ABSTRACT

U.S. environmental conservation hinges on the collective efforts of millions of private landowners, who often bear the burden of enacting best management practices (BMPs) that meet ecological, economic, and social needs. Engaging with these landowners is a vital task, but ever-limited resources necessitate more cost-effective methods of communicating BMPs' value towards adoption. One approach is to find and target outreach to "communication control points"—the few people who disproportionately influence how an innovative practice moves into their community. We hypothesize that we can find these "control points" through a survey that captures three key characteristics: (1) people are more highly *connected* in their social network, (2) more highly *knowledgeable* of environmental topics, and (3) more highly *persuasive* when sharing this knowledge to their many contacts. We use the BMP of riparian buffers in Pennsylvania as a case study to find people who self-identify with these characteristics, and we pair these surveys with a network analysis that tests if self-perceived characteristics translate to truly central actors in the network. Overall, our work could validate a powerful tool—a simple 15-item survey to find communication control points, who could then serve as contacts for targeted (and more cost-effective) environmental outreach.

PROJECT PROPOSAL

PROJECT RATIONALE

Pro-environmental communication campaigns are vital but costly

U.S. environmental conservation hinges on the collective efforts of millions of private landowners, who often bear the burden of enacting best management practices (BMPs) that meet ecological, economic, and social needs (Jenkins et al., 2015). Engaging with these landowners is a vital task, but ever-limited resources necessitate more cost-effective methods of communicating BMPs' value towards adoption (e.g., Metcalf et al., 2019). A timely case study is riparian buffer adoption in the Chesapeake Bay. Riparian buffers, the planting of vegetation along streams, are a high priority for Bay-wide nutrient reductions (Chesapeake Bay Program, 2015). This has led to ambitious state-level goals, such as Pennsylvania's intent to plant 110,000 acres of buffers by 2025 (DCNR, 2016). Despite significant cross-stakeholder investments, PA (like all Bay states) has consistently fallen short of its annual planting goals (Fig 1). Since 2010, state-wide planting has averaged 147 miles of a 900 mi/year goal—an 84% gap between target and outcome. PA's shortfalls are alarming, because PA contains most (75%) of the Bay's largest tributary (DEP, 2022). As such, **riparian buffer adoption in Pennsylvania offers a high priority case study to test novel outreach approaches.**

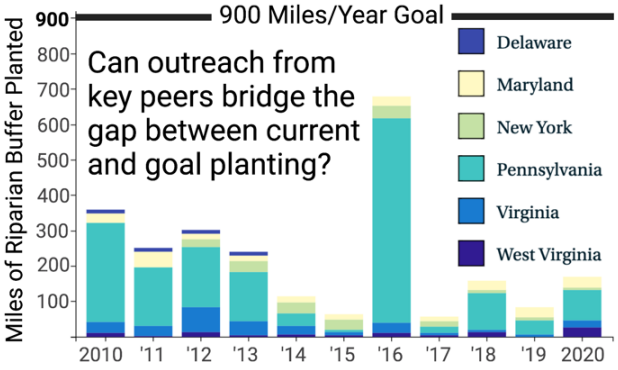

Figure 1. Annual miles of riparian buffer planted for each state in the Chesapeake Bay watershed (modified from Chesapeake Progress, 2022). Note that the 2016 spike is not from new buffers but historical plantings being first reported.

Communication "control points" could increase adoption of best management practices

Communication scholars have long noticed some people disproportionately influence their community's attitudes and behavior toward a desired direction or outcome (Katz & Lazarfeld, 1955), such as adopting innovative practices (Rogers, 2003). Though there are many terms for these **communication control points** (e.g., traditionally "opinion leaders" or, recently, "superdiffusers"), these terms attempt to capture the same idea—that **some people are more highly connected in their social network, more highly knowledgeable in the topic over which they exert control, and more highly persuasive when sharing this knowledge to their many contacts** (Rogers & Cartano, 1962; Boster et al., 2011). Identifying and targeting these points for communication interventions has fulfilled diverse agendas: from promotion of marketed products to health interventions in at-risk communities (e.g., Kelly et al., 1992). Yet there remains an increasing—and relatively unanswered—call to target control points in environmental communication to facilitate the adoption of BMPs that support pro-environmental outcomes (Dalrymple et al., 2013). A prominent example is using control points in boating and fishing communities to increase practices that mitigate the spread of non-native, ecologically harmful aquatic species (Dalrymple et al., 2013; Howell et al., 2015). However, environmental scientists know of many other practices that have consensus on their ecological value but lack widespread public adoption (Lintern et al., 2020)—a gap that could be bridged by communication control points within the communities of interest.

Research Objectives: How do we identify control points in riparian buffer communication?

The objectives of this research are to (1) identify self-perceived communication control points of environmental information within riparian landowner communities in four high-priority Pennsylvanian counties, and (2) construct and analyze these communication networks to (a) test if self-perceived control points are actually central to the network, (b) identify characteristics of control points within each county, and (c) contrast the networks across counties.

BACKGROUND INFORMATION

Control points are effective in messaging, but underused in environmental outreach

There is a pressing need to understand, and improve, the rate of BMP diffusion into Pennsylvania's riparian communities (Herbstritt et al., 2019). This phenomenon can be understood through the diffusion of innovation theory (Rogers & Cartano, 1962). Diffusion is the process by which an innovation (here, riparian buffers) is communicated through a social network over time (Rogers, 2003). Within these networks, certain actors function as "control points," in that a few people disproportionately influence diffusion and implementation of an innovation (Rogers, 2003). For riparian buffers, many current engagement strategies have focused on diffusing knowledge (i.e., "spreading awareness") of the practice through experts that are often external to the social network (e.g., DEP, 2021). However, a landowner learning that a practice exists is merely the first step in the process of adopting (or rejecting) a practice (Rogers, 2003). After acquiring knowledge, farmers will form attitudes or opinions about the practice that balance socioeconomic factors (Strong & Jacobson, 2005), past experiences (Allred & Gary, 2019), perceived social norms (Metcalf et al., 2018), and other environmental values and concerns (Commender, 2016; Ferich, 2021). During this crucial phase, communication scholars have found that individuals are best reached not by experts external to the social network, but by personal interactions with trusted peers (Rogers, 2003; Kelly et al., 1992; Carpenter et al., 2019). By identifying the most influential peers, scientists can connect with the actors that represent communities' values and needs in the co-design of best management practices (Mauser et al., 2013); in turn, these actors can facilitate and accelerate practice diffusion within their communities (Darlymple et al. 2013; Howell et al., 2015).

Communication control points have been studied extensively in marketing campaigns to encourage purchasing products or adopting health practices (e.g., Kelly et al., 1992). For example, Boster et al. (2012) found that while peers generally can influence university students to use multivitamins, just 31 of those peers that self-identified as control points could influence a community of over 36,000 students. This is powerful for cost-effective outreach campaigns, because experts can target a few key people for an intervention with radiating impact. **However, few studies have examined control points in environmental outreach**. We aim to fill this need by testing if key actors in interpersonal networks could influence the success of environmental communication campaigns for Pennsylvania stream management.

Proof of Concept: We have a valid and reliable scale for self-perceived control points

Boster et al. (2011) argue that identifying communication control points requires identifying three defining characteristics: (1) *connectivity,* they are highly connected within their social networks; (2) *mavenness*, they are highly knowledgeable in the topic within which they exert control; and (3) *persuasiveness*, they are highly effective at sharing this knowledge across their connections. We can measure these three first-order factors (**C**onnectivity, **M**avenness, and **P**ersuasiveness) directly using the "CMP" scale, a 15-item self-report scale that includes 5 items for each factor (modeled in Fig 2). The CMP scale has been found to be valid (i.e., measuring the one factor of interest) and reliable (i.e., obtaining the same result when retesting the same individual) (Boster et al., 2011, 2012, 2015).

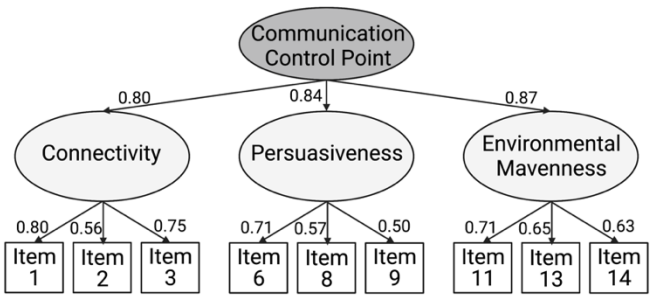

Figure 2. Hypothesized model of communication control points (modified from Boster et al., 2011). "Control point" (dark oval) is a second-order factor indirectly measured through three first-order factors (light ovals). First-order factors are averaged directly from survey items (white boxes). Numbers along arrows are correlations between items and factors from our data (n = 365). Items cut from final model not shown.

Because the CMP scale has been most rigorously tested for health maveness, we tested it tailored to environmental maveness. As part of a Penn State graduate class (IRB-exempt), we distributed an online survey containing the tailored CMP scale via a crowd-sourcing platform, Amazon's Mechanical Turk, which was completed by users (n = 364) who all passed an attention check (B. Manata, personal communication). This offered a large sample size to run a confirmatory factor analysis (CFA; Hunter & Gerbing, 1982), which assesses the correlations between survey items, the factor that the items intend to *directly measure* (*first-order factors*), and the *indirectly measured* factors (*second-order factors*). In essence, a CFA tells us how well a survey scale fits the intended measurement model (Fig 2). We found that, with minor trimming, the CMP scale provided a valid measure of how people perceive their social connectivity, persuasive skills, and environmental expertise. Further, we found support for a second-order model—that is, connectivity, persuasiveness, and mavenness (which we can directly measure) are driven by the same underlying (indirectly measured) construct of communication control points. To our knowledge, these are the first data to support a second-order structure in the CMP scale—a structure theorized, but unsupported, in its originating study (Boster et al., 2011) and not tested since (e.g., Boster et al. 2012, 2015). Together, this offers a proof-of-concept that our tailored CMP scale is a valid and reliable measurement tool for self-perceived communication control points in the general public, which encourages its use in a targeted population like riparian landowners proposed in the next section.

DESCRIPTION OF PROPOSED RESEARCH

Our methods are approved by PSU's IRB under STUDY00020761, which we briefly described here:

Identifying and Recruiting Participants

We identified riparian landowners from four Pennsylvania counties—Bedford, Centre, Lancaster, and York—prioritized to reduce 50% of state nitrogen pollution to Chesapeake Bay (DEP, 2022). Riparian landowners were identified through a geospatial analysis of 1–m^2 enhanced water flow path data (from Chesapeake Conservancy) joined with parcel landownership data. Parcels were quality controlled (e.g., remove duplicate landowners, public land, etc.), from which we randomly subsampled 625 mailing addresses per county. Subsampled landowners will receive two directly mailed postcards: an invitation to complete the survey and a reminder (a best practice for increasing response, see Sakshaug et al., 2019). The invitation will include both a hyperlink and QR code to the survey (hosted on Qualtrics). To incentivize participation, subjects will be included in a drawing for ten $10 Amazon gift cards.

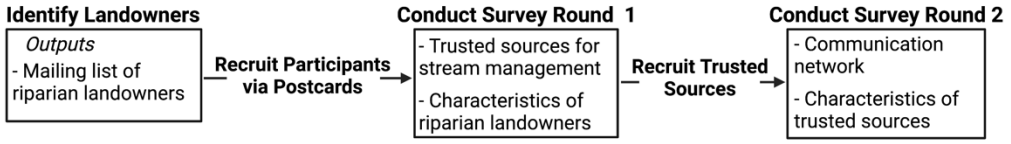

Figure 3. Pipeline of our methods with expected data outputs.

Survey Instruments and Analyses

Survey is available online at https://pennstate.qualtrics.com/jfe/form/SV_9FZnK3yXHBUsR4q

Obj. 1 *Identifying Self-Perceived Communication Control Points in Riparian Networks*

Hypothesis: Connectivity, environmental mavenness, and persuasiveness will capture self-perceived communication control points that are rare, but influential, in riparian social networks.

Approach: To identify self-perceived communication control points, riparian landowners will be invited to participate in a one-time online survey that will include our tailored CMP scale. The survey will also ask landowners about their environmental concerns (Schultz, 2001), if they have or plan to adopt a riparian buffer on their property, the motivations or barriers influencing this decision, and demographics (age, gender, education level, industry of occupation, political ideology, tenure, and length of tenure).

From these data, we can use confirmatory factor analysis (CFA; Hunter and Gerbing, 1982) to test the validity of the first-order theoretical model (Fig 2), and average scores from validated items to generate one "score" for connectivity, mavenness, and persuasion. Individuals that rank in the top 75th percentile for each first-order factor will be considered control points—consistent with previous recommendations to capture the top ~5% of the population (Boster et al., 2011). We will also use these averaged scores to test a second-order factor model. Overall, these methods provide insight into characteristics of actors who disproportionately influence the adoption of stream best management practices in their communities.

Obj. 2 *Constructing and Analyzing Riparian Communication Networks*

Hypothesis: Self-perceived communication control points will be more central to the network.

Approach: While Obj. 1 will identify self-perceived communication control points, expanding from the individual to the surrounding network is critical to (1) assure these self-reported actors are, indeed, central in the network, and (2) analyze the across- and within-county network structures to find critical actors that may not have been reached, and their characteristics, that influence the adoption of innovative practices (e.g., Scherer and Cho, 2003). To identify the structure of the communication network, the survey will ask landowners to name up to three individuals whose advice they most value on stream management. Any new individual names will serve as the second round of participants for a follow-up, shorter survey that will only include the self-perceived communication control points items, communication network items, and demographic items. From these data, we will construct the communication networks for each county to compare (1) between counties, through "whole-network" descriptive statistics; and (2) within counties, to find control points that have high in-degree centrality scores (many nominations from different respondents) and betweenness (ability to bridge otherwise separate clusters) (Newman, 2018). Overall, these methods will test if self-perceived characteristics identified in Obj. 1 translate to true centrality in the riparian communication network.

IMPACT OF RESEARCH

This work contributes fundamental and applied knowledge to more cost-effective environmental outreach using a timely and ecologically critical case study. Fundamentally, this work further validates (1) "communication control points" as an approach for targeted outreach and (2) the CMP scale as a tool to find those points. Boster et al. (2011) first proposed the "control points" construct as a second-order factor theoretical model (Fig 2)—meaning these points are an underlying concept that we indirectly measure through the CMP scale. Yet their data did not support a second-order model, and, to our knowledge, the model has not been tested again (e.g., Boster et al., 2012, 2015; Carpenter et al., 2019). Through confirmatory factor analysis (Obj 1), we will provide evidence that either supports this model or could call for construct revision. Further, tests of the CMP scale have relied on self-reporting, e.g., survey participants must perceive themselves as highly "connected" in their social network. By pairing the CMP scale with a network analysis (Obj 2), we can test if this self-perception is accurate, which could save us the time-consuming steps of tracing contacts to build a network. Together, this would solidify the CMP scale as a powerful tool to self-identify communication control points using a simple 15-item survey.

Such a tool has applications in countless landowner outreach efforts for adopting best management practices (BMPs). Extension agents could distribute this survey in a community, then follow-up with control points for targeted campaigns, such as trainings on how to talk with neighbors about a BMP. Such an approach maximizes potential impacts with limited time, funds, and staff. Also, this empowers communities to harness and express their internal, peer-to-peer expertise. By accessing entry points to local knowledge, external experts (like scientists) can better represent local values and needs in the co-design of BMPs and, in turn, local experts can accelerate adoption of these BMPs in their communities.

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