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COMMENTARY

Macrosystems Biology

Shared leadership can promote success in collaborative research networks in ecology

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Abstract

1. While collaborative science is becoming the norm in ecology, many ecologists participating in collaborations are less aware of the body of research that studies the processes by which collaborative teams organize and communicate.
2. Here, we discuss how we successfully used a shared leadership model in the Dry Rivers Research Coordination Network. We discuss how this model promoted our success in different stages of the project, using the Tuckman model of team development: forming, storming, norming, performing and adjourning.
3. Shared leadership in the forming phase helped us recruit a diverse membership from different scientific disciplines. In the storming and norming phases, shared leadership was especially useful in ensuring that all voices were heard in establishing group norms that promoted adhesion among and investment by RCN members. Shared leadership in the performing phase was crucial in providing opportunities for early career members to lead projects, and in the adjourning phase we reflected upon our entire collaboration to identify that shared leadership was crucial to our success, generating the thesis for this commentary.
4. It is our hope that others may find this discussion of our experience in implementing a shared leadership model useful in developing their own fruitful collaborations.

KEYWORDS
collaboration, leadership, research network, team development, team science

For affiliations refer to page 7.

1 | INTRODUCTION

Scientific research is an increasingly social enterprise, with recent decades witnessing a shift away from research produced by individual 'lone author' scientists towards team-based production (Rawlings & McFarland, 2011; Wuchty et al., 2007). What was once termed a 'violent transition' a half century ago (Price, 1963), the dramatic rise in scientific collaboration is now both commonplace and welcome (Stokols et al., 2008). Moreover, the trend towards team science has broken down silos and extended research beyond collaboration within a given discipline (Hara et al., 2003; Mazzocchi, 2019). Multi-author publications are now the norm in science, engineering and social sciences, but less so in the arts and humanities (Fortunato et al., 2018). Still, the shift towards team science is occurring in all disciplines (Lin et al., 2023). Multidisciplinary, team science helps fuel scientific discovery and is widely considered a prerequisite to tackling many of the grand environmental challenges facing humanity (Cheruvelil & Soranno, 2018; Ledford, 2015; Tallis & Lubchenco, 2014).

While team collaborations come with some risks (Forscher et al., 2023), when managed well, the risks are typically outweighed by a wealth of positive outcomes. There are many ways to measure the success of a collaboration. Scientific advances produced by the team are important and common measures of success, such as publications, proposals submitted and funded and awards received (Love et al., 2022). Some successes are more difficult to measure, such as workforce training and development, strengthening of interpersonal connections and scientific community cohesion and translational research with a broader societal benefit. The level of integration within the network and the engagement and satisfaction of team members can also indicate success, as can the presence of follow-up collaborations following project completion (Wu et al., 2019).

Challenges in team science often arise in the distribution of leadership. Leadership structures can vary from a strongly hierarchical model that is common in medical research, to a more egalitarian or 'shared' model common in social science (Griffin et al., 2013). Struggles can similarly arise in the sharing of data, due to conflicts between individual factors of scholarly altruism, perceived career risk and employer or contractor restrictions in data sharing (Kim & Stanton, 2016). Finally, a perennial issue is that the sharing of credit can be an obstacle, as authors often overestimate their contributions (Herz et al., 2020). These challenges are often exacerbated by a lack of available training for scientists, particularly early career scientists, on how to be successful with collaborative and team science (Baker, 2015).

Here, we argue that a shared leadership model has been crucial to overcoming these challenges and achieving success as the Dry Rivers Research Coordination Network (RCN, funded by the US National Science Foundation), a collaborative team of hydrologists, biogeochemists and ecologists, formed to understand non-perennial rivers from a multidisciplinary perspective. We define 'shared leadership' as a leadership style where responsibilities, influence and decision-making are distributed among multiple individuals rather than being concentrated in a single leader. We discuss how a shared leadership structure, clear guiding documents and a focus on early career scientists has led to what we believe has been a successful collaboration: productive in research, communication, peer mentorship, personal career advancement and continued collaboration and professional relationship building.

We use the Tuckman Framework to structure this discussion, as we examine how our shared leadership model facilitated the development of these elements of success throughout different stages of a project: forming, storming, norming, performing and adjourning (Table 1; Tuckman, 1965; Tuckman & Jensen, 1977). The forming stage is when the team is initially assembled, followed by the storming stage where conflicts occur, resulting from differing expectations about team dynamics and goals. In the norming stage, the team resolves these conflicts and reaches consensus on how to work together. This leads to the performing stage, when the team is most productive, and members work in smaller sub-groups as a multiteam system, completing sub-projects or components that contribute to the larger project. Finally, in the adjourning stage, the project winds down and ends and team members experience change and process feelings of termination and transition.

2 | FORMING

A fundamental part of the *forming* stage for collaborative networks is assembling a team and establishing early membership dynamics. In our experience, it is important to begin a project or sub-project with a core leadership team whose members have complementary strengths in terms of project management, interpersonal skills and ways of doing and communicating science (e.g. modelling, experiments, or other specialized skills). A diverse leadership team is foundational for the successful recruitment of participants from across multiple axes of technical and human diversity, both inherent and acquired (Cheruvelil et al., 2014). In the Dry Rivers RCN, this core leadership team was a steering committee of individuals who participated in the writing of the proposal that funded the group, and an advisory committee formed of individuals that represented different disciplines and geographic regions. Individuals of both committees were recruited to conduct searches that would recruit new members by open calls that were distributed within existing networks and by social media.

As members of a collaborative team are recruited, it is essential to discuss and agree on participant expectations, such as the overarching goals and mentoring philosophy, and defining the initial scope of the work. This will facilitate the creation of clear team norms, such as participant codes of conduct, authorship agreements and data sharing rules (Dodds, 2024; Love & Dickmann, 2025; The Lotic Intersite Nitrogen Experiments, 2014). Creating these documents can be time-consuming, but doing so may ultimately help avoid conflicts, or resolve them more quickly. For example, our code of conduct outlines the group's core values and expected behaviours to minimize interpersonal conflict in an equitable way, and importantly,

TABLE 1 Summary of team development stages in the Tuckman model and shared leadership practices used by the Dry Rivers RCN.

Stage	Definition	Shared leadership practices
Forming	Assembling a team and establishing early membership dynamics	A core leadership team creates an initial group vision to set expectations and recruit diverse team members
Storming	Creative differences and conflict in team vision and goals	Core leadership team provides an initial code of conduct that creates proactive guardrails, which is revised with team input to obtain buy-in and establish a safe and respectful environment
Norming	Developing a shared purpose and overcoming conflict	Team members focus on coming to an agreement on scientific differences as opposed to interpersonal conflict. Storming phases may be revisited following norming phases in iteration as the project develops, and new members join
Performing	Working together to achieve team goals	Use of shared documents, file storage drives, and communication channels. Regularly scheduled virtual meetings and co-working time coupled with less frequent in-person work retreats. Adaptive leadership that addresses challenges
Adjourning	Finalizing projects and team conclusion	Team reflection on successes and failures to evaluate the project. Providing opportunities to continue working together for those interested

it establishes consequences for unacceptable behaviour. In addition, the group discussed authorship guidelines and authorship contribution tables (see Supporting Information). The authorship guidelines outline a philosophy of inclusivity, criteria for authorship and promote personal reflection on individual contributions. The author contribution template provides a transparent mechanism for contributors to specify where and how they deem having contributed to a given manuscript. It provides a quantitative way for the lead authors to assign authorship order when linked to individual contributions. Developing data sharing policies requires meeting data availability requirements from funding agencies, then involves additional negotiation to balance the competing objectives, needs and value systems of team members. In many teams, participants strive to produce findable, accessible, interoperable and reusable (meta) datasets (i.e. FAIR (meta)data, Wilkinson et al., 2016). However, co-developing shared data policies still requires team members to negotiate through conflicting needs of project participants associated with early career publications, group-wide syntheses and making the data available to the larger scientific community.

As a large collaborative team is assembled, it is important to recognize that it is often made up of multiple smaller teams, so that the larger group functions as a ‘multi-team system’. These smaller teams may be responsible for individual components of the larger project, and individual collaborators may find themselves participating on multiple teams. This structure allows each team to identify specific goals, understand their role in the larger group and understand how their goals relate to those of the other teams on the project (Carter et al., 2019). Maintaining smaller team goals and emphasizing the dependence on other teams can promote performance and innovation, leading to overall group success (Carter et al., 2019; Murase et al., 2014; Shore et al., 2015).

Despite our efforts to broadly distribute recruitment opportunities into our RCN (e.g. via social media and professional message boards), we found it challenging to recruit beyond existing collegial networks. To help address this challenge, it is important that collaborative efforts offer a variety of tangible benefits to participants in terms of career advancement, skill development, funding support and professional networking opportunities, to name a few (Goring et al., 2014). In order to build trust across diverse communities, it may help to advertise opportunities using multiple platforms and languages prior to initiating collaborative efforts (Ejiogu et al., 2011; Yancey et al., 2006), and increase participation at national conferences such as the Society for the Advancement of Chicanos and Native Americans in Science and the American Indian Science and Engineering Society where relationships can be built. Finally, including members from historically underrepresented groups in the core leadership team at the onset of a project (e.g. the proposal writing stage before a project is even funded) would greatly aid in overcoming any inertial forces that can impede the creation of diverse research teams.

Defining a collaboration's technical scope and core objectives during the forming stage provides clarity that enables participants to understand how they can engage with and benefit from collaboration (Tuckman, 1965). Using a shared leadership approach and taking time for team members to build rapport and trust can help provide meaningful benefits (Cheruvelil et al., 2014). Shared leadership teams, in which the group's performance is driven by the members, and all members are invested as equal partners in overall project success, are often more productive and innovative than projects with hierarchical leadership (Xu et al., 2024). We approached team forming as an iterative process based on feedback from other stages of the collaboration lifecycle (i.e. across storming, norming and performing stages). However, the forming stage may look different over multiple iterations as new individuals join the effort and technical results emerge.

Despite best efforts, iterative forming stages may not always be successful. For example, one of the forming iterations of the Dry Rivers RCN occurred during the COVID-19 pandemic, when workshops and collaborations were occurring exclusively online. Some new members struggled to identify their roles in the larger group during this period. In subsequent recruitment efforts, we were more intentional and mindful about helping new members integrate into the existing group. For example, new team members were brought on with clear roles in mind based on their regional and disciplinary expertise, and in in-person workshops we organized regular icebreaker activities and networking sessions so that new members could integrate into the larger group more easily. We were much more successful in retaining members with this combination of providing clear mechanisms for involvement in in-person settings where social interactions are more natural.

3 | STORMING AND NORMING

The original definition of *storming* centres around interpersonal conflict, which is then resolved through the norming stage (Tuckman, 1965). The goal of the storming stage is to ensure that creative differences can arise in a constructive way; while recognizing differences, we strive to minimize negative outcomes that arise from personal or emotional conflict. Here, it is important to create an environment of psychological safety, where members feel safe in engaging in personal risk-taking to be able to engage in constructive conflict (Newman et al., 2017). The *norming* stage is associated with developing a shared purpose and vision for the group's work, overcoming conflict and identifying productive roles for all group members (Tuckman, 1965). During this phase, groups spend energy and time deepening working relationships that lead to productive outcomes. Our group's experiences with respect to navigating conflicts deviated from the original (Tuckman, 1965) model because our storming and norming phases happened iteratively, and often in concert (Figure 1). In setting the storming-norming stage for the DryRivers RCN, we used a shared leadership model to delegate tasks and responsibilities, and leadership roles were open to any interested individuals.

A key feature of our iterative storming-norming approach was developing shared 'norms' and values early after the team was formed. We were able to minimize interpersonal conflicts by creating guardrails for collaborations that were proactive instead of reactive. Some of these guardrails include the code of conduct that was first introduced in the forming stages (Supporting Information). In this phase, group members were provided time to reflect on these policies as well as suggest changes, thereby increasing personal buy-in for group norms and dynamics. In addition, the values and expected behaviours outlined in the code of conduct were crucial to creating an environment where team members could 'storm' in a safe, respectful way. As policies and expectations dictating conduct, leadership, and organizational structures are implemented and adapted, individuals begin to feel more comfortable with the team in collaborative space. This guiding frame allows group energy to be focused on digging into differences in scientific perspectives as opposed to interpersonal conflict. The norming stage ensures that the group grows beyond a performative set of expectations. We believe our shared leadership model facilitated this process, as we had a shared obligation to each other to follow administrative policies that we developed collaboratively.

Regularly revisiting administrative policies set in the storming-norming iterations is also crucial for overcoming conflict as the project develops. For example, authorship policies may need revision given the objectives and deliverables for specific projects. We developed 'opt-in' authorship guidelines where authors defined their planned contributions to the manuscript. During the development of each manuscript, authorship contributions were revised as needed based on the contributions made at various stages to ensure potential co-authors are contributing and to enable new people to join if they see opportunities to further develop the research. This iterative process allows for re-norming after significant changes that may happen along the course of the project as well. For example, the Dry Rivers RCN used anonymous polling to develop COVID-19 policies for its first in-person meeting after the pandemic to ensure all participants could comfortably and fully engage in in-person activities. Making collective group comfort a priority was essential for the success of the meeting and the overall success of the team.

The storming-norming phase can include conflict and resolution of scientific perspectives in addition to group interactions. This is especially important in interdisciplinary work, where bringing together different disciplines may have an inherent storming phase due to differences in research foci, methodology, vocabulary, etc. For example, the Dry Rivers RCN worked on a project identifying different mechanisms of wetting regimes and how each may impact ecological and biogeochemical processes (Price et al., 2024). From the beginning, we needed to establish what even was considered wetting, that is, return of continuous flow, any water in the channel even pooled, etc. This was viewed differently across group members that came from earth science versus life science backgrounds and led to a variety of definitions depending on the scientific focus area (storming). However, in the process, we were able to identify potential different wetting mechanisms, which led to the three categories of wetting described in the manuscript (norming).

4 | PERFORMING

In the *performing* stage, the team is fully functional and working together to achieve their goals (Tuckman, 1965). Project initiation with multiple perspectives and ideas fosters greater participation and

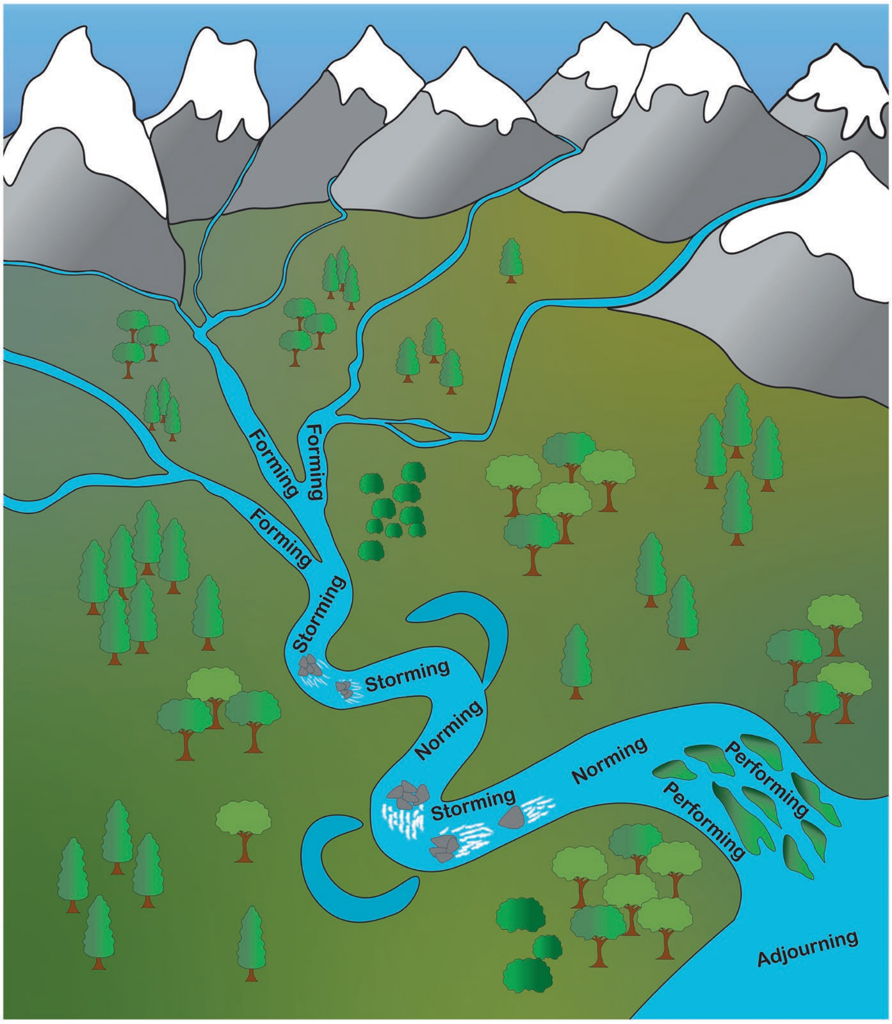

FIGURE 1 A conceptual diagram of how our Dry Rivers RCN progressed through the Tuckman stages of team development. Like tributaries flowing into a river, individual members joined the team in the forming stage. The team navigated conflict like river rapids in the storming phase, and then settled into the norming phase like a slow-moving pool. In the performing stage, our network operated as a multiteam system, with multiple sub-teams flowing downstream like a braided river. At the end of our project, our members adjourned out to sea and moved on to the next phases of their research careers.

higher 'collective intelligence' than when fewer members dominate conversations (Woolley et al., 2010). Promoting continual development of new projects with minimal pre-requisites reduces the initial hurdle of starting a project (expertise, time constraints, impostor syndrome) and gives room to all interested contributors to shape the project's scope. Project initiators are not required to take on continued leadership; they can start a project and call for others to take on the lead to carry it out. Once a project starts, contributors are invited to join the group at multiple stages, welcoming diverse levels of expertise on the topic and various roles in project development and manuscript writing. A continuous entry model also promotes regular ingress of new perspectives unbiased by project development history. Not all projects require the same organization, which also allows for a diversity of and easy entry points to contributions.

Working together in person for multiple days can move projects forward very quickly while concurrently building interpersonal relationships among team members (Love et al., 2021; Parker & Hackett, 2012). For example, the Dry Rivers RCN held work retreats in remote field stations with minimal distractions. Meeting agendas were largely crowd-sourced, where participants gave updates on projects to the larger group or led small, section-specific focal groups to move individual projects forward (typically peer-reviewed papers). Prior to work retreats, we would complete tasks that would make in-person work more efficient, such as compiling and organizing datasets or conducting core analyses. In addition to focused working periods, we found it beneficial to include informal meetings during work retreats, such as ice breakers, coffee breaks, shared meals and recreational activities. Such breaks and activities can further develop a shared, inclusive community which leads to more positive outcomes, fewer conflicts and further development of relationships (Cheruvelil et al., 2014; Parker & Hackett, 2012). We acknowledge that in-person workshops may not always be an option, and in these cases, we found online workshops or frequent co-working meetings to be effective at creating short bursts of excitement and connection. One way the Dry Rivers RCN has successfully collaborated during these short meetings was through online, cloud-based documents that allow for concurrent editing. This allowed participants to work cooperatively on the same version in real time, regardless of where virtual participants are located and contributed to the sense of a shared mission and teamwork. Through these activities, we provided multiple ways for people to engage with the work of the Dry Rivers RCN, leading to shared excitement and genuine engagement.

Whereas a strong centralized leadership model has a 'hub' that distributes drafts or centralized communications, we contend the use of shared documents, storage drives, informal communication channels, etc. allow the ownership of various elements of a project. These technologies also enable emerging leaders to readily 'own' new projects. At the start of meetings, brief tutorials were made available to ensure that all group members are comfortable using collaborative technology platforms and how the collaborative technology is organized. During project meetings, the agenda was open to contributions and meeting notes were accessible and editable by everyone in the group. This allowed built-in pauses for contributions by the whole team before moving on to the next agenda item, and for inclusive leadership using technology to solicit feedback and to delegate. After meetings, post summary notes, recordings, information about future directions, group assignments and individual action items were made accessible to the group. Openly sharing all data and codes in an open science philosophy promoted collaboration by allowing group members to understand idea development, methods and interpretation of results.

Finally, we also want to highlight that there are unique challenges to maintaining the performing stage using a shared leadership model. In particular, as leadership becomes more distributed, it is important that teams be mindful of accountability and follow through (i.e. who is going to finish the work, Love & Dickmann, 2025). This can be achieved through both formal and informal strategies. Informal strategies include developing strong team culture/norms and developing team structures with redundancy, while more formal strategies could include both rewards (i.e. paper authorship) and performance reviews. Other key risks include loss of initial vision of the project, misbranding and misattribution. However, these risks can be mitigated by integrating components of adaptive leadership, a leadership style that is open to feedback and ready and willing to work on changes (Heifetz, 2009). Reflective self-assessments can identify limitations of the present structure, revisit established norms and ensure that new participants are able to experience norming and storming phases that are essential for group development. Additionally, as sub-projects or project components start up and wind down, the infusion of new energy and ideas can keep the group motivated to continue performing. One way in which we achieved this in the Dry Rivers RCN was to facilitate newer and/or early-career team members to ascend to leadership roles for their areas and sub-projects of interest and to regularly recruit new members at different stages of the project.

5 | ADJOURNING

After the original model was published, Tuckman and Jensen (1977) added the *adjourning* stage, which focuses on the final stage of a group. This stage broadly emphasizes finalizing ongoing projects, the conclusion of the group project and the separation of the team. In this stage, the team should reflect on aspects of the collaboration that went well and what did not, enabling a more informative understanding of the best ways to move forward.

A crucial question to reflect upon is whether the project was successful. The most important measure of success for funding entities is whether the supported research solves the problems set out in the proposal or makes novel and unanticipated advances in the field. Traditionally, metrics for measuring success have been papers published, patents secured, databases compiled and mentees graduated. However, there are other measures of successful multidisciplinary collaborations that foster the broader impacts of research network development. These expanded success measures can include positive participant experiences, interpersonal communication growth, research culture building and maintenance, hires of early career participants into permanent positions and establishing connections with other research networks (Goring et al., 2014). While we informally discussed our progress towards such metrics throughout our project, we now realize we missed an opportunity to clearly define what metrics we most valued and what our attainment goals would be at the onset of our project. Had we done so, we could have regularly quantified our progress and adapted as needed to achieve our goals. We would encourage future collaborative groups to do this, as incorporating these expanded success measures as a priori goals will encourage effective and intended collaboration to solve challenging problems.

In the Dry Rivers RCN, we used our adjourning phase to evaluate our shared leadership approach as a hypothesis itself. One may hypothesize that if we pursue a set of scientific questions using a shared leadership model, it will lift up a community of researchers around those questions, and that the network itself will emerge as a metaphorical root that produces many branches. There are multiple ways to evaluate this hypothesis. Teams can catalogue the number and breadth of follow-up research efforts to ask whether there are numerous new branches. If there are not, one can reject the hypothesis. In our case, our RCN lasted 5 years in duration, and three additional funded projects that branched off our work were awarded to RCN members during our active period. Our final meeting included taking time to reflect on ways for the group to continue to work together, including developing new formal grant applications (one of which has been recommended for funding at this time), the formation of a formal society chapter on our project's research theme, and informal group meetings focused on sharing individual projects. Importantly, members who wanted to continue to be involved with the group could find multiple ways to continue to collaborate, while those who were ready to move on to other projects and topics could step away naturally. More generally, while all projects formally end from a funding perspective, they can carry forward by feeding their branches with the next set of hypotheses and questions and approaches that are informed by all aspects of project outcomes (knowledge, community, etc.). The adjourning phase can thus use the scientific method to catalyse project evolution and diversification.

6 | CONCLUSION

Collectively, the Dry Rivers RCN not only resulted in scientific development, but also allowed for the development of several emergent properties through its community. This included an unusually collaborative culture based on an open and inclusive model, a group of committed collaborations, and perhaps some luck to form groups with good 'chemistry'. Open science practices and the promotion of data sharing was an emphasis of this network that had developed through prior successful collaborations and probably will be carried into future research projects (Lowndes et al., 2017). The success of our RCN is empirically measured by a high publication output that will form the basis of future science on non-perennial rivers. The networking and connections made during this project will move science forward, seed future advances, and yield new scientific understanding of non-perennial streams. We hope that some of the tangible aspects of our collaboration, based on lessons the group learned from prior collaborative efforts, can assist others in forming fruitful collaborations in the future.

AUTHOR CONTRIBUTIONS

Daniel C. Allen, Amy J. Burgin and Thibault Datry conceived the idea for the manuscript. Daniel C. Allen and Julian D. Olden wrote the Introduction section with contributions from Amy J. Burgin and Annika W. Walters, and with edits from Erin C. Seybold, Michelle H. Busch, Amy J. Burgin, Thibault Datry, Margaret Shanafield, Adam N. Price and Yaqi You. Walter K. Dodds and James C. Stegen wrote the Forming section with edits from Daniel C. Allen, Michelle H. Busch, Julian D. Olden and Annika W. Walters. Corey A. Krabbenhoft wrote the Storming section with edits from Daniel C. Allen, Walter K. Dodds, Amy J. Burgin, C. Nate Jones, Sarah E. Godsey, Meryl C. Mims and Michael T. Bogan. Erin C. Seybold, Michelle H. Busch and Amy J. Burgin wrote the Norming section with contributions from Corey A. Krabbenhoft and edits from Daniel C. Allen, Kate S. Boersma, Arial J. Shogren, Stephen Plont, Yaqi You and Michael T. Bogan. Amy J. Burgin wrote the Performing section with edits from Daniel C. Allen, Kate S. Boersma, Thibault Datry, Meryl C. Mims, Yaqi You and Mathis L. Messager. Daniel C. Allen wrote the Adjourning section with contributions from Amy J. Burgin, Michelle H. Busch and Carla L. Atikinson. Erin C. Seybold and Margaret Shanafield wrote the Conclusion section with edits from Daniel C. Allen, Amy J. Burgin and Carla L. Atikinson. C. Nate Jones, Sarah E. Godsey, Arial J. Shogren, Stephen Plont, Meryl C. Mims, Adam N. Price, Chelsea R. Smith and Michael T. Bogan contributed to text that was eventually removed from the final manuscript. Richard H. Walker led the design of the conceptual figure with Kate S. Boersma, and Daniel C. Allen, Erin C. Seybold, Walter K. Dodds, Carla L. Atikinson, Chelsea R. Smith and Rachel Stubbington provided feedback that improved the final design. Daniel C. Allen and Amy J. Burgin led the framing and discussions during meetings with Erin C. Seybold, Walter K. Dodds and Amy J. Burgin; and with contributions from Corey A. Krabbenhoft, Kate S. Boersma, James C. Stegen, C. Nate Jones, Sarah E. Godsey, Arial J. Shogren, Stephen Plont, Meryl C. Mims, Adam N. Price, Chelsea R. Smith, Ryan M. Burrows and Margaret A. Zimmer.

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Daniel C. Allen is an associate editor of functional ecology, but took no part in the peer review and decision-making processes for this paper.

DATA AVAILABILITY STATEMENT

No data is presented in this commentary.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

Data S1. Author contributions.

Data S2. List of Dry Rivers RCN publications.

Data S3. Authorship agreement.

Data S4. Code of conduct.

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