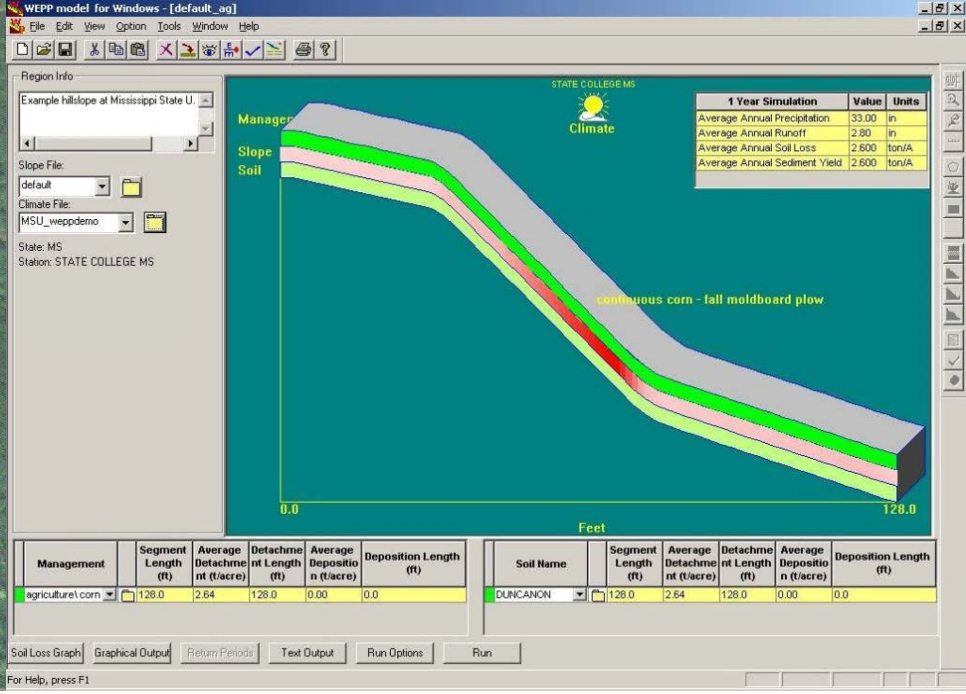

Managing forests for water harvesting under changing future climate in Korea using the WEPP model

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1. Background and Objectives

Water Harvesting by Forest Management

Nation/ Region	Species/ forest type	Treatment	Change in runoff
USA	Whole US	LAI 20%, 50%, 80% decrease	3%, 8%, 13% increase
CA		40% thinning	9% increase
AZ	Ponderosa	50% thinning	8% increase
Japan	Japanese cypress	58% thinning (43% DBH area)	241mm (7.4% individual, 4.8% monthly precipitation increase)
Australia	Eucalyptus	12~50% thinning	10~35% increase (effect lasts for 4~15 years)
Italy	Calabrian pine	50% thinning (30% DBH area)	Groundwater increase in spring and summer
Greece	Oak	50% DBH area	13.2 mm increase
Turkey	Deciduous	11% thinning	8 mm increase in first year
	Oak	18% thinning	No change in RO (20% threshold)
W Africa		Minimum 50% thinning	Runoff increase

1. Background and Objectives

Water Harvesting by Forest Management

- Forest provides various ecosystems, including water
- Assessing the effects of forest management (thinning, timber harvesting, and wildland fire) on water resources → Modeling tool is needed
- Applying a water resource model to Korea
- Choosing a physically-based model and modeling for baseline conditions (long-term undisturbed forest)
- Modeling for managed (disturbed) forest conditions
- Modeling for future climate conditions

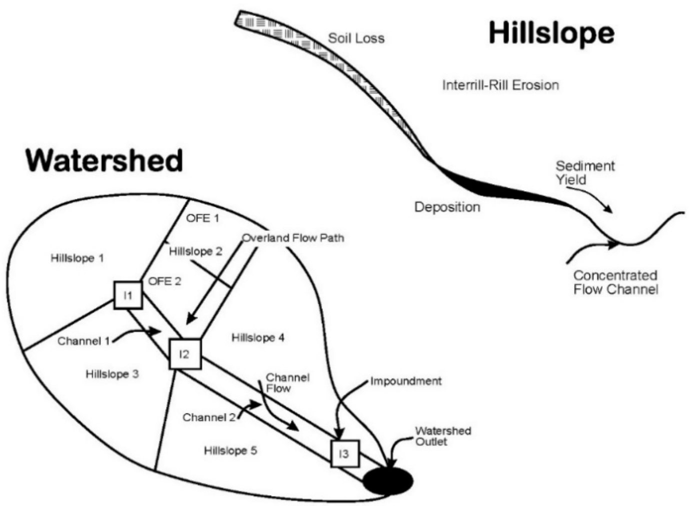
2. Method

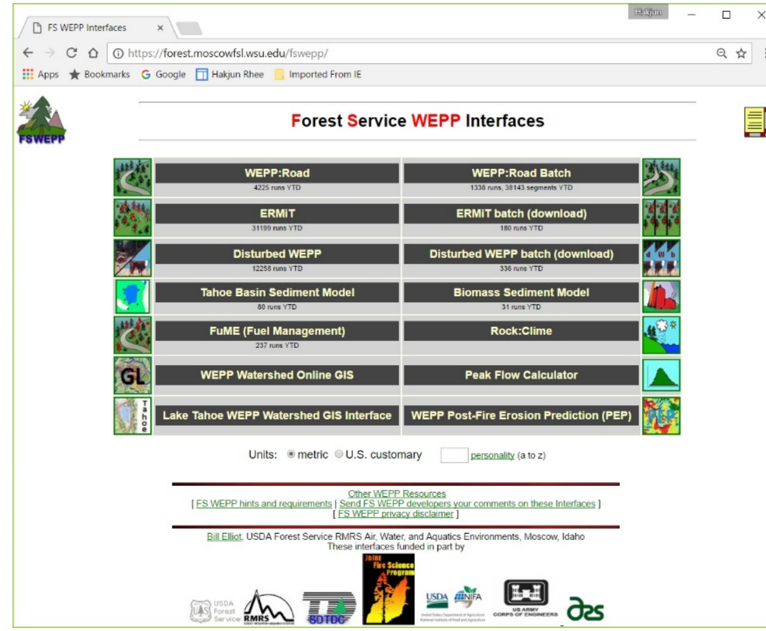
WEPP Model

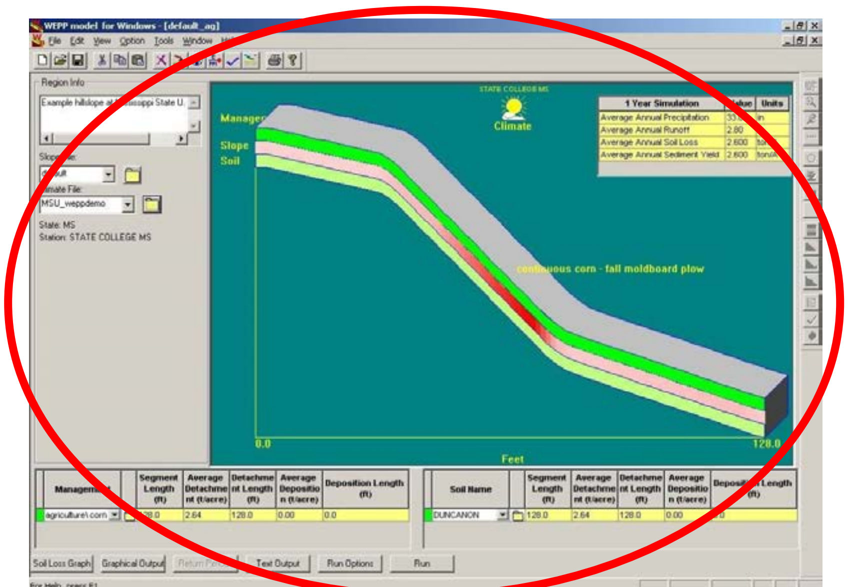
- WEPP (Water Erosion Prediction Project)
  - A physically-based and distributed-parameter watershed hydrology and erosion model
  - WEPP simulates the hydrologic and erosion impacts of
    1. Climate
    2. Soil
    3. Topography
    4. Land use and vegetation growth
  - WEPP outputs daily water balance, sediment yield and deposition
  - Adequate for small-size watersheds

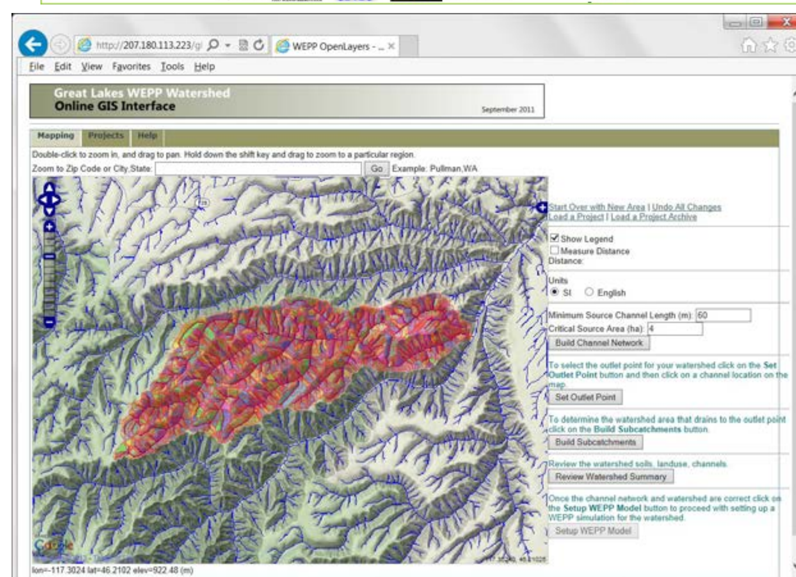
2. Method

- Various types of interfaces







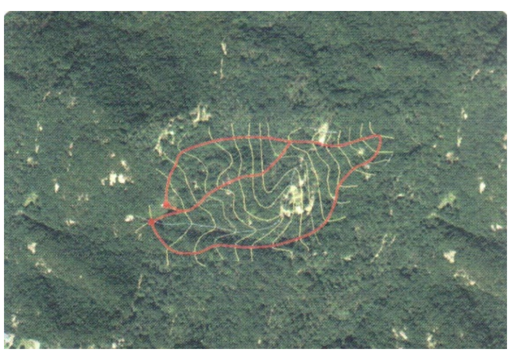


2. Method

Modeling Sites in Korea

- Gwangneung-Conifer
- Watershed size: 13.6 ha
- Annual precip: 1,503mm
- Soil depth: 30~60cm
- Parent rock: Granite gneiss
- Soil texture: Sandy Loam
- Forest type: Conifer
- Species: Korean pine, fir
- Age class: IV

- Gwangneung-Deciduous
- Watershed size: 22.0 ha
- Annual precip: 1,503mm
- Soil depth: 30~60cm
- Parent rock: Granite gneiss
- Soil texture: Sandy loam
- Forest type: Deciduous
- Species: Oak, Japanese larch
- Age class: VI



- Yangju-Mixed
- Watershed size: 5.2 ha
- Annual precip: 1,503mm
- Soil depth: 30~60cm
- Parent rock: Granite gneiss
- Soil texture: Sandy loam
- Forest type: Mixed
- Species: Pine, oak
- Age class: IV

2. Method

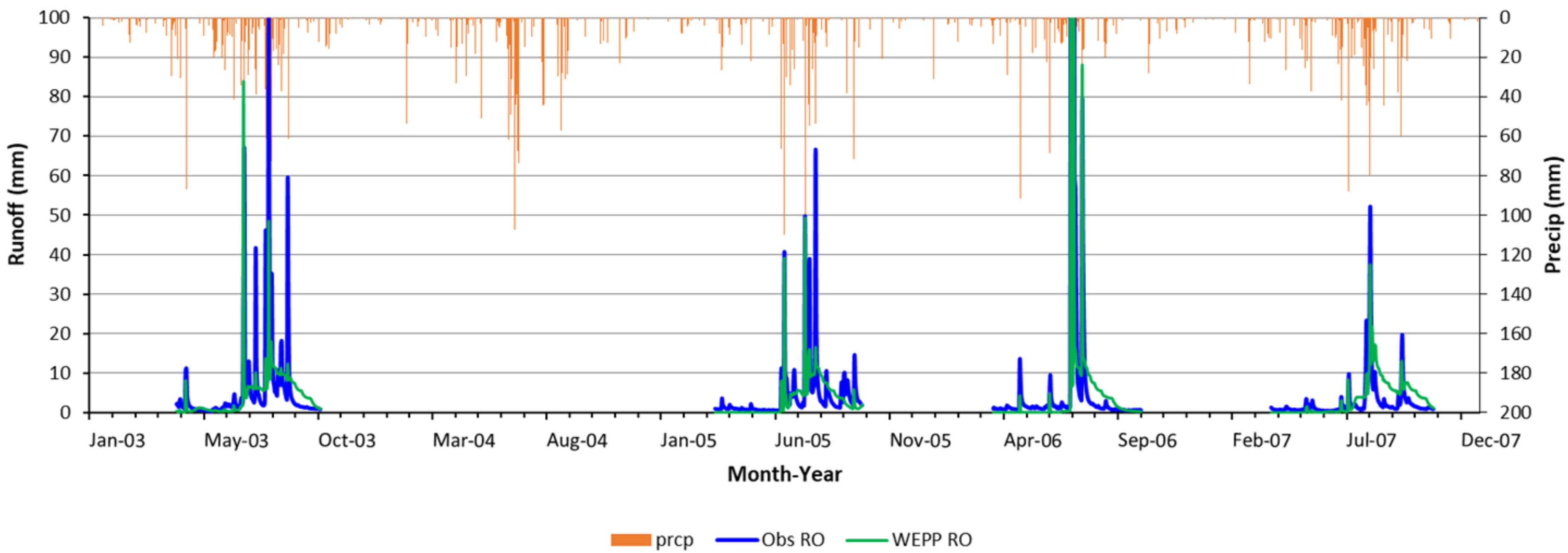
WEPP Inputs and Information for Modeling Sites in Korea

- Window Interface Version Sep 17 2017
- Inputs
  - Clmate: Korea Meteorological Administration AWS (Automatic Weather System) data for Gwangneung and Yangju
  - Soil: Modified sandy loam forest soil file based on western US
  - Land use: Forest file (Forest.rot) in WEPP and LAI (Leaf Area Index) 6
  - Penman-Monteith equation for ET
- Long-term (15 years of) monitoring stream runoff data (2003-2017)

3. Results

3.1. WEPP Stream Runoff Modeling: Gwangneung-Conifer

- Gwangneung-Conifer daily precipitation, observed runoff, and WEPP simulated runoff from 2003 to 2007



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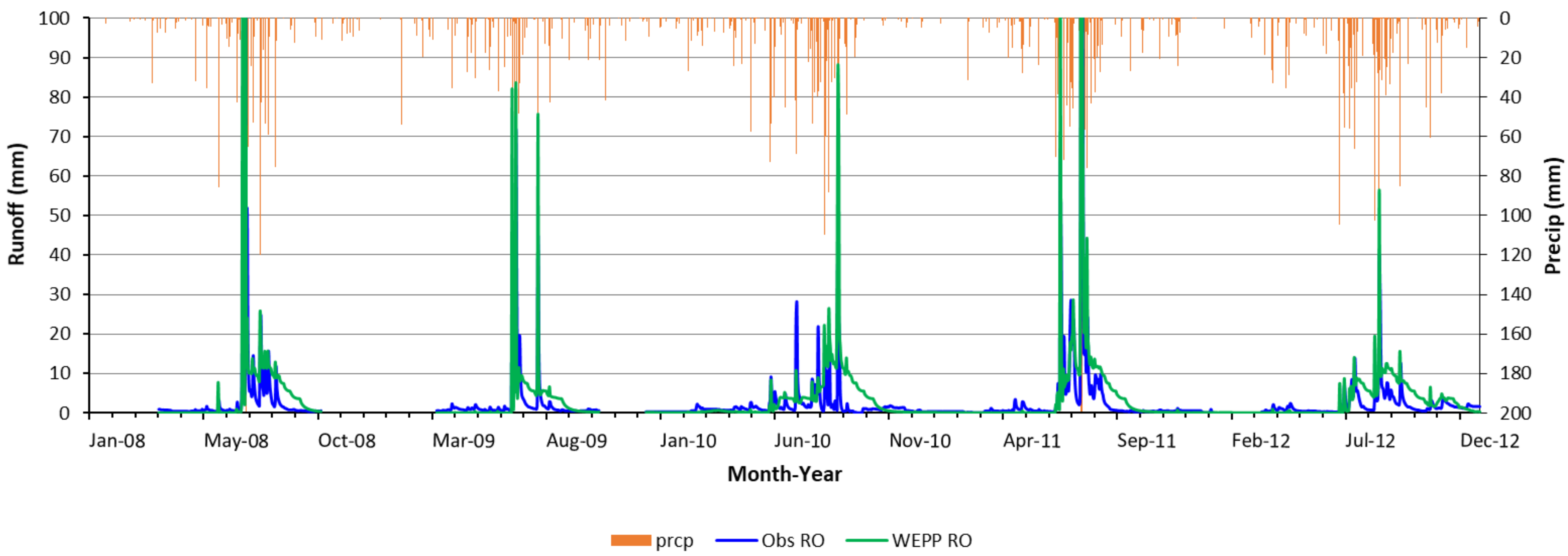

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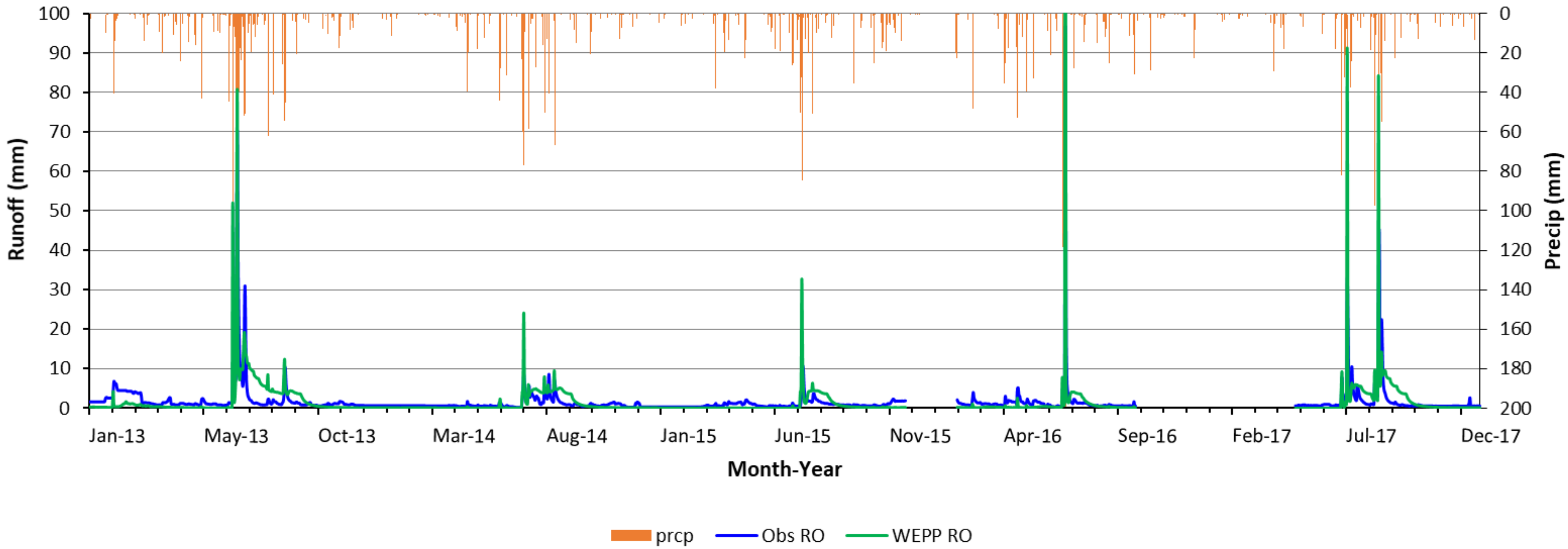

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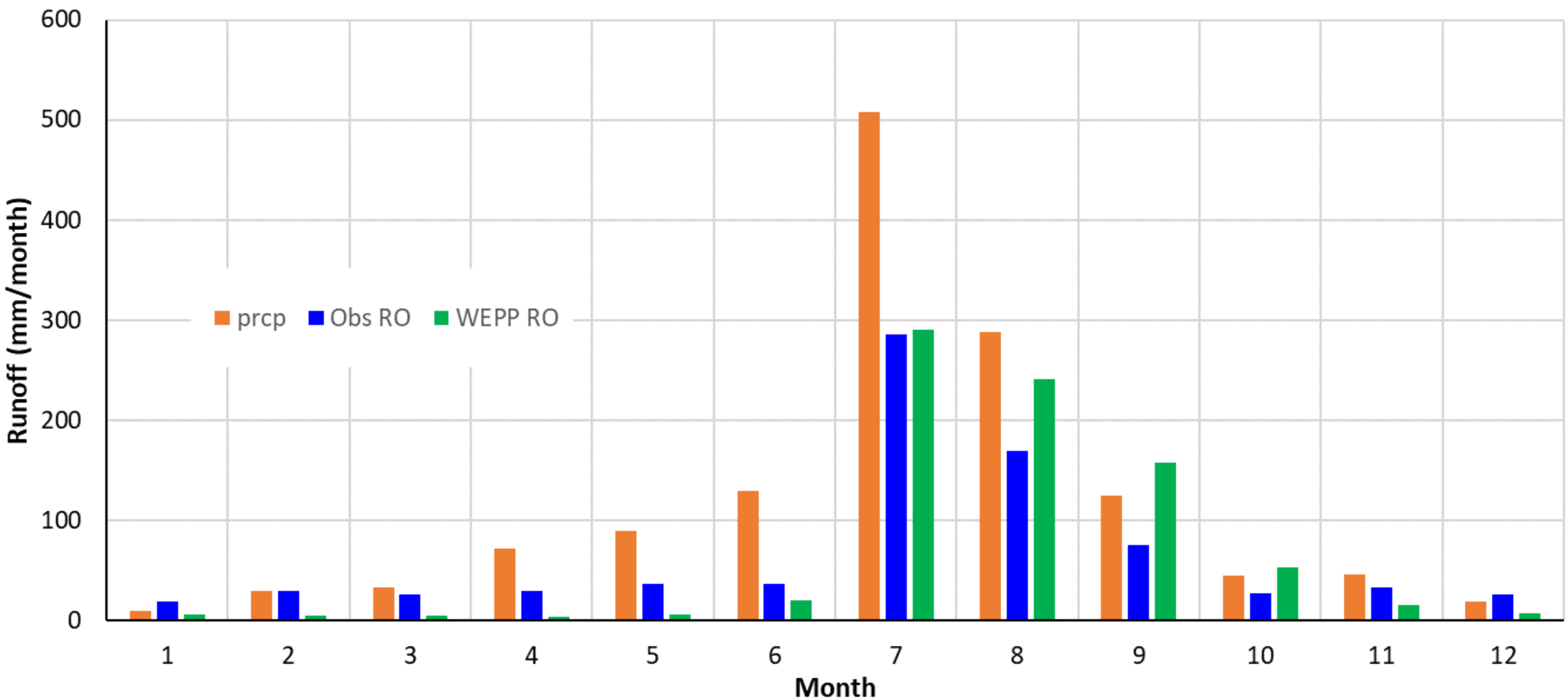
3.1. WEPP Stream Runoff Modeling: Gwangneung-Conifer

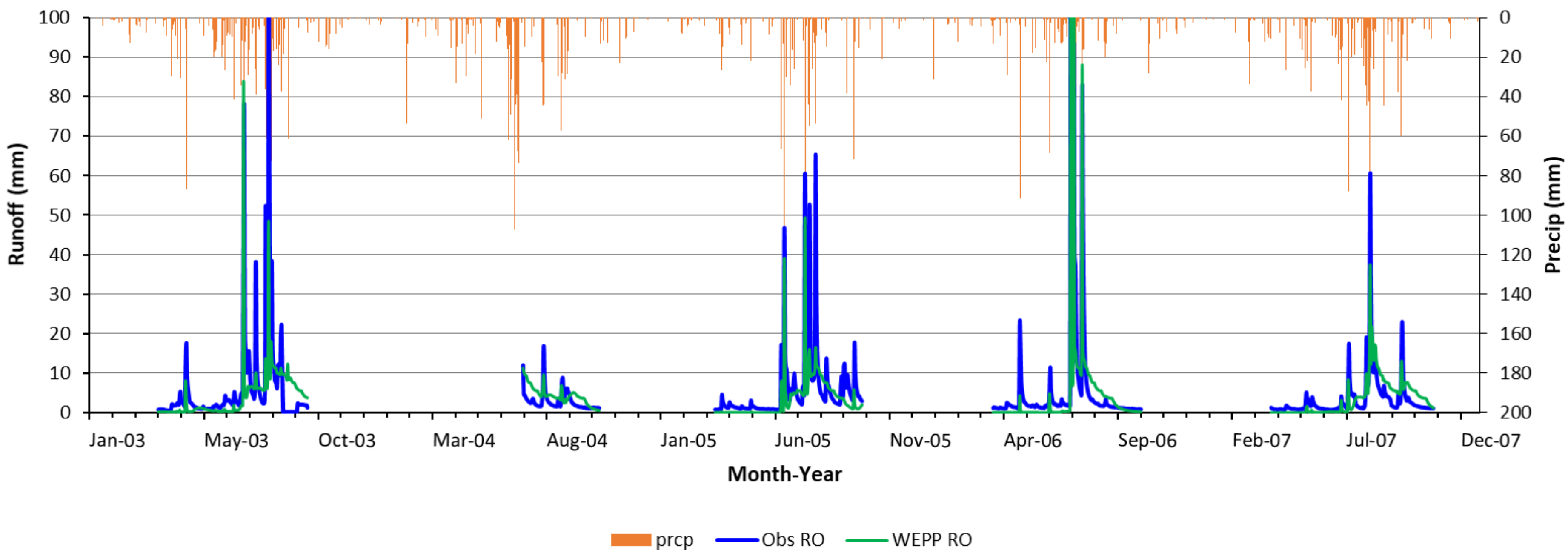
- Gwangneung-Conifer monthly precipitation, observed runoff, and WEPP simulated runoff from 2013 to 2017



3. Results

3.1. WEPP Stream Runoff Modeling: Gwangneung-Deciduous

- Gwangneung-Deciduous daily precipitation, observed runoff, and WEPP simulated runoff from 2003 to 2007



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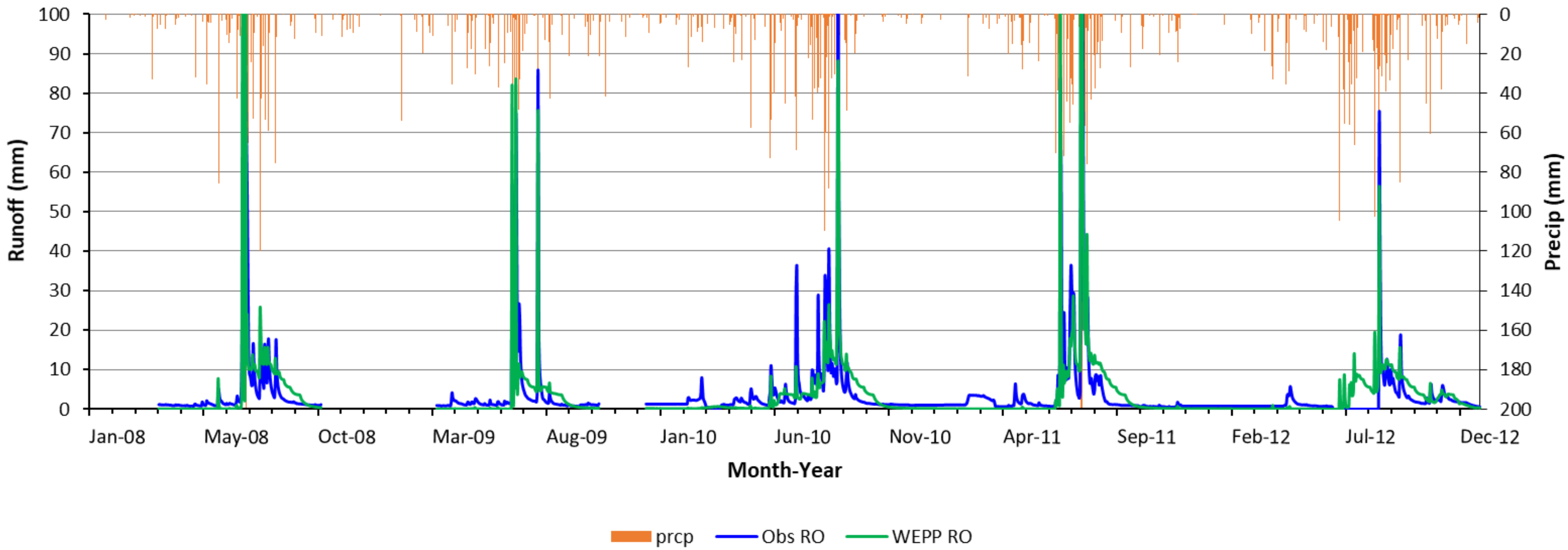

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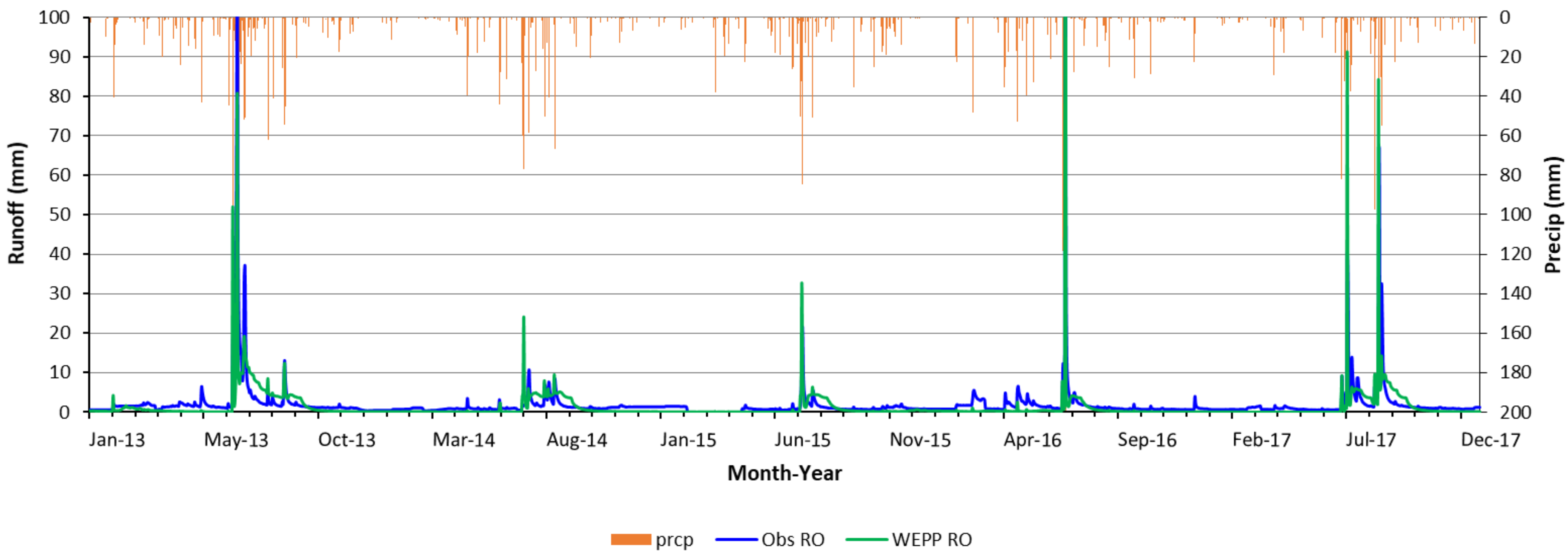

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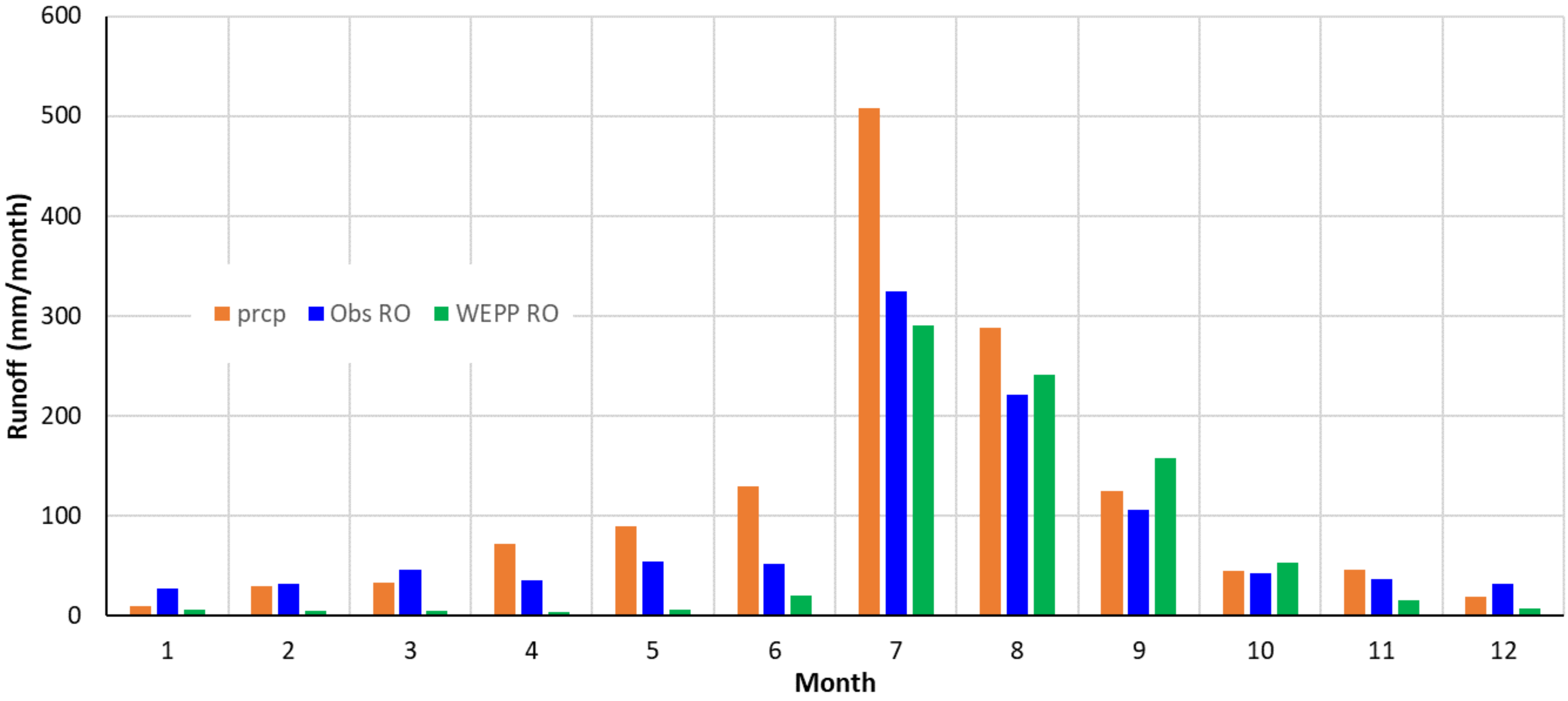
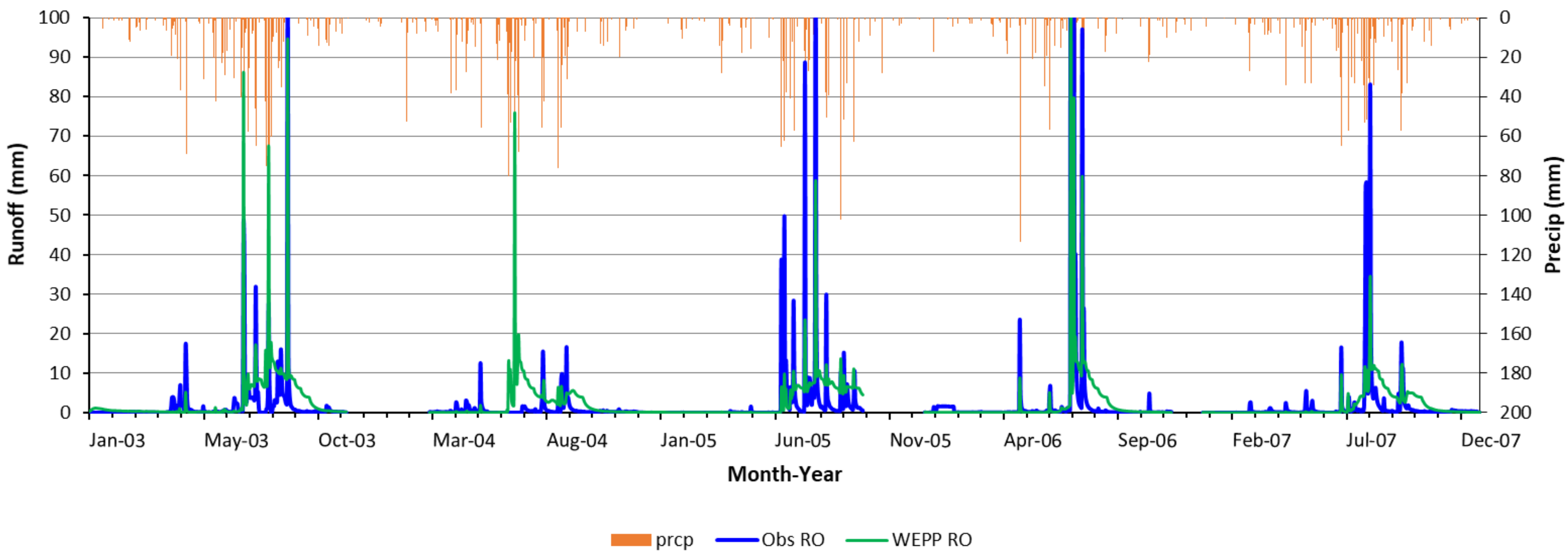


3. Results

3.1. WEPP Stream Runoff Modeling: Yangju-Mixed

- Yangju-Mixed daily precipitation, observed runoff, and WEPP simulated runoff from 2003 to 2007



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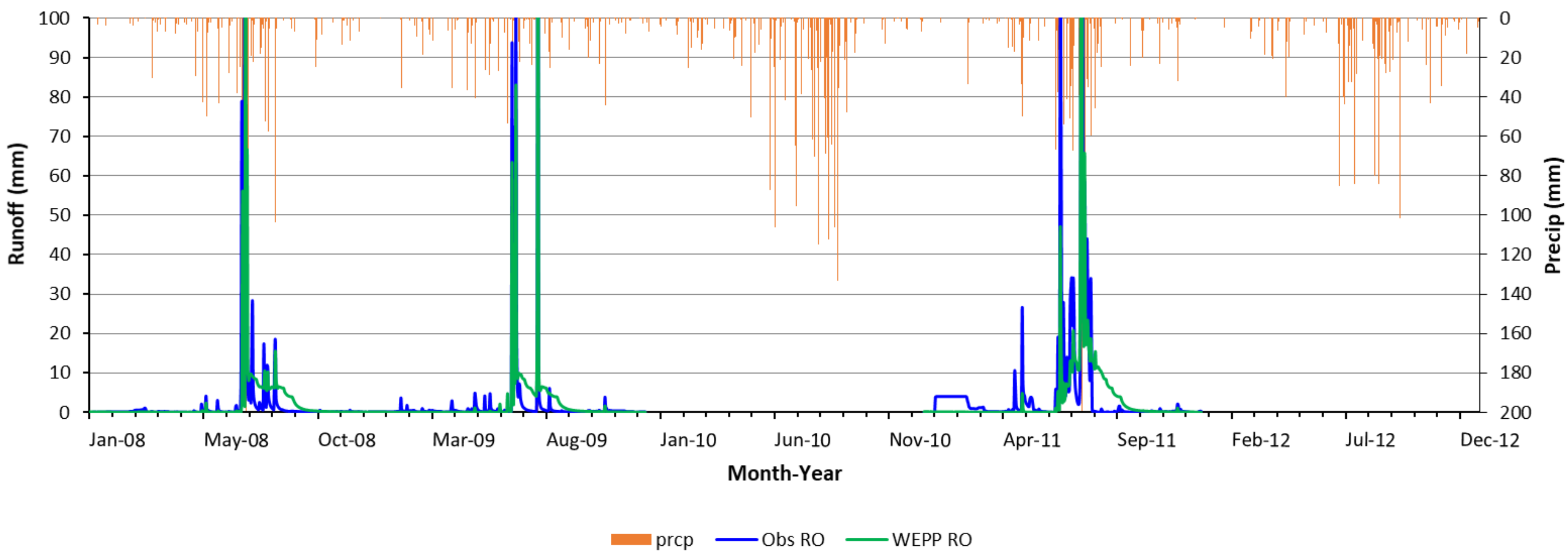

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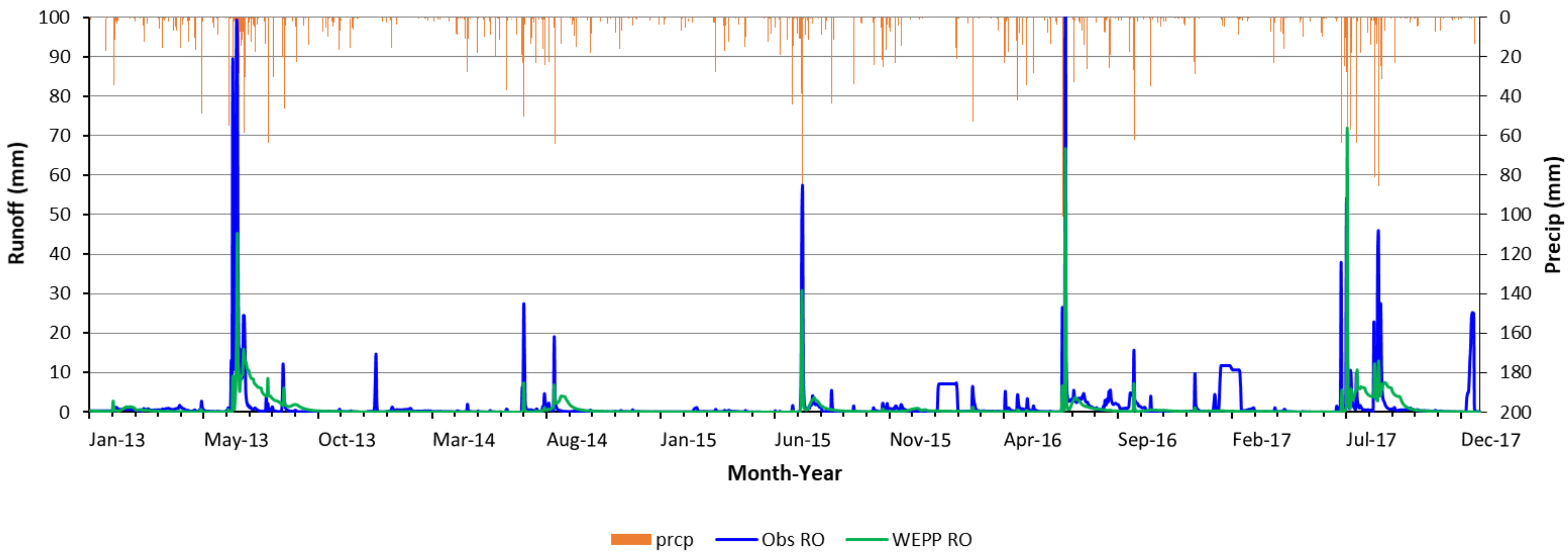

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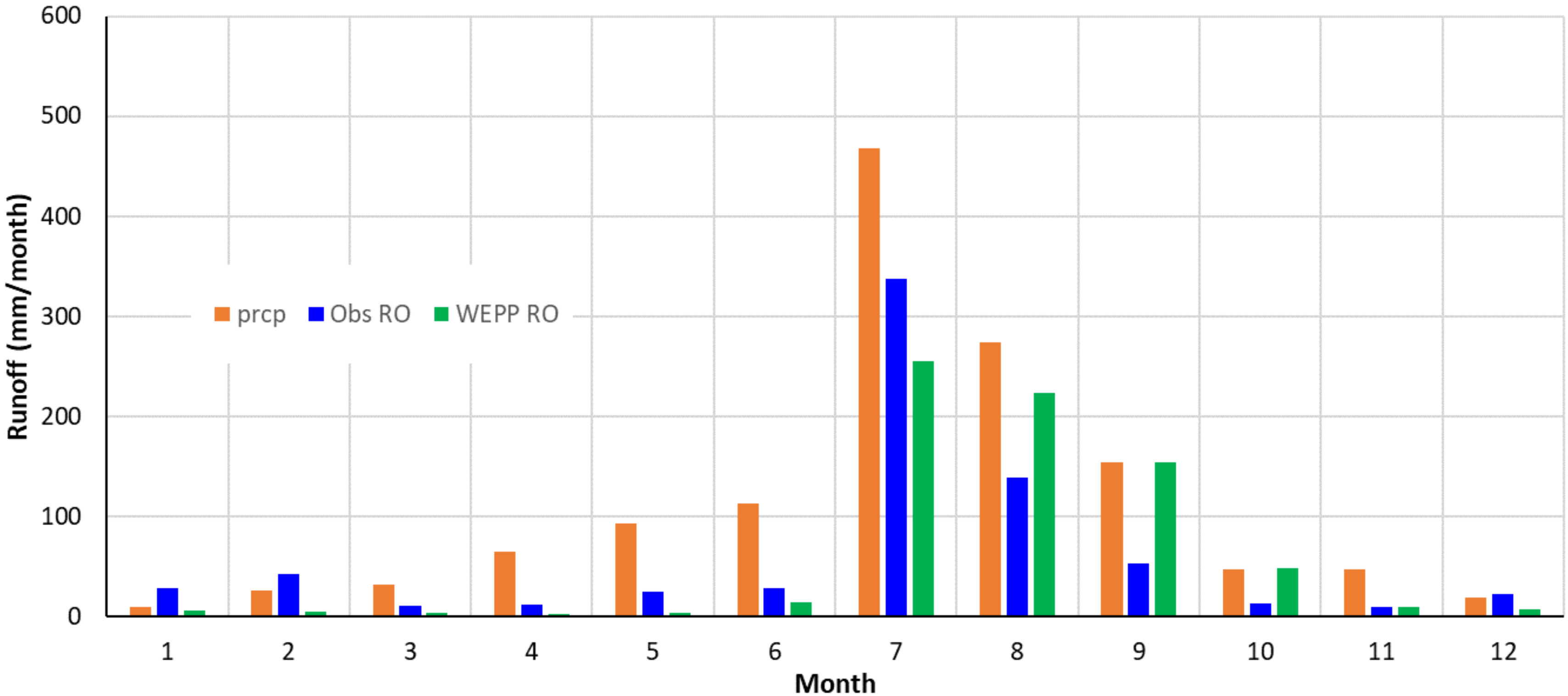


3. Results

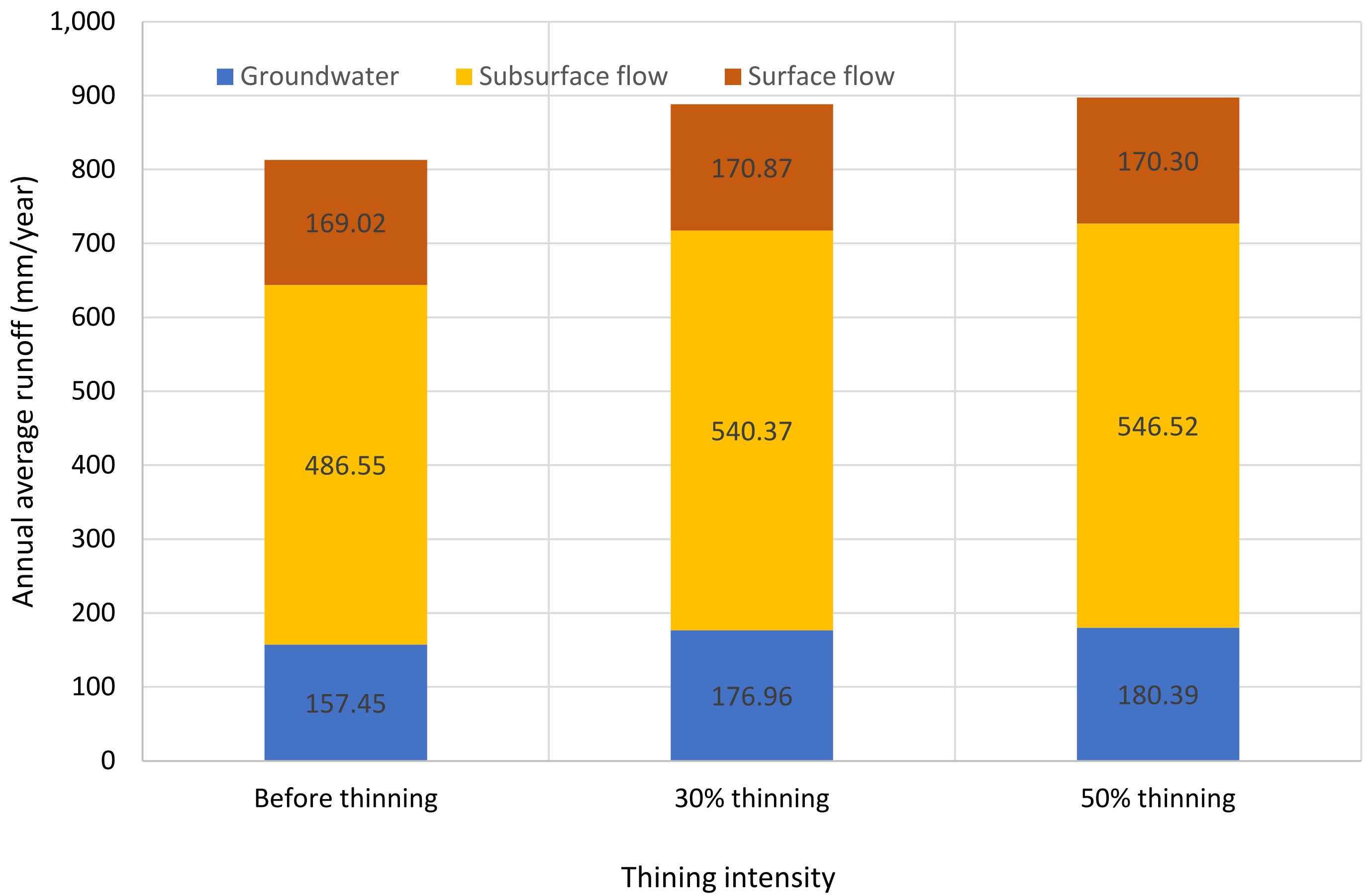
3.1. WEPP Stream Runoff Modeling: Comparisons

Site	Gwangneung-Conifer	Gwangneung-Deciduous	Yangju-Mixed
Average annual precip	1,394 mm/m^2	1,394 mm/m^2	1,350 mm/m^2
Observed annual RO	797 mm/m^2	1,011 mm/m^2	736 mm/m^2
WEPP simulated annual RO	813 mm/m^2	813 mm/m^2	724 mm/m^2
Observed ET rate	42.8%	27.5%	46.4%
WEPP simulated ET rate	41.7%	41.7%	45.5%
Nash-Sutcliffe Efficiency	0.696	0.660	0.557

3. Results

3.2. Thinning Effect Using WEPP: Gwangneung-Conifer

- Gwangneung-Conifer annual WEPP simulated runoff by thinning intensity



3. Results

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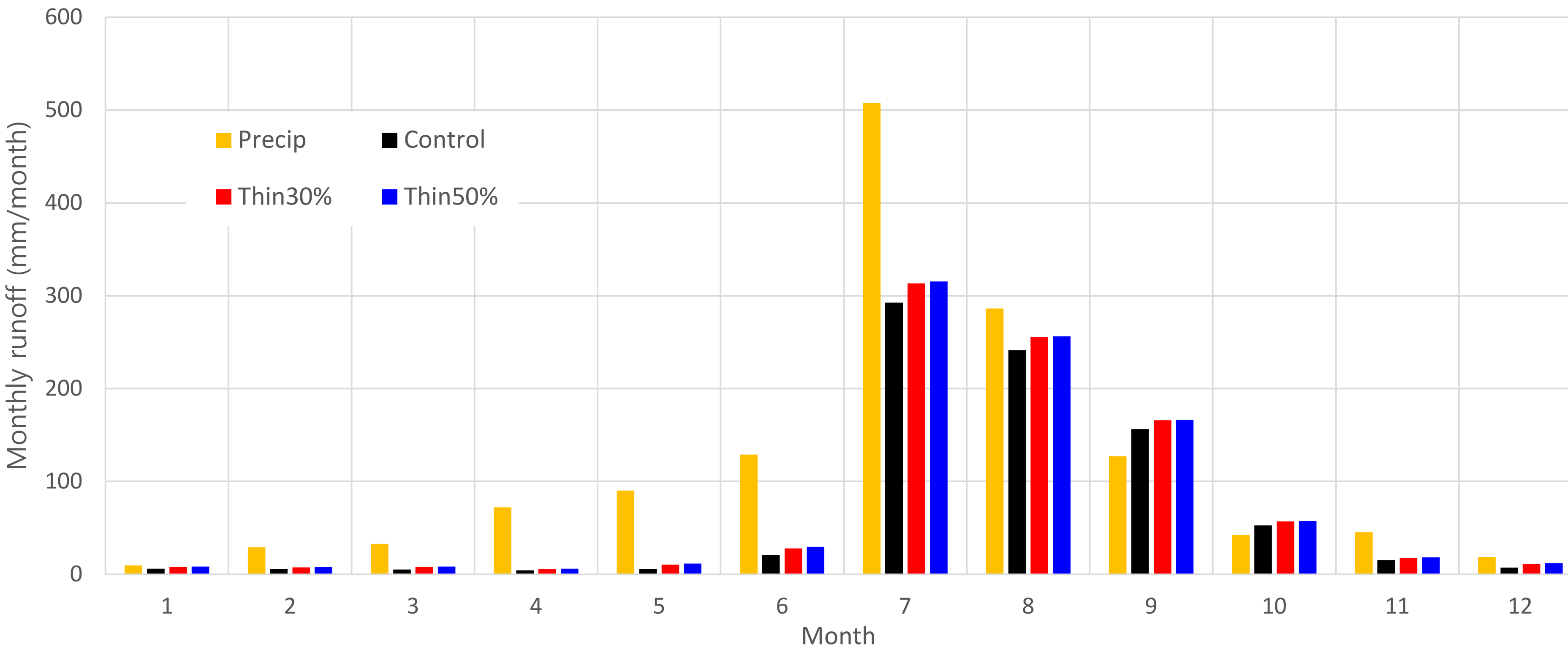
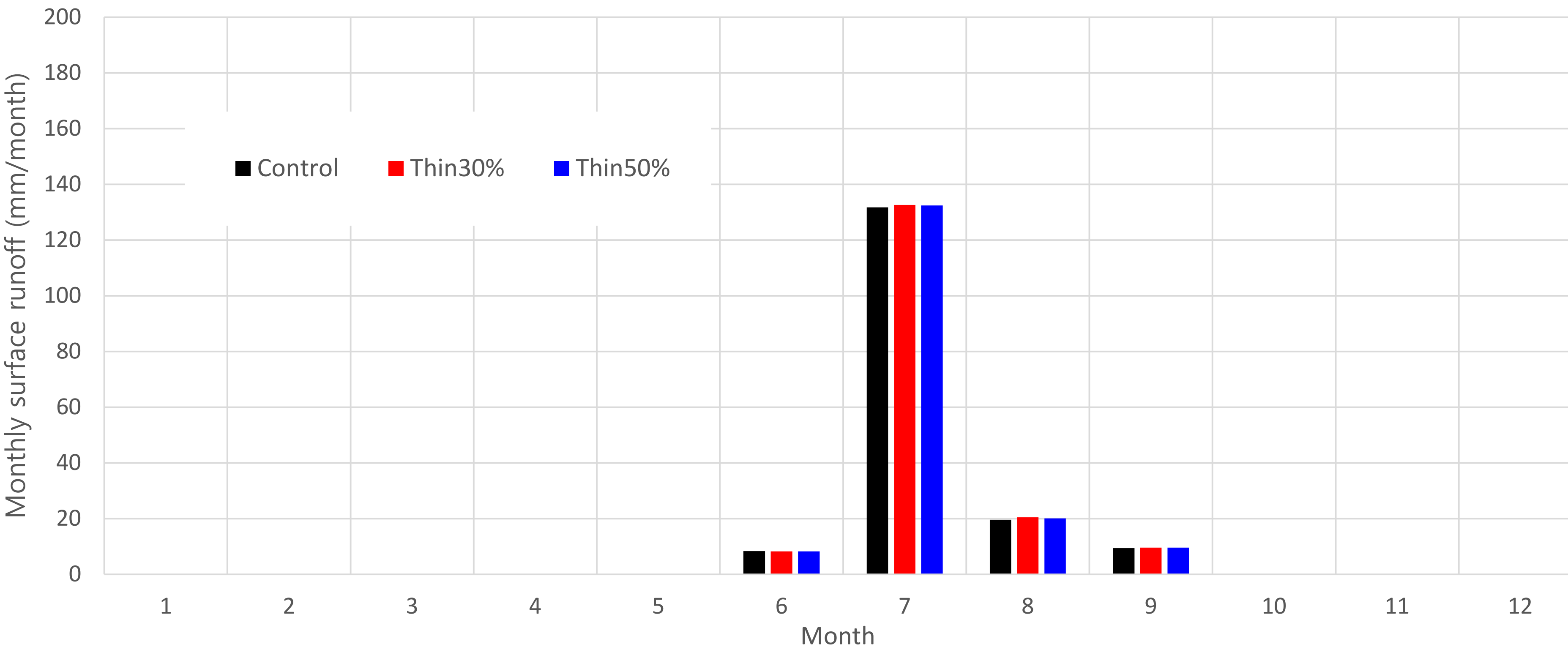
- Gwangneung-Conifer monthly WEPP simulated runoff by thinning intensity



3. Results

3.2. Thinning Effect Using WEPP: Gwangneung-Conifer

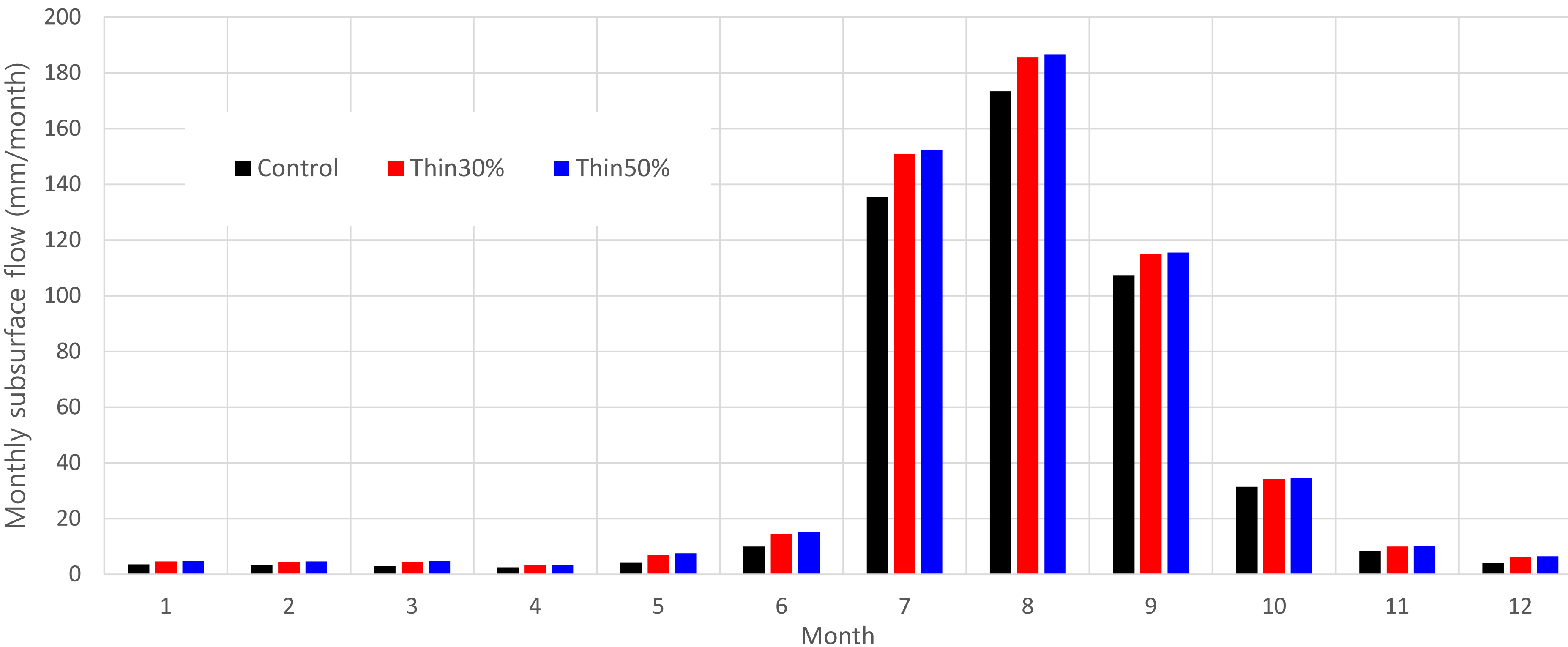
- Gwangneung-Conifer monthly WEPP simulated surface runoff by thinning intensity



3. Results

3.2. Thinning Effect Using WEPP: Gwangneung-Conifer

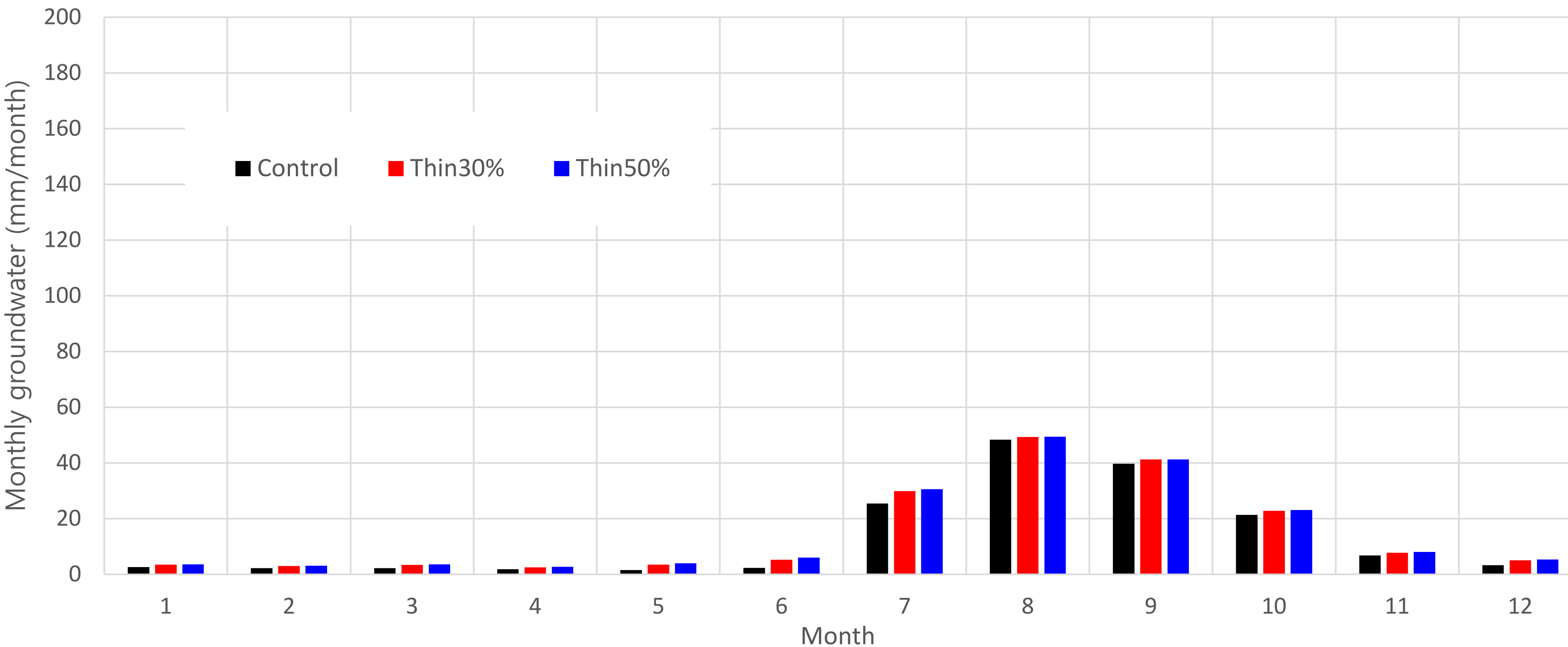
- Gwangneung-Conifer monthly WEPP simulated subsurface flow by thinning intensity



3. Results

3.2. Thinning Effect Using WEPP: Gwangneung-Conifer

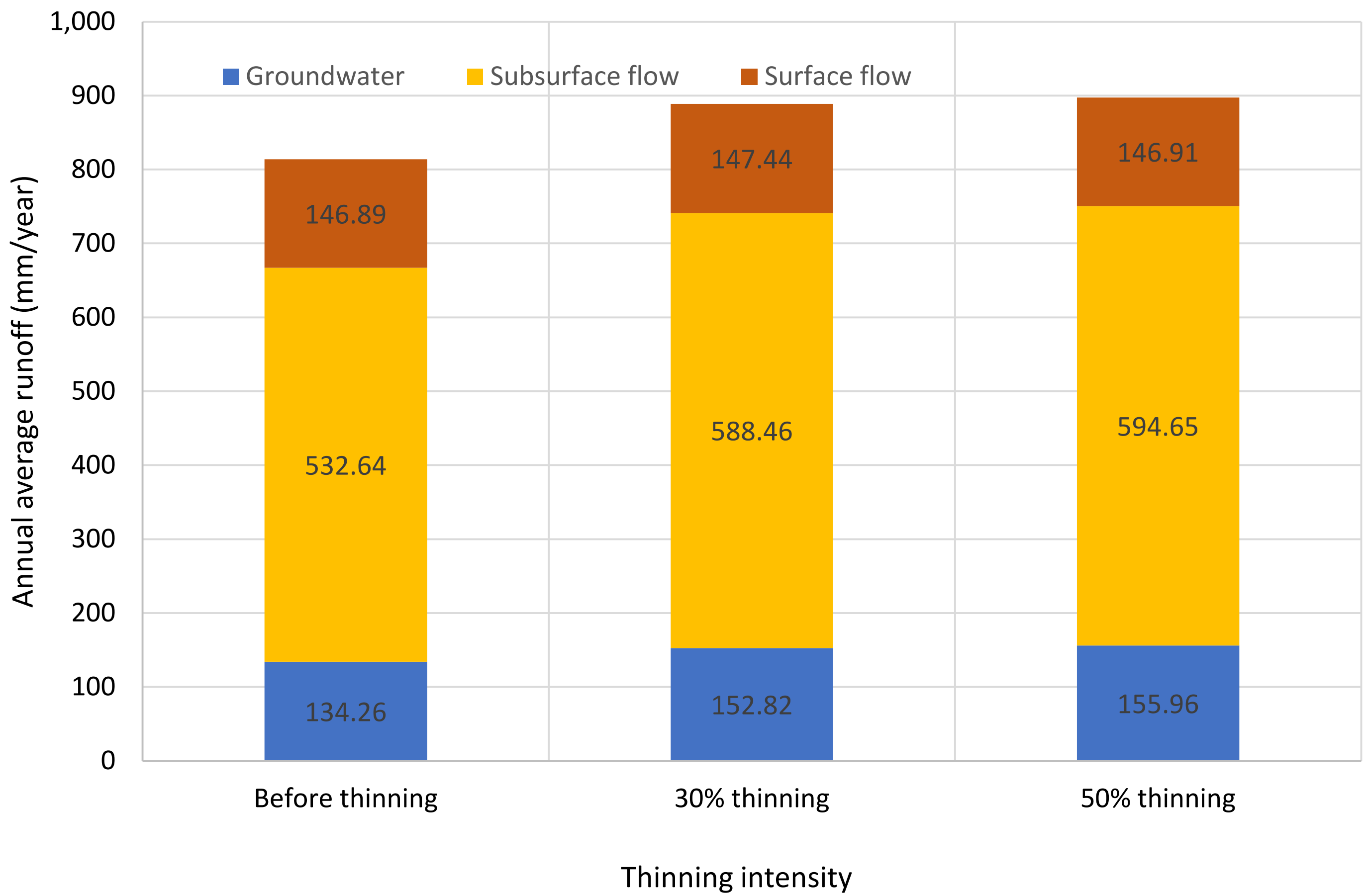
- Gwangneung-Conifer monthly WEPP simulated groundwater by thinning intensity



3. Results

3.2. Thinning Effect Using WEPP: Gwangneung-Deciduous

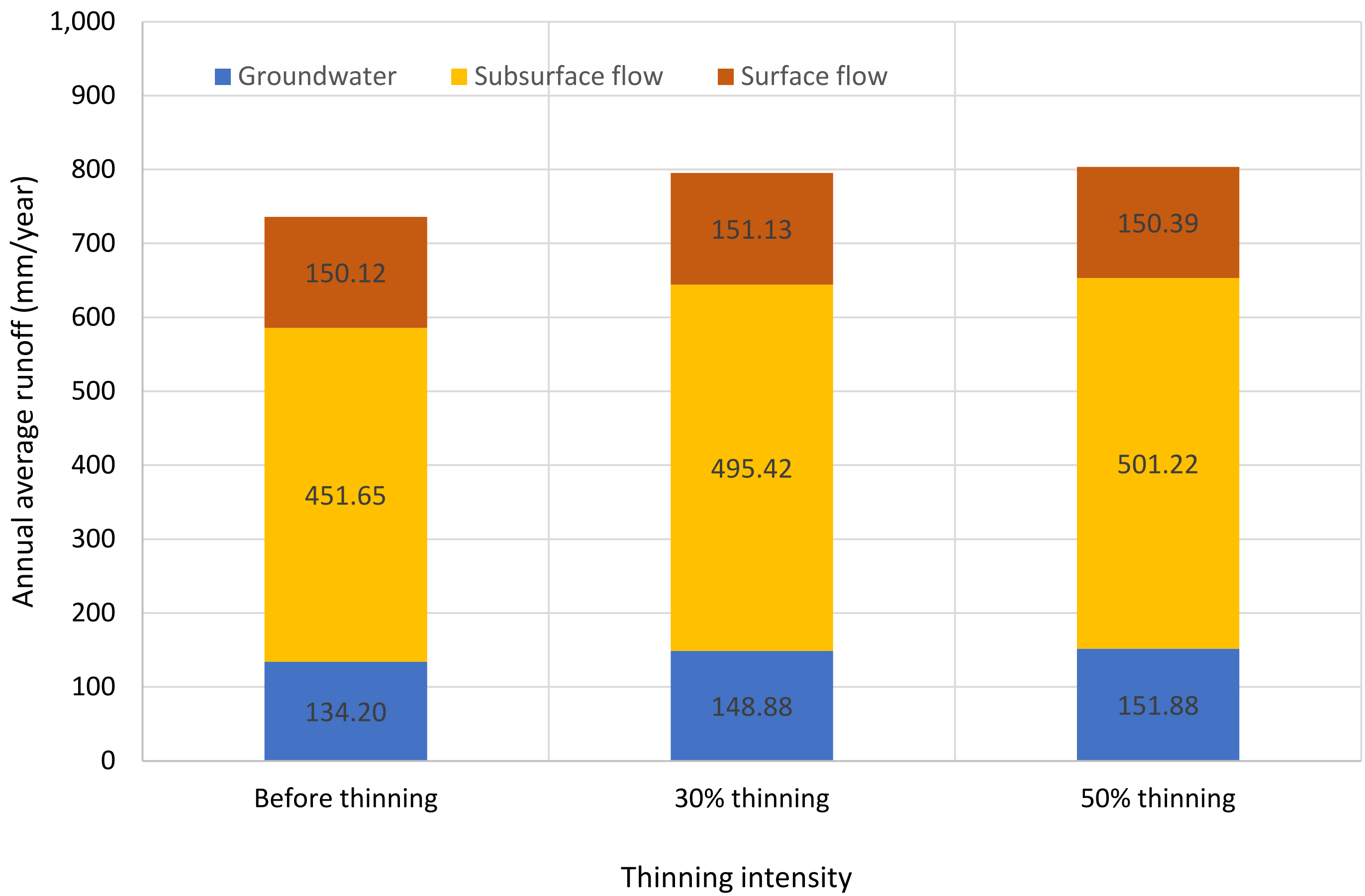
- Gwangneung-Deciduous annual WEPP simulated runoff by thinning intensity



3. Results

3.2. Thinning Effect Using WEPP: Yangju-Mixed

- Yangju-Mixed annual WEPP simulated runoff by thinning intensity



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3. Results

3.2. Thinning Effect Using WEPP: Economics

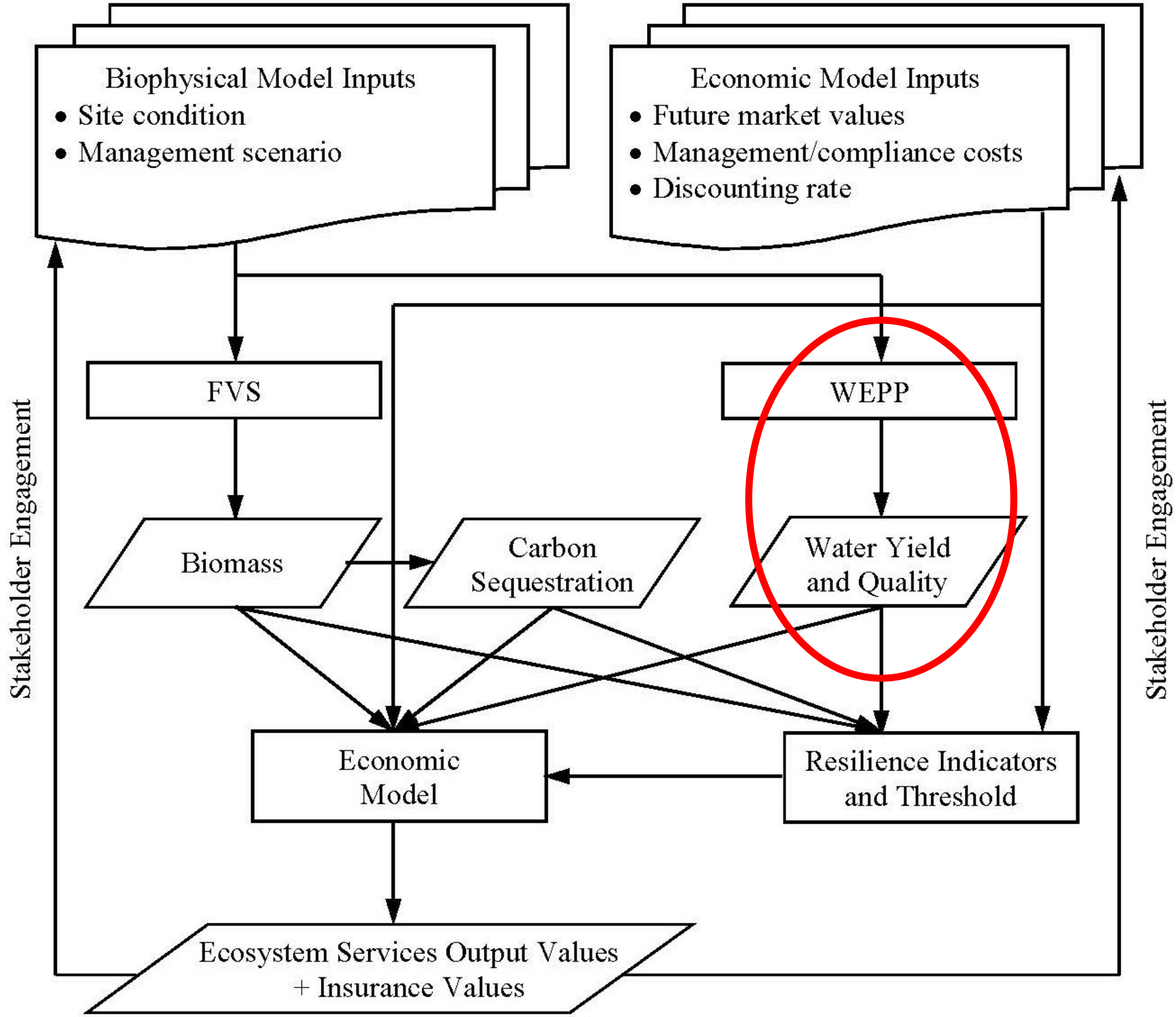
Site	Gwangneung-Conifer		Gwangneung-Deciduous		Yangju-Mixed	
Thinning intensity	30%	50%	30%	50%	30%	50%
RO increase (mm/yr/ha)	75.2	84.2	74.9	83.7	59.5	67.5
OR increase value ($/yr/ha)	33.0	37.0	32.9	36.8	26.1	29.7
Thinning cost ($/yr/ha)	112.9	112.9	112.9	112.9	112.9	112.9
Thinning profitability (0% subsidies, $/yr/ha)	-79.9	-76.0	-80.0	-76.2	-86.8	-83.3
Thinning profitability (90% subsidies, $/yr/ha)	21.7	25.7	21.6	25.5	14.8	18.4
Gov subsidies @ breakeven (%)	70.8	67.3	70.9	67.4	76.9	73.7

3. Results

3.3. Water Harvesting Modeling Under Future Climates

- Still on-going efforts
- Several methods to model water harvesting under future climates
  - Need to find the most adequate way to model future climate effects using WEPP
- Cannot present the results today

4. Future Direction



5. Conclusions

- WEPP simulates stream runoff reasonably
- WEPP underestimates stream runoff, especially in winter and spring
  - Still needs improvements
- WEPP could be used to simulate forest management effects on water resources
  - Runoff increase by forest management (thinning) is not economically feasible under current climate condition in Korea
- On-going efforts to model future climate conditions
- This modeling approach will be later incorporated into multi-objective forest management decision support system (DSS) in Korea

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Korea Forest Service

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Thank you

Obligado