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Research article

Confronting a post-pandemic new-normal—threats and opportunities to trust-based relationships in natural resource science and management

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ABSTRACT

Natural resource governance is inherently complex owing to the socio-ecological systems in which it is embedded. Working arrangements have been fundamentally transformed throughout the COVID-19 pandemic with potential negative impacts on trust-based social networks foundational to resource management and transboundary governance. To inform development of a post-pandemic new-normal in resource management, we examined trust relationships using the Laurentian Great Lakes of North America as a case study. 82.9% ($n = 97/117$) of Great Lakes fishery managers and scientists surveyed indicated that virtual engagement was effective for maintaining well-established relationships during the pandemic; however, 76.7% ($n = 89/116$) of respondents indicated in-person engagement to be more effective than virtual engagement for building and maintaining trust. Despite some shortcomings, virtual or remote engagement presents opportunities, such as: (1) care and nurturing of well-established long-term relationships; (2) short-term (1–3 years) trust maintenance; (3) peer-peer or mentor-mentee coordination; (4) supplemental communications; (5) producer-push knowledge dissemination; and, if done thoughtfully, (6) enhancing diversity, equity, and inclusion. Without change, pre-pandemic trust-based relationships foundational to cooperative, multinational, resource management are under threat.

Novelty and relevance

Our article is novel, timely, and relevant. We advance environmental resource management by synthesizing threats to and opportunities for maintaining and building trust-based relationships as we emerge from the COVID-19 pandemic and shape new norms in natural resource management. Our intent is to encourage governments and other relevant institutions to make wise decisions and policy to continue to build and maintain trust-based relationships critical to sustainable natural resource management (see [Table 1](#)).

1. Introduction

Natural resource governance is inherently complex owing to the socio-ecological systems in which it is embedded ([Cvitanovic et al., 2015](#); [Gaden, 2016](#)). Transboundary resource governance is even more complex because resources span multiple jurisdictions where management authorities can differ in philosophy, politics, and legislation, and the spatiotemporal scale at which ecological dynamics operate can be broad ([Berkes et al., 2003](#); [Levin, 1998](#)). Recent trends from centralized management toward interjurisdictional, adaptive, co-management

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Table 1
Threats and opportunities associated with maintaining and building trust relationships in post-pandemic COVID-19 resource management.

	Threats	Opportunities
<i>Financial</i>		
Travel	<ul style="list-style-type: none"> · Reduced; complicated approval process; budget reductions · Policies ephemeral and vary among jurisdictions 	<ul style="list-style-type: none"> · Short-term financial gains where travel is reduced
Capital	<ul style="list-style-type: none"> · Technology, infrastructure, training requirements are costly, particularly for rural communities 	<ul style="list-style-type: none"> · Reduced facilities costs (e.g., fleet, office space, maintenance) through asset sharing, remote working conditions, etc.
<i>Operational</i>		
Decision making	<ul style="list-style-type: none"> · Reduced effectiveness of support tools (e.g., SDM) · Less meaningful engagement with stakeholders 	<ul style="list-style-type: none"> · Broader rightsholder representation at decision making tables
Knowledge exchange	<ul style="list-style-type: none"> · Reduced opportunity (e.g., brainstorming, syntheses, workshops, strategic planning; (Nguyen et al., 2021b)) · Limited engagement and experiential learning; no opportunity for place-based learning 	<ul style="list-style-type: none"> · Accessibility beyond typical actors and audiences · Additional and new platforms available · Asynchronous learning (e.g., online training courses) · Minoritized voices may be more effectively heard
Formal communications	<ul style="list-style-type: none"> · Personality can strongly influence level of engagement 	<ul style="list-style-type: none"> · Exploration and effective use of new virtual social platforms
Informal communications	<ul style="list-style-type: none"> · Reduced or lost opportunities for social engagement · Interpersonal relationships not maintained · Loss of “decision priming” (Song et al., 2019) 	<ul style="list-style-type: none"> · Small group breakouts
Information quality	<ul style="list-style-type: none"> · Misunderstanding about sources and quality of data can lead to a loss of that information as a valuable decision point 	<ul style="list-style-type: none"> · Greater transparency · Broader adoption of formal evidence synthesis methods · Pan-global collaboration through virtual scholarly communities
Field operations	<ul style="list-style-type: none"> · Interjurisdictional travel subject to change and variable among jurisdictions · Reduced contractor availability may strain interagency relationships 	<ul style="list-style-type: none"> · Multi-jurisdictional asset sharing (e.g., boats) could offset challenged commitments · Enhanced opportunity for local engagement (e.g., community-based monitoring, citizen science)
Logistics	<ul style="list-style-type: none"> · Approvals uncertain · Planning more challenging · Policies frequently changing · Travel requirements (e.g., vaccine) differ within and among jurisdictions 	<ul style="list-style-type: none"> · Enhanced coordination; efficiency in administration and planning
<i>Social</i>		
Trust and relationships	<ul style="list-style-type: none"> · Virtual engagement not effective for trust building · Potential erosion of trust due to reduced interpersonal connection 	<ul style="list-style-type: none"> · Virtual opportunities for increased maintenance and nurturing of well-established relationships
Collaboration	<ul style="list-style-type: none"> · Virtual meeting fatigue · Reduced creativity (Brucks and Levav, 2022) · Personal disconnection 	<ul style="list-style-type: none"> · Technology may increase frequency of opportunities · Novel supplementary working platforms
Inclusion and equity	<ul style="list-style-type: none"> · Greater inequity, but also greater acknowledgement of those inequalities (see Kantamneni, 2020) · Masking and social distancing restrict non-verbal communication disproportionately for hearing impaired · Virtual engagement requires technological capacity, such as bandwidth or training · Virtual engagement may be inconsistent with cultural norms 	<ul style="list-style-type: none"> · Broader reach and participation (where infrastructure and training allows) · Closed-captioning, recording, and chat features in modern virtual platforms may increase accessibility for some user groups · Enhanced opportunity for less-represented and underfunded groups · Greater equity in academia (King et al., 2020)
Work-life balance	<ul style="list-style-type: none"> · Remote work may present multiple distractions and competing interests resulting in lack of focus · Emotional fatigue (living-at-work) · Increased frequency of virtual meetings reduces opportunities for product-based tasks · Disrupted childcare or school · Virtual fatigue 	<ul style="list-style-type: none"> · Greater flexibility in time allocation and living arrangements
Work-life conflict	<ul style="list-style-type: none"> · No reduction in tension associated with boundaries between work and nonwork roles (i.e., work-life conflict) for parents with children <12 yrs old (Schieman et al., 2021) 	<ul style="list-style-type: none"> · Work-life conflict reduced among those with no children or teenage children at home (Schieman et al., 2021)
<i>Environmental</i>		
	<ul style="list-style-type: none"> · Erosion of social license 	<ul style="list-style-type: none"> · Reduced carbon footprint (potentially; Berkes et al., 2003) · Re-envisioning how we engage with wildlife and wilderness · Re-invention of sustainable, equitable, and inclusive conference and meeting models

(Holling, 1978) have relied on establishment of strong social networks (Bodin and Crona, 2009; Hahn et al., 2008; Mulvaney et al., 2015; Song et al., 2019). Central to the establishment and maintenance of resource governance networks is trust (Cvitanovic et al., 2021; Lacey et al., 2018; Song et al., 2019; Stern and Baird, 2015; Toman et al., 2021). While various conceptualizations of trust exist, in its broadest sense, trust is defined as a psychological state in which an entity (i.e., a trustor) accepts some level of vulnerability based on a positive expectation of another entity (i.e., a trustee; Rousseau, 1998). Trust among individuals and groups influences the extent to which it is possible to collaboratively identify and implement management or stewardship philosophies and actions that are embraced by and benefit diverse resource users and maintain or restore ecosystem function and services (e.g., van Putten et al., 2022).

Since 2020, the COVID-19 pandemic resulting from the SARS-CoV-2 novel coronavirus has influenced natural resource networks, potentially affecting governance through strain on trust-based networks and relationships among individual actors. Erosion of public trust in science resulting from rampant misinformation (Agle, 2020), threats to biodiversity, conservation, and environmental sustainability (Awuh et al., 2021), Indigenous self-governance and access (Walters et al., 2021), human resources and organizational capacity (Kantamneni, 2020), inconsistent supply chains (Chowdhury et al., 2021), and knowledge exchange (Nguyen et al., 2021a) are all resource management challenges affecting or affected by trust-based relationships and exacerbated during the pandemic. How governments and the international science and management communities respond to changes brought about by COVID-19 over the next few years will influence sustainability of natural resources and societal well-being for generations to come. Moreover, COVID-19 has the potential to disrupt decades of relationship-building, the very foundation of cooperative resource management (Leahy and Anderson, 2008; Smith et al., 2013).

Herein, we review threats to and opportunities for natural resource stewardship associated with the COVID-19 pandemic transformation of working relationships. We examined fisheries of the North American Laurentian Great Lakes (hereafter Great Lakes) as a case study to assess how trust-relationships—the foundation of governance networks—may be affected in a post-pandemic new-normal (*sensu* Srivastava et al., 2021). Basin-wide survey data from Great Lakes fishery management and science communities illustrate perceived implications of pandemic working arrangements on trust-based relationships. We synthesized available knowledge on how the COVID-19 pandemic has affected resource governance informed by our survey and drawing on examples from the case study. Finally, we conclude our review with a perspective including recommendations to policymakers and management officials as we emerge from the COVID-19 pandemic and begin to shape a new-normal in natural resource management.

2. Case study: Great Lakes fishery governance

The Great Lakes are a fitting model for assessing effects of the COVID-19 pandemic on relationships because they are: (1) the largest freshwater ecosystem in the world (16,900 km of coastline; Herdendorf, 1982; Sterner et al., 2020); (2) complex—they generate their own weather; (3) diverse—being home to more than 38 million Indigenous and settler peoples (Fergen et al., 2022); (4) an economic powerhouse supporting an approximated 3.5 trillion dollar U.S. economy (data from 2018 to 2022; Decadal Great Lakes Science Strategy, 2022); and (5) multi-jurisdictional (i.e., eight states, one province, >120 Indigenous nations, two federal governments, and three Tribal treaty organizations playing coordination roles and interacting with a diverse suite of stakeholders and rightsholders). Given their scale, complexity, and importance, transboundary governance and management of the Great Lakes requires commitment by many organizations and actors across multiple jurisdictions to exchange multidisciplinary knowledge, coordinate policy, make collective decisions, and leverage funding. We

further focus our case study on multinational coordination of Great Lakes fisheries, which is made possible through trust-relationships facilitated by A Joint Strategic Plan for Management of Great Lakes Fisheries (JSP), a non-binding agreement among fishery management agencies in the Great Lakes basin (GLFC, 2007; adopted in 1997 and supersedes 1981 original).

The Great Lakes Fishery Commission (hereafter, Commission) is a binational organization established by the 1954 Canada-United States Convention on Great Lakes Fisheries to coordinate fisheries research, control the invasive sea lamprey *Petromyzon marinus*, and facilitate cooperative fishery management among state, provincial, Tribal, and federal management agencies (U.S. Department of State, 1956). Article VI of the Convention directs the Commission to “establish and maintain working arrangements” among fishery management agencies and others as a primary duty, to achieve the once elusive goal of facilitating multi-jurisdictional fishery management (Gaden et al., 2012). Trust-based relationships are at the core of the Commission’s ability to coordinate and maintain “working arrangements” among fishery partners, rightsholders, and stakeholders (Gaden, 2007) and are the foundation of the JSP.

The JSP committed 17 agencies to strategic cooperation without abrogating any individual jurisdictional authorities or responsibilities. The JSP established a shared goal for Great Lakes fisheries, identified issues and management strategies, and specified working arrangements (i.e., institutional and social networks) within which the signatories would engage to achieve that goal (GLFC, 2007; subsequently updated in 2007; GLFC, 2007; Gaden et al., 2008). The JSP is facilitated by the Commission and implemented by individual Lake Committees composed of senior fishery managers from state, provincial, and U.S. Tribal agencies that have jurisdiction on each of the lakes (<http://www.glfc.org/joint-strategic-plan-committees.php>). The Council of Lake Committees, composed of representatives from each jurisdiction and lake, considers issues and problems of common concern affecting two or more of the Great Lakes. Prior to the COVID-19 pandemic, the JSP committees and several other Commission boards met in-person multiple times per year to conduct their business and foster trusting relationships; these committees and boards convened virtually between spring 2020–22. Shifts from in-person to remote working arrangements associated with the pandemic could affect the nature of fundamental relationships at the lake and basin scales with trickle-down effects on implementation of the JSP regionally and locally.

2.1. Survey methods

We polled scientists, managers, and others engaged in interjurisdictional Great Lakes fishery management who are part of the Great Lakes Fishery Commission network (Table S1.1) to obtain their perspectives about potential implications of the COVID-19 pandemic on relationships and trust. Stern and Coleman (2015) outlined four types of trust: (1) dispositional trust based on a propensity to trust others in general; (2) rational trust based on the calculated utility of trusting, such as reciprocity and strategic exchange; (3) affinitive trust based on perceived personal qualities and characteristics of others such as shared values or identity; and (4) procedural trust based on the systems governing the interactions between the trustor and trustee (Cvitanovic et al., 2021; Lacey et al., 2018). Our questions were designed to survey all four aspects of trust.

The survey (Table S1.2) was constructed and implemented via Typeform™ and a link to the survey was distributed via e-mail between 18 May and June 03, 2022. The survey yielded both quantitative and qualitative data on survey population demographics and perceptions of COVID-19 on trust-based relationships. We did not control for survey redistribution and where appropriate, distributed the survey to directors or board and committee chairs with a request for them to consider distribution to their staff or membership. As such, we estimate the survey could potentially have reached 730 individuals (Table S1.2), which

translates to a potential response rate of ~16% (117/730).

To summarize and visualize survey results, responses were grouped based on self-reported roles into the following four groups: (1) “Manager/Official”, which included (i) resource manager for an Indigenous, state, or provincial government and (ii) official for a federal government; (2) “Researcher,” which included (i) researcher or technician for an Indigenous, state, provincial, or federal government; (ii) researcher, technician, or trainee at a university or college; and (iii) researcher or technician for the private sector or a non-governmental organization; (3) “Stakeholder,” which included non-Indigenous stakeholder (e.g. angler, commercial fisher), and (4) “Rightsholder,” which included Indigenous rightsholders. To simplify the data visualization and facilitate examining differences between manager/official and researchers, records for which a role was not indicated (4/117), those who did not respond to the question (13/117), and those who identified as non-Indigenous stakeholders (4/117) or Indigenous rightsholders (0/117) were excluded from the summaries and visualizations. All data were retained in calculating summary statistics. Diverging stacked bar charts organized according to the groups described above were generated in R version 4.0.4 (R Core Team, 2022) using the Likert function (Heiberger and Robbins, 2014) within the HH package (Heiberger, 2022).

2.2. Survey results

We received 117 survey responses from 17 jurisdictions (2 Tribal; 11 states; 4 provinces; Fig. S2.1). Among respondents who indicated a gender, 16% were female (19/117) and 78% were male (92/117; Table S2.1). Equal numbers of respondents identified as managers/officials (41.9%) and researchers (41.9%) with 3.4% identifying as stakeholders (Fig. S2.2A). 41.9% (49/117) of respondents identified as mid-career, 39.3% (46/117) late-career, and 8.5% (10/117) retired (Fig. S2.2B).

Establishment of new relationships with others through virtual engagement in Commission activities (question 1; Table S1.1) was reported by 33.3% (39/117) of respondents, whereas 66.7% (78/117) either did not or were unable to establish new relationships during the pandemic (Fig. 1A). However, only 26.5% (31/117) of respondents were able to establish trust as part of relationship building (Fig. 1B) and only 7.7% (9/117) of respondents strongly agreed that they were able to establish trust as part of new relationships through virtual engagement with Commission activities. 25% (30/117) of respondents neither agreed nor disagreed that they were able to establish trust as part of new relationships through virtual engagement with Commission activities while 23% (27/117) disagreed that they formed trust relationships through virtual engagement. One respondent stated: *“I tend to trust new folks that I meet on virtual meetings in general, but the level of trust is superficial compared to the trust that can be established through in-person interactions.”* While our survey did not distinguish types of trust, we interpreted responses as primarily referring to dispositional trust, which was largely absent prior to the formation of the Commission in 1954 (Gaden et al., 2021). Rational and affinitive trust are particular strengths of the JSP’s lake committee process and likely embedded in responses particularly those responses from late-career and retired respondents.

Surprisingly, 56% (65/116) of survey respondents indicated that the shift to virtual engagement during the COVID-19 pandemic has had either positive (13.8%) or no (42.2%) effects on existing relationships, while 36.2% (42/116) indicated the transition to virtual engagement had negative (34.5%) or strong negative (1.7%) effects on existing relationships (Fig. 1E). We interpret these data to indicate that well-established relationships throughout the Great Lakes network have withstood the short-term challenges associated with the COVID-19 pandemic; 82.9% (97/117) of survey respondents indicated that well-established trust-based relationships were maintained through >2 y of virtual engagement (Fig. 1C). Time will tell for how long relationships can persevere given that 76.7% (89/116) of survey respondents indicated in-person engagement to be more (25.6%; 30/117) or far more

(50.4%; 59/117) effective than virtual engagement for building and maintaining trust (Fig. 1D). To highlight this latter point, one survey respondent remarked: *“Virtual engagements do not lend themselves to establishing new relationships and are more one-way communications than a face-to-face engagement. They make it hard to build up and/or establish trust relationships and over time I feel it would be non-sustainable or harmful to trust as the social interactions and sidebar discussions are being lost.”* Another respondent felt *“My work relationships have suffered as a result of virtual communications. I don’t know how people are*really* doing or what they’re going through.”* By contrast, some survey respondents clearly identified value in virtual engagement with 21% (25/117) indicating virtual being equal to or more effective than in-person engagement for building and maintaining trust. One respondent claimed *“I feel that the Commission puts more effort into face-to-face interaction than is likely necessary to carry out its mission. I would wager that up to half of all meetings hosted by them could be virtual with little to no loss of productivity (if not some gains).”* While this was a rare sentiment among written survey responses to open ended questions, it draws attention to potential efficiencies and value that could be gained by judicious use of remote or virtual interactions.

Indigenous resource managers comprised only 4.3% (5/117) of survey respondents and researchers or technicians for an Indigenous government only 2.6% (3/117) of survey respondents (Fig. 2.2A). Although all respondents with Indigenous affiliation indicated they had been able to maintain existing trust-based relationships with others through virtual engagement, 37.5% (3/8) indicated in-person engagement was more and 62.5% (5/8) indicated in-person engagement was far more effective than virtual engagement for building and maintaining trust.

Great Lakes Fishery managers and scientists had remarkably similar experiences with 89% overall agreement regarding their ability to establish new relationships, establish trust, maintain existing trust-based relationships, and their perceptions of in-person versus virtual engagement on trust and relationships (survey questions 1–5; Table S1.1). The greatest source of differing opinion among managers and scientists, albeit small, was with respect to establishing trust as part of new relationships through virtual engagement (question 2). Among managers, 34% (12/35) agreed they were able to establish trust as part of new relationships through virtual engagement, whereas 66% (23/35) did not. By contrast, 41% (16/39) of scientists agreed they were able to establish trust as part of new relationships through virtual engagement, whereas 59% (23/39) did not. Eight (9%; 8/85 total respondents) scientists and 2 managers indicated that in-person engagement was less effective than virtual engagement for building and maintaining trust (question 4).

3. Post-pandemic threats to natural resource governance

The COVID-19 pandemic accelerated a generational retirement (Faria e Castro, 2021) and fast-tracked successional plans within many North American natural resource agencies and likely elsewhere. Many incoming agency staff have never met one another in person, nor have they had the opportunity to build meaningful relationships with academics, rightsholders, or stakeholders. These threats are reflected by one survey participant who remarked *“The pandemic isolation has had far reaching impact on relationship building, especially given the number of new staff my center is hiring and the large number of people retiring. Many of my new staff have not even worked in my center yet and met their colleagues, let alone meet and build relationships with other agency colleagues.”* Long-term relationships are nurtured by individuals as opposed to institutions (Baker et al., 1999); therefore, staff turnover coupled with remote working conditions during the pandemic could jeopardize long-term relationships.

3.1 Trust—A rich literature highlights the importance and benefits of trust in natural resource management. For example, in relation to environmental and sustainability challenges, trust is recognized as a

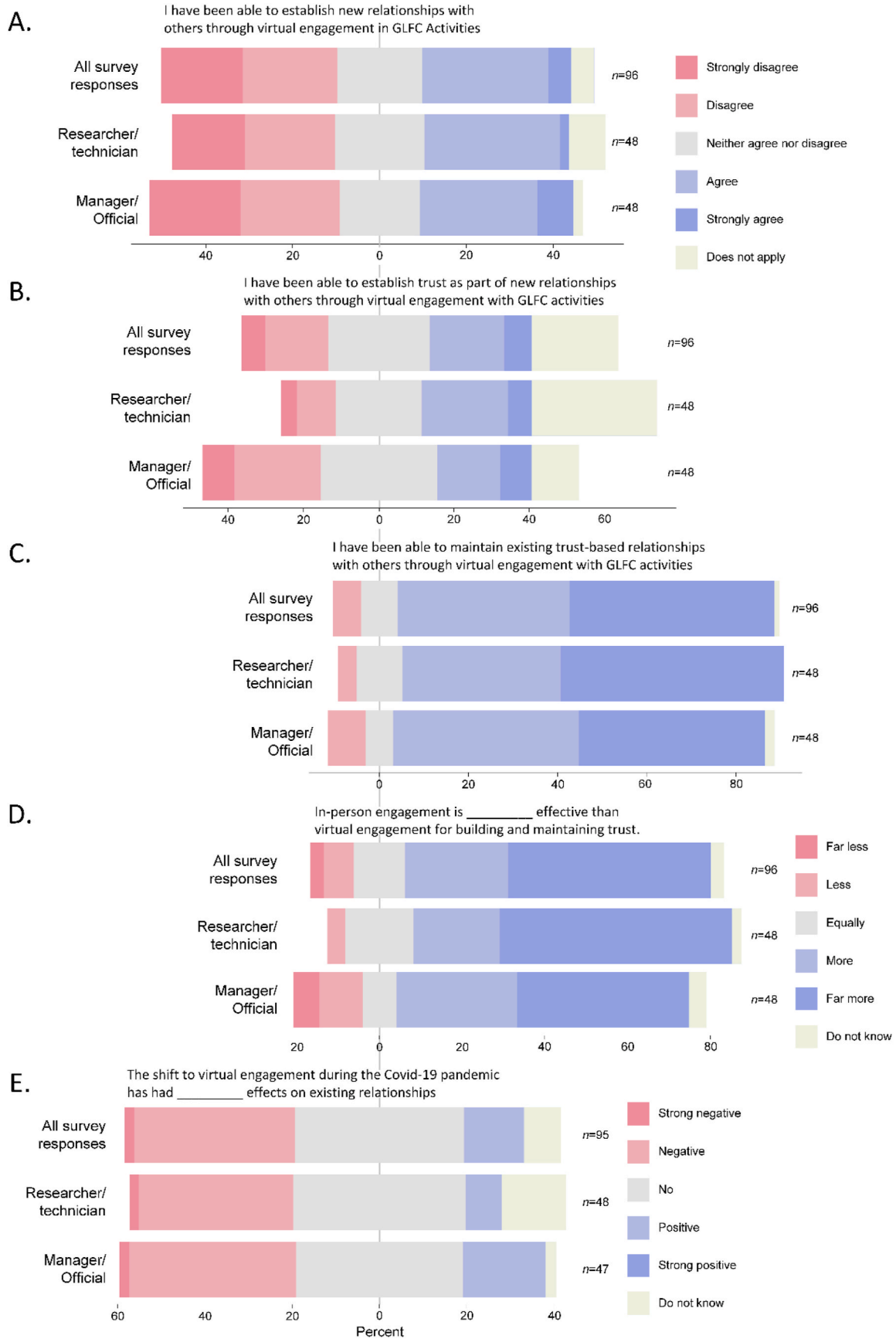


Fig. 1. Diverging stacked bar chart with counts (n) for survey responses (18–27 May 2022) from the Great Lakes fishery management and science communities. N.B., only data from researchers and managers/officials are depicted in this visualization and non-responses were excluded (see methods).

critical pre-condition underpinning effective knowledge exchange among scientists and decision-makers to enable evidence-informed decision-making (Cvitanovic and Hobday, 2018; Song et al., 2019). Looking across disciplines, trust (and trusted relationships) has also been linked to organizational success (Meyerson et al., 2006), improved capacity for problem solving (Nielsen and Nielsen, 2009), and innovation (McEvily et al., 2003)—all of which are necessary for successfully navigating modern-day environmental challenges.

The JSP process is a key example of a management regime that succeeds because of long-term, trust-based institutional and individual relationships. The JSP is not a formal treaty and signatory agencies have not abrogated their jurisdictional authorities to participate. As a result, the JSP works through the development of relationships that allow for trust building when developing consensus decisions. Long-term success is reinforced through personal communication and interaction. Prior to the formation of Lake Committees in 1964, cross-border cooperation, harmonized regulations, collaborative science, and trust were virtually non-existent, resulting in considerable damage to the fishery and the ecosystem (Gaden et al., 2021). Under the working arrangements detailed in the JSP, Lake Committees, and their subcommittees, have been convened at least annually, in-person, since 1964; COVID-19 stopped those meetings in 2020. Relationships are important, noted Gaden (2007, p. 91), in a study of the JSP process, because they “increase understanding among committee members; they increase trust and, therefore, the feeling that decisions made will be kept; they make dishonesty or insincerity undesirable because such behavior threatens future relations; and they make interjurisdictional cooperation enjoyable.” A quotation from a Lake Committee member in 2004, gathered during a study about the JSP process, puts a fine point on the value of relationships:

“The amazing thing is, people have these critical dialogues during the day and they

disagree, they disagree, they disagree. Nobody walks out of the door and says ‘you son

of a bitch, I am going to screw you the next time.’ We go and have dinner and we

continue the discussion” (Gaden, 2007, p. 93).

The development and management of trusted relationships, however, is not without its challenges. For example, trust is highly dynamic and fragile in nature, and while considerable time and effort is required to build trust, it can be rapidly lost (Cvitanovic et al., 2021). Unsurprisingly, the time, effort, and activities required to build and manage an effective and optimal trusted relationship is very costly, both in a monetary and non-monetary (e.g., emotional effort) sense (Karcher et al., 2022). These data represent a clear warning that without change, the relationships foundational to cooperative, multinational fishery management in the largest freshwater ecosystem in the world are under threat. We suspect similar threats pervade natural resource stewardship globally.

3.2 Communications—Effective multiway communication among decision makers, technical staff, rightsholders, and stakeholders within jurisdictions and externally among bordering jurisdictions is paramount to effective transboundary resource stewardship (Song et al., 2019). Like many natural resource institutions, in-person, public meetings continue to be the primary vehicle for formal communication related to JSP implementation. Formal meetings provide fora for multiway communications among jurisdictions and their constituents. Discharge of duties, research results, management decisions, and emerging issues are communicated and discussed at formal in-person meetings. Formal meetings are often open to the public and can provide opportunities to obtain feedback from colleagues, rightsholders, and stakeholders on pertinent natural resource issues.

Perhaps the greatest casualty related to trust-based relationships realized throughout the COVID-19 pandemic was the reduction or loss of

informal communication through spontaneous in-person meetings (e.g., coffee, watercooler), chance conversations, or afterhours social engagements. Indeed, informal communications can serve to reduce conflict by “priming” the formal decision-making process (Gaden, 2007; Song et al., 2019). Said a Lake Committee member, surveyed in 2004, “never, never underestimate the importance of the social interactions after the meeting” (Gaden, 2007, Pp. 91–92). This same sentiment was clearly evident in our 2022 survey where one respondent noted “People are just faces on a Zoom call; getting to know people, identify common research and management goals and values happens outside formal meeting settings which can’t be replicated with online interactions.” Another participant in our survey lamented that because of COVID-19, trust-building interactions have been “essentially eliminated.” Through hierarchical modeling of survey data collected from civil servants working in the Great Lakes, Song et al. (2019) reported that informal communicative impact, largely determined by the frequency of informal communication, substantially influenced decision-making through formal channels within the Great Lakes transboundary governance network. While some informal communication channels remained intact throughout the COVID-19 pandemic, loss or continued reduction of informal opportunities to interact and effectively communicate will continue to affect trust-based relationships and ultimately natural resource decision making (see Fig. 1D).

3.3 Science synthesis and exchange—Knowledge generation was clearly affected during the pandemic through limited access by scientists and trainees to both the laboratory and field. Synthetic activities important in condensing, reconciling, and interpreting a corpus of knowledge are typically piggybacked on conferences or symposia, or addressed through dedicated workshops. After March 2020, conferences were canceled, were postponed, or pivoted to a virtual format. For instance, 28% of 587 conferences in the fields of business, economics, information technology, and management between March and August 2020 went virtual due to government laws, travel restrictions, gathering bans, or border closures (Falk and Hagsten, 2020), the remainder were either canceled or postponed (e.g., due to anticipated low attendance).

As we emerge from the pandemic, knowledge generation, synthesis, and exchange activities could be further influenced by fewer or less effective opportunities to collaborate (i.e., interact, communicate, brainstorm, plan, and create). The Canadian Forest Service knowledge practitioners reported the loss of interpersonal connections, social learning, and reduced information flow (i.e., “being in the know”) as the primary challenges and risks to knowledge exchange in a virtual world (Nguyen et al., 2021a). Sociologists view knowledge as embedded in social relations; therefore, interpersonal engagement including relationship building and maintenance is key to accessing, interpreting, and sharing knowledge (Nguyen et al., 2017). The downstream effects of slowing the progression and transfer of science is that the knowledge-action-gap (i.e., gap between data, evidence, and knowledge generated by researchers and those that are actually used by natural resource managers to make decisions) could broaden in a post-pandemic world (Fig. 2; Nguyen et al., 2017). A broadened knowledge-action-gap could reverse decades of progress toward closing the gap, thereby diminishing the ability of natural resource managers to identify and effectively respond to constituent needs with scientifically supported management strategy (Nguyen et al., 2021a). Reduced ability to respond to public concerns, for example, could further erode public trust and strain sometimes tenuous relationships between resource managers and their constituents.

On a positive note, we also observed that the pandemic itself led to much greater understanding by the public and decision makers about the value of rigorous evidence synthesis to guide public health decisions (<https://www.mcmasterforum.org/networks/covid-end>). As the evidence base grew and evolved, public health guidance often changed (Williams et al., 2020). This is not a failure, but rather the power of continually revisiting decisions based on an evolving evidence base (Elliott et al., 2021). Constantly updated evidence syntheses have

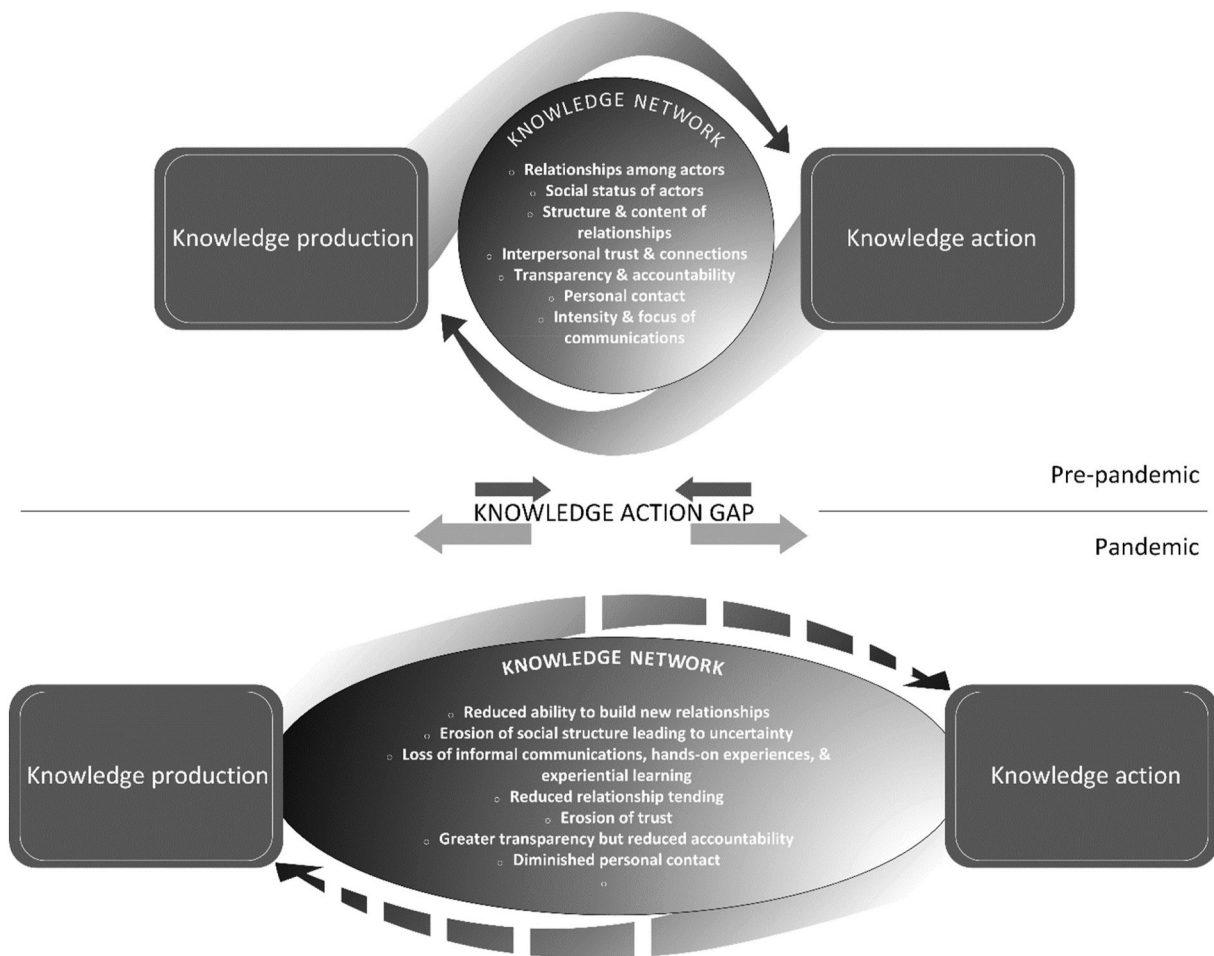


Fig. 2. Knowledge-action framework (Modified from Nguyen et al., 2017) showing key elements of a knowledge network that serve toward reducing the knowledge-action-gap (top panel). Working conditions associated with the COVID-19 pandemic continue to affect several elements of the framework potentially broadening the knowledge-action-gap by reducing the reciprocal flow of information among resource managers and scientists (actors) in the network.

become normalized in public health and would represent a useful advance in the natural resources and environmental management realm. Although many of the pandemic-related outcomes specific to synthesis arising from in-person interactions were lost, there is also potential for greater acceptance of formal evidence synthesis methods in the environmental sciences and natural resources such as systematic reviews (see <https://environmentalevidence.org/>) and rapid evidence syntheses that were common in health fields during the pandemic.

3.4 Stakeholder engagement and decision support—Decisions for natural resources management often involve different perspectives and values (Gregory et al., 2012; Keeney, 2004), uncertainty, and the need for collaboration across jurisdictions and institutions. Decision analysis (i.e., structured decision making and adaptive management [SDM]) provides a unique framework for making collaborative, transparent, and rigorous decisions for natural resource management (Robinson et al., 2021). Through the SDM process, groups work collaboratively to frame a problem, identify a set of objectives that describe rightsholder, stakeholder, and decision-making values, develop a suite of alternatives, or actions, that could be implemented to achieve the objectives, identify the consequences of each alternative action on each objective, and make tradeoffs among objectives (Hammond et al., 1999). A strength of decision analysis is the ability to account for multiple, sometimes competing objectives, as well as uncertainties in ecological and social aspects of the decision at hand (Peterman and Peters, 1998; Robinson et al., 2019). However, trust among stakeholders and decision makers is paramount when values differ and uncertainty can affect decisions (Jones et al., 2016).

A pre-pandemic success story of stakeholder engagement to inform fishery management decision making is the Lake Erie Percid Management Advisory Group (LEPMAG). The ability to use SDM to bring stakeholders together offered them the opportunity to know each other and understand individual values and perspectives before decision inputs were needed (Robinson et al., 2019). Informal relationships among a diverse group of stakeholders, as the SDM process unfolded, allowed stakeholders to share their perspectives and arrive at acceptable advice to the Lake Erie Committee (LEC) about walleye *Sander vitreus* and yellow perch *Perca flavescens* harvest objectives. As a result, the LEC has developed new walleye and yellow perch management plans (Lake Erie Committee, 2019, Lake Erie Committee, 2020; available: <http://www.glfc.org/pubs>). The LEPMAG process, with its stakeholder input, also has allowed the LEC to reach consensus about highly contentious annual allowable catches of these two valuable species much more easily than before the LEPMAG process began. Because of the trust built between managers and stakeholders during the LEPMAG process, recent quota reductions for yellow perch were understood and accepted by stakeholders. These sorts of benefits from long-term, face-to-face discussions would not be possible in a completely virtual setting.

In contrast to the successful LEPMAG process, the shift to virtual decision analysis workshops during the COVID-19 pandemic arguably has led to a lack of or diminished building of trust among SDM workshop participants. Although virtual meetings have allowed for stakeholder participation without associated travel and costs, when stakeholders have different values, the lack of opportunities for building trust through shared experience (e.g., meals and breaks) has emerged as a significant

impediment to virtual SDM. In addition, the SDM process itself is time-consuming, which has led to multiple, short virtual meetings, with some stakeholders expressing frustration, leading to associated attrition in participation (K.F.R. personal observation based on five ongoing SDM projects). For example, an ongoing SDM project focused on a fisheries decision in the Great Lakes was conceived of as two 2-day workshops. However, after an initial presentation to potential stakeholders in February 2020, the timeline extended and pivoted to four virtual workshops (2–3 h in duration) with a final, in-person workshop that was conducted in September 2022. Although the absolute number of attendees remained similar throughout (mean = 15 attendees), high participant turnover hindered the process. Seven stakeholders attended only the first one to two workshops, whereas another six stakeholders entered late in the process, only attending the last one to two workshops. This turnover in attendance led to a subset of stakeholders who did not understand the foundation of the process, as well as a loss of collective knowledge attributable to attendee turnover. The extended timeline, long gaps between meetings, and inability to feel trust and ownership in the process likely contributed to observed attrition and changes in participation. Ultimately, resource stewardship decisions can suffer from a lack of trust in formal decision support processes if in-person engagement is not part of a post-pandemic new-normal. With one exception, our survey was not distributed to stakeholders, but with respect to new clients and stakeholders who have only experienced virtual engagements without meeting in person, one federal official in our survey remarked “*That is not a good trust or relationship builder.*”

4. Opportunities in post-pandemic new-normal

Despite the many threats posed by operating in a virtual-first world, resource management agency staff rose to the challenge and made the most of opportunities presented, and new opportunities emerged during the pandemic. Many Commission partners (e.g., invasive sea lamprey control agents; see description in section 4.4) noted that virtual platforms allowed them to participate in meetings that otherwise they would not have been able to, which has enhanced transparency in decision making and recommendation processes leading to better trust among the Commission, its sea lamprey control task forces, and control agent staff. Likewise, some of our survey respondents noted that e-communications have actually increased engagement with staff and partners. One respondent noted that “*Communications have increased because of the virtual tools. We know that the quantity of communications increased, the question is, has the overall quality?*”

4.1 Inclusion and Equity—Teams are more effective and innovative when they consist of individuals with diverse backgrounds, experiences, and perspectives – particularly if those teams can effectively draw upon the diverse expertise of each member (Bear and Anita, 2011; Bodla et al., 2016; National Research Council et al., 2015). In the Laurentian Great Lakes, many rights holders, for example, have been excluded from science and management forums. Virtual platforms could expand opportunities for less-represented communities, rightsholders, stakeholders, and the public to participate in natural resource meetings where finance, time, or distance restrict in-person engagement (Nguyen et al., 2021a). The extent to which the pandemic will facilitate the reinvention of conference and other meeting models that are sustainable, equitable, and inclusive remains to be seen (see Niner et al., 2020). Many less-represented communities are interested in being at the table, but in various ways, may have limited capacity to participate. For instance, portfolios for many Indigenous community representatives are far more burdensome than can be accommodated—perhaps some of that burden can be alleviated through appropriate use of virtual platforms where available.

Virtual meetings represent an opportunity to engage professionals who face socio-economical barriers to travel and in-person meetings (Fulweiler et al., 2021). For instance, women have borne the brunt of increased child-care responsibilities and greater conflict among multiple

life roles during the COVID-19 pandemic (Kantamneni, 2020). Unbalanced childcare responsibilities have led to differences in the number of pre-print publications generated by women (+2.7%) compared to men (+6.4%; Viglione, 2020) during the early part of the pandemic. Despite challenges, women with young children and a college degree were more likely to work in 2021 than before the pandemic (Goldin, 2022). Women in STEM fields are likely to benefit from the greater career flexibility offered by virtual platforms. The call by King et al. (2020) for a fairer post-pandemic academic world where recruitment, retention, and promotion processes are more aggressive in enhancing diversity and minimizing inequities should be heeded as a new-normal evolves.

Closed-captioning, recording, and chat features available in many virtual platforms can enhance inclusion and active engagement of diverse communities with non-English language bases. To some extent, power structure may also be less prominent on a virtual platform, where participants can offer opinions at their discretion via multiple channels (e.g., chat) and where teams as opposed to individual chairs host and implement meetings, thus distributing power more broadly. In our experience, virtual meeting etiquette seems to have evolved to the point where most questions are acknowledged either directly or through the chat feature.

Notwithstanding the potential opportunities to enhance diversity, inclusion, and equity in a post-pandemic world, several challenges need to be addressed to realize benefits. For instance, many lesser-represented communities may lack technological capacity, such as bandwidth or training, to effectively engage via a virtual platform. Some knowledge systems may be incompatible with a virtual experience where time and place are essential elements of the experience; therefore, a virtual platform may be inconsistent with cultural norms of engagement. As we enter a post-pandemic new-normal, reconsideration of both formal and informal communication structures to enhance diversity, equity, and inclusion should be a driving consideration across environmental sciences and resource management. Ensuring those who want to participate can participate and hearing their voices will go a long way toward fostering new trust-based relationships and mending fractured relationships in natural resource management.

Multinational, interagency coordination—Multinational, interagency coordination and collaboration provides resilience to networks and stability to resource stewardship programs, which becomes especially apparent during times of austerity, crisis, or rapid ecological change. Asset sharing, workload partitioning, and method standardization are among the many potential benefits of multinational, interagency coordination. In the Great Lakes, these strong relationships, implemented via various agreement tools, are a primary reason that long-term data series (e.g., forage fish surveys) have been maintained through time.

Article VI-d of the 1954 Canada-United States Convention on Great Lakes Fisheries establishes the Commission duty to “formulate and implement a comprehensive program for the purpose of eradicating or minimizing the sea lamprey populations in the Convention Area (U.S. Department of State, 1956)” to allow for the rehabilitation and maintenance of economically and ecologically important fish communities. Invasive parasitic sea lamprey control is implemented in the Great Lakes via communications and memoranda of agreement among the Commission, U.S. Fish & Wildlife Service (USFWS; U.S. Control Agent), Department of Fisheries & Oceans Canada (DFO; Canadian Control Agent), and Great Lakes management agencies via the Council of Lake Committees and JSP process. Implementation of sea lamprey control was threatened during the COVID-19 pandemic due to travel restrictions that: (1) limited control actions to areas in close proximity of biological stations; and (2) prevented cross-border collaboration for field operations between USFWS and DFO. As a result, sea lamprey control activities were severely limited during 2020, such that only 25% of sea lamprey treatments were completed across the basin. Given the lifecycle of the sea lamprey, pandemic-related effects on control will likely be realized in the coming years and could result in dramatic losses of Great

Lakes fishes.

During 2021, strong multijurisdictional and multi-agency relationships were critical in facilitating rapid adaptation in the prosecution of effective sea lamprey control despite continued challenges of operating during a pandemic. Collaboration between DFO (a Canadian Federal Agency) and New York Department of Environmental Conservation and USFWS – Region 5 (Lake Champlain sea lamprey control agents, which are outside of the Great Lakes Basin) allowed for sea lamprey treatments to be conducted during 2021 on the U.S. side of Lake Ontario. Without robust trust-based relationships, coordinating and mobilizing the resources of two countries necessary to treat the U.S. waters of Lake Ontario within one year would never have been possible. This is but one example of potential threats mitigated in a timely way due to multinational, interagency coordination and collaboration. Adapting to COVID-19 pandemic related crises both highlighted the resilience of such relationships, but also the opportunities to strengthen and formalize interagency agreements and working arrangements.

A decade long trust-relationship between U.S. Geological Survey’s (USGS) Great Lakes Science Center, a federal agency, and the Great Lake states, Tribal agencies, and the Canadian Province of Ontario (via the Council of Lake Committees) provides another example of the kind of multinational collaboration that can provide continued coordination through crises, such as a pandemic. This relationship was formalized through a 2004 Memorandum of Understanding (MOU) that facilitated U.S. federal investment in the deep-water science services required for Lake Committees to make informed decisions about native species restoration and stocking of top predator fishes in the Great Lakes. Since 2004, the MOU has resulted in strong, binational, interagency coordination and cooperation. Mutual commitment to the MOU has allowed USGS to modernize its vessel fleet and maintain the necessary scientific staff and vessel crews to operate throughout the Great Lakes, including Canadian waters, providing key time series survey data to support Council of Lake Committee decision making. Personal relationships from USGS vessel staff all the way up to their director, and Council of Lake Committee members were critically important to the success of this initiative. Formal agreements could strengthen other activities, such as bridging water quality and fishery managers towards an ecosystem-based approach to resource management.

5. Implications for natural resource governance

We argue that moving forward in a largely virtual world presents many challenges to our collective social license and support for resource stewardship. To confront present challenges, we urge governments to

prioritize informal interactions fostered by in-person meetings while also recognizing the importance of virtual meetings to conduct routine business in a cost-effective manner. Annual financial gains from limiting staff travel will not offset long-term impacts to the trust relationships vital for multi-jurisdictional and multinational resource management. Societies have learned and grown tremendously during the past three years. Similarly, limiting opportunities for face-to-face public engagement by decision-makers and practitioners will erode trust and represent a step backwards in partner-engaged co-management. Many opportunities emerged out of pandemic working arrangements and we urge policy makers and influencers to seize these opportunities. Adoption of a conceptual framework (Fig. 3) where the outcomes of the decision-making process drive the appropriate level of engagement could help agencies prioritize and plan resource allocation.

5.1. No substitute for in-person engagement

Humans are social creatures. The human brain evolved in a social setting to integrate real-time information from as many as five senses to inform decision making. Virtual platforms engage only two senses, sight and hearing; therefore, virtual engagement for some occurs under sensory deprivation, and will never be a wholesale substitute for in-person engagement. For instance, videoconferencing may narrow cognitive focus and has been shown to inhibit production of creative ideas (Brucks and Levav, 2022). On the other hand, virtual platforms may be a more effective communication platform for some, due to options for accommodating differing abilities (e.g., closed-captioning). Thus, the information communicated in-person differs substantially from that conveyed across a virtual platform, which may either impede or enhance ability to effectively communicate, interpret, and act on the information being conveyed in a virtual-first world (Brucks and Levav, 2022).

Despite some shortcomings, virtual engagement will certainly be part of a post-pandemic new-normal and welcomed particularly where efficiencies can be realized, such as: (1) care and nurturing of well-established long-term relationships; (2) short-term (1–3 years) trust maintenance; (3) peer-peer or mentor-mentee coordination and administration; (4) supplemental communications; (5) producer-push knowledge dissemination; and if done thoughtfully, (6) enhancing diversity, equity, and inclusion.

5.2. What is the role of hybrid meetings?

In general, a hybrid meeting is where a subset of the participants is together in the same physical location whereas the remainder of the

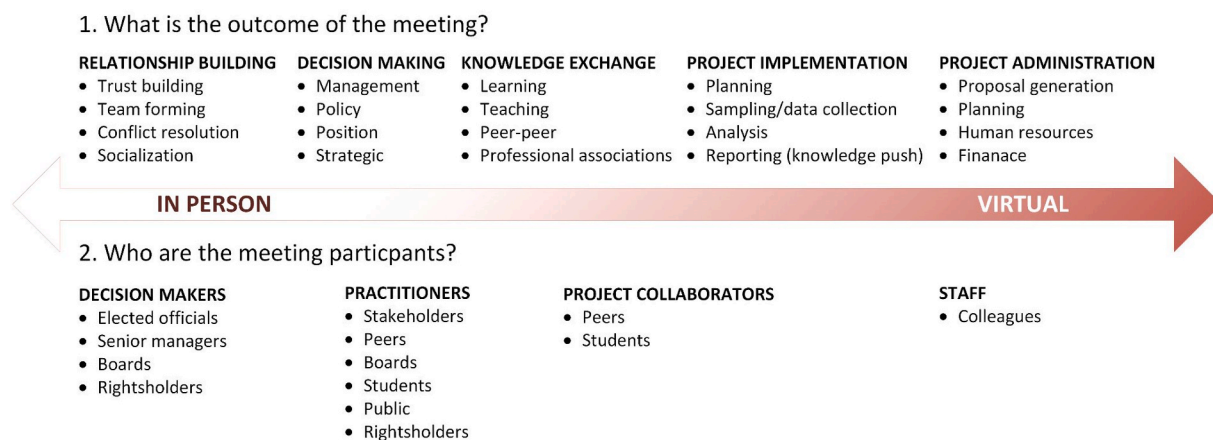


Fig. 3. Considerations for meeting planning in a post-pandemic new-normal. Meeting outcomes, relevance of actions, and type of participants should be considered in justifying the meeting platform. All outcomes are important as are the participants and other considerations, such as health and safety, are critical to meeting planning. But the meeting itself is not the product of the decision and this conceptual model offers some guidance on whether resources should be committed to in-person versus virtual engagement assuming health and safety of staff are not jeopardized.

participants are remote. Here, we differentiate between in-person meetings or conferences where a virtual link is available for additional participants to watch and pose questions versus meetings where all participants are vested and responsible for exchanges, debate, decision making, and ultimately meeting outcomes affecting sustainable natural resource stewardship. In practice, a hybrid meeting could assume many forms; therefore, explicitly defining what we mean by hybrid meeting and documenting best hosting practices, appropriate technologies, and effective facilitation tools is required to ensure effective meeting delivery and equitable engagement among all meeting participants, regardless of their physical location. If the above challenges can be overcome, several hurdles to implementation of an effective hybrid meeting remain. For instance, travel approvals for in-person participation may not be granted if a remote participation option is available; remote participants are not privy to informal discussions on the meeting margins or during social engagements setting up potential inequities; the collective meeting experience is limited to in-person participants; and a great deal of technical orchestration is required to pull off a successful hybrid meeting. Moreover, hybrid meetings are antithetical to history and what we know about why resource management processes like the Joint Strategic Plan for Management of Great Lakes Fisheries work. That is not to say that hybrid meeting options do not provide value and meet many needs; they certainly do. For instance, hybrid meetings are likely going to be the norm for the foreseeable future due to disparate vaccination statuses, travel and office policies, and individual personal risk acceptability. For instance, unvaccinated participants have been excluded from in-person meetings where venue policies mandate vaccines. In-person scientific conferences require travel which often disadvantages certain groups including individuals from low- and middle-income countries—hybrid conferences and events could help to provide those individuals a voice. As such, a hybrid format may become more common in the future, particularly as technology advances, because it increases access for people who could not otherwise participate in-person. We suggest that a hybrid model is not likely to be an effective replacement of fully in-person resource management meetings moving forward and should be used with caution as a potential bridge to a new-normal that prioritizes face-to-face supplemented by virtual meetings.

5.3. Recommendations

We envision a post-pandemic new-normal to embrace a commitment to funding and supporting resumption of safe in-person engagement, particularly for resource management meetings involving decision making. Our review of available literature and survey clearly indicate that trust-based relationships—the foundation of resource governance networks—require in-person engagement. Virtual platforms certainly offer opportunities to supplement, and in some cases improve in-person engagement as evidenced by our survey results. Meeting objectives and outcomes should drive meeting platforms where diversity, equity, and inclusion are critical elements of meeting planning (Fig. 2). Hybrid meetings should be considered only when there is no alternative to an in-person meeting as a post-pandemic new-normal evolves. Having a hybrid virtual option in an otherwise in-person meeting should not be deemed as a means to opt-out of an in-person meeting except in circumstances where that model enhances inclusion (e.g., by allowing immunocompromised individuals, parents, elder care providers etc., to participate). Indeed, we should also heed the lessons of the COVID-19 pandemic and explore how we can conduct in-person meetings in more inclusive and sustainable ways instead of returning to the previous status-quo. As one Great Lakes federal government researcher put it: *“These new people that I have met remain at my initial “default” trust setting, but the trust has not grown in the virtual space.”*

Credit author statement

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Writing – original draft, Writing – review & editing, Visualization, Supervision, Project administration, J.R. Bernhardt: Methodology, Writing – original draft, Writing – review & editing, N.W. Boucher: Validation, Formal analysis, Writing – review & editing, Visualization, C. Cvitanovic: Conceptualization, Methodology, Writing – original draft, Writing – review & editing, J.M. Dettmers: Methodology, Writing – original draft, Writing – review & editing, M. Gaden: Conceptualization, Methodology, Writing – original draft, Writing – review & editing, J.L. M. Hinderer: Conceptualization, Methodology, Writing – original draft, Writing – review & editing, Visualization, B. Locke: Methodology, Writing – original draft, Writing – review & editing, K.F. Robinson: Methodology, Writing – original draft, Writing – review & editing, M.J. Siefkes: Writing – original draft, Writing – review & editing, N. Young: Conceptualization, Methodology, Writing – original draft, Writing – review & editing, S.J. Cooke: Conceptualization, Methodology, Writing – original draft, Writing – review & editing

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Declaration of competing interest

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Data availability

Data will be made available on request.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jenvman.2022.117140>.

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