staffs' perception of NRCS' commitment to change (e.g., NRCS investing resources to fulfill ACPF data requirements), and their perceived efficacy to use the ACPF – referred to as change efficacy.

Bringing together the two aforementioned theoretical perspectives and our definition of organizational readiness, we postulate that agency staffs' perceptions of the organization (i.e., NRCS) and the scientific innovation (i.e., ACPF) will collectively influence their decision regarding whether or not, and the degree to which, findings from the ACPF are incorporated into decision-making (e.g., development of conservation plans). Agency staffs' decision about incorporating the ACPF into their decision-making is characterized as use of science in our study. As pointed out by Ouimet et al. (2009), incorporating science in decision-making involves several interconnected steps, such as: recognizing the value of information, acquiring the information, evaluating the information, and finally applying the information. These steps, in the context of DOI theory, roughly translate to the five stages of the innovation-decision process: knowledge, persuasion, decision, implementation, and confirmation (Rogers 1995, 170). DOI theory goes on to identify several characteristics of the potential adopter and the innovation that affect likelihood of adoption (Rogers 1995; Weiner 2009). In parallel, use of science theory has identified several characteristics of the potential user and the science product that affect likelihood of use (Cash et al. 2003; McNie 2007; Ouimet et al. 2009). Taken together, the two theoretical perspectives highlight the factors and the decision-making processes that come into play when a decision-making unit readies itself to adopt an innovation.

We would like to acknowledge that the intended "users" of an innovation, and the ways in which the innovation is put to "use", are not homogeneous within an organization. For instance, a set of agency staff (e.g., GIS Specialists) might interface more with the technical side of the ACPF by running the ACPF toolbox and generating datasets. Whereas another set of agency staff (e.g., District Conservationists) might interface more with the socio-technical side of the ACPF by presenting ACPF generated maps to farmers and explaining the technical and bio-physical aspects of conservation planning for their farm. Making this role-based distinction is important because it not only affects the ways in which an innovation is put to use, but it could also affect agency staffs' perceptions of barriers towards its adoption in their organization. For example, GIS staff might perceive a need for the NRCS to support

[1] For a visual of the three figures, please refer appendix 1.

technical trainings and dataset preparation, whereas, field-staff might perceive a need for the NRCS to support socio-technical trainings that help them convey the technical aspects of conservation planning to farmers.

3. Innovation diffusion context: The organization and the innovation

3.1. NRCS: The organization

The NRCS, along with the Farm Production and Conservation (FPAC) Business Center, Farm Service Agency (FSA), and the Risk Management Agency (RMA), is housed within the USDA to meet its Farm Production and Conservation mission. In order to fulfill this mission, these agencies interact to mitigate risks, provide conservation programs and technical assistance, and deliver financial programs to farmers (USDA 2021). The NRCS also partners with other local (city and county governments, Soil and Water conservation Districts (SWCDs)), state (state departments of agriculture, resource management, etc.), and federal (U.S. Fish and Wildlife, EPA, etc.) organizations to fulfill its mission. The organizational structure of the NRCS flows from a national level to the field office level. Program development, large scale funding priorities, and goals are established at the national level which is then channeled to regional offices across the United States which serve as leadership representatives of the Chief Conservationist in Washington DC (NRCS 2021a). At the state level, State Conservationist offices provide state-specific management and directives to support administrative and technical functions for coordinating and implementing natural resource conservation, often including public and private entities (NRCS, 2021b). The NRCS and FSA have multiple field offices within each state that serve as the main points of contact for farmers. The NRCS and FSA work in conjunction with local SWCDs to provide services to farmers for technical assistance, financial, and commodity programs. Field office organization varies state-by-state to be single county offices or clusters of counties within a field office service area to efficiently serve farmers. The staffing at this level varies, but the NRCS work conducted in field offices includes resource inventory and assessment, technical assistance, conservation planning, BMP implementation, and program administration.

3.2. ACPF: The innovation and its current status of use

The ACPF is an innovative DST that uses watershed planning concepts to identify opportunities for BMP placement within field, at the field edge, and in riparian areas to reduce nutrient and sediment loss in agricultural landscapes (Tomer et al. 2013; Porter et al. 2018). The ACPF operationalizes watershed planning concepts using publicly available geospatial datasets and an ArcGIS toolbox to facilitate field scale BMP placement and watershed planning at the HUC 12 watershed scale (typically 15,000–40,000 acres; or 6070–16,187 ha) (Tomer et al. 2015a; Ranjan et al. 2019). Using high-resolution LiDAR-based elevation data, National Agricultural Statistics Service Cropland Data Layer (NASS CDL) land use data (USDA-NASS 2019), NRCS Soil Survey (soils database), field boundary data, and watershed boundary data, the ACPF enables: (1) hydro-conditioning, terrain processing, and hydro-enforcement of elevation data to mimic expected flow of water over the actual terrain; (2) delineation of the perennial stream network and catchments in a watershed; (3) identification of fields in a watershed that may be most likely to contribute nutrients and sediment to surface water; and (4) sites where within field, edge-of-field, and riparian BMPs could be implemented (Porter et al. 2018). Presently, the ACPF identifies locations for the following BMPs by evaluating site-specific criteria and suitability: drainage water management, grassed waterways, contour buffer strips, bioreactors, nutrient removal wetlands, water and sediment control basins (WASCOBs), riparian buffers, and saturated riparian buffers (Porter et al. 2018). Results from the ACPF provide landowners, land managers, and conservation planners with suites of conservation planning options and opportunities (Ranjan et al. 2019; Zimmerman et al. 2019). The ACPF distills complex geospatial data, processing, and analyses into outputs for use in conservation planning. Outputs from ACPF include attribute tables and maps that identify and visualize relatively high-risk areas of the watershed and potential BMP locations (see Fig. 1). The ACPF does not provide site-level engineering design information for specific BMP's. However, the analytical capacity of ACPF is continually expanding; for example, recent add-on ACPF toolboxes are available to estimate nutrient reduction outcomes as a percent nitrate-N reduction at basin scales, or per unit load basis and financial costs associated with conservation scenarios (Bravard et al. 2020).

The ACPF was initially developed in 2015 by a team of practitioners and researchers with applications in watersheds located in Iowa and Illinois (Tomer et al., 2015a,b). Since its initial development, the ACPF has been used to inform conservation planning in selected watersheds across the US Midwest (Church, et al., 2019a; Rundhaug, et al., 2018; Srinivas, et al., 2020). However, the ACPF is still in the nascent stages of being considered for widespread use across the NRCS, in state- and field-level offices both within and outside the US Midwest. As such, the overall awareness and usage of the ACPF among conservation professionals, including agency staff, is low (Ranjan et al., 2020a), and the agency-wide use of ACPF has not been formalized in any state.

4. Methods

The data for this study come from semi-structured, in-depth interviews with NRCS staff holding leadership positions in the state or area offices of the NRCS. Specific states were selected under the purview of, and with guidance from, a bigger team that the authors of this study were part of. Under the larger team efforts to study NRCS' readiness to adopt the ACPF, states participating in the study were classified as either 'current' or 'novel' state. Current states include those that are located in the upper Midwest where individual agency staff have used the ACPF as part of selected watershed projects, and are therefore somewhat more familiar with how the ACPF can be used to address state-specific resource concerns. Novel states include those that are located outside the upper Midwest and are characterized by either limited use by individual agency staff or familiarity with how the ACPF can be used to address state-specific resource concerns. However, as we mentioned earlier (see section 3.2), agency-wide use of ACPF has not been formalized in any state. Within each state, our criteria for selecting interviewees were their awareness of the ACPF, and their ability to provide technical, social, and/or organizational insight about NRCS' readiness to adopt the ACPF. Initial interviewees were recruited in consultation with the larger team. Snowball sampling was used with the initial interviewees to identify additional interviewees (Patton 1990). Interviews were conducted until no additional interviewees were identified.

Twenty-three semi-structured interviews were conducted, which involved a total of 27 individuals (see Tables 1 and 2). Interviews were conducted in-person and over-the-phone between December 2019 and April 2020. Interviews ranged from 30 min to 90 min, using a series of 26 questions that explored benefits and challenges associated with agency-wide use of ACPF. Among others, questions explored topics around ACPF's role in and contribution to conservation planning, ACPF adoption throughout the agency, compatibility with other DSTs and planning processes, and education and training needs associated with the ACPF. All interviews were recorded and transcribed.

Data analysis occurred in four stages: 1) initial coding, 2) intercoder reliability tests, 3) final coding, and 4) synthesis. Following Church et al. (2019b), coding and intercoder reliability tests were conducted using NVivo 12 (QSR International Pty Ltd, Doncaster, Australia). One of the co-authors reviewed interview transcripts and developed an initial codebook based on the interview guide. Three of the study authors read two transcripts and independently assigned interview content to

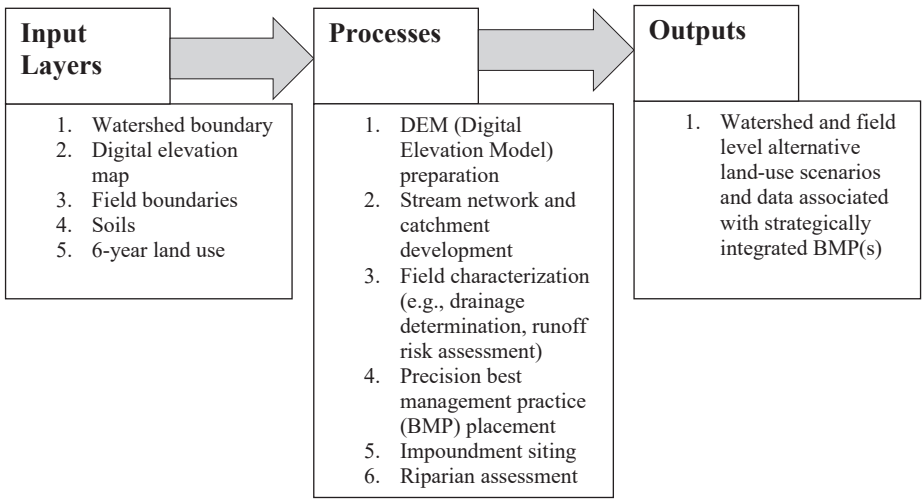

Fig. 1. Simplified schematic of Agricultural Conservation Planning Framework showing key input layers, GIS-based processes, and outputs (Porter et al. 2018). Adapted from Zimmerman et al. (2019).

Table 1
Interview count by state.

State	Type	Count
Illinois*	Current	1
Indiana	Current	2
Iowa*	Current	4
Kansas	Current	1
Missouri	Current	2
Nebraska	Current	2
Ohio	Current	1
Wisconsin*	Current	2
Arkansas	Novel	2
Maryland	Novel	1
Mississippi	Novel	1
Oklahoma	Novel	1
Vermont	Novel	3

*interview includes multiple interviewees

Table 2
Interviewee designations.

Interviewee designation	Count
Assistant State Conservationist	1
Cartographer	1
Civil Engineer Tech	1
District Conservationists	2
GIS Coordinator	2
GIS Specialist	2
Initiatives Coordinator	1
Planning Specialist	1
Resource Conservationists	1
Resource Inventory Specialist	1
Soil Scientist	2
State Conservationist	1
State Resource Conservationist	7
Water Resources Staff	2
Watershed Specialist	1
Wildlife Biologist	1

relevant codes. Codes were added iteratively through the initial coding process, resulting in codebook refinement. After each transcript was coded an intercoder reliability test was conducted to assess initial levels of coding agreement. The three study authors discussed coding disagreements until they agreed upon shared meanings of code definition. Once the final coding framework was established and agreed upon, an intercoder reliability test was conducted on a subset of four interviews, resulting in a Cohen's Kappa of 0.76, indicating adequate consistency between the three authors (Viera and Garrett 2005). The remaining interviews were coded independently by two of the study authors. Finally, four of the study authors, including the three who participated in the intercoder reliability process, synthesized coded interviews. The synthesized data was interpreted in the context of DOI and use of science theories, and was structured around looking for instances when key concepts from the two theories were mentioned by the interviewees. Throughout the results, we include representative quotations for each theme reported, along with whether the interviewee worked in a current or novel state.

5. Results and discussion

In this section, we present organizational- and individual-level drivers of NRCS' readiness to adopt the ACPF. The first half of the results section presents evidence in support of organizational capacity, hierarchy, and structure as it relates to NRCS' readiness to adopt the ACPF (see Table 3). The second half of the results section presents evidence in support of agency staff's knowledge and perceived characteristics of the ACPF. Before we present the drivers of NRCS' readiness, we want to acknowledge that even among the states where ACPF use has been relatively more frequent – classified in our study as 'current states', we found limited ACPF awareness, including its applications to conservation planning. For example, an interviewee from a current state mentioned, "*…even though ACPF has been out for a number of years, I think we need to do a better job of sort of teaching* [the NRCS] *leadership what this thing really is…we just have to do a really good job of explaining* [the ACPF] *so that they can get behind it and make it a priority for our field staff to be using* [the ACPF]. *We're not at that point yet here in* [our state]."

5.1. Organizational-level drivers of ACPF

5.1.1. Agency capacity

Interviewees from both current and novel states expressed several themes that were indicative of NRCS' capacity, or lack thereof, to adopt the ACPF. NRCS's capacity to facilitate ACPF adoption was expressed with respect to needs pertaining to research and technical infrastructure and personnel. Needs pertaining to agency research and technical infrastructure were expressed in terms of coding skills and infrastructure, and the ability of the NRCS to ensure that states have access to LIDAR data, which is required to run the ACPF and generate results. Needs pertaining to research and technical infrastructure were expressed by several interviewees, and are illustrated by the following quotes:

Table 3
Organizational- and individual-level drivers of NRCS' readiness to adopt ACPF.

	Drivers of readiness (expected effect)†	Drivers of NRCS' readiness	Overall influence on NRCS' readiness
Organizational-level drivers	Agency capacity (+)	Agency lacks capacity	HINDERS
	Agency champions (+)	Champions exist across organizational levels	HELPS
	Agency openness (+)	Agency has openness	HELPS
	Agency centralization (-)	Agency has centralization	HINDERS
	Agency formalization (-)	Agency has formalization	HINDERS
Individual-level drivers	Awareness knowledge (+)	Awareness knowledge is low	HINDERS
	How to- and principles-knowledge (+)	How to- and principles-knowledge is low	HINDERS
	Relative advantage (+)	Relative advantage exists	HELPS
	Compatibility (+)	Compatibility is variable	BOTH HELPS & HINDERS
	Complexity (-)	Complexity exists	HINDERS
	Trialability and observability (+)	Trialability and observability	††
	Perceived scientific credibility (+)	Perceived scientific credibility is high	HELPS

Notes:
† Expected effect is based on diffusion of innovations and use of science theories.
†† Insufficient data.

> *"…we don't have the skill in the agency. We don't have the coding skills. We don't have the coding infrastructure. We don't have the computing power…I don't see NRCS developing that kind of skill any time soon."* – Current state
> *"ACPF has to be tuned to each watershed…ACPF tuning to the watershed* [and] *achieving coverage* [of LIDAR data]*, I think those are big challenges…And we're just not going to get full coverage anytime soon. I think that's one of the challenges with it right now."* – Current state
> *"…are we going to get LiDAR flown every year? Doubtful…especially in these Delta regions where you've got the heaviest amount of farming going on, how often are you going to get that LiDAR data?"* – Novel state

Whereas the preceding quotes highlight agency-level research and technical infrastructure needs pertaining to ACPF adoption, an interviewee acknowledged that housing the ACPF within the NRCS will be key to ACPF adoption. Illustrating this point, an interviewee from a novel state mentioned, *"If you get outside of the box with NRCS, the possibility of* [a tool] *being integrated into the agency would be dramatically reduced… I think it* [the ACPF] *would have a higher chance of adoption within the NRCS if it were housed in NRCS and we had partners feeding into it."* Needs pertaining to personnel that included hiring and training new staff, and funding, also emerged in our study. Interviewees frequently mentioned needs pertaining to personnel to facilitate ACPF adoption. For example, highlighting the need for NRCS to hire staff who can deal with information technology (IT) issues, an interviewee from a current state mentioned, *"I think where NRCS struggles a little is the funding aspect of staffing when it comes to IT-related technical issues…it just seems like it's a very uphill battle with resources and resource allotment in that regard."* Many interviewees from both current and novel states indicated that agency restructuring and staff retirement, combined with administrative and technical changes, further created a need for not only hiring staff but also bridging the knowledge and skill gaps among new staff. The quotes below are illustrative of this theme:

> *"…a few years ago, they* [NRCS] *consolidated to try to make things* [administrative functions] *consistent across the country…but, until that structure was in place, they didn't hire people…and then, when the new administration came over, they decided to do this across us* [NRCS] *and our sister agencies…So, now there is a FPAC* [Farm Production and Conservation] *Business Center, which is a separate agency outside of NRCS, that is to handle all of our hiring…* [FPAC] *is not directly in our chain of command, so we can make upper-leadership aware of our* [staffing] *issues but there's nothing, really, within our control to have that happen quicker."* – Novel state
> *"…we're actually moving away from ArcGIS as our planning platform software. And so, one of my concerns is our ArcGIS skillset is going to diminish among our employees as we move to CD* [Conservation Desktop]*, which is a web application."* – Current state

Knowledge deficits among newly hired staff, combined with a lack of adequate training, and a scenario where ACPF specific training needs to be delivered across different organizational levels of NRCS, were frequently discussed as barriers to its adoption. The quotes below are illustrative of this theme:

> *"Just giving people a tool* [such as the ACPF] *without actually walking them through how to use it. That happens a lot. Where this thing comes down* [from the NRCS leadership]*, we don't have adequate training,* [but] *we're supposed to use it. Some people who are really motivated and interested use it…But* [for] *everybody else, it's one more thing on their plate and it doesn't get adopted."* – Novel state
> *"I would just say the way the organizational structure is, if a lot of training is having to be delivered down between different levels, like down from national and then, to the state and then, from the state down, that would be a hindrance* [for ACPF adoption]*."* – Novel state

Overall, interviewees from both current and novel states suggest that NRCS' capacity to adopt the ACPF was affected by several factors that manifested as needs pertaining to research and technical infrastructure and personnel. Agency staff who are trained to run the ACPF, and have the time to do so, combined with the agency providing funding support, were additional factors related to NRCS' readiness to adopt the ACPF. For example, an interviewee from a current state mentioned, *"…the amount of time from data analysis all the way down to data delivery is a hurdle we need to figure out how to get around, I think, as an agency."* The interviewee further added that this will continue to be a hurdle, *"…unless we add some person* [with] *at least a quarter of their time is directly in their* PD [position description] *that says, 'You're really doing ACPF for the next five years or whatever.'"* The need for financial support was identified by multiple interviewees as a driver for ACPF adoption, and is illustrated by the following quote:

> *"…a lot of good science does not get implemented or applied because it doesn't have the financial resources to support it. So, we can* [run] *APCF* [but] *once it's done, now we're talking about actually applying it and using it long-term, we need to build financial capacity to be able to maintain it."* – Novel state

5.1.2. Agency hierarchy and structure

Rogers (1995, 411) identifies several variables that are positively and negatively related to organizational innovativeness. As described below, we found several of these variables pertaining to NRCS' hierarchy and structure, which enabled and hindered NRCS' readiness to adopt the ACPF.

a). Champions across organizational levels

Rogers' DOI theory establishes the role of "change agents" and "champions" in positively influencing adoption of innovations. In our study, individuals holding specific designations within the NRCS emerged as those who could play the role of champions. Expressing this theme, an interviewee mentioned:

> *"Key* [NRCS] *positions* [that could help facilitate ACPF adoption]*… are conservation planners, our soil conservationists and our resource conservationists at the field level. If you had their buy-in across the state, there would be nothing stopping the tool from being adopted."* – Current state

In addition to emphasizing the role of champions in promoting the ACPF, the aforementioned quote highlights the importance of field-level staff endorsing the ACPF. A reference to field-level staff by the interviewee also highlights the fact that NRCS is a multi-level organization, and how these levels can be leveraged to promote the ACPF. In similar vein, endorsement of the ACPF from NRCS' national leadership was identified as a point of leverage to promote the ACPF by a majority of interviewees from both current and novel states. The following quotes are illustrative of this theme:

> *"I think if the agency at the national level is supportive of the use of a tool like* [the ACPF]*, that certainly helps facilitate the adoption and use within the states."* – Current state
>
> *"If you find the right person at* [NRCS] *headquarters who can promote* [ACPF] *and be the leader or champion…They sell the program to the state conservationists who sell it to us, line of staff people, and then we sell it to the field…So, if we wanted to really be successful, that's the route you'd have to take."* – Current state
>
> *"Local offices could implement something, but ultimately, if* [the ACPF is] *going to tie together with any of our other programs and our other tools, it'll have to be at a higher* [leadership] *level to be able to make it work together."* – Novel state

Taken together, our findings suggest that ACPF endorsement and promotion needs to occur from both top-down and bottom-up directions across the NRCS, and that individuals holding specific designations across different levels of the agency can play an important role in promoting the use of ACPF by acting as champions of the innovation.

b). Agency openness: partners as enablers of NRCS' readiness to adopt the ACPF

Rogers (1995, 408) defines *system openness* as "the degree to which the members of a system are linked to other individuals who are external to the system." This DOI construct is positively related to organizational innovativeness. In our study, interviewees frequently identified partners and organizations external to the NRCS as key enablers of NRCS' readiness to adopt the ACPF. From a theoretical perspective, this is indicative of NRCS' openness to working with external entities to facilitate ACPF adoption. Interviewees frequently acknowledged the role partners can play in enabling NRCS to overcome their staffing and outreach capacities, and therefore, overcome barriers to ACPF adoption. The following quotes are illustrative of this theme:

> *"The two* [ACPF] *projects that we have going on right now are partner-initiated* [local SWCD and a nonprofit organization]*…So, partners, I think, are critical especially given all of the challenges that we have* [as an agency]*. Critical for actually doing the number crunching and for working with the local groups to promote the output."* – Current state
>
> *"We've trained our employees and our partners where we're attempting to expand* [efforts pertaining to the ACPF] *with our partners because again, it's more than just what NRCS can do."* – Current state

While novel states have not yet established partnerships to promote the ACPF, most novel state interviewees echoed current state's emphasis on the importance of partnerships to enable ACPF adoption. The following quote illustrates this theme:

> *"For us…*[our state's] *water quality partnership. They're going to be a key-stakeholder partner in terms of adoption. Non-adoption would be* [our state's] *water quality partnership not supporting the tool."* – Novel state

A few interviewees also felt that partners should be included in agency driven conversations around the ACPF, which in turn can enable NRCS' readiness to adopt the ACPF. For example, an interviewee from a current state mentioned, *"…the EPAs* [United States Environmental Protection Agency] *of the world and the state environmental agencies also need to see these* [ACPF generated] *products and then be part of this conversation as well on how do we get more of this* [ACPF] *across the nation."*

c). Agency centralization

Rogers (1995, 412) defines *centralization* as "the degree to which power and control in a system are concentrated in the hands of a relatively few individuals." This DOI construct is negatively related to organizational innovativeness. In our study, narratives around agency control and power emerged in the context of NRCS being a top-down agency, and bureaucratic challenges imposed by other organizations and offices within the USDA (e.g., FPAC, IT, etc.). As a result of these factors, multiple interviewees in our study felt that their decision-making abilities are constrained. The following quotes are illustrative of this theme:

> *"We seem to have this thing where we get something and we have no idea what it is, or we're told something's coming* [top-down from NRCS leadership] *and it's delivered and then all of a sudden it's like, 'Oh, this is what this is and this is how you use it,' and getting the cart before the horse on that kind of stuff."* – Current state
>
> *"…*[FPAC business center] *handles all the administrative stuff. They handle all the dollars. They handle all the personnel. They handle hiring. IT is its own branch…it controls a lot of the tech, a lot of the computer equipment, a lot of the software, a lot of the security things, a lot of the network…and those things are all significant…we are constantly trying to work around constraints that they put on us in the name of security, but sometimes it's a little too much."* – Current state

Given that power and control rested with the national leadership, current state interviewees felt that agency staff holding leadership positions should overcome inertia and a tendency to maintain the status quo, which in turn can then facilitate ACPF adoption. Challenges related to status-quo bias were not discussed by novel state interviewees, as these states are in the early stages of exploring how the ACPF can be used in their state. The following quotes are illustrative of this theme discussed by several current state interviewees:

> *"I can tell you what's hindered* [ACPF adoption] *in the past. And that's just that decision makers are so unbelievably busy, it's just hard for them to see it…just with everything else they* [the national leadership team] *have going on it was just too much, too many things happening. And I think that's kind of a barrier."* – Current state
>
> *"There's just so much inertia at* [the national] *level* [towards] *getting* [the ACPF] *speared…I like ACPF. I think it's really powerful, but there's so much inertia at the higher levels…"* – Current state

d). Agency formalization

Rogers (1995, 412) defines *formalization* as "the degree to which an organization emphasizes its members follow rules and procedures." This DOI construct is negatively related to organizational innovativeness. In our study, the agency's emphasis on following rules and procedures emerged in the context of how ACPF might interface with NRCS' programmatic constraints and requirements. However, these constraints and requirements were not only driven by the NRCS, but also other organizations and offices within the USDA, and the overall bureaucratic

and political context. This theme was expressed by a few interviewees, and is illustrated by the following quotes:

> *"…this is not a technical issue. It's a programmatic issue. But one way* [to promote ACPF is]*, if we had the ability to say, 'You're only eligible for the program if you have a conservation plan that's been prior prepared.' But Congress won't let us do that. The program rules, the farm bill rules, the political pressures, the* [agency] *infrastructure prevent us from taking that hard and fast stance…"* – Current state
>
> *"I guess I don't know how* [ACPF] *would work on a field-by-field basis, especially when our field definitions change based on FSA* [Farm Service Agency]*. And a lot of that plays into the subsidies the FSA does, and field boundaries change based on that kind of stuff. And I just I don't know how that* [ACPF] *would work when that stuff changes regularly."* – Current state

Agency emphasis on following rules and procedures also emerged in the context of conservation planning being limited to the list of BMPs that are approved by the NRCS. For example, an interviewee from a current state mentioned, *"…a bureaucratic limitation* [is that conservation planning]*…is limited to our practice list…that's just how NRCS thinks of things, because those are essentially the bullets we have to address these things* [resource concerns]." An emphasis on following rules and procedures resulted in agency staff having limited time to deliver programs and practices to farmers. For example, an interviewee from a current state mentioned, *"…this year is a great example in that we haven't even really announced any of our programs yet, because we're waiting on final rules from the Farm Bill to be posted, and interpretation of rules…* [as a result of which] *we have a short time frame to get programs delivered in a normal year."*

5.2. Individual-level drivers of ACPF

Rogers' (1995, 170) model of five stages of the innovation-decision process provided a useful theoretical grounding for the themes expressed by interviewees in our study. The first two stages in the innovation-decision process are the knowledge stage and the persuasion stage. As per Rogers (1995, 171), the knowledge stage commences, "when an individual is exposed to an innovation's existence and gains an understanding of how it functions." At the persuasion stage, an individual "forms a favorable or unfavorable attitude towards the innovation (Rogers 1995, 174)." Interviewees in our study expressed several themes that fit within the knowledge and persuasion stages of the innovation-decision process. As described below in detail, these themes provide a nuanced understanding of factors that can facilitate or hinder NRCS' readiness to adopt the ACPF from the perspective of an individual.

5.2.1. The knowledge stage

Rogers (1995, 173) identifies three types of knowledge about an innovation: awareness knowledge, how-to knowledge, and principles-knowledge. Awareness knowledge primarily focuses on an individual's awareness that an innovation exists. How-to knowledge primarily consists of the information an individual needs to use an innovation properly. Principles-knowledge primarily consists of information that helps an individual understand the functioning principles underlying how an innovation works.

a). Awareness knowledge

Interviewees in our study expressed that the overall awareness of the ACPF was low, and that there was a need to impart awareness knowledge by including ACPF modules in agency delivered planning courses and trainings, and by developing a narrative promoting the ACPF. Low awareness knowledge was expressed by several interviewees, and is evident in the following quote from a current state interviewee: *"…other than a few people in this office, there's very little awareness of what ACPF is…So, they* [field-office staff and NRCS partners] *would recognize the usefulness* [of] *the tools…if they were provided with some explanation."* This interviewee and many others felt that a useful medium for increasing ACPF awareness was to include ACPF modules in area-wide planning courses. They mentioned, *"A year ago, I had area-wide planning course, a great course,* [but] *it did not include ACPF in it.* [When] *I talked to the instructors about it, they were aware of the* [ACPF]*, but it wasn't on their radar to include it…that would be a key thing if they start teaching it."* Low levels of ACPF awareness, and the need to develop a narrative to promote it, is evident in the following quotes from both current and novel state interviewees:

> *"…just making people aware of what it* [ACPF] *actually is. It's not writing the conservation plan for anybody, but it's a support piece. Making sure they* [field-office staff and NRCS partners] *understand that…So, if we can get that sales piece telling them what it's all about. That's probably the biggest hurdle we have right now."* – Current state
>
> *"As long as we can show how it's going to help, better get conservation on the ground, target conservation. And maybe help our people be more efficient and streamlined, I think everybody will buy into it."* – Novel state

b). How-to- and principles-knowledge

It is logical that low ACPF awareness knowledge would translate into low how-to- and principles-knowledge among agency staff. Indeed, interviewees felt that there was a need to train agency staff in both basic and advanced functionalities of the ACPF. However, the need for imparting these two knowledge dimensions among agency staff was nuanced. Many interviewees recognized that staff who work at the field-level should be knowledgeable about the basic functionalities of the ACPF. The following quotes are illustrative of this theme:

> *"As long as our new staff understand what those tools are doing and what the outputs of those tools mean, I think there would be a very significant asset to our planning efforts…"* – Current state
>
> *"…the other need is to train the field office in what the* [ACPF generated output] *maps mean and how to access them and how to print them out and how to fill them…that's not a high-level training you need."* – Current state

Whereas these quotes reflect the need for field-level staff to have the basic how-to knowledge pertaining to the ACPF, several interviewees felt that they did not need training in advanced ACPF functionalities, i.e., understanding the functioning principles underlying how the ACPF works. The following quotes are illustrative of this theme:

> *"…we want to go to the field staff and say, 'Hey, here's how to effectively use this tool,' rather than, 'Hey, help us figure out how to effectively use this tool.' They don't have time to go through that learning process. They have to learn something and use it rather than what I call the discovery phase, if you will, of a new technology."* – Current state
>
> "[Field staff] *will also need* [ACPF] *training. It probably wouldn't be the inner workings of the tool…I think what they would need to know is, 'Okay. This is what's been done in the background of running this report. Here's the information presented. How do I use it? What is it useful for?'"* – Novel state

Our results highlight underlying nuances in promoting adoption of an innovation when the decision-making unit is an organization. As mentioned earlier (see section 2), intended "users" of an innovation within and organization are not homogeneous. Therefore, their knowledge needs for effectively using an innovation are different. As our findings indicate, for effective "use" of the ACPF, field staff should have awareness- and how-to-knowledge about the ACPF. In contrast, agency staff such as GIS Specialists who "use" the ACPF, for example to generate datasets, might need to be knowledgeable about the functioning principles of how the ACPF works, and therefore also have principles-

knowledge.

5.2.2. The persuasion stage

The main outcome of the persuasion stage in the innovation-decision process is an individual forming a positive or a negative attitude towards the innovation (Rogers 1995). At this stage, the five perceived attributes of the innovation – relative advantage, compatibility, complexity, trialability, and observability, are especially important in an individual developing a favorable or unfavorable attitude towards the innovation. Perceived scientific credibility of the ACPF is another factor that could potentially affect agency staff's attitudes, which in turn can then influence their decision to use, or not to use, the ACPF.

a). Relative advantage

Rogers (1995, 229) defined relative advantage as, "the degree to which an innovation is perceived as being better than the idea it supersedes." A few interviewees in our study recognized the relative advantages of the ACPF while reflecting upon their experiences of using existing models within the NRCS. The quotes below are illustrative of this theme:

> *"…*[ACPF] *would…give us something that we don't have right now. The model I used last year, I could calculate overall tons in a watershed of sediment loss and nutrients loss, but then, I didn't have anything to show like critical zones or anything like that."* – Novel state
>
> *"…I think* [ACPF is] *actually a more useful tool for planning than what we're getting with CART* [Conservation Assessment Ranking Tool; which is] *not looking at specific locations for* [conservation] *practices, it's more looking at whether or not that practice is planned on that field…"* – Novel state

Relative advantage of an innovation indicates the benefits associated with its adoption. The anticipated benefits associated with using the ACPF was expressed along several dimensions by multiple interviewees in our study. One such dimension was ACPF's role in watershed assessment and planning, specifically, with respect to making the process efficient and enabling effective generation of solutions. The quotes below are illustrative of this theme:

> *"The value of ACPF is it is one of the first tools…that does allow us to get a good picture of a watershed or a landscape and actually see it in a very efficient way and quickly and on that large of a scale."* – Current state
>
> *"In the past, we would generate all this map output…and we have all these really great pieces of information, but they didn't really talk to each other…never really* [we could]*…bring everything together to come up with better answers. And that's where I think ACPF would fit…"* – Current state

Other dimensions of anticipated benefits frequently highlighted by interviewees pertained to the ACPF acting as a means to help new agency staff gain an understanding of the watershed context, and resulting in social outcomes such as improving the stakeholder engagement process. Specifically, benefits pertaining to stakeholder engagement were expressed in light of informing agency's education and outreach efforts, and subsequently channelizing resources specifically towards farmers and farms where they could be most effective. The following quotes are illustrative of the aforementioned themes:

> *"ACPF would allow us to say this part of the county is where all of our drainage water management* [BMPs] *would apply. Let's hold the training there…let's target our efforts on these farmers where* [our outreach effort is] *going to apply best and be the most effective."* – Current state
>
> *"I think* [ACPF] *has the ability to give a* [newly hired] *planner sit down and use it before they've actually met with the producer on their farm…I think that may accelerate the learning curve and give them a lot of confidence when they're talking to the producer.* – Current state
>
> *"As far as engaging the farmers, I think it* [the ACPF] *gives us an opportunity to provide them information, describe what we think is going on as far as why is the water quality declining or how can we solve this problem, and then giving them the method and the financial assistance to do that."* – Novel state

Overall, our findings indicate that ACPF has high relative advantage, which stem from ACPF bringing-in improved functionalities to the watershed assessment and planning process, and by providing multi-dimensional benefits. Agency staff perceiving that the ACPF has high relative advantage could encourage them to use it.

b). Compatibility

Rogers (1995, 240) defined compatibility as, "the degree to which an innovation is perceived as consistent with the existing values, past experiences, and needs of potential adopters." Similarly, McNie (2007, p. 19) and Cash et al. (2003) identify the "salience" of a scientific product to a potential user, who sees it is compatible with their information needs, as important. From the perspective of an organization, compatibility is especially important in relation to the degree to which an innovation is perceived to be compatible with the policies, programs, and processes that are in place within an organization. Broadly, compatibility was discussed with respect to how the ACPF could fit within NRCS' current approach to conservation planning and program delivery. Specifically, compatibility was discussed in the context of ACPF supporting current landscape-scale NRCS initiatives such as the Mississippi River Basin Initiative (MRBI), National Water Quality Initiative (NWQI), and Regional Conservation Partnership Program (RCPP). The ACPF was also perceived by several interviewees to be compatible with NRCS' programmatic goals and objectives, for example, by assisting in accomplishing policy directives around prioritizing funding at the regional, state, and local level. The quotes listed below are illustrative of the aforementioned themes:

> *"…I would say just the structure right now* [under programs such as NWQI and MRBI]*…where we have to develop a watershed assessment and then use that to request funding, I think that structure leads us to need programs like* [the ACPF]*"* – Novel state
>
> *"Well, the specific programs like our EQIP…well, actually every program…CSP* [Conservation Stewardship Program]*, our CRP* [Conservation Reserve Program]*, our Wetland Reserve Easements. Those* [conservation] *opportunities through ACPF could help identify and prioritize and target opportunities for all our programs…"* – Current state

ACPF was also perceived to be compatible with NRCS' nine-step conservation planning process – a key agency approach to conservation planning and program delivery. Under this process, the agency helps farmers develop a conservation plan, which is a schedule of implementation and supporting information (maps, designs, fact sheets, etc.) for BMPs needed to treat one or more identified natural resource concerns on a unit of land (see Appendix 2). Many interviewees frequently identified specific steps of the conservation planning process where ACPF could be useful. For example, an interviewee from a novel state mentioned, *"I think the ACPF is going to assist us.* [Step] *one, identify problems and opportunities and step four, which is analyze resource data. Step seven, make decisions, and then also step eight is implement the plan. Step nine is evaluate the plan. I think that's where ACPF is going to really work."* Whereas the ACPF was perceived to be compatible with the nine-step conservation planning process, several interviewees also discussed the need for ACPF to be compatible with existing DSTs, platforms, and processes. The following quotes are illustrative of this theme:

> *"What I don't understand is how* [ACPF is] *going to interface with what we're doing with CD and CART and some new tools that our agency's coming out* [with]*…"* – Current state
>
> *"If* [ACPF is] *determined to be valuable to the agency as a whole, having it built into* [Conservation] *Desktop or CART as an option to run* [the ACPF] *within our normal planning and assessment and ranking process, I think would be very valuable."* – Current state

Whereas several themes emerged around how and why the ACPF was perceived to be compatible, several interviewees also discussed why ACPF might not be compatible within certain geographic contexts. In this light, perceived (*in*)compatibility was discussed with respect to the need to account for diversity in geographic contexts and their unique needs, as well as the type of BMPs that might be applicable in a given context. While both current and novel state interviewees mentioned this potential challenge, this theme was more prevalent in novel states, as these states are outside the original geographic scope (the upper Midwest) of the ACPF. The following quotes are illustrative of this theme:

> *"*[ACPF] *is really geared toward cropland…We're a state that's two-thirds grassland and forest…the long-term* [goal] *would be try to develop* [ACPF] *to where it better fits* [our state]*, than just the Midwest."* – Novel state
>
> *"One of the obstacles that comes with the* [ACPF] *is if there are things specific to* [our state's] *landscape that the model doesn't take into account, that may place practices and locations that just aren't suitable. That could be a detriment if it happened…"* – Novel state
>
> *"…within* [our state]*, there wasn't a vast number of practices* [generated by the ACPF] *that I recall that really were applicable here…obviously, filter strips, field borders, those types of things would be relevant to* [our state]. [However]*…some of the other practices like bio-reactors* [are not]*."*– Current state

Overall, our findings indicate that ACPF was perceived to be compatible with the organizational context of the NRCS, especially in relation with their policies, programs, and processes. However, there was also a need for the ACPF to account for different geographies and their unique needs, in order it to be applicable more widely.

c). Complexity

Rogers (1995, 257) defined complexity as, "the degree to which an innovation is perceived as relatively difficult to understand and use." Complexity emerged as a cross-cutting theme, i.e., discussions around the complex nature of the ACPF emerged in the context of several of the aforementioned themes. For example, indicating how personnel needs and capacity might intersect with the time needed to run the ACPF, an interviewee from a current state mentioned, *"…*[ACPF] is *complicated enough that I don't know that having someone in every office being able to use it is a realistic thing."* Complexities pertaining to using the ACPF often emerged at the intersection of the staffing capacity needed to run the toolbox, and the need to make ACPF input and output data applicable to the local context. The following quotes are illustrative of this theme mentioned by a majority of interviewees:

> *"…you've got to do some conditioning of that DEM* [Digital Elevation Model] *and digitizing the culverts to get the water running right. Because…ACPF is really that stream network…so getting that hydro conditioned DEM correct is pretty critical…So, obviously, that's a huge obstacle for anybody* [to] *turnaround the ACPF."* – Current state
>
> *"It would be more than a full-time job just to do ACPF, and just to keep running it and make watersheds. And it's not just a matter of automating a process and spitting out the answers for the whole state. I mean, we could do that. But we're not really capturing the identity of each watershed when we do that."* – Current state

Whereas the aforementioned quotes highlight the complexities pertaining to using the ACPF, the need to deliver training across different organizational levels of NRCS (see section 5.1.1), was indicative of the complexities pertaining to understanding the ACPF. Taken together, complexities around understanding and using the ACPF could deter agency staff from adopting it.

d). Trialability and observability

Rogers (1995, 258) defined trialability as, "the degree to which an innovation may be experimented with on a limited basis" and observability as, "the degree to which the results of an innovation are visible to others." As such, quotes illustrating trialability and observability only emerged in two current states, and were therefore not considered to be recurring themes in our study. Nevertheless, our initial findings suggest the need for NRCS field offices to pilot the ACPF, assess whether or not the tool provides its intended benefits, and have an opportunity to provide feedback regarding potential improvements. Highlighting these points, one interviewee from a current state mentioned, *"If we can't pilot* [the ACPF] *and our people* [in the field office] *can't give feedback on it, it won't be successful."* Adding further nuances to their response, the interview mentioned:

> *"…we've got to put some of our better field offices and see if it's a tool that really adds value, and then listen to those folks very, very closely as to what value it adds and what it doesn't…that's the thing that I think leadership has to guard against is…that they* [new tools] *actually add value at the field level more than anything else."* – Current state

In addition to highlighting the importance of trialing the ACPF at the field-office level, the aforementioned quote highlights the need for the ACPF to add value, i.e., have tangible benefits. Tangibility of results and that results are observable by others are important components of the DOI construct of observability. The quotes below are illustrative of this:

> *"*[ACPF responds to] *demand from partners that are wanting to do* [watershed] *planning but need the technical support. So, if there's success or success stories out there of how* [ACPF] *has helped them in practice and others see that and say, 'We want this in our watershed or our county so we can use your dollars effectively',* [that could] *motivate a State Conservationist through a State Technical Committee* [to adopt the ACPF]*…"* – Current state
>
> *"If we have people at that field level that are showing how they used it to actually put conservation on the ground, that's where you need to be* [to promote the ACPF]. *You need to be able to show, 'We did a cost-share with this farmer, and it was partly because of the fact that we are using these new tools to help with showing a farmer his property on a map.'"* – Current state

e). Perceived scientific credibility

McNie (2007) and Cash et al (2003) point out the impact of the perceived validity and credibility of a scientific product on its use. For example, if an innovation is perceived to be science-based, and therefore valid and credible, agency staff are likely to develop a favorable attitude towards it – a key outcome of the persuasion stage in DOI theory. A positive attitude can then foster use of ACPF by agency staff. Most interviewees in our study felt that ACPF was grounded in science, and that using a scientific tool further added credibility to agency staff when working with farmers. The following quotes are illustrative of this theme:

> *"…*[ACPF is] *science-based…one of the most important things that goes into ACPF, is that it's got excellent science behind it. That, I think, is one of the most important parts of it."* – Current state
>
> *"The relationship the farmer has with the conservation planner and their credibility is critical…when you're going out to the farm and you say, 'I think this particular area's a critical point for you to address,' in addition to my findings if I had a map that was done by a scientific tool* [such as the ACPF] *that came up with the same conclusion, that gives me that much more credibility."* – Novel state

Other interviewees reiterated the importance of ensuring that the results generated by the ACPF were validated, in order to enhance its trustworthiness, applicability, and usefulness. For example, an interviewee from a current state mentioned, *"validating the data, making sure it's applicable; it's efficient; it's easy to use. I think all those things culminate in the adoption of* [ACPF]*."* Using a cautionary tone, the interviewee further added: *"My overarching pause…is making certain that tools like* [the

ACPF], *and other models, are calibrated and validated so that at the end of the day, we have a resource that we can trust* [and] *that the research community* [can] *say, 'Yes, this tool is as accurate as we can make it with the resources that we have today'."* Expressing the importance of validating ACPF data, an interviewee from a current state mentioned, *"…if you run ACPF for every watershed, what is your plan for verifying those results?… without that it's not going to be very useful."*

To sum up, our theoretically grounded enquiry confirmed many elements of DOI and use of science theories, and in doing so, helped answer the following question of practical importance: how ready is the NRCS to adopt the ACPF? We found that several organizational- and individual-level factors influenced NRCS' readiness to adopt the ACPF (see Table 3). The following organizational- and individual-level factors were predominantly positive indicators of NRCS' readiness to adopt the ACPF: champions across organizational levels, agency openness, relative advantage, and perceived scientific credibility. The following organizational- and individual-level factors were predominantly negative indicators of NRCS' readiness to adopt the ACPF: agency capacity, agency centralization, agency formalization, level of ACPF knowledge, and complexity. Compatibility emerged as a factor that affected ACPF adoption both positively and negatively.

6. Conclusions

Agricultural DSTs are a type of innovation that is increasingly becoming the norm in conservation planning. However, owing to the complex nature of the innovation-decision process in an organization, limited scholarly attention has been paid to assessing organizational readiness for innovation. In order to fulfill this knowledge gap, we drew upon theories of DOI and the use of science to examine organizational- and individual-level factors that could enable or deter the NRCS to adopt the ACPF. Semi-structured interviews conducted with NRCS staff holding leadership positions resulted in an in-depth descriptive illustration of the agency's readiness to adopt the ACPF, as well as several theoretical and practical insights.

Our finding that NRCS' readiness to adopt the ACPF was an outcome of both organizational- and individual-level factors finds support in scholarship around the theory of organizational readiness for change (ORC) (Gustafson et al., 2003; Weiner 2009; Lokuge et al. 2019), the Consolidated Framework for Implementation Research (Keith et al. 2017; Miake-Lye et al. 2020), and findings from DOI and use of science theories (Rogers 1995; Ouimet at al. 2009). For example, as per ORC, organizational readiness is an outcome of an organization's commitment to change (referred as change valance), adequacy of resources necessary to implement the change (referred as change efficacy), and contextual factors such as having flexible organizational strategies and partnerships (Lokuge et al. 2019). The ORC also highlights the importance of assessing staff's perceptions of an organization's push for change (Kelly et al. 2017). Confirming the aforementioned theories and frameworks, we also found that NRCS' readiness to change and use the ACPF was a function of agency staff's perceptions of the organization and the innovation, and the broader organizational context.

A novel theoretical contribution of this study is the demonstration of synergies between DOI and use of science theories. When organizations prepare to adopt an innovation that is a scientific product, a host of factors come into play. While use of science theory does recognize agency personnel as working within agencies, DOI theory brings a more nuanced treatment of agency characteristics such as champions, external partnerships, centralization, and formality. DOI theory also highlights specific elements of the innovation itself not included in use of science theory, such as relative advantage, complexity, trialability, and observability. On the other hand, use of science theory calls attention to the credibility of the scientific product as a critical factor, which is a key focus of the scientific method and a theme that emerged from our data. An important overlap between the two theories is the DOI factor "compatibility", which is essentially the same concept as "salience" in the use of science literature. Finally, studies grounded in the use of science theory highlight an important factor not highlighted by DOI research: legitimacy of the process of creating the scientific product. Legitimacy did not emerge as a key factor in the adoption of the ACPF, which is an unexpected result and worth further inquiry.

Several of our findings are supported by the current literature. For example, ACPF's relative advantages of improving stakeholder engagement and acting as a medium for agency staff to gain an understanding of their watershed have been documented in the current literature (Ranjan et al. 2019; Zimmerman et al. 2019). Perceived scientific credibility and compatibility of an innovation are other themes from our study that are supported by the current literature. As documented in the literature around use of science, in order to foster uptake of science by civil servants, the scientific information should not only be perceived as credible but it should also be applicable to the local context (Koontz 2019). We found that the ACPF was perceived as credible by agency staff, however, they also felt that the ACPF should account for different geographies and their unique needs, to make the findings from the ACPF locally applicable.

Whereas a strong theoretical foundation allows us to test DOI and use of science theories by applying it in the novel context of NRCS, a key question remains – what do our findings mean for the NRCS? Several of the individual-level themes in our study fall under the knowledge and persuasion stages of Rogers' innovation-decision process (Rogers 1995, 170). Conceptualizing NRCS as the decision-making unit, this is indicative of the agency being in the initial stages of getting ready to adopt the ACPF, i.e., gaining knowledge which then translates into forming an attitude towards the innovation. Moreover, the fact that trialability and observability did not emerge as recurring themes in our study indicates that agency staff are still forming an attitude towards the ACPF. From a practical standpoint, this highlights the need for NRCS to continue to invest resources towards piloting the ACPF in different watersheds, and measuring both social and bio-physical outcomes to aid observability. Doing so could help the agency move further along Rogers' next three stages of the innovation-decision process: decision, implementation, and confirmation (Rogers 1995, 170).

Several of the organizational-level themes we found constitute internal and external characteristics of the NRCS documented by Rogers (1995, 411) and Ouimet et al. (2009, 337). From the perspective of the process of adopting an innovation or incorporating science into decisions, interviewees expressing several research and technical infrastructure, and personnel needs (see section 5.1.1) indicates that the agency is currently in the "initiation" phase of the innovation process (Rogers 1995, 421). Indeed, the ability of the ACPF to foster a 'small watershed approach' (Konopacky and Ristino 2017) and perhaps engender a fundamental shift in NRCS' conservation planning approach, fits with the following two stages within the "initiation" phase of the innovation process: agenda setting and matching (Rogers 1995, 421). From the perspective of ORC, this is also indicative of NRCS' commitment to change, referred as change valance (Lokuge et al. 2019). However, our finding that agency staff are still in the stage of forming an attitude towards the ACPF, suggests the need to prioritize efforts towards piloting the ACPF and measuring social and bio-physical outcomes.

As per Rogers (1995, 412), an organization emphasizing that its members' follow rules and procedures (*formalization*) can "inhibit the consideration of innovation by organization members but encourage the implementation of innovations." We found that programmatic constraints and requirements discouraged interviewees from considering the ACPF. However, an agency emphasizing that rules and procedures are followed, can also result in a structure that encourages the adoption of innovations. For example, ACPF's compatibility with NRCS' nine-step conservation planning process – a rule-oriented, structured process that facilitates conservation planning, can encourage agency staff to adopt the ACPF. Similarly, we found that the agency structure can create opportunities for ACPF endorsement and promotion to occur from both

top-down and bottom-up directions. Organizational structure can also enable members to gain access to each other's expertise, and perhaps create an organizational milieu that helps them overcome their initial perceptions regarding the value of the innovation, and therefore encourage adoption in the longer run (Frank, et al. 2004). Therefore, whereas rules and procedures can initially impede agency staff to consider the ACPF, in the longer run, agency structure can also enable ACPF adoption.

Like all studies, this one has limitations. For example, as pointed out by Rogers (1995), one could question how well the perceptions of staff holding leadership positions represent those of staff at the field-level. While we acknowledge this limitation, including interview data from field staff was beyond the objectives and scope of this study. We would also like to acknowledge that selection of initial interviewees in consultation with the larger team could have resulted in selection of interviewees, especially those from current states, who might have had a more favorable attitude towards the ACPF. That said, we took steps such as carefully wording interview questions, and running intercoder reliability tests, to negate any underlying biases. Another limitation of our study design is that we are unable to make any claims about the relative significance of any given driver of NRCS' readiness to adopt the ACPF, and the generalizability of our findings beyond the NRCS. That said, being a multi-level organization – a type of organizational structure common to many government agencies, NGOs, and non-profits, the NRCS provided us with a fitting platform to test theories around organizational readiness for innovation. By doing so, our hope is that we are able to inform agency-level discussions around adoption of DSTs. Lastly, we would like to acknowledge that due to the limitations of our research design, we are not able to compare and contrast findings across different state (i.e., novel versus current) and interviewee types (e.g., leadership- versus field-staff). Indeed, no systematic differences across state and interviewee types emerged in our study. Future research could use quantitative approaches to identify drivers of organizational readiness, their relative importance, and any variations across geography and respondent designations and roles.

By employing an exploratory approach, we were able to identify and describe organizational- and individual-level factors that could both enable or deter the NRCS from adopting the ACPF. In doing so, we confirmed what we had initially postulated, i.e., agency staffs' perceptions of the organization and the scientific innovation will collectively influence their decision to adopt or reject the ACPF. Overall, our findings suggest that NRCS is currently in the "initiation" phase of the innovation process, with agency staff still forming an attitude towards the ACPF. Both these factors indicate that the agency is getting ready for change, but there is a need to invest resources towards piloting the ACPF and measuring outcomes, and helping agency staff overcome both real and perceived barriers to adopting the ACPF.

CRediT authorship contribution statement

Pranay Ranjan: Conceptualization, Methodology, Validation, Writing – original draft, Writing – review & editing, Funding acquisition. **Emily M. Usher:** Conceptualization, Methodology, Validation, Investigation, Formal analysis, Project administration, Writing – review & editing. **Hanna T. Bates:** Conceptualization, Methodology, Validation, Investigation, Formal analysis, Project administration, Writing – review & editing, Funding acquisition. **Emily K. Zimmerman:** Conceptualization, Methodology, Writing – review & editing, Funding acquisition. **John C. Tyndall:** Conceptualization, Methodology, Writing – review & editing, Funding acquisition. **Chris J. Morris:** Conceptualization, Methodology, Writing – review & editing. **Tomas M. Koontz:** Conceptualization, Writing – review & editing. **Linda S. Prokopy:** Conceptualization, Methodology, Resources, Supervision, Writing – review & editing, Funding acquisition.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

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