Summer streamflow deficits from regenerating Douglas-fir forest in the western Cascades, OR

Julia Jones

Professor, Geography

College of Earth, Ocean, and Atmospheric Sciences

Oregon State University

With input from Michael Nelson, Professor, Forest Ecosystems and Society

Contents

- Science, values, and policy/management
- Water scarcity and declining summer flow
- History of forest management in the PNW
- Paired watershed experiment design
- Paired watershed experiment results
- Summary
- Science, values, and decisions

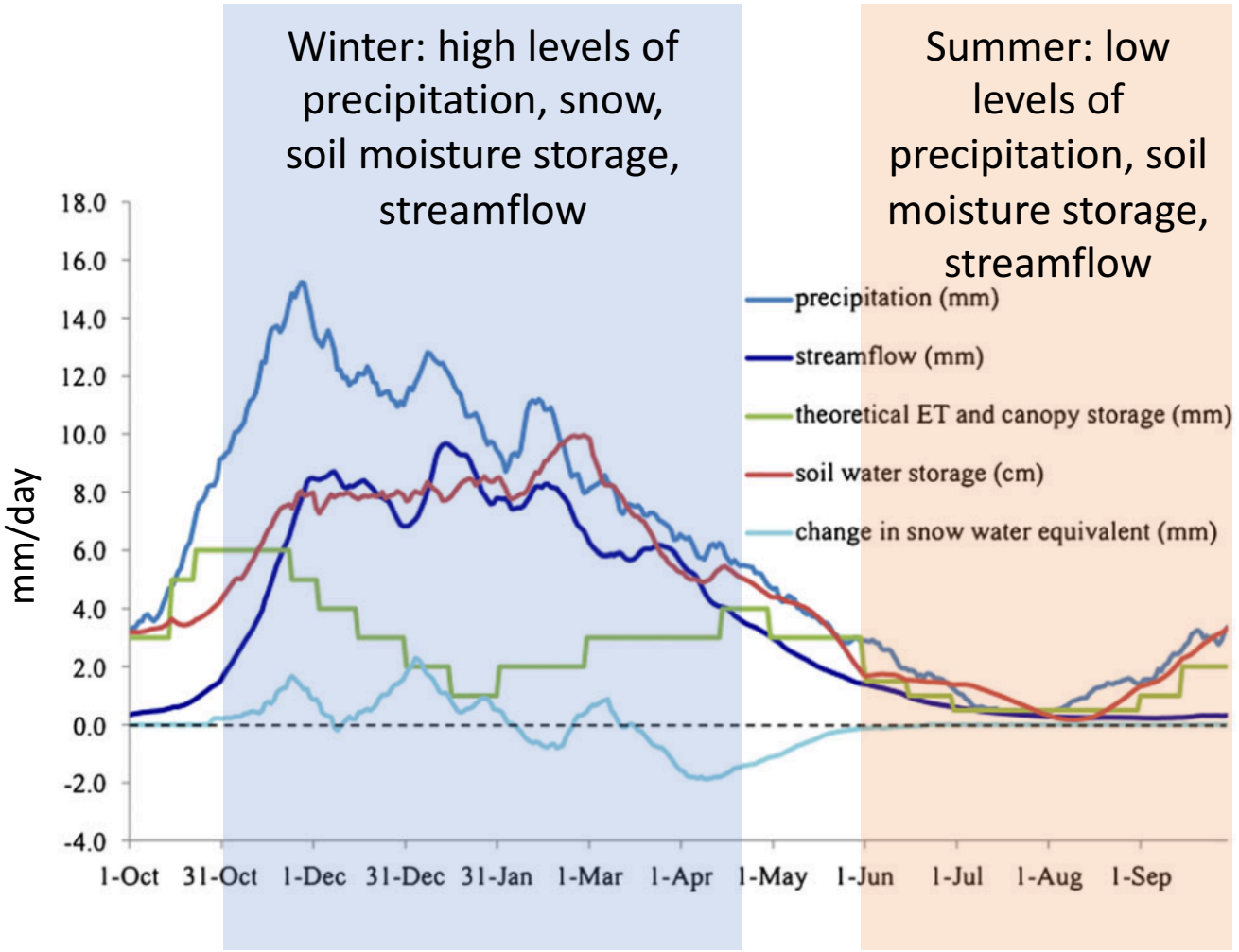
Science, values, and decisions

(inspired by Michael Nelson, Professor of environmental philosophy)

Michael Paul Nelson

- 20 years ago, there were big discussions about peak flows and forestry
- Facts and values were confused in those discussions
- “best available science” does not mean that science determines policy
- Decisions are made based on both facts (science) and values (ethics)
- This presentation does not address values

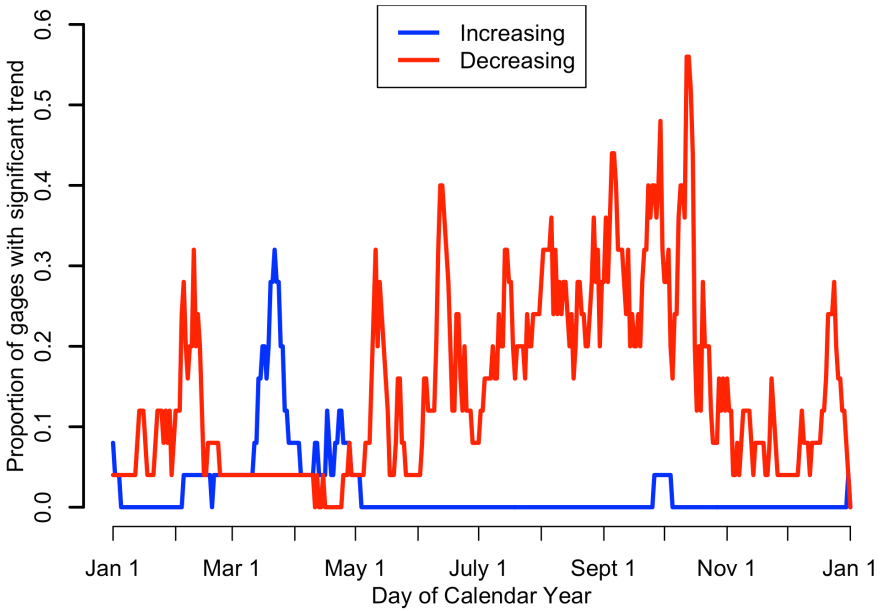
Water scarcity is part of life – summer low flows



Water balance at Andrews Forest WS2, old-growth forest, based on 50 years of data

US-Canada Columbia River Treaty renewal: Need to address declining summer flows

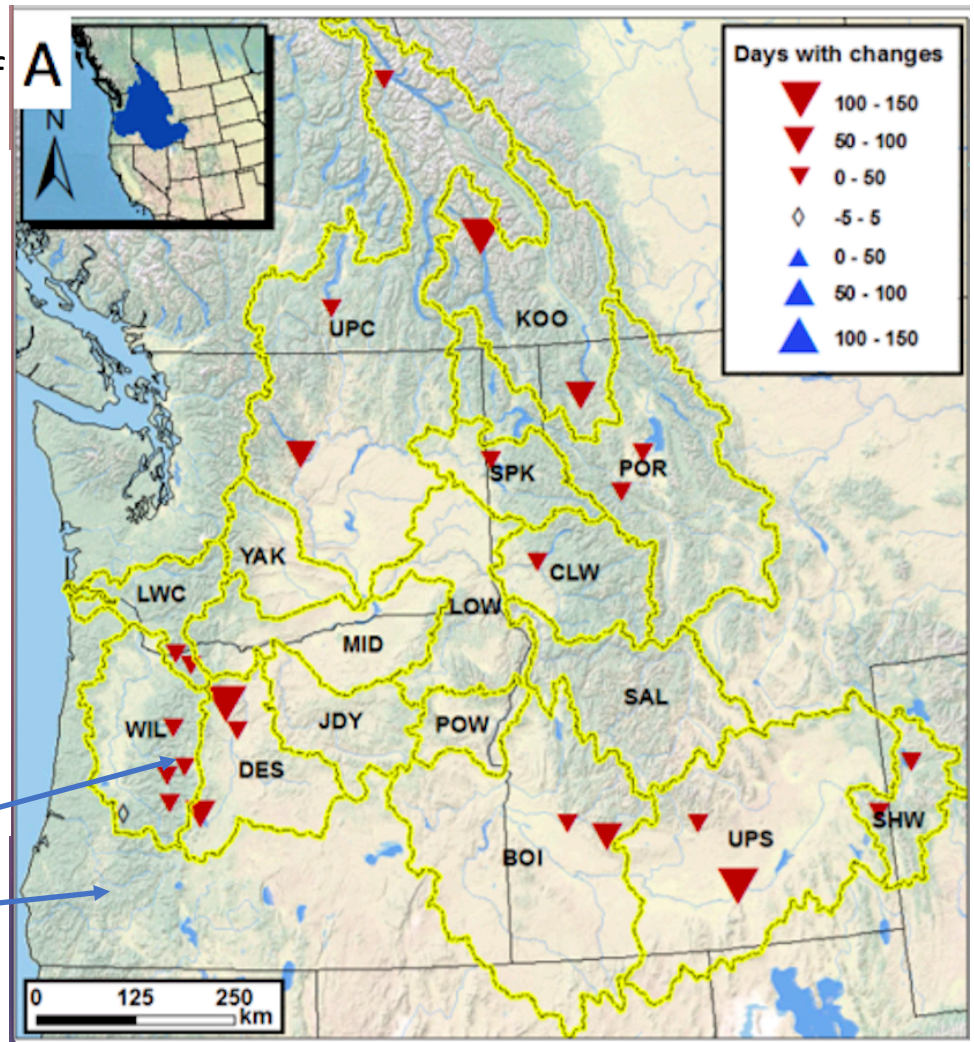
From 1950 to 2012, most USGS reference watersheds above reservoirs in the CRB experienced declining summer flows. Most of these watersheds contain managed forests.



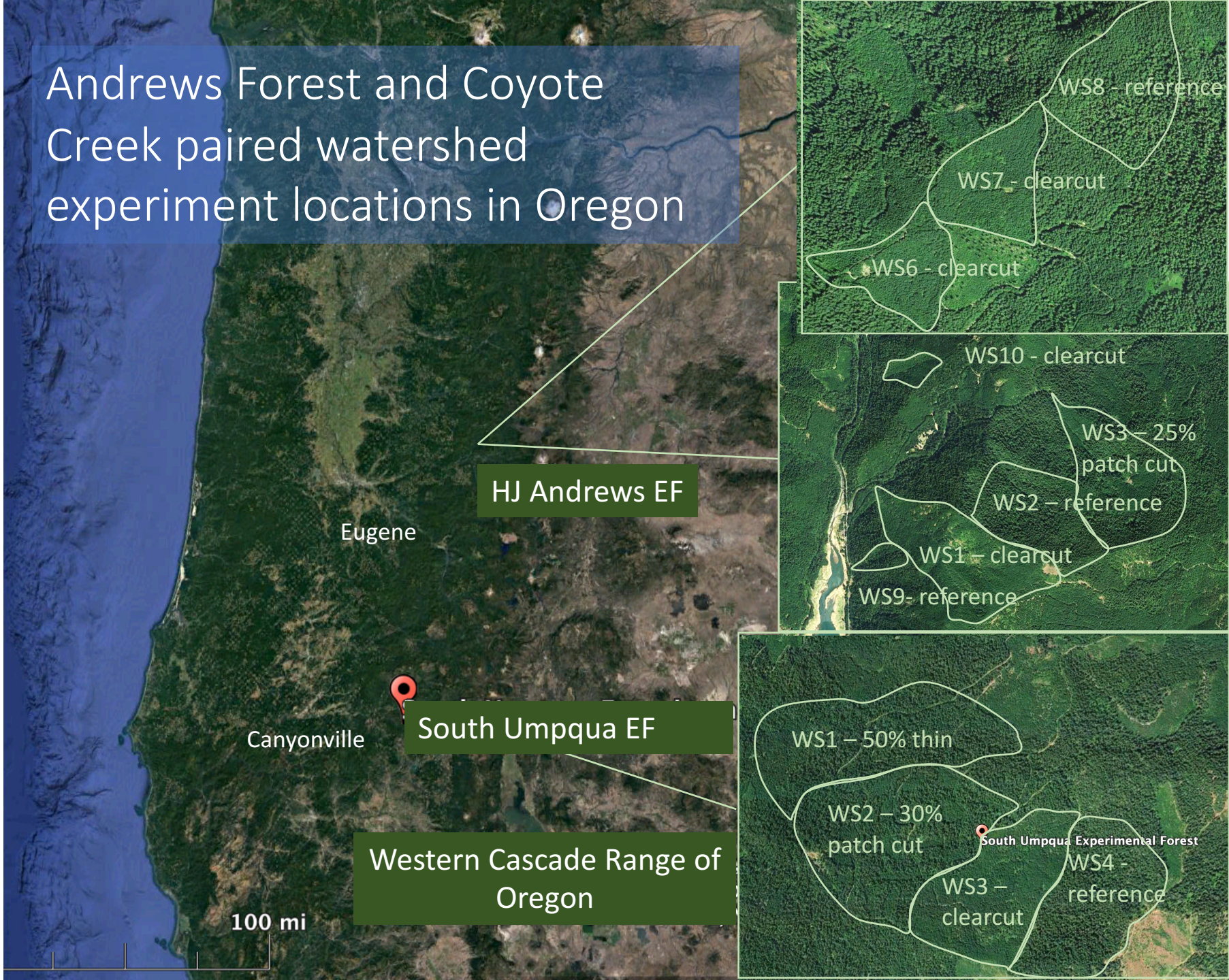
Andrews Experimental Forest

Coyote Creek (S. Umpqua Experimental Forest

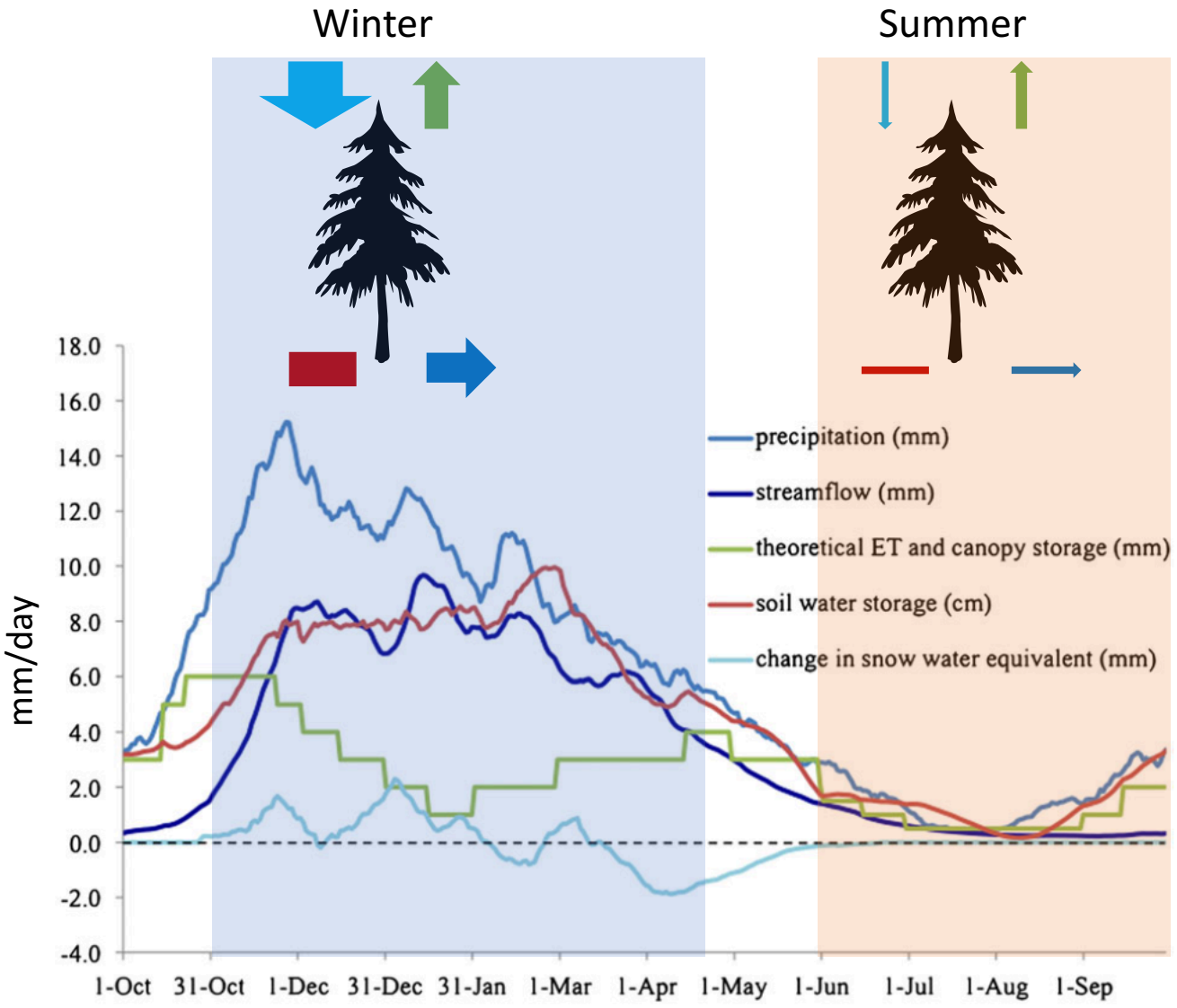
Hammond 2015; Hammond et al. in review



Andrews Forest and Coyote Creek paired watershed experiment locations in Oregon



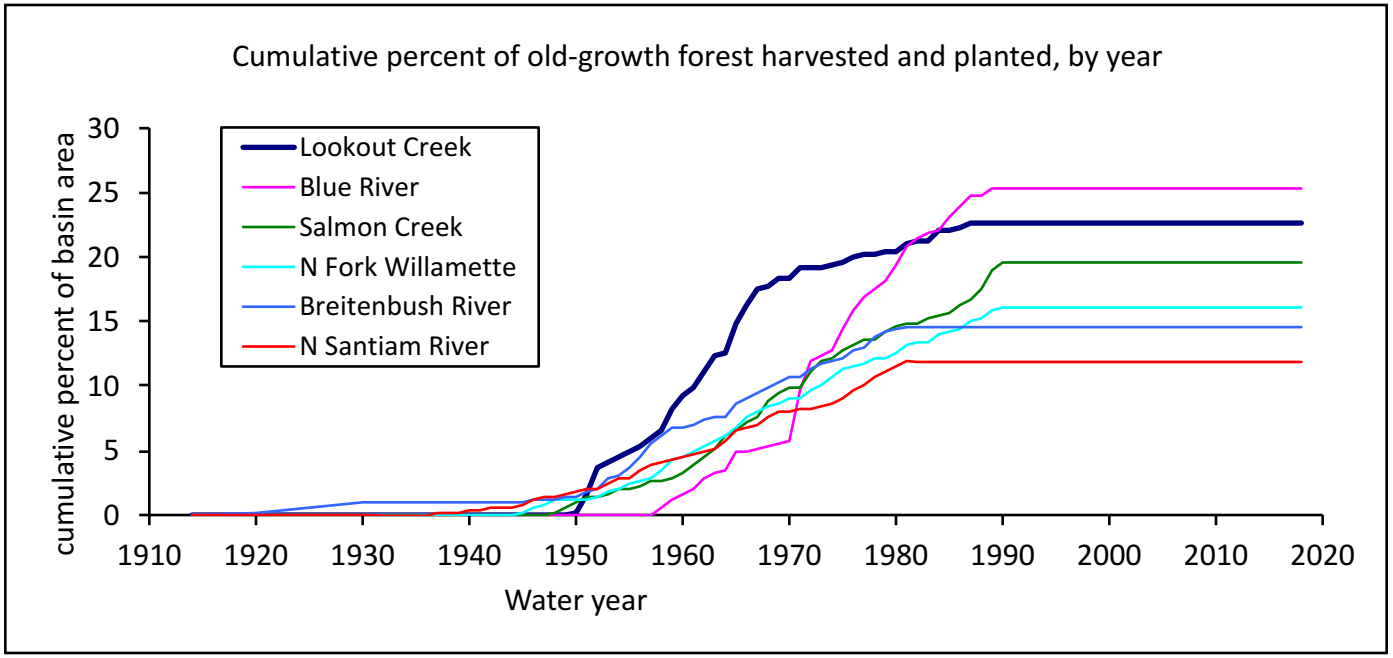
What controls summer streamflow?
Past precipitation, snowmelt, **forest water use**



Water balance at Andrews Forest WS2, based on 50 years of data

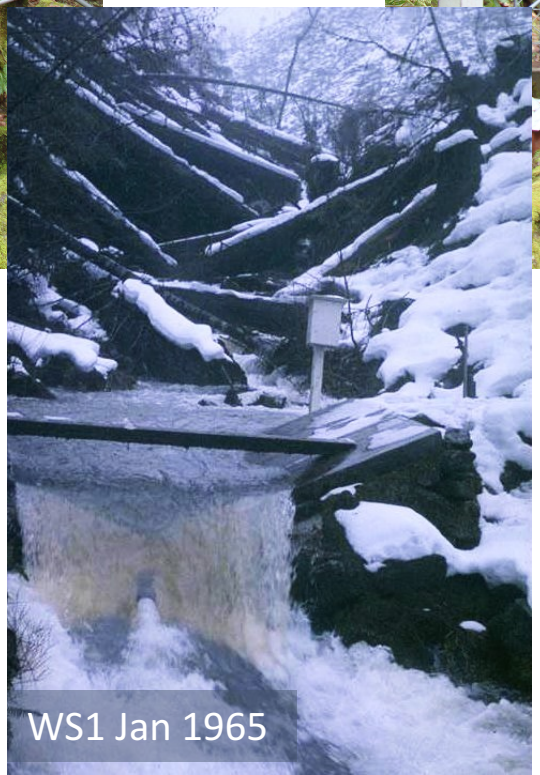
The area of young forest plantations has increased in the past century in the PNW

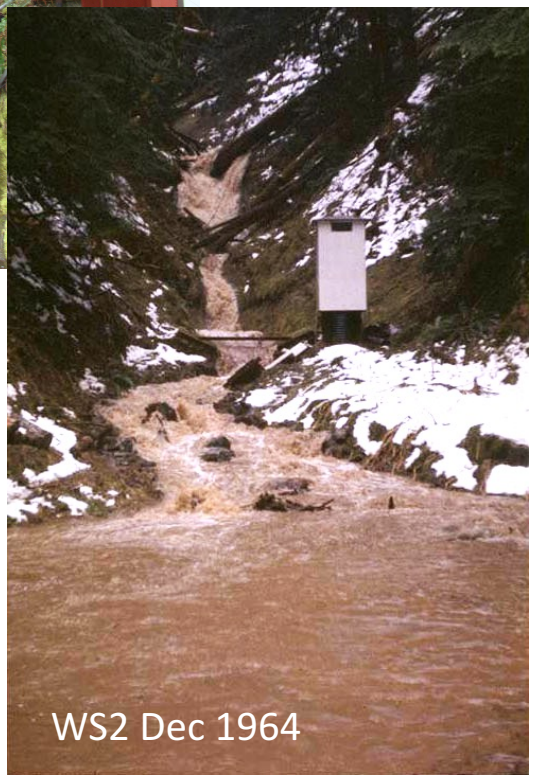
As of 2018, 12 to 25% of the Willamette National Forest is in plantations aged ~30 to 70 yrs



Jones and Grant, 1996

Paired watershed experiments





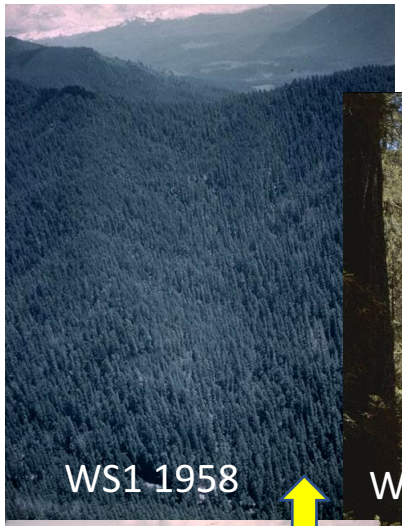
Continuous gaging of flow (since 1952) in treated (WS1) and reference (WS2) watersheds

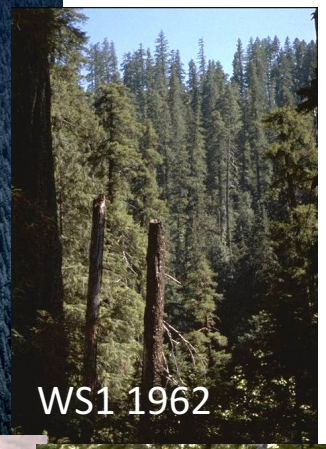
Paired watershed experiments: Compare flow at treated vs. control before and after treatment

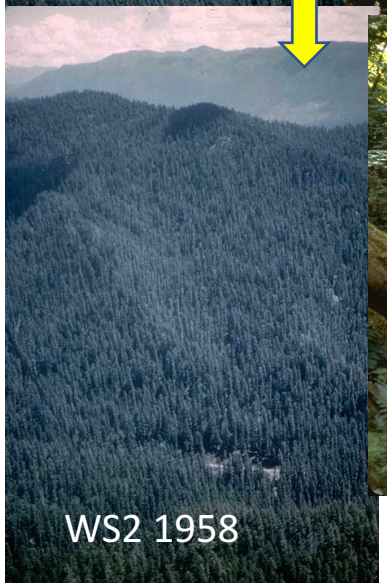
Pre-treatment → 1 to 5 yrs post-harvest → 50+ yrs post-harvest

Treated watershed

Reference watershed

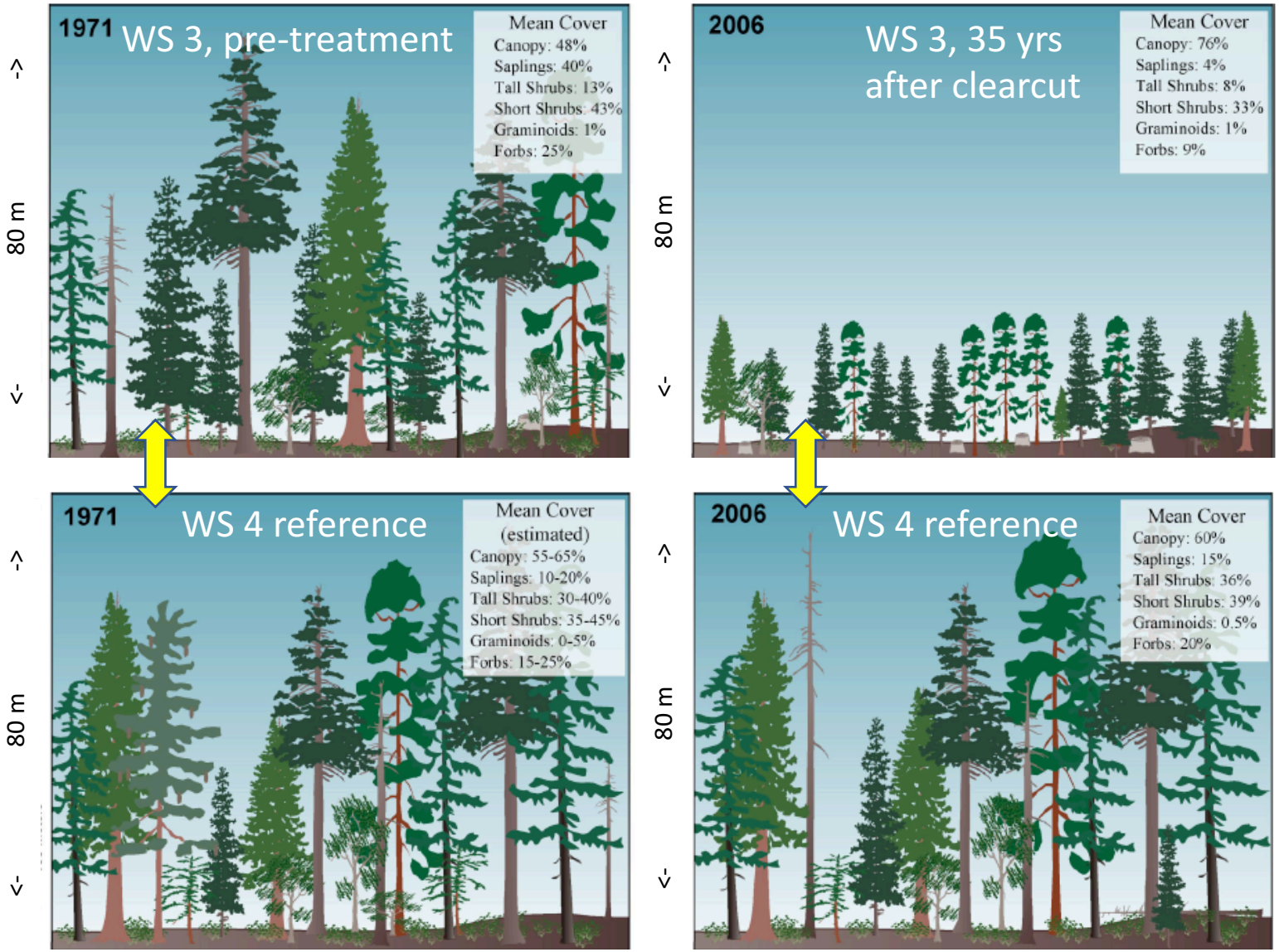






Time →

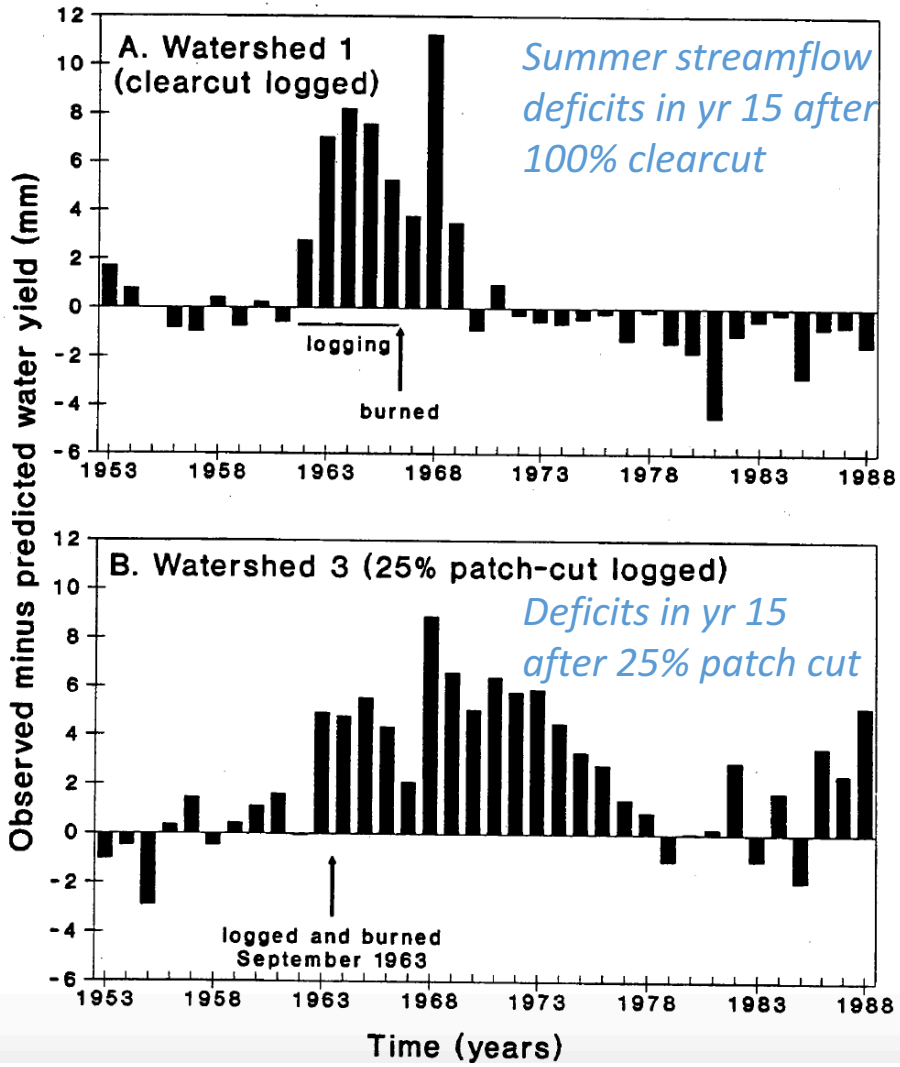
Coyote Creek paired watersheds - before treatment (1971) and in 2006



Arthur 2007

Summer streamflow deficits noted early

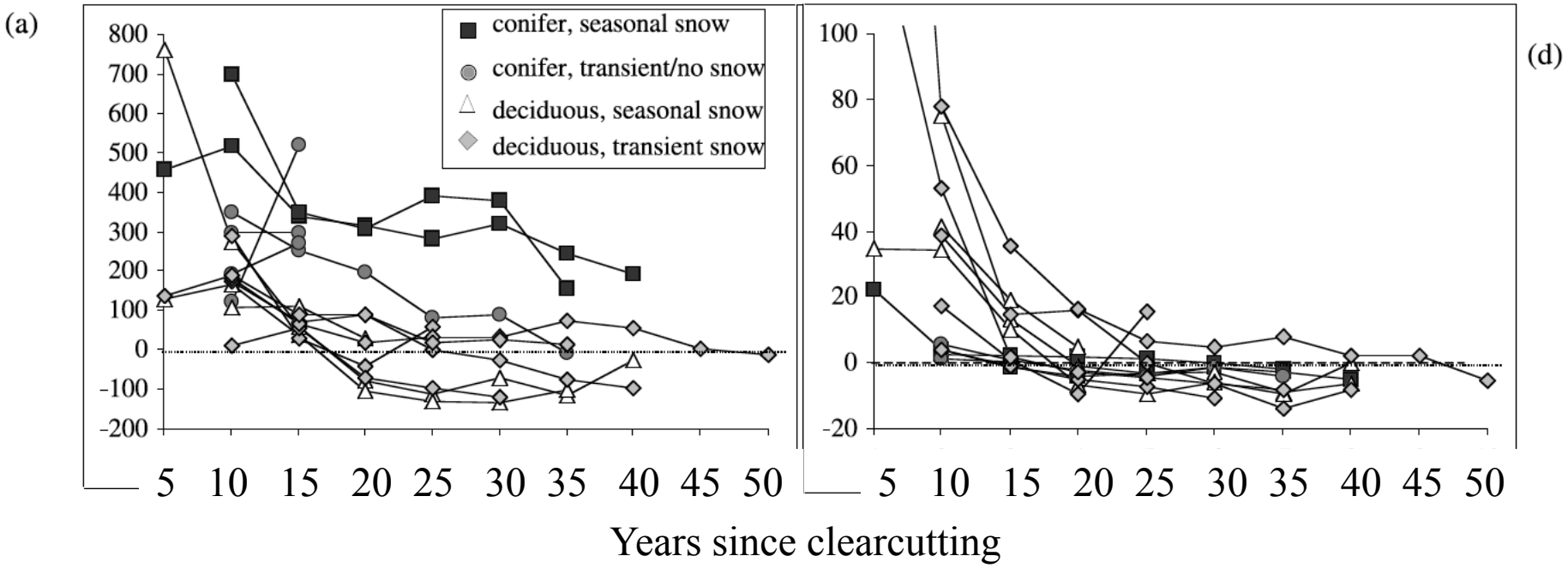
August streamflow, WS1/2 WS3/2



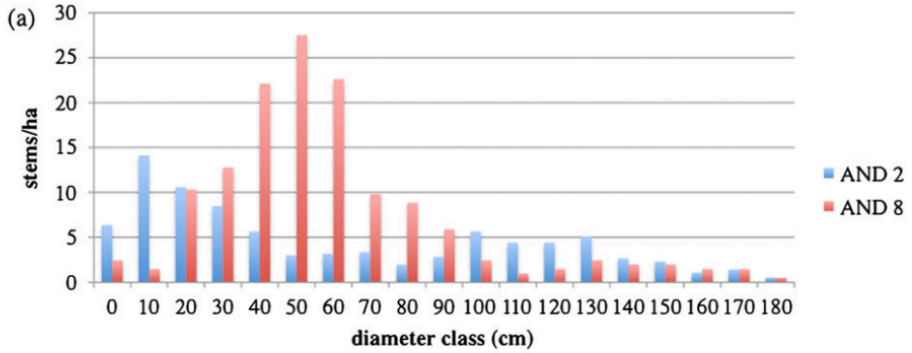
Hicks Harr and Beschta, 1991

Summer streamflow deficits noted elsewhere

Deficits in total (left) and summer (right) streamflow appeared by year 15 to 20 after 100% clearcut at paired watershed experiments in NC (Coweeta) and NH (Hubbard Brook)



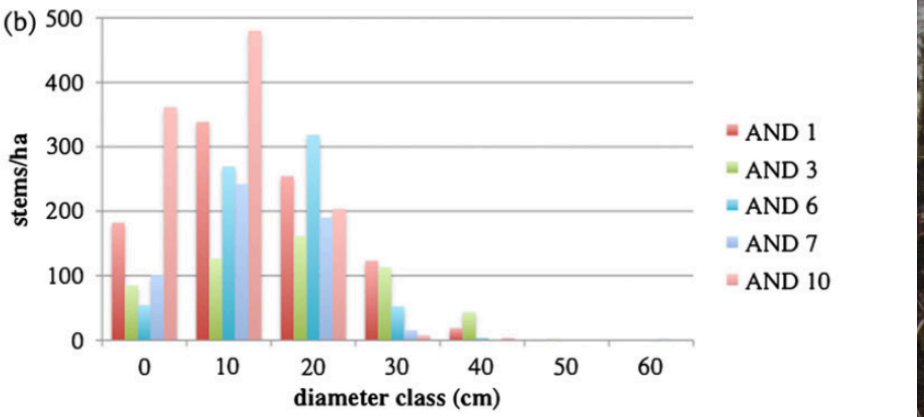
Jones and Post 2004



Today: Reference watersheds: many stems > 50 cm dbh; trees aged 150 to 500 yrs

WS3 2018

WS2 2018



Today: Treated watersheds: most stems <40 cm dbh; trees aged up to 52 yrs

WS3 2018

WS1 2018

Regenerating forest in paired watersheds is comparable to low-productivity managed forest plantations in western Oregon

How does site class affect lowflow trends?

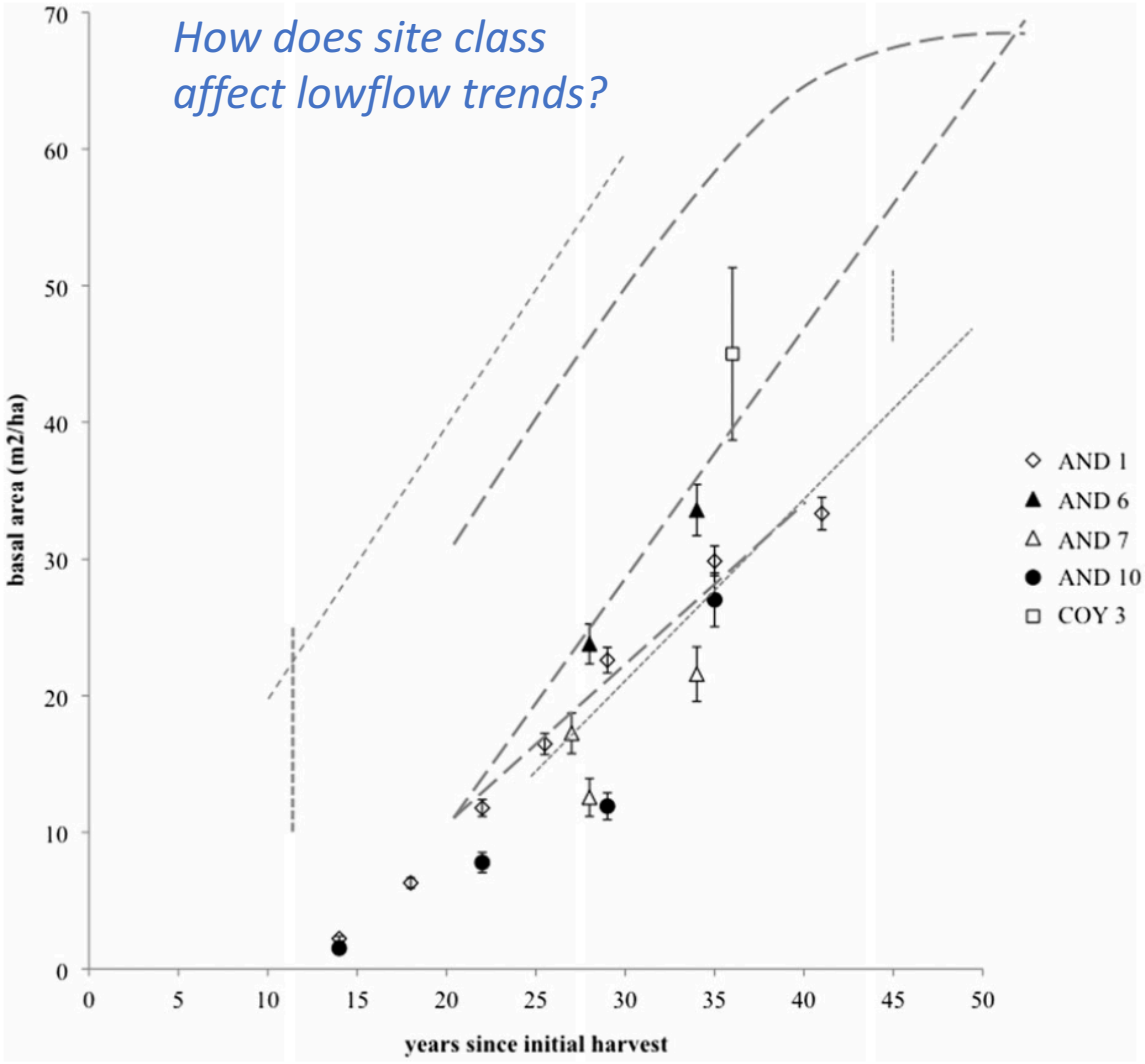
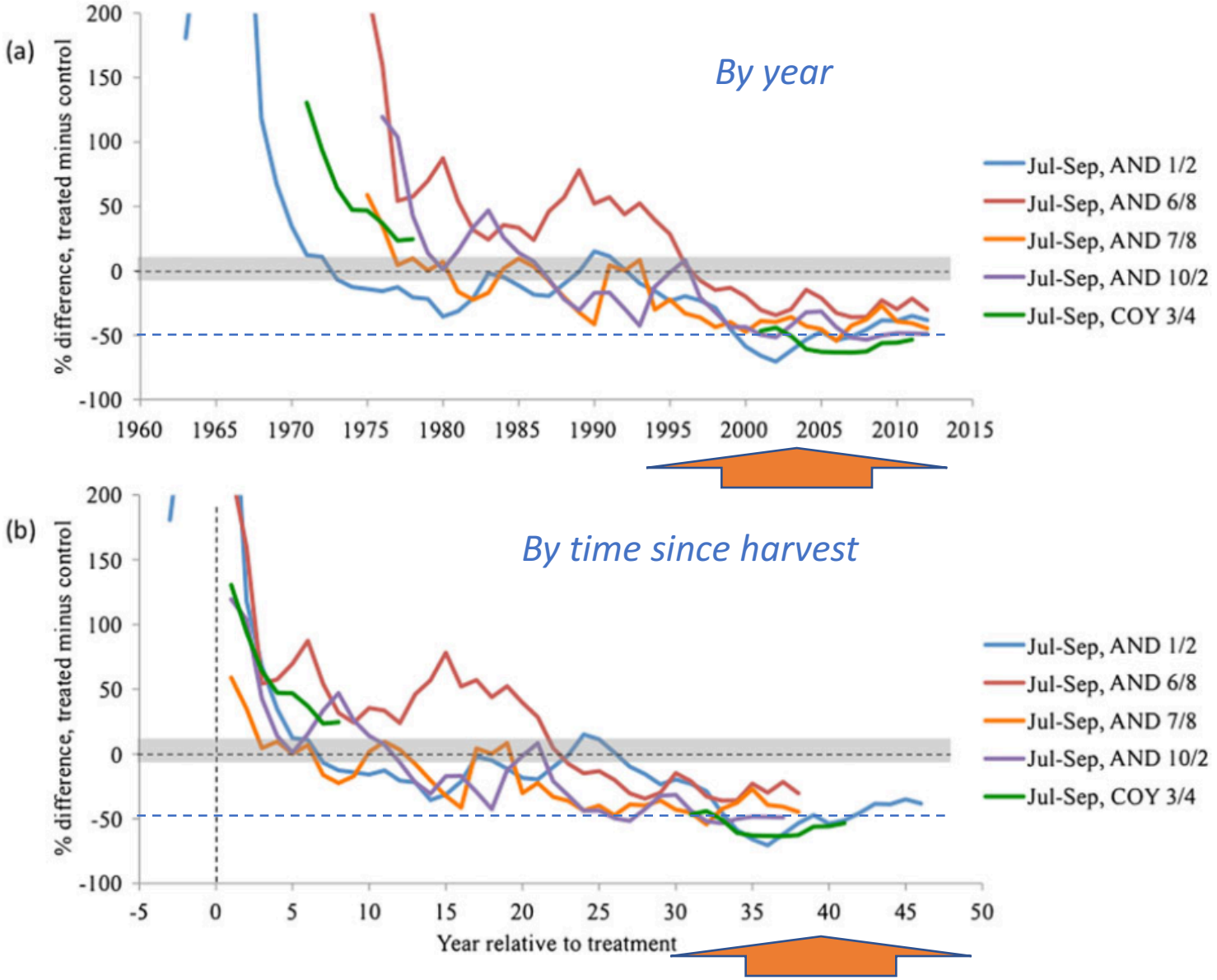
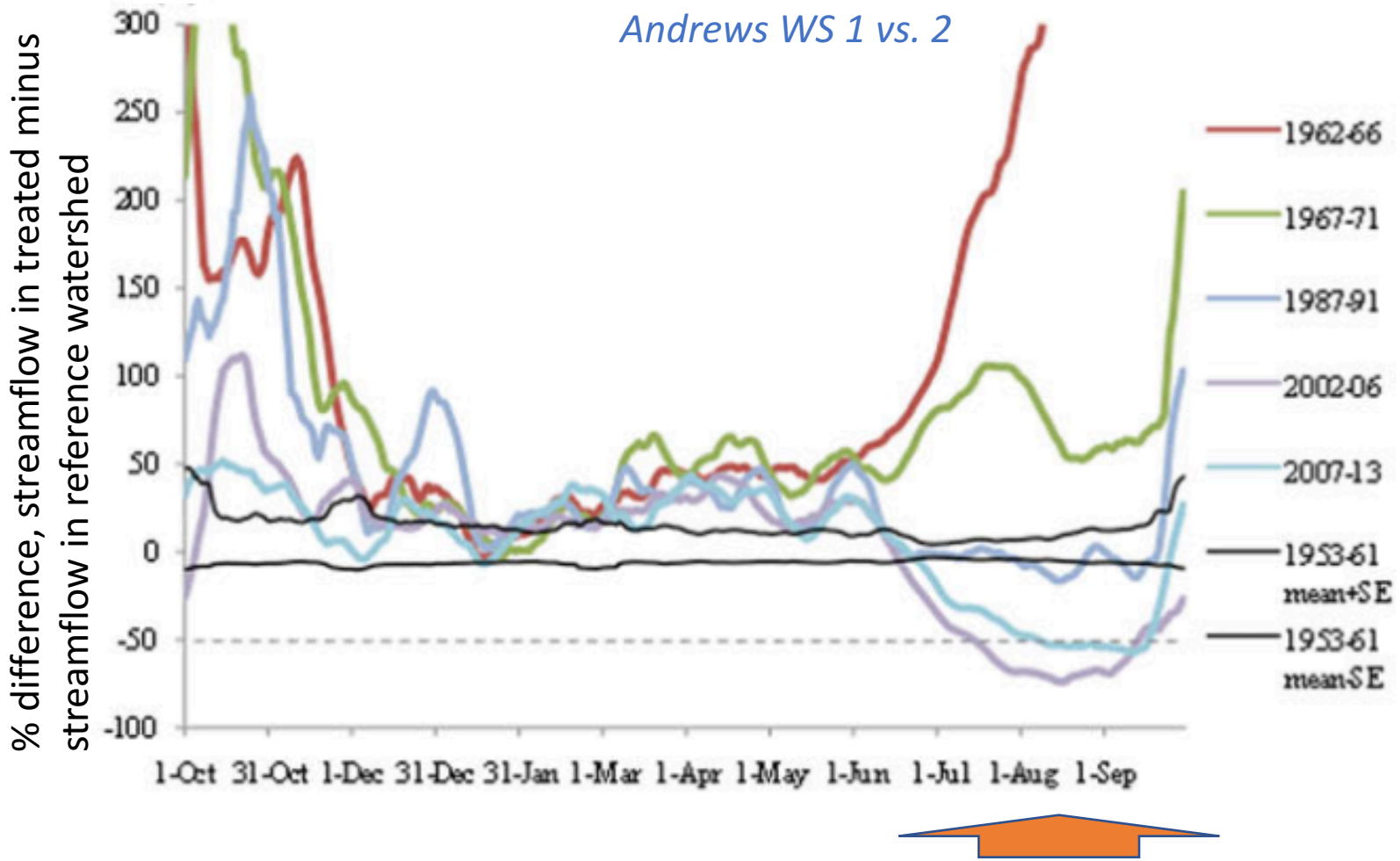


FIGURE 3 Basal area as a function of time since treatment in basins with forest plantations. Symbols are means ± standard error from numbers of plots shown in Table 2. The diagonal thick grey dashed lines are the basal area reported from control (unthinned) plots (upper line), heavily thinned plots (lower line), and lightly thinned plots (middle line) in the Hoskins levels-of-growing-stock (LOGS) installation (site II) in western Oregon (Marshall & Curtis, 2002). The diagonal thin grey dashed line indicates average annual basal area for Douglas-fir plantations on relatively high site productivity locations affected by various levels of infection from Swiss needle cast in the Oregon Coast Range (Maguire, Kanaskie, Voelker, Johnson, & Johnson, 2002). The thin grey diagonal dotted line indicates basal areas for experimental Douglas-fir plantations at low site productivity locations (site V) at Wind River (100 km north of the Andrews Forest, at a similar elevation to the experimental basins; Harrington & Reukema, 1983). The vertical grey dotted line is estimated Douglas-fir basal area from growth and yield models for 45-year-old stands (Marshall & Turnblom, 2005). The vertical grey dashed line is range of basal areas in stands of Douglas-fir, western hemlock, and mixtures (Amoroso & Turnblom, 2006)

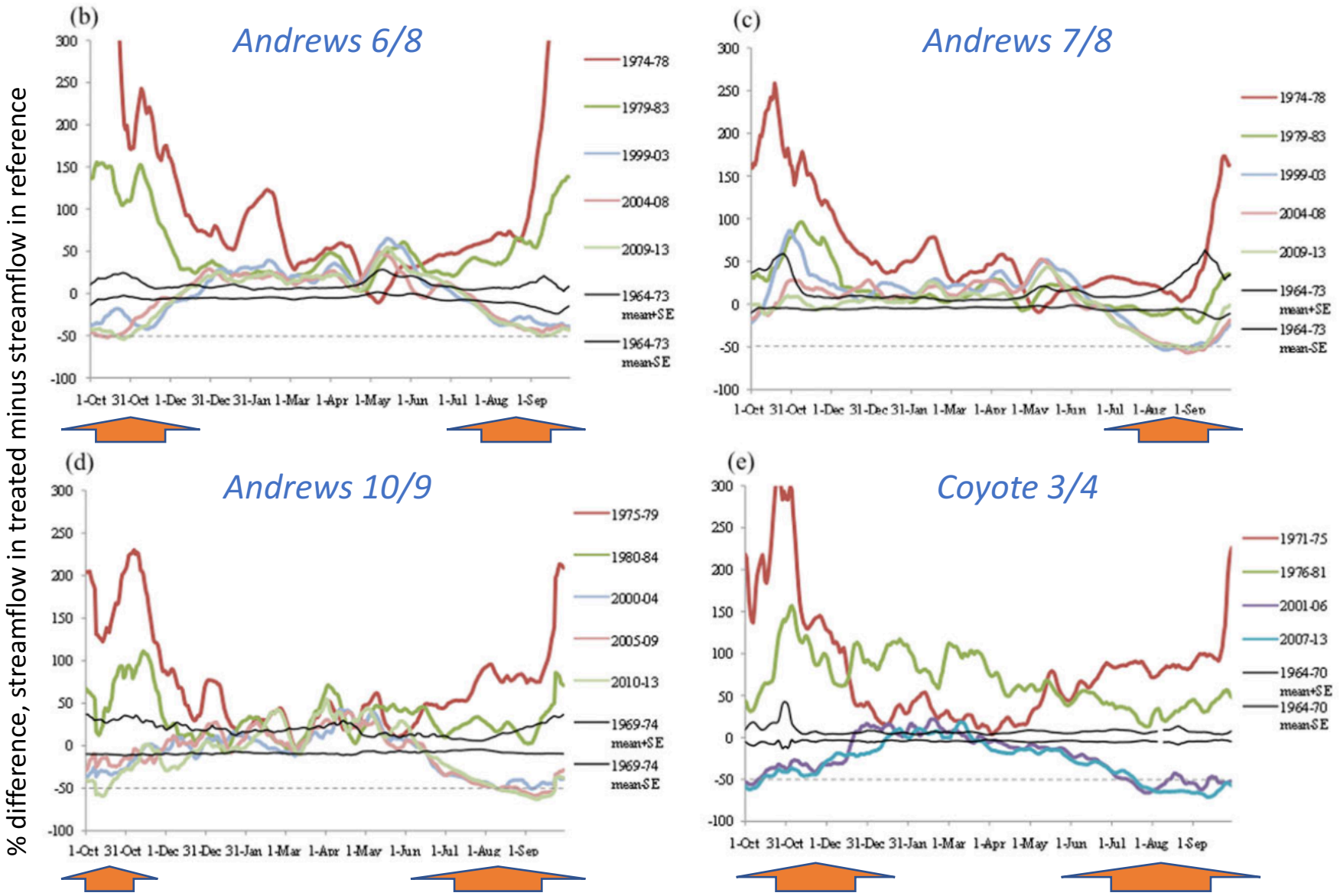
Young (25-45-yr-old) forests yield up to 50% less summer streamflow than reference old growth



Summer lowflow deficits emerge in early summer and persist to the onset of the wet season



Summer lowflow deficits can last from early June to late December



Questions about research

Question	Response
Do declining summer flows show up downstream of paired watersheds?	Yes, flows are declining throughout the Columbia River basin, including in large watersheds downstream of paired watershed experiments.
Are the paired watersheds representative of other forests?	Yes, regenerating forest in paired watershed experiments is similar in growth rate and basal area to managed forest plantations
Is level of statistical significance appropriate?	Yes, statistical significance level selected to balance errors due to (I) detecting a change that occurred by chance, (II) failing to detect a change that actually occurred
Are streamflow data accurate?	Yes, very high quality; results not affected by changes in gaging or rating curves
Are reference watersheds holding constant over time?	Yes, streamflow has not changed over time at reference watersheds.
Are these trends simply due to climate change?	No, paired watershed experiments disentangle climate change from forest change effects.

Conclusions

- Summer streamflow is declining throughout the Columbia River basin and much of the western US
- Forests aged 25 to 45+ yrs yield as much as 50% lower summer streamflow than reference old-growth forest
- The results from paired watershed studies are representative of a significant fraction of the area of forest lands in the region
- No specific policy or management direction follows from these findings. Let's clearly state our values and norms if we talk about policy and management
- Further work is needed

Further work

- How does forest age and growth rate affect summer lowflow trends?
- How might alternative forestry treatments (such as various approaches to thinning) influence summer low flows?
- What are tradeoffs of managing for lowflows vs. other forest and stream management objectives?