Learning Frameworks

Complex Socio-Ecological Systems

Why is learning about complex socio-ecological systems important?

All social and ecological systems interact in a complex web of relations across time and place. These are referred to as socio-ecological systems. Understanding complex socio-ecological systems is increasingly important in a world that is socially and ecologically shifting at rapid rates. For example, it is important for people to be able to reason about patterns in the Earth's climate or diversity of life. Systems reasoning, or being able to understand properties and behaviors of systems, is an academic demand in science learning environments but also increasingly a demand of everyday communal life.

This framework provides an overview of the dimensions of socio-ecological systems, and the types of reasoning that facilitate complex systems sensemaking. Previous research has claimed that systems sensemaking was too hard for novices, leading to models of science education that simplified concepts into linear and hierarchical relationships. However, more recent research has demonstrated that there is cultural variation in how people understand and make decisions about socio-ecological systems. Importantly, learners can understand and reason about complexity from a young age (early elementary or younger!). Designing instruction with the right scaffolds can support learners to sensemake, deliberate, and make decisions about socio-ecological phenomena in ethical and rigorous ways. This includes fostering multiple types of reasoning and integrating family and cultural knowledges and practices.

Features of complex socio-ecological systems

Complex systems, such as the Earth's climate, food webs, or the human nervous system behave in web-like organization (as distinct from linear chains), have emergent properties, and are self-organizing across time and space. Complex ecological systems, such as a coral reef or forest, refer to natural systems and the dense web of relationships and interactions of which they are comprised. *Social* systems refer to human systems, such as cultural communities, economies, and governments. *Socio-ecological* systems bring these different systems and their interactions in focus and consider the relationships between human systems and ecological systems.

Socio-ecological systems are dynamic, continuously adapting systems that are comprised of a wide range of factors (such as natural, socioeconomic, and cultural factors) and relations that exist and interact across multiple *spatial, temporal, and organizational* scales. In other words, a socio-ecological system can span across time and places - from momentary interactions in one place, to large-scale processes that span geologic eras and global events. For example we are living in a geological era known as the Anthropocene, in which humans are having a huge effect on climate and ecological systems. This era has a long time scale - events and decisions in the past have impacts that are far reaching into the future and across the globe. At a small scale, this impacts our day to day lives, and in turn, our daily decisions contribute to these global processes.

As in all complex systems, socio-ecological systems do not have one, central organizing mechanism. Instead, they consist of multiple, dynamically-interacting actors and forces. Interactions and relations among parts of a socio-ecological system produce emergent behaviors. For instance, when a set of relationships reach a certain threshold, the result is a phenomenon that is greater than the sum of its parts. For example, a decision made by an individual, like buying seasonal produce, can have a small impact, but that decision made by a large number of people can have a huge impact. Similarly, a small decision made by a large company or institution can have a large impact. Supporting learning about these different scales and understanding what makes different scales unique is important for learning. For example, learning the behavior of singular agent, like a beaver (e.g. the cutting of trees or its impacts on a singular river bank) verses studying the impacts of a species in the aggregate, like beavers across a watershed (e.g. critically important role in water storage and seasonal flows) leads to very different insights These multiplicities can pose challenges and are important to support in learning environments through scaffolds and representations. Further, the multiple parts of a complex system interact in both direct and indirect "feedback loops" - when a change in a particular variable has an effect on that variable and scale, as well as other parts of the system and can manifest at a different scale. Another important feature of socio-ecological systems is that because they are non-central and non-linear, they have their own "memory", or historicity. Events and phenomena that occurred in the past always live on in the system, and whether it plays a dormant or active role depends on power.

How to use this framework

Learner Sense-Making: Use this framework to scaffold learner sensemaking across multiple dimensions of socio-ecological systems. Support learners to engage in multiple forms of reasoning, depending on the phenomenon of interest. Make connections to family and cultural knowledges and practices, and to reflect on the (many) socio-ecological systems that are part of their lives.

Collaborative Practice: Socio-ecological systems span across multiple communities, places, and time scales. Model complex socio-ecological systems sensemaking by collaborating with other multiple stakeholders that are part of a given socio-ecological system; this includes: educators, families, and community members, and so on.

Planning and Implementation: Place walks, researching histories of places, and learning about local and global impacts of decisions are important ways to plan for learning and instruction about socio-ecological systems. Additionally, make heterogeneous (diverse) perspectives central in the learning environment by connecting to learners' lived experiences and family and cultural knowledges and practices.

Educator Reflection: Reflect on the multiple (and often intersecting) socio-ecological systems that you are connected to. Think about how your role intersects with the roles of learners' and their families. For example, how did you facilitate sensemaking using multiple types of reasoning, or about the behaviors and functions of species and kinds within socio-ecological systems?

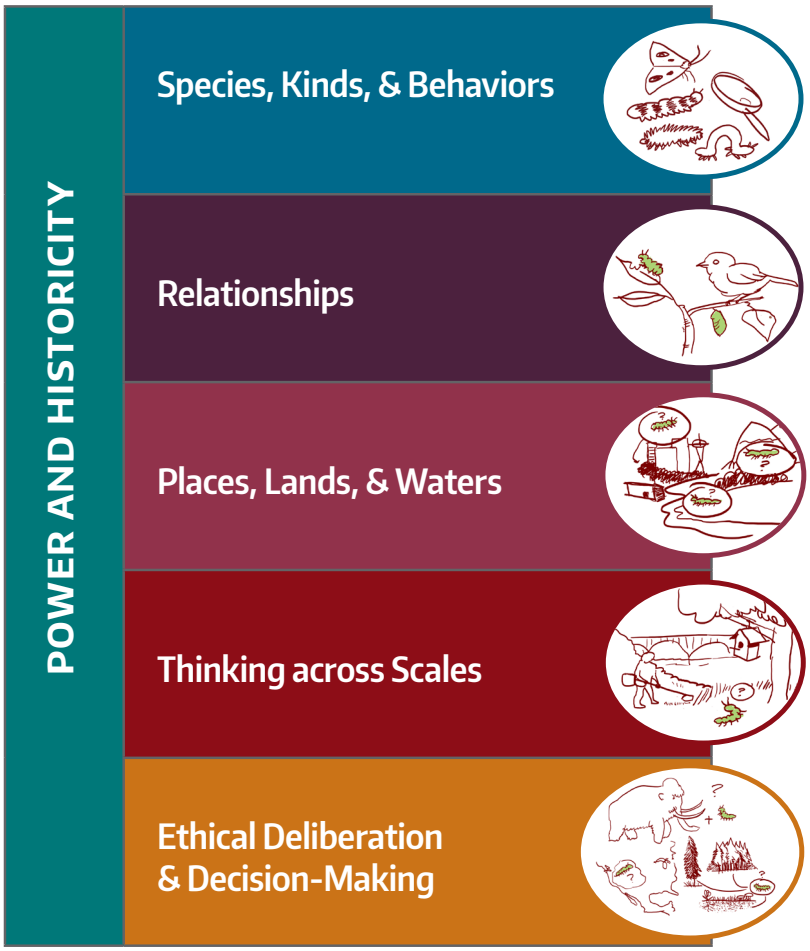
Co-Design and Assessment: Use this framework to guide co-planning with other educators, families, and communities to foster socio-ecological systems thinking. Also, use this framework to guide formative assessments that help you understand how learners are sense-making across multiple scales, about the interdependent relationships among species and kinds, and connections to places and lands and waters. Assess if and how sensemaking and deliberations led to ethical decision-making about socio-ecological systems.

Connections to expert thinking:

Scientists studying plastic in the environment have found that nearly every living organism on Earth has some amount of microplastics in their body. These findings highlight the vast interconnections of socio-ecological systems. In this research, scientists are engaging in many forms of complex systems reasoning in order to trace the production and flows plastics in the environment. Toggling between multiple spatial and temporal scales, tracing microplastics has shown that this phenomenon cannot be traced to a central, organizing mechanism. Small daily decisions made by lots of individuals can accumulate and lead to impacts at a large scale. More importantly, at the same time, decisions made by medium-sized companies and large industries contribute a disproportionate amount of plastics pollution. Moreover, the intricate connections between what happens on land and how that relates to the ocean, as well as complex food webs and climate and ocean patterns all contribute to the movement of microplastics throughout socioecological systems. Taken together, the decisions and production of plastics, including devastating extraction methods such as fractions, have reached a point where broken feedback loops (such as the ability for the system to rebound from disturbances) have reached a threshold in which socio-ecological systems are out of balance.

5 Dimensions of Reasoning About Complex Socio-Ecological Systems

There are many opportunities to connect learners' socio-ecological sensemaking with their lived experiences, interests, cultural practices, and the like. Here are some ways to start:



- **Power and Historicity**
  Power and historicity shape every aspect of socio-ecological systems.
- **Species, Kinds, & Behaviors**
  Species include humans, animals, plants, fungi, etc. Kinds include land, water, air, and soil, etc. Behaviors are the roles, actions, or decisions that species and kinds make within a system.
- **Relationships**
  All socio-ecological systems consist of interdependent relationships among species (including humans), and kinds. Webs of relationships can vary across scales - from agent (individual) to aggregate (population level).
- **Places, Land, and Water**
  The function (purpose and roles)socio-ecological systems are intimately tied to places, lands, and waters. Places, lands, and waters shape and are shaped by human and more-than-human behaviors and decisions.
- **Thinking across Scales**
  Socio-ecological systems are dynamic and span across multiple temporal and spatial scales. Sensemaking about socio-ecological system requires learning about histories of places, observing phenomena in multiple locations, and taking the perspective of others.
- **Ethical Deliberation and Decision-Making**
  Humans have always made, and will continue to make, important daily and large scale decisions that impact socio-ecological systems. Deliberating - or carefully considering - the impacts of human decisions is a moral and ethical endeavor.

Forms of Reasoning about Socio-Ecological Systems

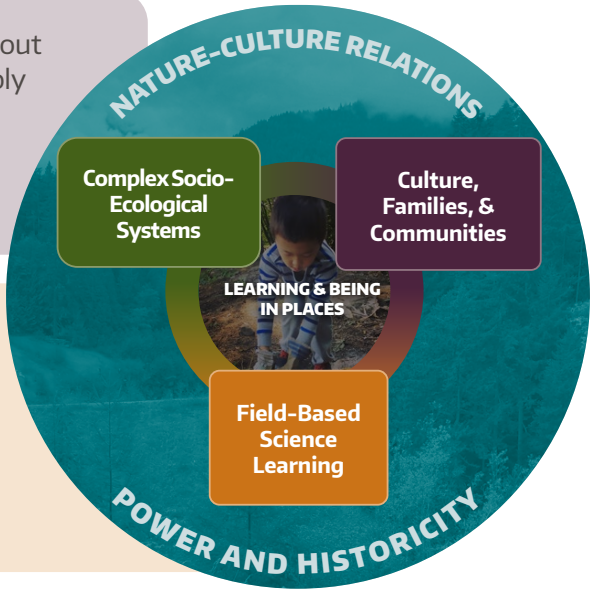
The list below provides sample types of relational reasoning that support sensemaking about socio-ecological systems. The goal is for learners to engage in *multiple* forms of reasoning. Educators can foster this over time and across activities. The list is not exhaustive, but meant to highlight what learners are already doing, and what can be scaffolded.

Different Forms of Reasoning for Complexity	
Relational	**Chain-Like Relationships** start with 1-1 then extend into chains that follow a linear relationship (e.g., fly - frog - snake; or succession of trees in an ecosystem). This is particularly helpful to support making predictions.
	Weblike Relationships among 3 or more organisms/kinds that follow a weblike relationship (e.g., eagles, bears, and humans eat salmon, and trees absorb nitrogen from salmon die-off). This is helpful to support reasoning across different spatial and temporal scales.
Analogic	Reasoning that relies on an analogy to compare similarities across two or more entities. Finding the limits of similarities is often also a helpful aspect of analogical reasoning. Analogical reasoning is a very robust and helpful form of sensemaking. This type of reasoning can support many different aspects of complex systems reasoning. For example, exploring **functions and roles of species or kinds** within a socio-ecological system. For example, bioengineers have specific relationships with land/waters and many different organisms perform this role including humans, beavers, bees, ants, etc).
Perspectival	Taking the perspective of others in order to make sense of behaviors or functions of different parts of a system. This includes taking the perspective of other than humans! For example, reasoning about the **impacts of human decisions** on human and more-than-human relationships requires considering conflicting perspectives about positive, neutral, or negative impacts to different relationships.
Toggling	Thinking with at least two scales at a time (could be temporal, spatial, agent/aggregate, relational, etc) or holding complementary/contrasting perspectives. In complex systems reasoning, it is important to toggle across scales because these systems e*xist at multiple scales and a change at one scale can lead to unpredictable or nonlinear changes at another level.* Any given place, phenomenon, or event has multiple histories, and connections to phenomena in other places.
Reasoning with Uncertainties	In complex systems decision-making, there are a series of factors and relationships that are seemingly obvious, but making decisions about them is less clear. It is important for learners to think about possible, emergent connections or decision.

Connections to the Learning in Places Rhizome:

Nature-Culture Relations: Sensemaking and decision-making about socio-ecological phenomena varies across cultures. These are deeply impacted by family- and culturally-based conceptions of nature-culture relations, or whether humans are considered part of or apart from the natural world.

Field-Based Science Learning: Field-based science learning can support complex socio-ecological sensemaking. Through scaffolded observations, rigorous data collection across multiple places, times, and with community members, learners can deepen their understanding of components of a system and how they interact.



Power and Historicity: Power and historicity are deeply embedded in socio-ecological systems. These dynamics shape, and are shaped by, socio-ecological factors and relationships. For example, we are now living in a global age known as the Anthropocene, a time in which human impacts are disproportionately affecting the balance of ecological and social systems. Local and global decisions have led to this era, and are rooted in powered ideas of human supremacy and dominance. Importantly, these decisions have disproportionate impacts on marginalized communities–particularly communities of color. Actively seeking to recognize and dismantle these power imbalances is a critical part of ethical decision-making about socio-ecological phenomena.

Suggested Citation

Learning in Places Collaborative. (2020). *Framework: Complex Socio-Ecological Systems.* Bothell, Seattle, WA & Evanston, Il: Learning in Places.