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Calibrating SWAT Model Parameters of an Ungaged Forested and Coastal Watershed using Regionalization: A Case Study of North Depoe Bay Creek, Oregon

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Outline

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Motivation

Objectives

Study Site

Methodology

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Acknowledgements

Motivation

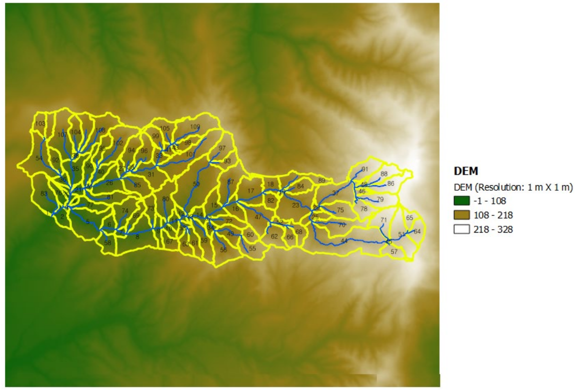
- Many coastal watersheds in Oregon are ungaged — no long-term streamflow data.
- Uncalibrated SWAT models → high uncertainty in flow, yield, and runoff predictions.
- Small communities like Depoe Bay, OR depend on these creeks for drinking water and ecological health
- Challenge: How can we calibrate models when monitoring data are missing?
  - This study applies the Regionalization Method.
  - Transfer parameters from similar gaged watersheds
  - Based on land cover, soil, and topographic similarity

Objectives

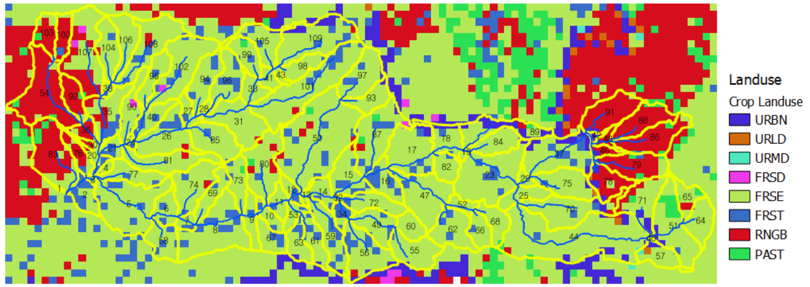
- **Evaluate** the effectiveness of a Regionalization Method for SWAT calibration.
- **Test** whether calibrated parameters from a nearby gaged watershed can be transferred to an ungaged watershed.
- **Verify** results with new flow sensor data installed in the ungaged watershed.

Study Site

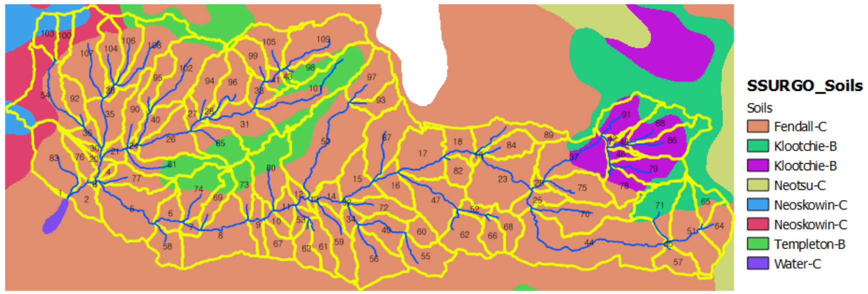
DEM (1 –meter Digital Elevation Model)



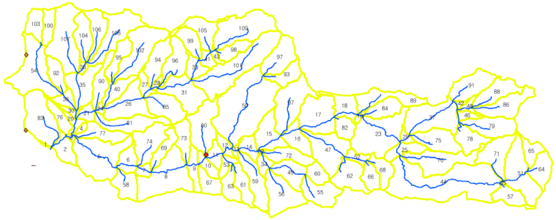
USDA Crop Data Layers (2023)

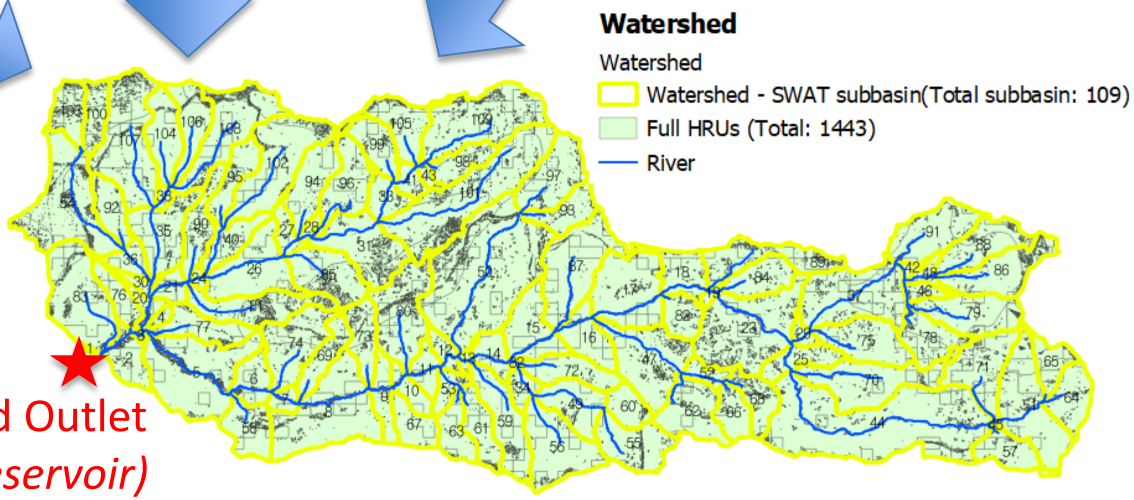


SSURGO Soil layer



OWRD Water Rights Database
(POUs and PODs)





Watershed Outlet
(Inlet to reservoir)

Area: 203.36 ha
We use the inlet of reservoir as the watershed outlet.

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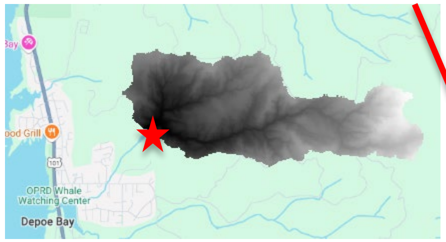
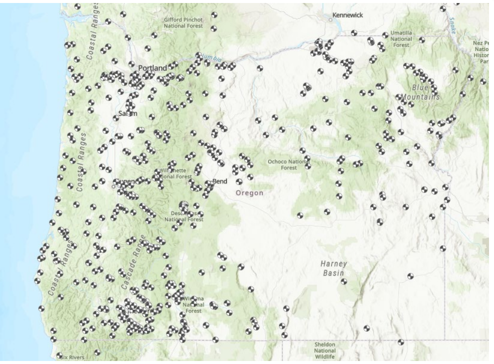
- Ungaged watershed: North Depoe Bay Creek (coastal, forested).
- Candidate gaged watersheds: Miami River, Drift Creek, Yachats Watershed
- New sensor installation: North Depoe Bay Creek, Oct 2024 – Sep 2025 data collected.

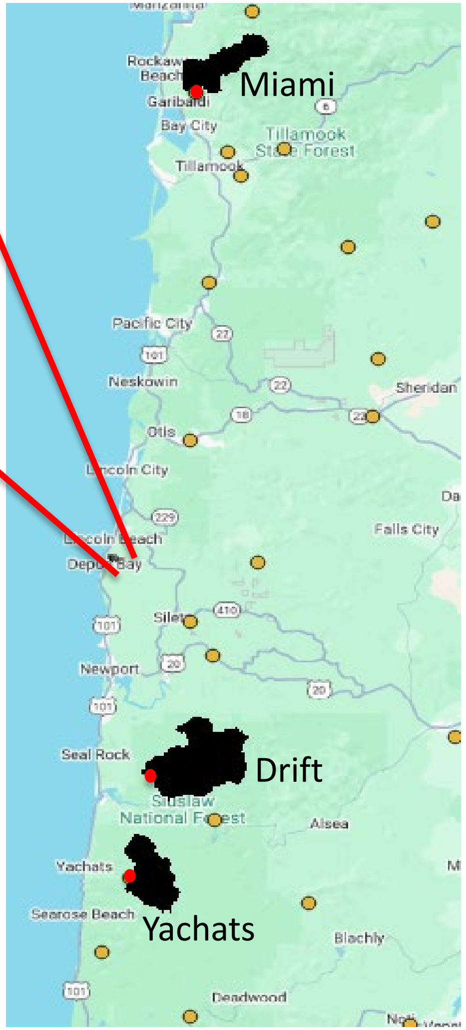
★ New sensor installation



North Depoe Bay Creek



OWRD gaged Station Map
:https://www.arcgis.com/apps/mapviewer/index.html?layers=485f754e3ffc48a68663057308ce5deb



• Gaging station

Methodology

Step 1: Watershed Similarity Analysis	Compare watersheds → select most similar gaged watershed (Miami River, Drift Creek, Yachats Watershed)
Step 2: Model Calibration for selected Watershed	Calibrate SWAT model for the best watershed.
Step 3: Parameter Transfer to North Depoe Bay Creek	Transfer calibrated parameters → North Depoe Bay Creek SWAT model.
Step 4: Model Validation with Sensor Observations	Validate model predictions using newly collected sensor data (2024–2025).

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- Regionalization Method
- Traditional Parameter Transfer Methods(Meng et al., 2020):
- The model parameter transferability method is to transfer one or more parameters of a donor catchment model into the ungauged target catchment model according to certain rules as its model parameters.
- Using Attribute Similarity Principle, calculate the similarity between the target catchment and donor catchments.

$$\emptyset = \sum_{i=1}^{n} \frac{\left| X_i^G - X_i^U \right|}{X_i^U} \times 100$$

X_i^G: Donor gaged watershed
X_i^U: Ungaged watershed
$\emptyset$: the attribute similarity between the two catchments

Methodology

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- Where ∅ is the attribute similarity between the two catchments; X_i^G and X_i^U are the ith attribute value of the donor catchment and the target catchment, respectively. The smaller the value of ∅ is, the more similar the two catchments will be.

$$\emptyset = \sum_{i=1}^{n} \frac{\left|X_i^G - X_i^U\right|}{X_i^U} \times 100$$

X_i^G: Donor gaged watershed
X_i^U: Ungaged watershed
∅: the attribute similarity between the two catchments

- The attribute similarity principle can determine the catchment with the highest attribute similarity and then transfer the parameters of this catchment model to the target catchment model.

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Watershed characteristics considered in Attribute similarity principle (Gita et al., 2010)

- Average elevation (E)
- Average annual precipitation (P)
- Average annual maximum temperature (T)
- Average annual minimum temperature (T)
- Average slope (S)
  - %Slope [0-2]
  - %Slope [2-5]
  - %Slope [5-10]
  - %Slope [10-9999]
- Soil Type
  - %A
  - %B
  - %C
  - %D
- %Forest
- %Pasture/Hay
- %Urban

The Climatic Data Date : 2010 - 2023 (Precipitation, Min and Max Temperature)

Results

North Depoe Bay Creek has not been monitored for streamflow. Regionalization method for calibration of SWAT Model was used

Hydrologic Attribute	North Depoe Bay	Yachats	Miami River	Drift
Area [ha]	203.36	7969.53	7160.75	15718.53
Mean elevation [m]	162.2	221.52	292.74	329.86
%Forest	82.32	97.98	92.11	90.94
%Pasture/Hay	14.44	1.34	6.47	8.76
%Urban	3.24	0.68	0.74	0.29
%Slope [0-2]	0.53	0.89	1.04	0.33
%Slope [2-5]	1.35	0.47	0.8	0.22
%Slope [5-10]	4.34	0.50	0.33	0.26
%Slope [10-9999]	93.78	98.13	97.84	99.19
%A (Soil group)	0	0	0	0
%B (Soil group)	16.54	92.61	96.77	99.79
%C (Soil group)	83.46	7.39	3.23	0
%D (Soil group)	0	0	0	0.21

North Depoe Bay Creek has not been monitored for streamflow. Regionalization method for calibration of SWAT Model was used

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Hydrologic Attribute	North Depoe Bay	Yachats	Miami River	Drift
Average Precipitation (mm)	2001.04	2090.46	3311.41	2343.85
Average Minimum Temperature (°C)	7.76	6.60	6.11	5.77
Average Maximum Temperature (°C)	14.53	15.60	14.75	15.33

Attribute Similarity Principle (ASP)	North Depoe Bay	Yachats	Miami River	Drift
Φ(phi)	–	1029.42	1127.92	1116.99

Yachats had the lowest Φ value

$$\emptyset = \sum_{i=1}^{n} \frac{\left|X_i^G - X_i^U\right|}{X_i^U} \times 100$$

X_i^G: Donor gaged watershed
X_i^U: Ungaged watershed
$\emptyset$: the attribute similarity between the two catchments

Yachats Calibration Results (01/2013-12/2018)

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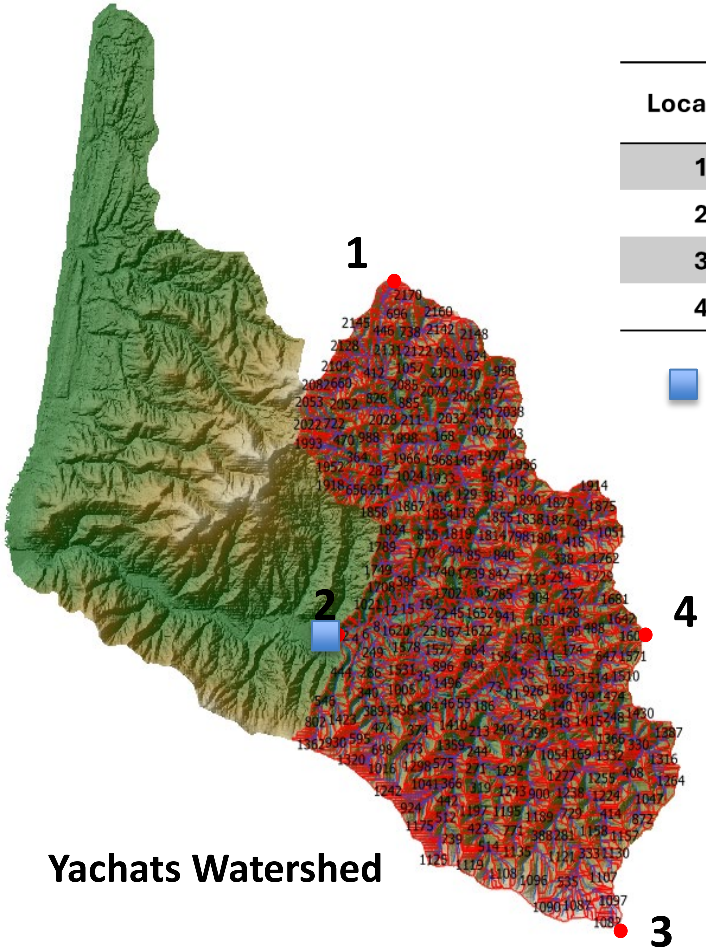
Parameter Name	Min	Max	Landuse	Best Value
r_CN2.mgt	-0.5	-0.17	FRSE	-0.204650
r_CN2.mgt	-0.4	-0.07	FRST	-0.138310
r_CN2.mgt	-0.4	-0.07	PAST	-0.222130
a_ESCO.bsn	-1.05	-0.2	-	-0.763550
r_GWQMN.gw	-0.8	4	-	-0.315208
a_CH_K2.rte	-8	11	-	5.204999
a_LAT_TTIME.rte	-7	12	-	3.203000
a_CANMX.hru	16	46	PAST	19.090000
a_CANMX.hru	13	38	FRST	35.075001
a_CANMX.hru	-6	32	FRSE	19.650000



Location	Latitude	Longitude
1	44.3624	-123.995
2	44.2931	-124.011
3	44.2949	-123.918
4	44.2361	-123.924

Gaging Station Point

NSE = 0.78

PBIAS = 23.5 %

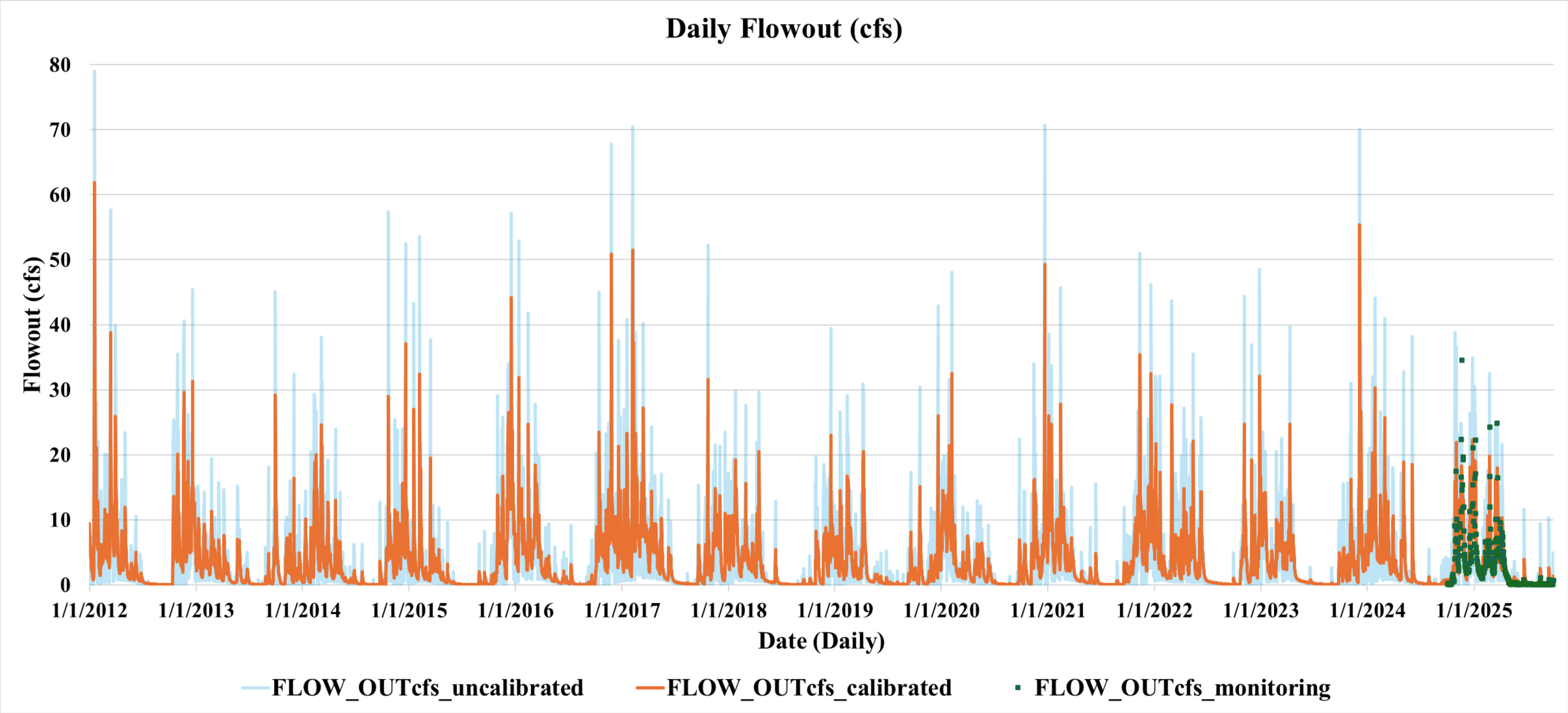
NSE	PBIAS (%)	Performance Rating
$0.75 < NSE \leq 1.00$	$PBIAS < \pm 10$	Very good
$0.65 < NSE \leq 0.75$	$\pm 10 \leq PBIAS < \pm 15$	Good
$0.50 < NSE \leq 0.65$	$\pm 15 \leq PBIAS < \pm 25$	Satisfactory
$NSE \leq 0.50$	$PBIAS \geq \pm 25$	Unsatisfactory

(Moriasi et al., 2007)

- The Yachats model achieved good calibration performance, making it a reliable donor watershed for parameter transfer.

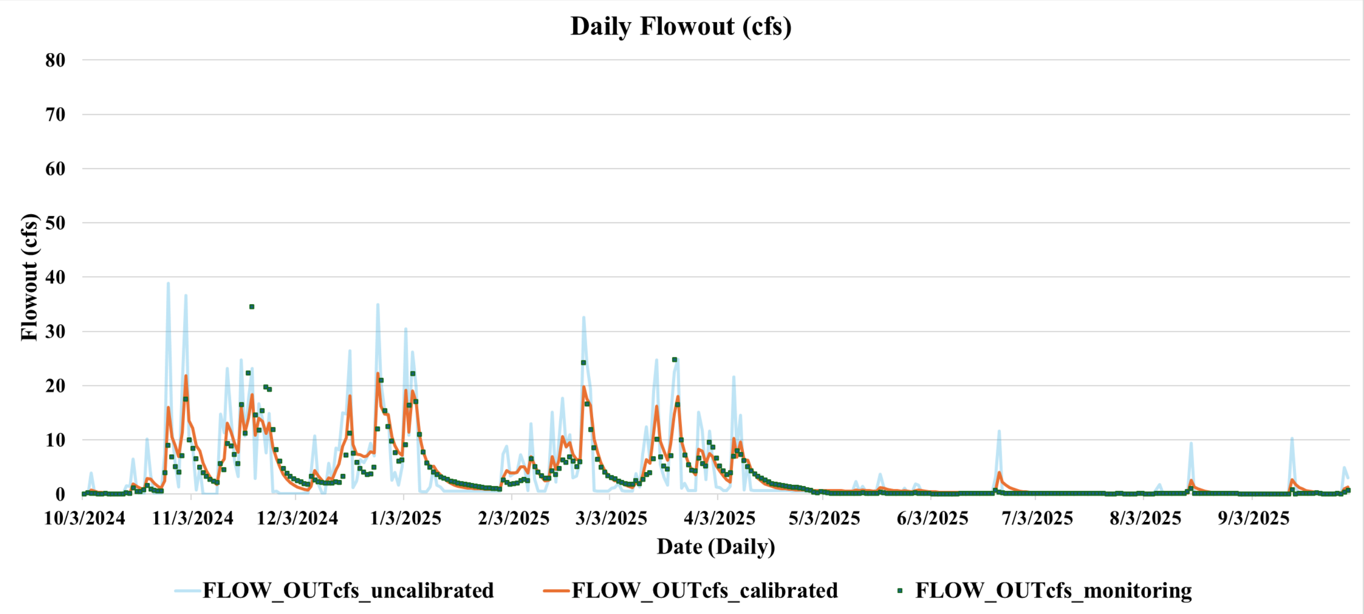
North Depoe Bay Creek Daily Streamflows
Uncalibrated versus Calibrated versus New Sensor Data

- SWAT Simulation Dates: 01/01/2012 – 09/30/2025
- Sensor Dates: 10/03/2024 – 09/30/2025



Calibrated Model (via Regionalization Method) versus New Sensor Data

- SWAT Simulation Date: 01/01/2012 – 09/30/2025
- Monitoring Date: 10/03/2024 – 09/30/2025



NSE = 0.81

PBIAS = -8.99 %

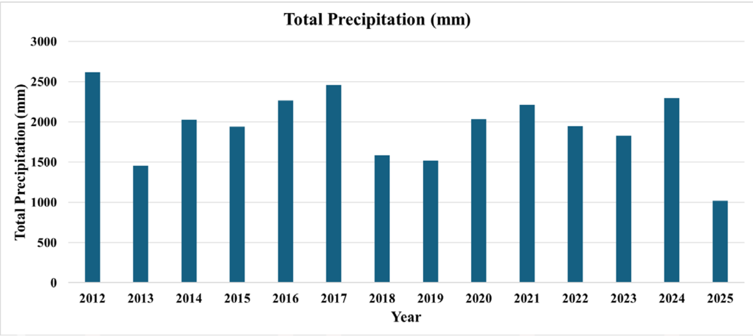
NSE	PBIAS (%)	Performance Rating
0.75 < NSE ≤ 1.00	PBIAS < ±10	Very good
0.65 < NSE ≤ 0.75	±10 ≤ PBIAS < ±15	Good
0.50 < NSE ≤ 0.65	±15 ≤ PBIAS < ±25	Satisfactory
NSE ≤ 0.50	PBIAS ≥ ±25	Unsatisfactory

(Moriasi et al., 2007)

- The regionalization-based calibration successfully reproduced the observed streamflow behavior in the ungaged watershed.

- The parameters calibrated in Yachats were highly transferable to North Depoe Bay Creek, proving the effectiveness of this method for data-scarce coastal basins.

Results of Model – Annual Mean Water Yield



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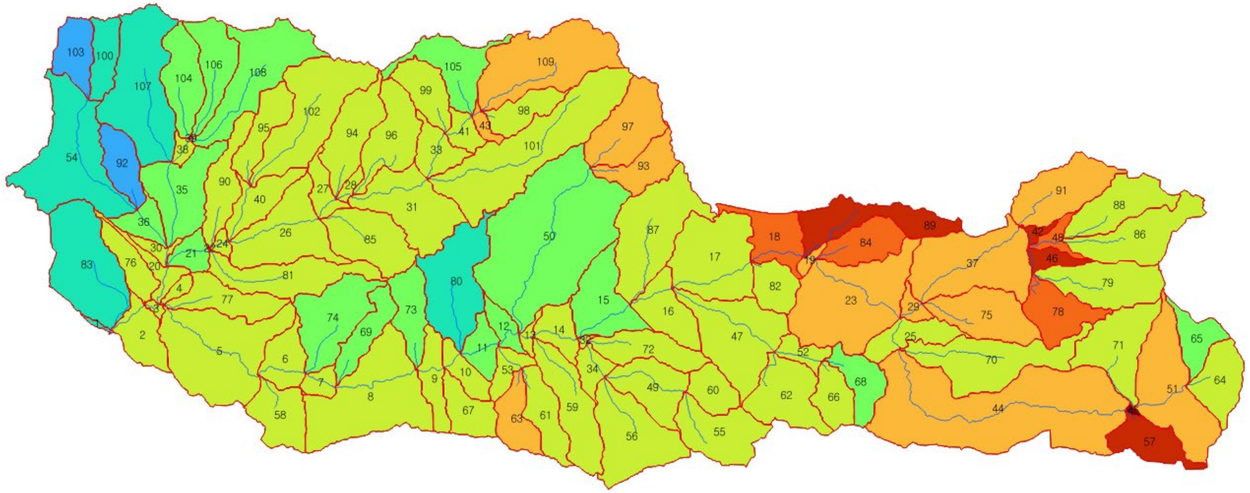
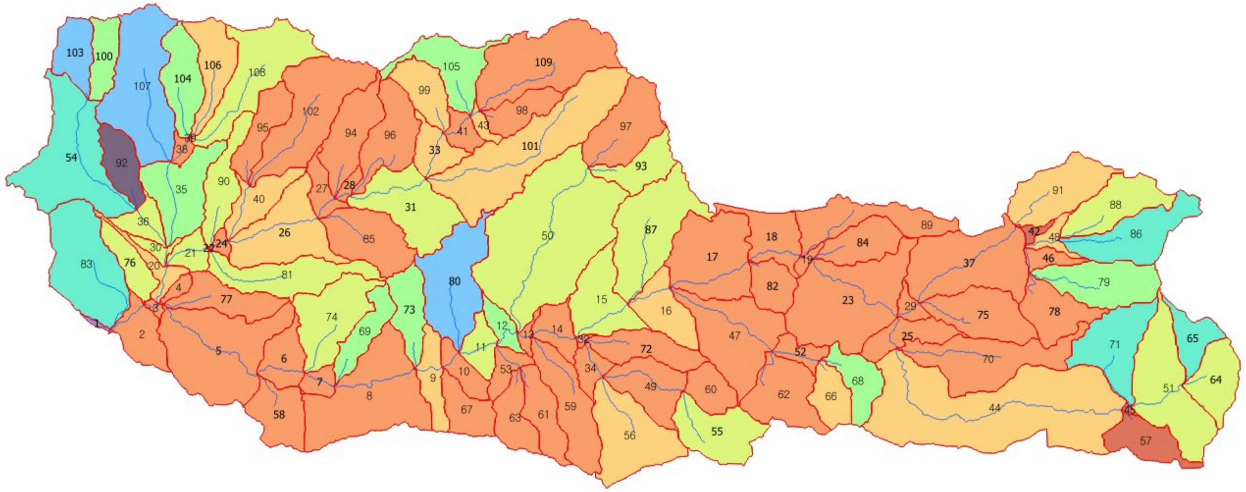
Uncalibrated Watershed Model



Annual Mean Water Yield (mm)

- 1510 - 1520
- 1520 - 1530
- 1530 - 1540
- 1540 - 1550
- 1550 - 1560
- 1560 - 1570
- 1570 - 1580
- 1580 - 1590
- 1590 - 1600
- > 1600

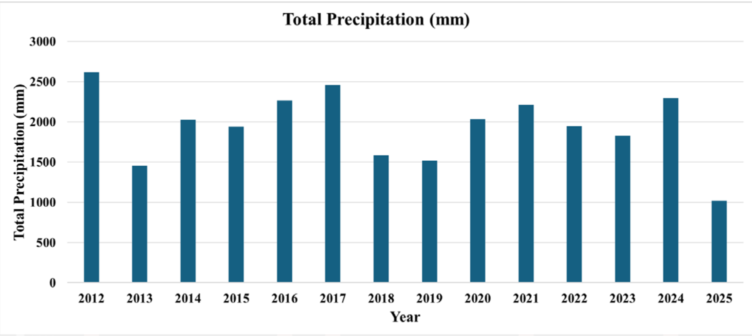
Calibrated Watershed Model



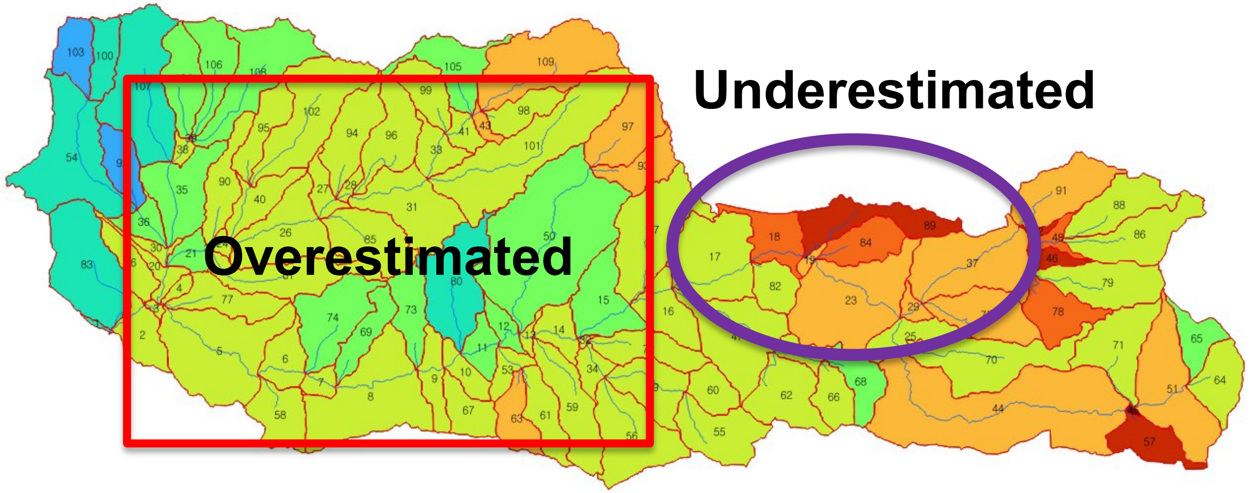
Annual Mean Water Yield (mm)

- 1510 - 1520
- 1520 - 1530
- 1530 - 1540
- 1540 - 1550
- 1550 - 1560
- 1560 - 1570
- 1570 - 1580
- 1580 - 1590
- 1590 - 1600
- > 1600

Results of Model – Annual Mean Water Yield



Uncalibrated Watershed Model



Annual Mean Water Yield (mm)

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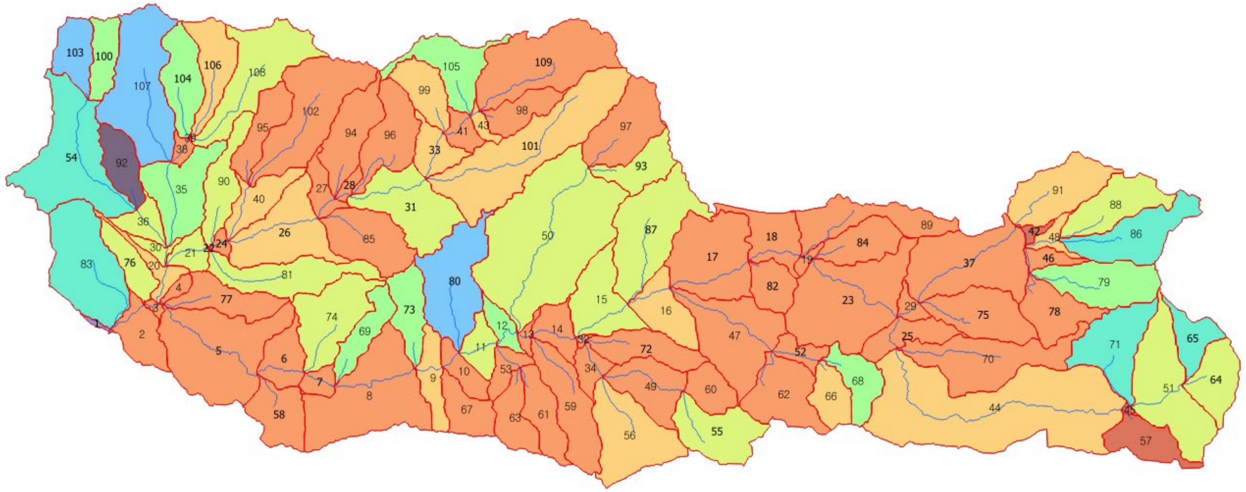
- 1530 - 1540
- 1540 - 1550
- 1550 - 1560
- 1560 - 1570
- 1570 - 1580
- 1580 - 1590
- 1590 - 1600
- > 1600

Calibrated Watershed Model



Annual Mean Water Yield (mm)

- 1510 - 1520
- 1520 - 1530
- 1530 - 1540
- 1540 - 1550
- 1550 - 1560
- 1560 - 1570
- 1570 - 1580
- 1580 - 1590
- 1590 - 1600
- > 1600

Discussions

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- Yachats (donor watershed) calibration:
  - NSE = 0.78 and PBIAS = 23.5 % (daily flow, 2013–2018).
- North Depoe Bay (target watershed) validation:
  - NSE = 0.81 and PBIAS = -8.99 % (validation with 2024–2025 sensor data).
- Demonstrates strong transferability of parameters across similar watersheds.
- Highlights practicality of regionalization in data-limited, ungaged settings.

Conclusions

- Regionalization can be effective for SWAT calibration in ungaged coastal watersheds.
- Provides a valuable tool to support small communities relying on local water resources.
- Informs scenario planning and current hydrologic assessments where monitoring is limited.
- Future long-term data collection can improve robustness of results.

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Acknowledgements

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Sea Grant OREGON

Thank you!

Soil & Water Assessment Tool SWAT

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