Great public engagement with science is **Cumulative**

Great public engagement with science is:

- **Strategic** - guided by clearly articulated, audience-specific goals and objectives
- **Cumulative** - supports ongoing, positive encounters between scientists and publics via multiple pathways
- **Reciprocal** - grounded in two-way exchange and mutual meaning-making
- **Reflexive** - operates in iterative loops of reflection and adaptation
- **Equitable** - recognizes systemic injustices in science and society, acknowledges biases, and is intentionally inclusive
- **Evidence-based** - builds from knowledge about how people learn about and use science

What does it mean to be cumulative?

Effective public engagement with science (PES) happens through repeated experiences and across time. PES goals for communities and scientists involve changes in behavior that are only expected to happen over time and as trust is built through repeated interactions and experiences. As such, PES is most effective in aggregate, with multiple and varied opportunities to engage, across institutions and contexts.

Via multiple pathways

One way to think about PES in aggregate is the idea of a STEM learning ecosystem that includes a range of activities and tactics to support an overall goal. As depicted in the figure below, the collection of those activities and tactics form an engagement landscape. In some cases, those opportunities may focus on engaging the same community members over time. In others, the cumulative mindset involves thinking about ways a community has engaged with science collectively. Learning ecosystems are expected to evolve over time to ensure that opportunities are responsive to community needs and interests.

Cumulative PES brings intention to designing a landscape of engagement opportunities. Research organizations, for example, might be based in the Work + Business section of the graphic below and choose to work in relationship with faith-based communities in specific neighborhoods that could benefit from and contribute to

STEM Learning Ecosystems
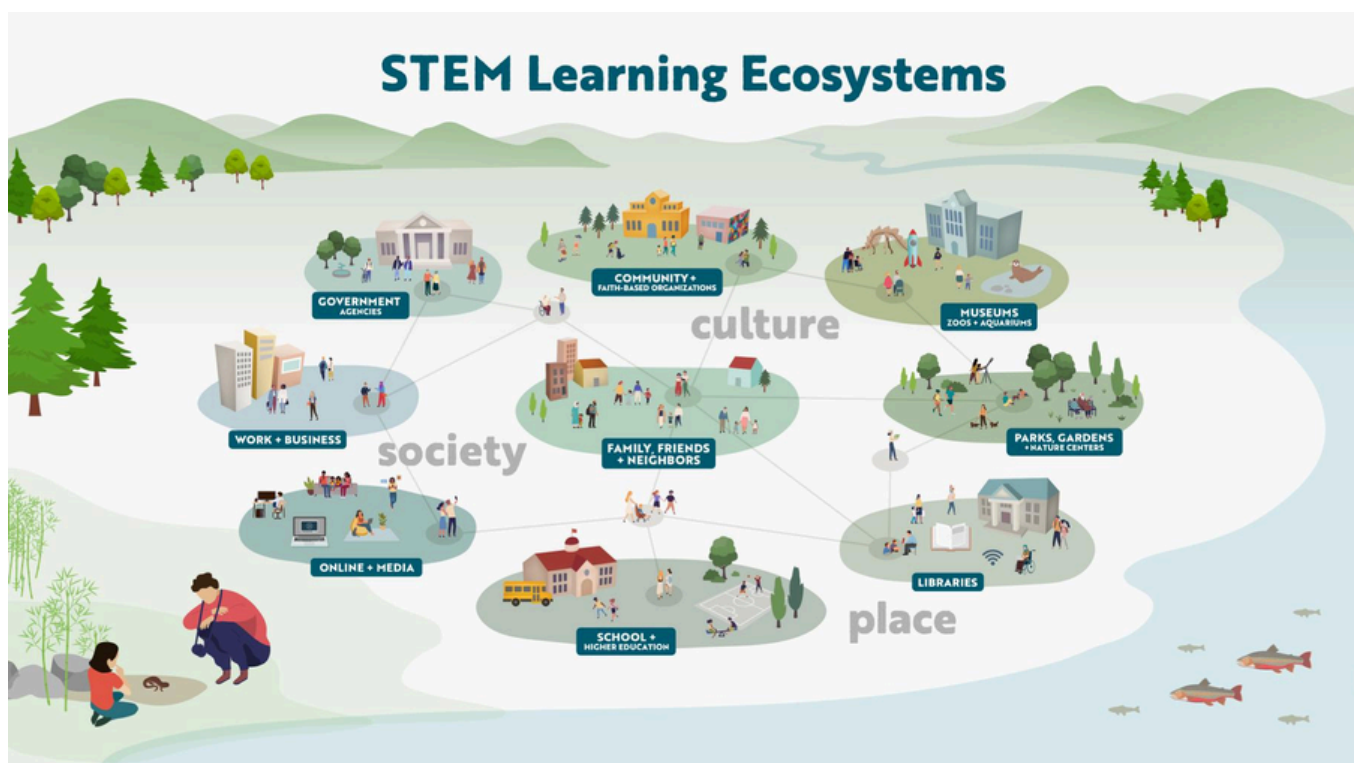
Case Study: Cumulative PES in Action

By Clarrise Hart, HFR Director of Outreach & Education, and Jonathan Thompson, HFR PI

Harvard Forest (HFR) has developed a relationship with local government that is cumulative both over time and across multiple siloed government agencies. For decades, HFR's long-term data has informed forest policy in the Northeast U.S., revealing forest carbon as an effective nature-based solution. In 2020, HFR PI Jonathan Thompson's lab published the Massachusetts Land Sector Report, which analyzed the ways land-based carbon dynamics can contribute to the state's legislatively mandated net-zero goals by 2050. In Massachusetts, forests cover 64% of the land area. The Land Sector analysis showed the carbon offset power of these forests if left intact in a changing climate through 2050, as well as the variability of their potential climate-fighting power under tighter regulatory policies on development and forestry. But government agencies often work in silos, rather than cumulatively. Decarbonization efforts in the energy sector have incentivized ground-mount solar throughout the state, which has cleared over 8,000 acres of forest since 2010, resulting in the emission of over half a million metric tons of CO_2—more than the annual emissions of 100,000 passenger cars.

To bring these threads together, the Thompson Lab co-authored a 2023 report titled "Growing Solar, Protecting Nature" that proposed a policy-incentivized shift from large-scale, ground-mount solar to solar projects on rooftops, parking lots, and already-developed lands. More than a dozen policy briefings, regional meetings, and listening sessions have brought these ideas to agencies and communities, which has resulted in a shift in the way that publics and state policymakers think about the trade-offs between alternative energy and natural and working land. Indeed, the state's Climate Chief, Mellisa Hoffer, shared that the report, "provides a clear-eyed analysis of the impacts of the Commonwealth's solar policy to date and provides a roadmap for better aligning our goals of rapidly transitioning away from fossil fuels, protecting our forests that help to drawdown carbon, and protecting biodiversity."

local research efforts. Engagement opportunities across a given year might then focus on ways to design and apply locally-relevant research, and be hosted across a wide range of venues that are meaningful and relevant to the scientists and communities involved, focused on families and adults, and designed to integrate cultural and group norms. Within this collective landscape of opportunities, scientists and community members might lead and/or engage in one or multiple activities.

Over time

Creating continuous learning opportunities is considered to be a stronger educational approach compared to one-time experiences. By hosting PES programs that unfold as a series of events over time, scientists and community groups have greater potential to build relationships with one another. With time and repeated encounters, scientists and publics can lay a foundation of trust, allowing publics to see scientists as relatable members of their community and scientists to see publics as people with valuable input. Cumulative PES also provides a context for scientists and community members to recognize and boost their confidence and expectations for engaging with one another.

Within organizations and across networks

Across scientists within an organization, engagement efforts should be aligned to common goals that build a cumulative portfolio of engagement internally and contribute to the creation of a STEM learning ecosystem externally. Organizations with related goals and objectives may choose to think about the ways their work is complementary, to create cumulative engagement opportunities that strengthen both their network and the STEM learning ecosystem. Thinking cumulatively broadens the possibilities for widespread and deep impacts.

Evaluation planning

An event tracking system is a great way to capture the cumulative nature of PES. Details about the type of event, the timing, location, modality, and the publics and scientists who designed and attended the event can be logged, along with whether PES activities are stand-alone events or part of a series. If organizations across a network all track this information in a shared system, the data will tell the story of the cumulative engagement at an individual site and across the network.

Learn More

The summary shared here was informed by these publications. The figure on the first page was created by the NISEnet project and shared via a Creative Commons License. Additional versions can be found here: https://www.nisenet.org/stem-learning-ecosystems-illustrations.

Bevan, B., Garibay, C., & Menezes, S. (2018). What is a STEM Learning Ecosystem? Retrieved from https://www.informalscience.org/sites/default/files/BP-7-STEM-Learning-Ecosystem.pdf (to read more about STEM learning ecosystems)

American Association for the Advancement of Science, AAAS (2016). Theory of Change for Public Engagement with Science. Accessed: https://www.aaas.org/programs/center-public-engagement-science-and-technology/theory-change-public-engagement-science (to learn more about (to learn more about the theory behind the long-term aggregate impact of PES)

Storksdieck, M., Stylinski, C., & Bailey, D. (2016). Typology for Public Engagement with Science: A Conceptual Framework for Public Engagement Involving Scientists. Corvallis, OR: Center for Research on Lifelong STEM Learning. (to learn more about the many categories and rubrics for PES)