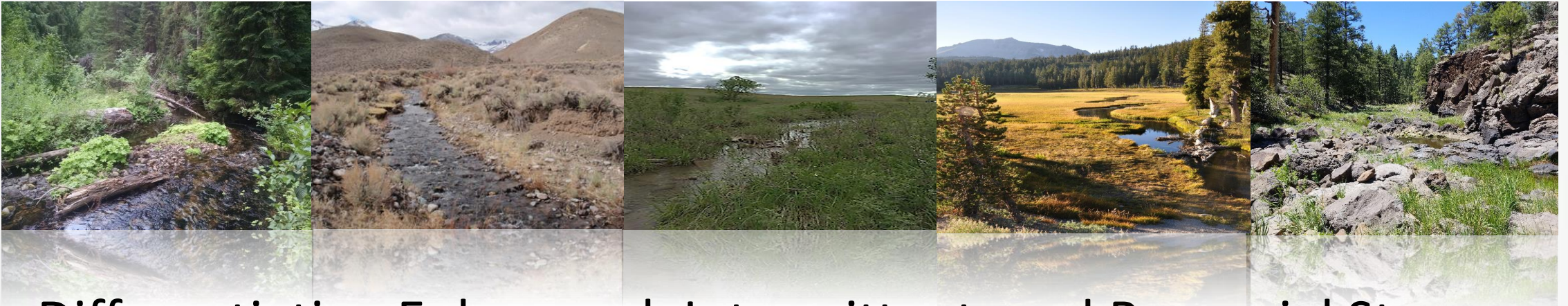




Streamflow Duration Assessment Methods Covering the West



Differentiating Ephemeral, Intermittent, and Perennial Streams

11 July 2022

Western States Water Council

WOTUS Regional Concept Pre-workshop #2

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USEPA Region 10 & Office of Wetlands, Oceans, and Watersheds



- What are Streamflow Duration Assessment Methods (SDAMs)?
- How are SDAMs used?
- How are SDAMs developed?
- Regional SDAMs covering the West



Stream drying

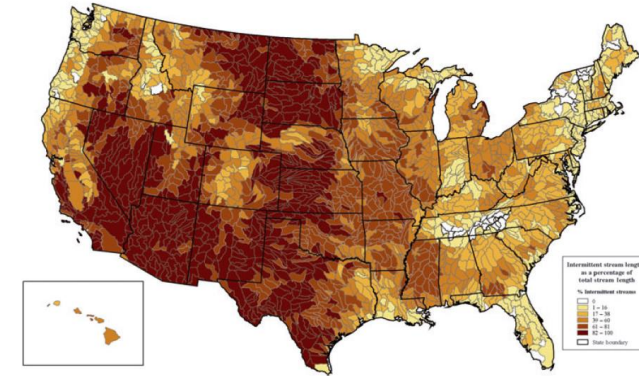


- Strong driver or filter for ecological and biogeochemical structure and functions
- Classifications used by federal, state, tribal, and local policies & programs
- Widespread, but not completely & easily documented



What are Streamflow Duration Assessment Methods?

- Rapid field-based assessment tools
 - Single site visit
 - Site specific determination
- Use physical, hydrological, and/or biological indicators to determine flow duration class of stream reaches (indirect classifier)
- Flow duration class = perennial, intermittent, ephemeral



Intermittent and ephemeral stream length in the U.S. (Nadeau & Rains 2007)

Ephemeral – flow only in direct response to precipitation

Intermittent – flow for only part of the year, typically during a wet season when the streambed is below the water table or when snowmelt provides sustained flow

Perennial – flow continuously during a year of normal rainfall, streambed located below water table



How are SDAMs used?



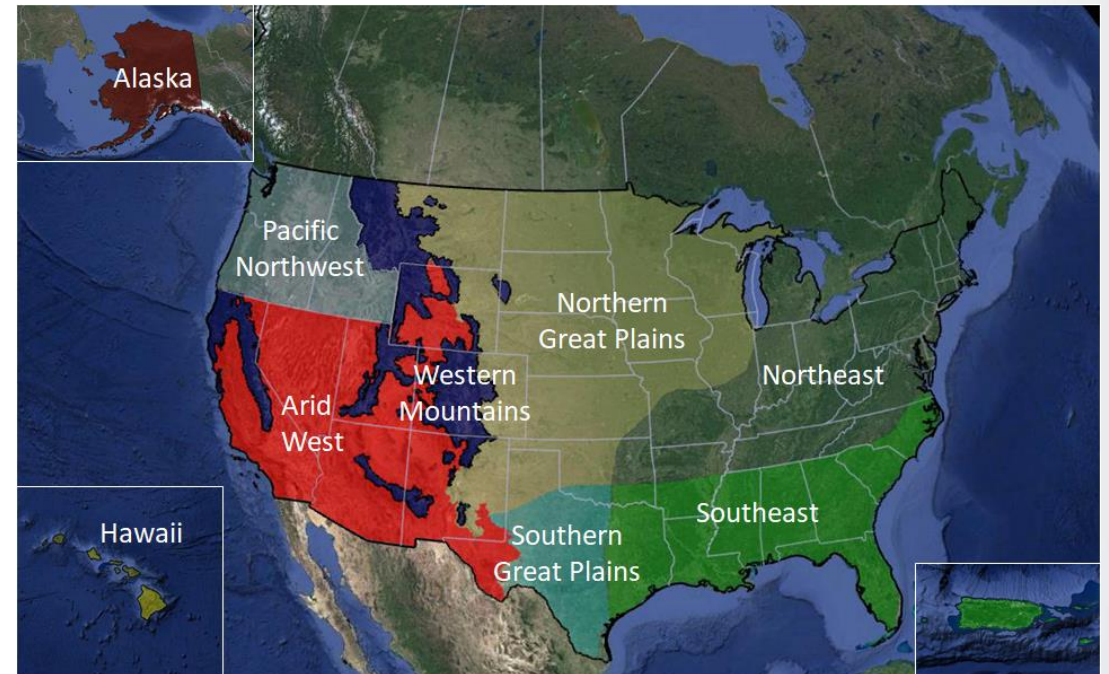
- Implementation of state and local ordinances
- Improved ecological assessment (e.g., expectation of function; provision of ecosystem services)
- Application of appropriate water quality standards
- Prioritization of restoration & protection efforts
- Ambient monitoring and understanding responses to a changing climate
- Assist with timely & predictable jurisdictional determinations



Developing SDAMs for Nationwide Coverage

EPA and the U.S. Army Corps of Engineers are working collaboratively to:

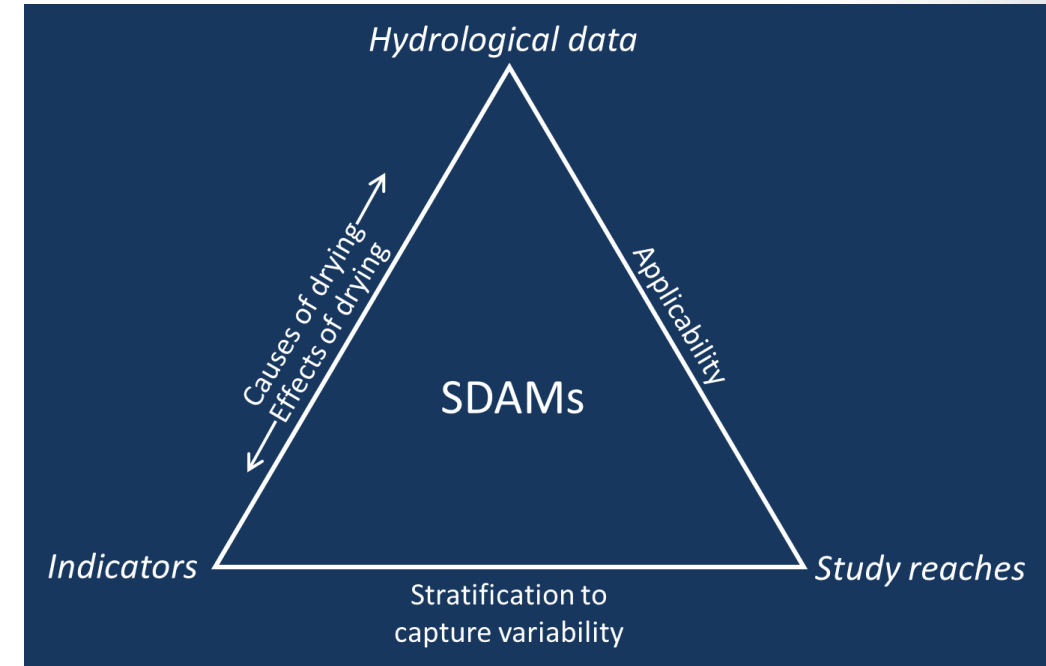
- Develop robust SDAMs, at appropriate regional scales, nationwide
- Identify and test existing and candidate indicators of streamflow duration assessment
- Conduct validation studies that result in accurate, consistent, and defensible SDAMs
- Contribute to our understanding of intermittent and ephemeral streams



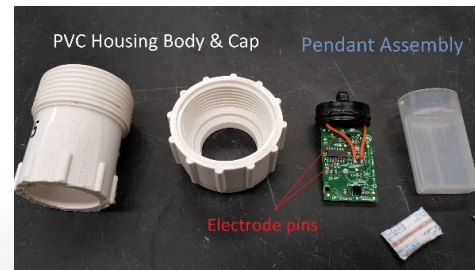
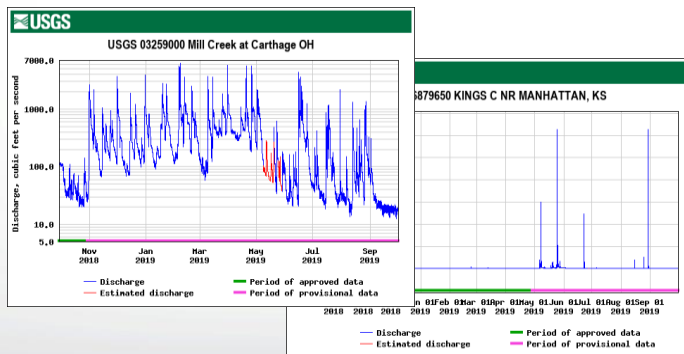


Key Pieces to SDAM Development

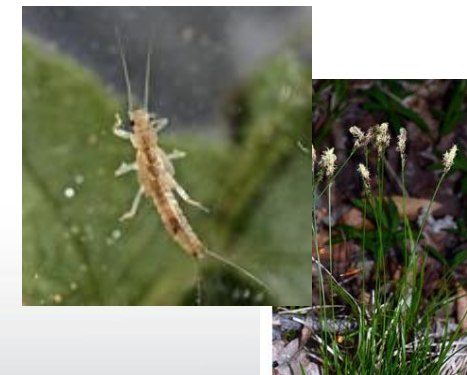
- Study sites across a range of flow conditions, representative of region
- Direct classification of hydrology
 - Gage data
 - Data loggers, wildlife camera imagery
 - Recurrent visits
- Set of indicators (geomorphology, hydrology & biology)



(Fritz et al. 2020)

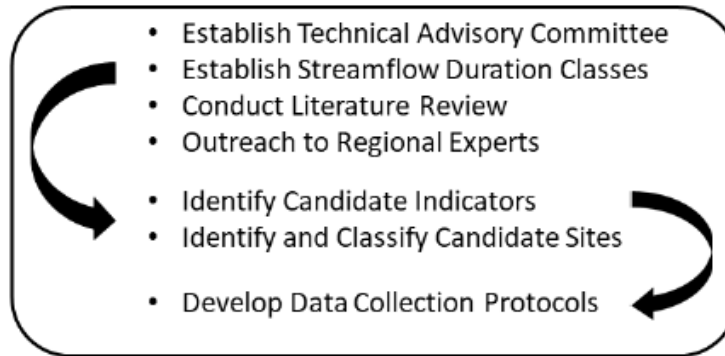


Electrical resistance (ER) and temperature data logger

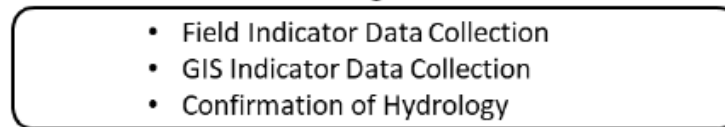


SDAM Development Steps *(Fritz et al. 2020)*

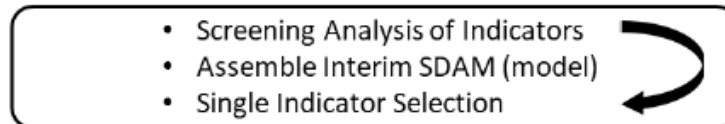
Preparation



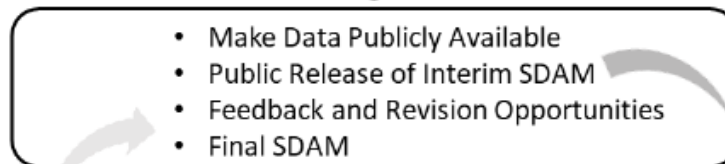
Data Collection



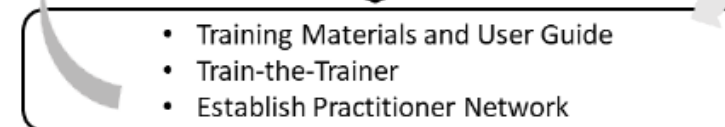
Data Analysis



Method Evaluation



Implementation

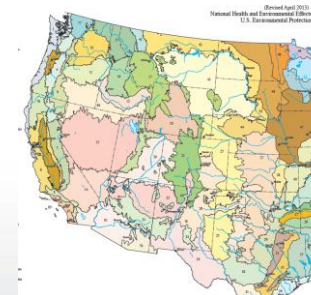


} **Method Rollout**



Example Indicators

Biological	Hydrological	Geomorphological	GIS
Aquatic invertebrates Algae Riparian vegetation Hydrophytic vegetation Iron-oxidizing bacteria Fish Amphibians Bryophytes	Soil moisture Hydric soils Woody jams	Slope Channel width Sinuosity Entrenchment ratio Riffle-pool sequence Substrate sorting Sediment deposition	Climate Ecoregion Land cover Watershed Geology and soils



Data Collection:

- Collect data (candidate indicators) at study sites (known hydrology) using consistent field protocols (QA/QC'd)

Data Analysis:

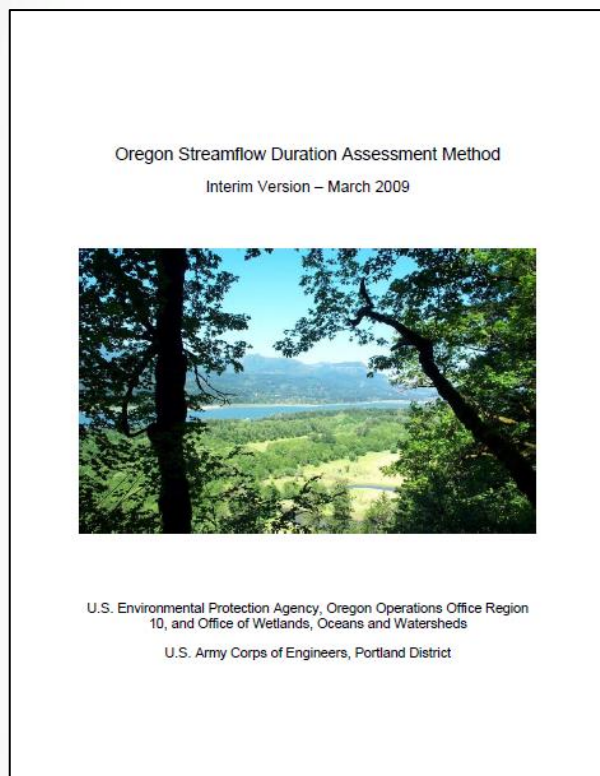
- Machine learning technique to build “forest” of decision-trees to identify top candidate (predictor) indicators

Build SDAM Method (Model):

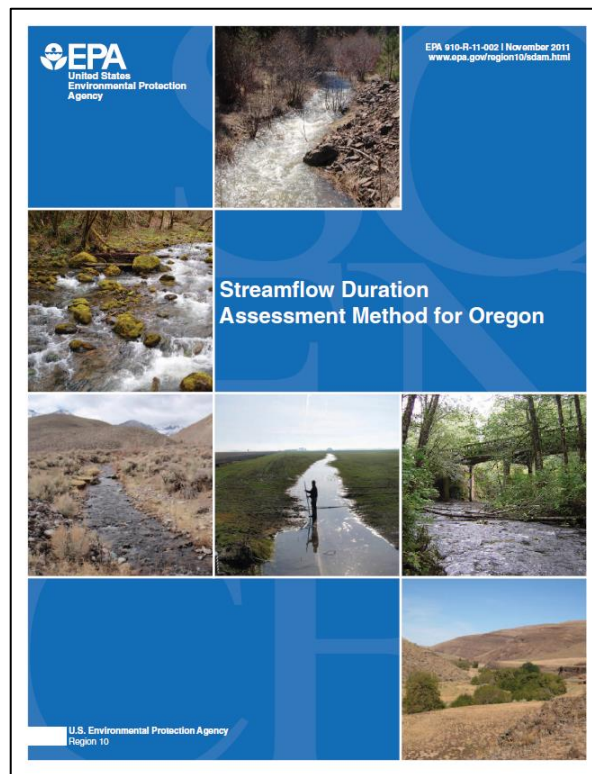
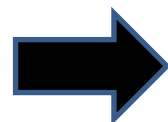
- Consider rapidity, repeatability, robustness of top (predictor) indicators



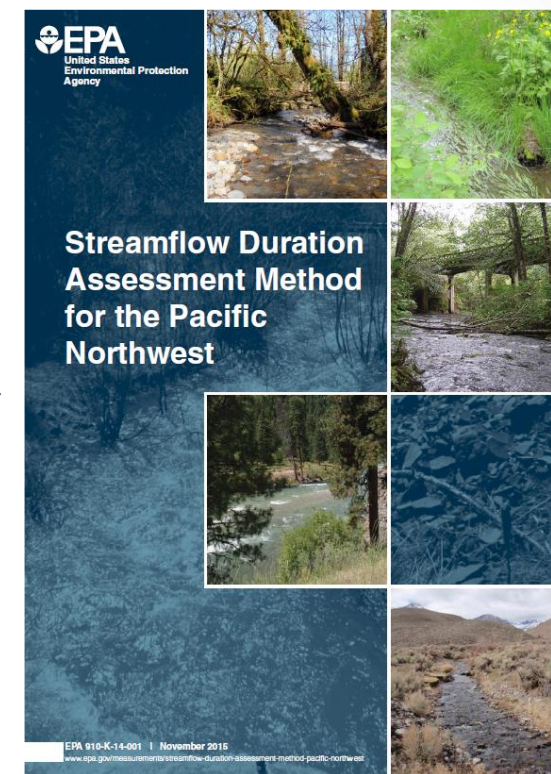
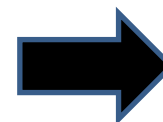
Development of SDAM for the Pacific Northwest



Interim method for OR
Multimetric (21 + 3 indicators)
(2009)



SDAM for OR
Decision tree (5 indicators)
(2011)

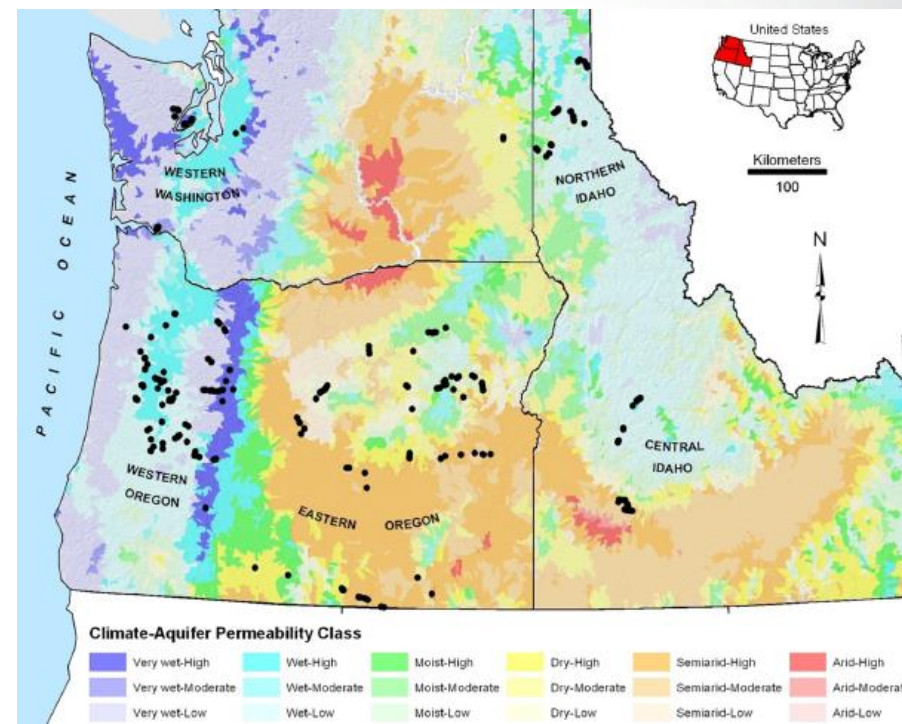


SDAM for ID, OR & WA
Decision tree (5 indicators)
(2015)

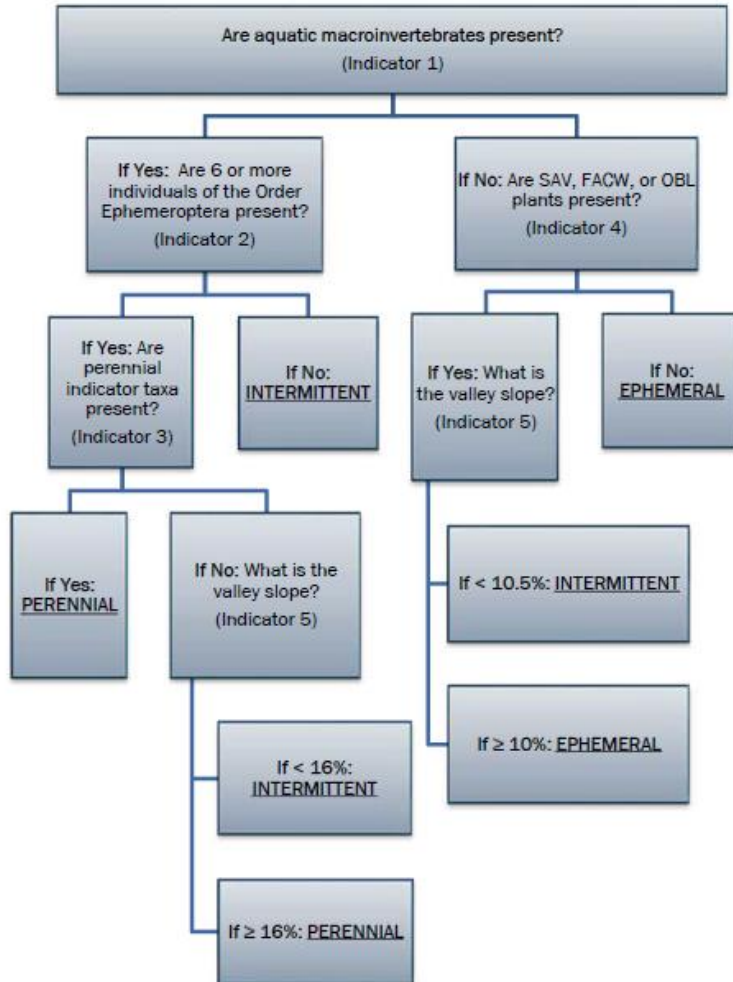
Development of SDAM PNW

EPA Region 10/Corps Portland District/Oregon Dept. of State Lands

- Focused on low-order headwater streams, public lands, 1°-2° roads
- **OR (2009-10):** 178 sites
 - East & west of Cascade Mountains
 - 77 perennial, 59 intermittent, 42 ephemeral (nominally)
 - Sampled in spring (wet) & late summer (dry)
- **ID & WA (2010-11):** 86 sites
 - Western WA, northern ID, central ID
 - Sampled in spring & late summer
- ~80 sites with ER data loggers, others (independently assigned streamflow class) based on multiple hydrologic observations
- Xerces Society Macroinvertebrate Field Guide



SDAM PNW – Decision Tree Approach



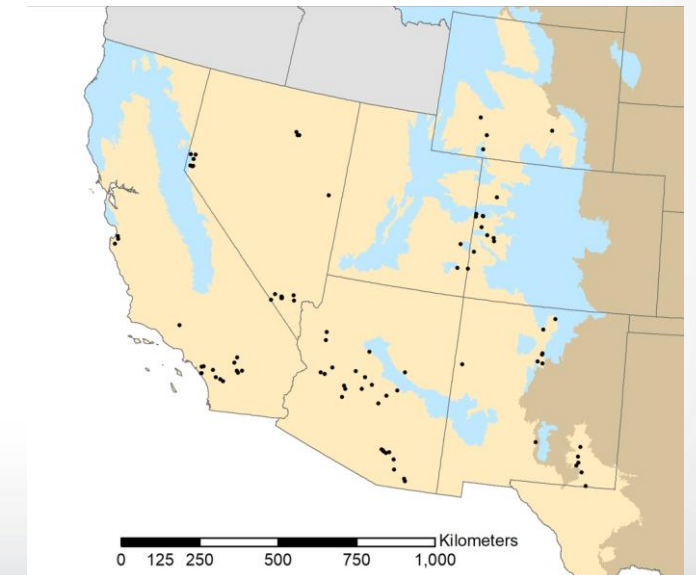
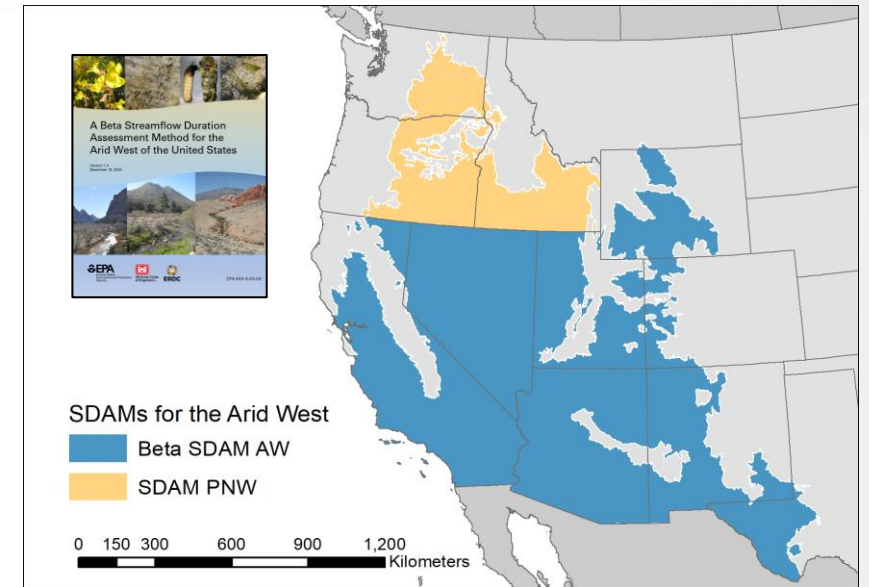
(Nadeau et al. 2015)

- 43 field indicators (geomorphology, hydrology & biology) collected from 264 reaches (528 observations)
- Used machine learning technique to build a “forest” of decision trees to identify 9 candidate indicators:
 1. All macroinvertebrates (ordinal)
 2. Perennial or intermittent macroinvertebrates (ordinal)
 3. Presence of perennial macroinvertebrates
 4. Sum of 2 & 3
 5. Ephemeroptera abundance
 6. Indicator status of most hydrophytic plant in streambed
 7. Channel slope (%)
 8. Streamer mosses or algal mats on streambed (ordinal)
 9. Leaf litter or other debris accumulated in thalweg (ordinal)
- Decision tree constructed that resulted in the highest agreement with direct hydrologic classifications – 84.3% accuracy (94.3% for *at least intermittent*) and relies on 7 indicators.

Development of beta SDAM for the Arid West

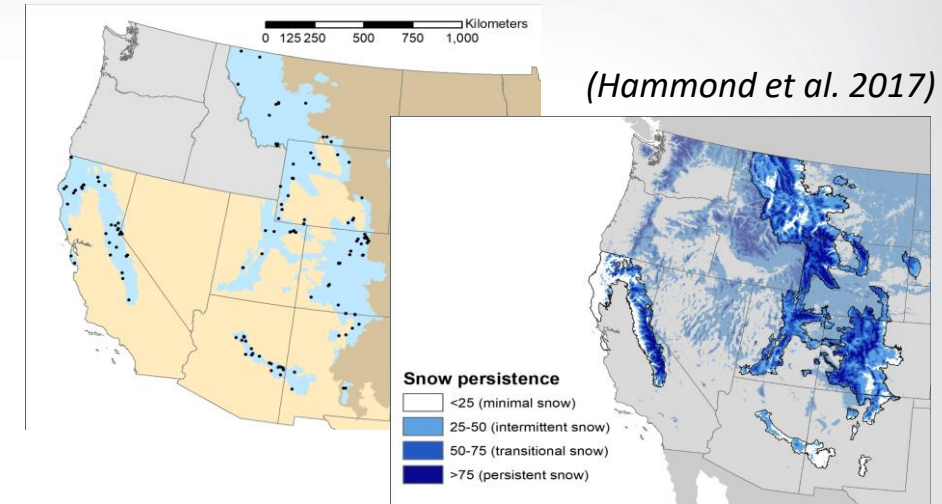
(March 2021)

- 89 study sites
 - Known flow duration
 - 30 ephemeral, 34 intermittent, 25 perennial
- 21 indicators collected
- 5 biological indicators predict streamflow class
 - Number of hydrophytic plant species (up to 5)
 - Number of aquatic macroinvertebrates
 - Presence of EPT taxa
 - Presence of algae
 - Presence of fish; % algal cover
- 81% accuracy for *at least intermittent*; 56% accuracy distinguishing all 3 classes



Development of beta SDAM for the Western Mountains (November 2021)

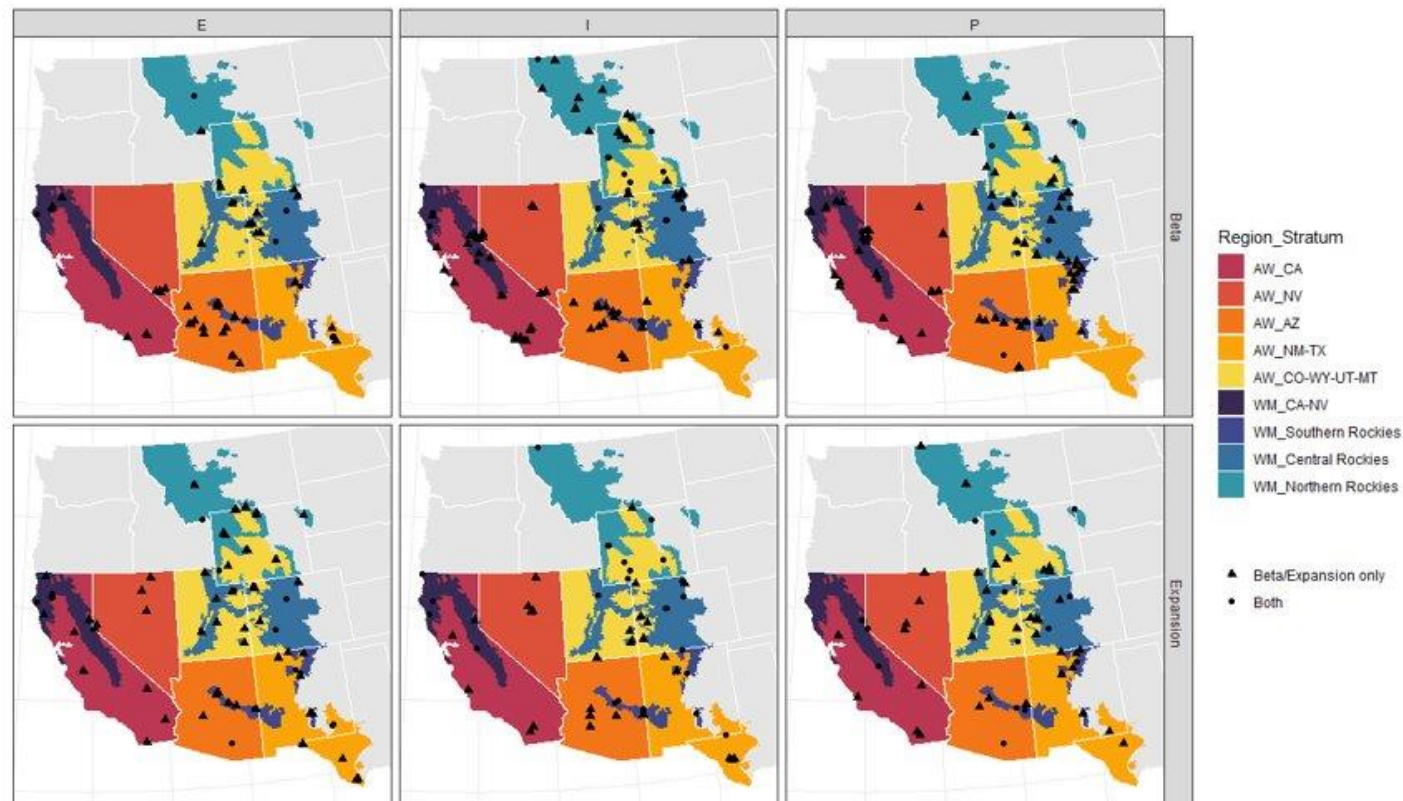
- 149 study sites
 - Known flow duration (48 instrumented)
 - 31 ephemeral, 66 intermittent, 25 perennial
- 21 indicators collected
- Stratified by degree of snow influence at assessment reach
- 89% accuracy for *at least intermittent*; 69% accuracy distinguishing all 3 classes



Snow-influenced areas	Non-snow influenced areas
Aquatic invertebrates: <ul style="list-style-type: none"> • Total abundance • Abundance of perennial indicator families • Number of perennial indicator families 	Aquatic invertebrates: <ul style="list-style-type: none"> • Abundance of mayflies • Number of perennial indicator families
Algal cover on the streambed	Algal cover on the streambed
Fish presence (as a single indicator)	Fish abundance (as a core indicator) and Fish presence (as a single indicator)
	Differences in vegetation
Channel width	Channel width
	Sinuosity
Climate <ul style="list-style-type: none"> • October precipitation 	Climate <ul style="list-style-type: none"> • May precipitation • Annual maximum temperature

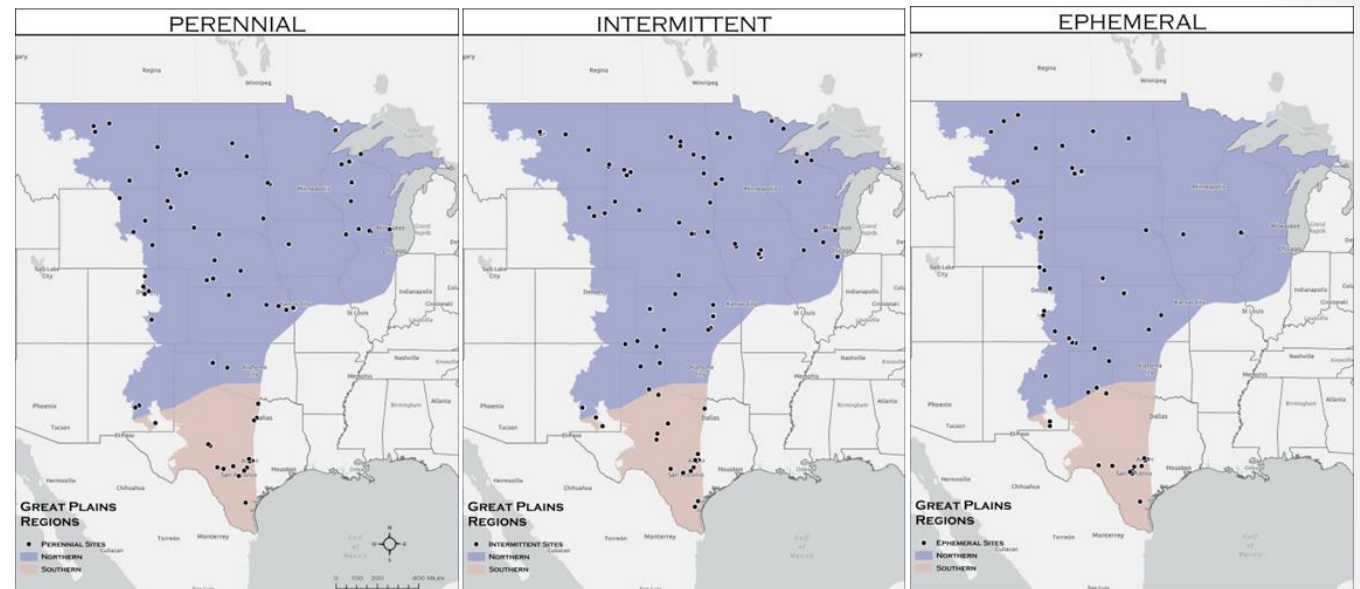
Development of Final SDAMs for AW & WM

- Additional 100 sites being sampled per region
- All have 2 data loggers
- Covered states that were previously unrepresented (Arid West TX, MT) or minimally represented (Western Mountains NV, SD)
- Data collection complete December 2022
- Anticipated final methods released Fall 2023



Development of beta SDAM for the Great Plains (anticipated release Fall 2022)

- 251 study sites
 - Known flow duration (180 instrumented)
 - 71 ephemeral, 100 intermittent, 80 perennial
- 27 indicators collected

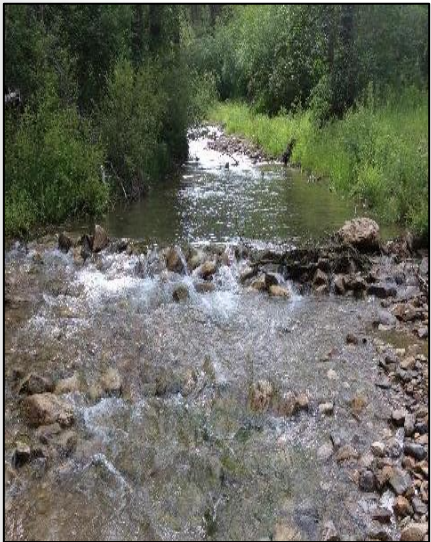


Comparison of Regional SDAMs Applicable in the West

	Western Mountains (beta)	Arid West (beta)	Pacific Northwest
Types of indicators	Biological, geomorphological, and climatic	Biological	Biological and geomorphological
Single indicators	Fish	Fish Algal cover $\geq 10\%$	Fish Aquatic life stages of snakes or amphibians
Type of tool	Random forest model	Classification table (simplified from random forest model)	Decision tree (simplified from random forest model)
Stratification	Snow-influence	None	None
Classifications	Perennial, intermittent, ephemeral, and at least intermittent.	Perennial, intermittent, ephemeral, at least intermittent, and need more information.	Perennial, intermittent, ephemeral, and at least intermittent.
Aquatic invertebrate identification	Required at Family level	Required at Order level	Required at Family level
Hydrophytic plant identification	None	Required	Required
Field time required	Up to 2 hours	Up to 2 hours	Up to 2 hours



Questions



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Website: epa.gov/streamflow-duration-assessment

- User Manuals, data, published papers, data analysis supplements, status of regional method development