Esri-NEON Tribal Lands Collaboratory: An ODE to Phenology

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Overview

Large-scale environmental changes are unfolding at an unprecedented pace, magnitude, and scale across the globe. These changes impact socio-ecological systems, including the natural capital that provides the goods and services which society depends on. Tribal entities are especially prone to such changes. The natural resources that they have rights to, and on which cultural norms may be dependent, are impacted by environmental stressors whose scale extend far beyond legal tribal jurisdictions.

The US Government (USG), through initiatives like the Climate Action Plan and the inter-agency National Climate Assessment, recognizes these challenges. The USG is also advocating better integration of US environmental observation assets (like the National Ecological Observatory Network, NEON) and making those data freely web accessible for science, education, and management. There is also widespread recognition that we should align climate-adaptation options with the best available science and data.

The Tribal Lands Collaboratory (TLC) is an Esri-NEON collaboration to assemble existing technologies into a web-based workbench that enables multidisciplinary teams to perform integration, analysis, and interpretation of environmental data. Teams may comprise students, scientists, natural resource managers, and even the general public. The value-chain of transforming data to information and knowledge is captured at each step to enable traceability and reproducibility.

Partners include the USA National Phenology Network (NPN), the American Indian Higher Education Consortium (AIHEC), and the Tulalip Tribes.

Tribal Lands Collaboratory (TLC): Requirements and Knowledge Management Principles

The White House has called for the better integration of data from existing satellite platforms, aircraft mounted sensors, and in-situ observations measured by sensors and by humans[4].

Those data, when integrated with tribal observations and ingested into appropriate models and tools, may be used to inform options for local climate adaptation.

The Tribal Lands Collaboratory (TLC: Fig. 3, https://goo.gl/LaZ7z7) aims to facilitate data integration for science, eduation, and decision-support. The requirements for an ideal TLC are listed below. Many of these requirements are consistent with the tenets of open science.

"Collaboratory Objects" refer to entities that are created and managed within the Collaboratory, like data, code, documents, media objects, workflows.

- **Traceability:** The detailed workflow capturing the integration and transformation of data to information and knowledge should be expressed as modular, discrete steps, with explicit linkages between steps. This facilitates reproducibility, highlighted as an important aspect by the US Congress and NSF.
- **Unique identification and citability:** In a linked open data world, Collaboratory Objects should ideally have a persistent unique identifier, so that objects can be linked, traced, and cited.

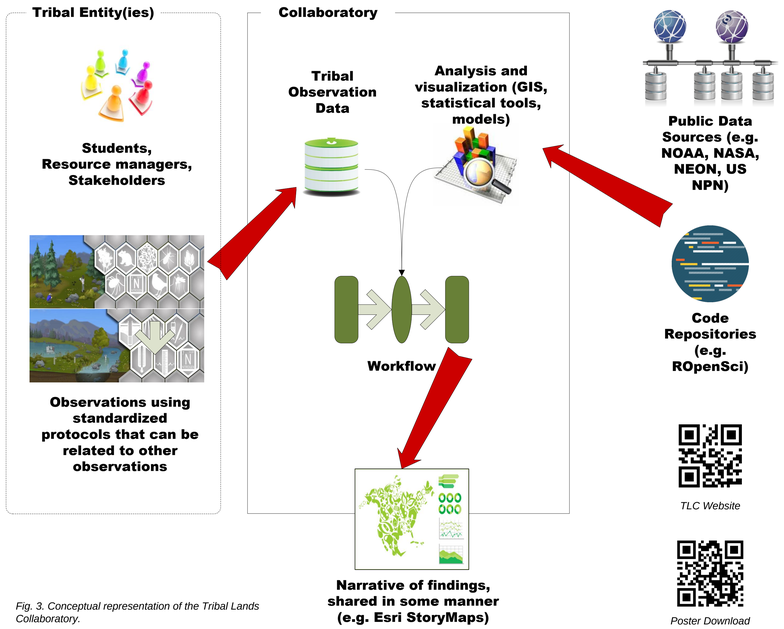

Fig. 3. Conceptual representation of the Tribal Lands Collaboratory.

Requirements for an ideal TLC, continued.

- **Ability to manage access rights:** Collaboratory administrator(s) should be able to manage the access rights of Collaboratory users. This facilitates the management of sensitive Collaboratory Objects, while making other Objects public and reusable.
- **Ability to repurpose:** There should be minimal barriers for repurposing Collaboratory Objects. E.g. replicating an entire workflow and modifying certain steps. This can be achieved via appropriate licensing mechanisms.
- **Scalability:** The ease with which Collaboratory Objects can be repurposed for other domains speaks to the ability of the Collaboratory to scale for other tribes, scientific questions, environmental challenges, and analytical tools.

A prototype version of the TLC that meets most of the above requirements uses the Open Science Framework, DropBox, and Esri technologies (ODE for short). The prototype focuses on analyzing the effect of local environmental changes on plant phenology in the Pacific Northwest. The target users are individuals from the Tulalip Tribes and Northwest Indian College. Phenology data from Haskell Indian Nations University were used to boot-strap the prototype.

We envision future Collaboratories for water quality, coastal green infrastructure, and salmon management.

Climate Change Impacts on Indigenous Peoples

The 2014 National Climate Assessment (NCA) states that the "*consequences of observed and projected climate change have and will undermine indigenous ways of life that have persisted for thousands of years.*"[1] Indigenous practices and cultures that are grounded in the "power of place" are played out against a backdrop of legal and political arrangements with non-indigenous entities that impose geographical constraints. This is exacerbated by large-scale environmental changes that are oblivious to such institutional agreements.

The Tulalip Tribes, in current day Washington state, used to benefit from a healthy Snohomish Basin ecosystem before the Westward expansion. Since then, forests have dramatically changed in stand-age and species composition[2]. Salmon populations have decreased by 90%[3]. These changes adversely affect the local economy, and threaten important ceremonies and practices that connect the present to the past.

There is an evolving perspective that traditional knowledge and western-based approaches can be used to inform management options in the face of these challenges (Fig. 1). The latter includes the science of phenology.

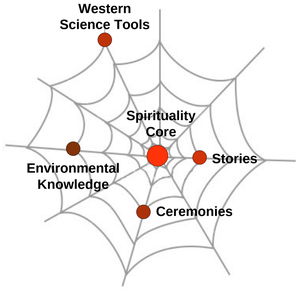

Fig. 1. Conceptualization of Traditional Ecological Knowledge within an indigenous knowledge web (modified after Food and Agriculture Organization).

What is Phenology

Phenology is a branch of science focused on relationships between climate and the seasonal timing of biological phenomena, such as fish spawning, bird migration, and plant blooming dates. It is one of the most sensitive and easily observed indicators of biotic response to climate variability (Fig. 2).

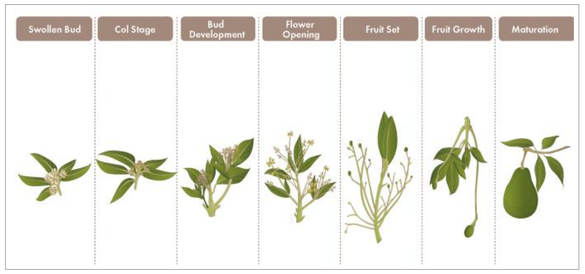

Fig. 2. Phenological stages of avocado. Credit: www.sqm.com

Observing the timing and duration of phenological stages in plant and animal communities on tribal lands can provide insight to the direct impacts of climate change on culturally significant tribal resources like traditional foods, materials, and medicine.

Phenology observations are undertaken by both specialists (e.g. NEON trained field staff) and non-specialists (e.g. citizen scientists) alike. NEON and the USA NPN both support professional and citizen-science phenology observations.

Phenology Related Harmonization Efforts Worldwide

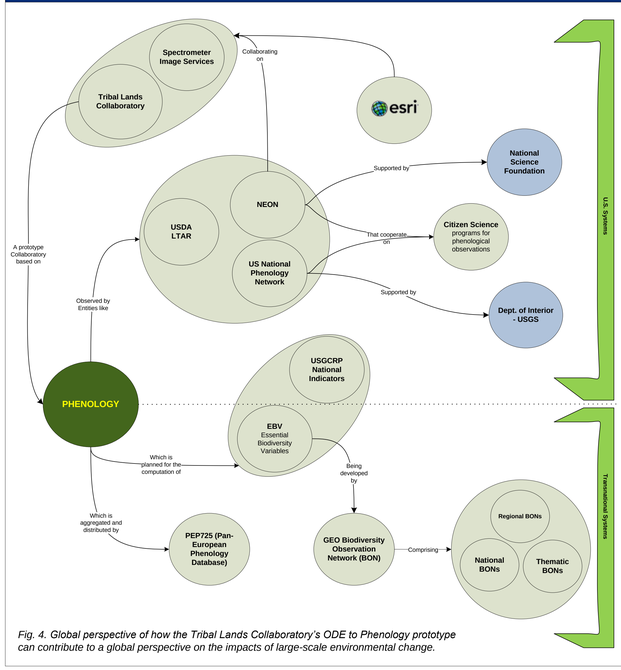

Fig. 4. Global perspective of how the Tribal Lands Collaboratory's ODE to Phenology prototype can contribute to a global perspective on the impacts of large-scale environmental change.

Harmonizing scientific measurements and technical standards for informatics and e-infrastructure enhances interoperability between scientific environmental observation systems. This facilitates the use of such data for science and decision-support using tools like the TLC (Fig. 4). Initiatives that have done this include:

- NEON utilizes USA NPN protocols for its plant phenology observations across its national constellation of sites. NEON is also part of a US PhenoCam Network that uses automated cameras.
- The USDA Long-term Agro-ecosystem Research Network, National Park Service, Fish and Wildlife Service have adopted or are planning to adopt USA NPN protocol at various locations.
- USA NPN and NEON are exploring the applicability of these protocols for tribal concerns.
- The US Global Change Research Program has adopted phenology as one of its national climate change indicators.
- The Pan-European PEP725 Database aggregates and serves plant (only) phenology measurements from 30 European countries.
- The Group on Earth Observation's Biodiversity Observation Network (GEO BON) is considering including phenology as one of its global Essential Biodiversity Variables (EBVs).

[1] Bennett, T. M. B., N. G. Maynard, P. Cochran, R. Gough, K. Lynn, J. Maldonado, G. Voggesser, S. Wotkyns, and K. Cozzetto, 2014: Ch. 12: Indigenous Peoples, Lands, and Resources. *Climate Change Impacts in the United States: The Third National Climate Assessment*, J. M. Melillo, Terese (T.C.) Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, 297-317. doi:10.7930/J09G5JR1. || **[2]** Boumans, R., Christin, Z. 2014. Using Model Integration to Create Baseline Carbon Budgets in the Snohomish River Basin. Earth Economics. Tacoma.
[3] US Climate Resilience Toolkit – Saving their sacred salmon (https://toolkit.climate.gov/taking-action/tulalip-tribes-saving-their-sacred-salmon). || **[4]** July 2015 National Plan for Civil Earth Observations: Product of the National Science and Technology Council, Executive Office of the President.