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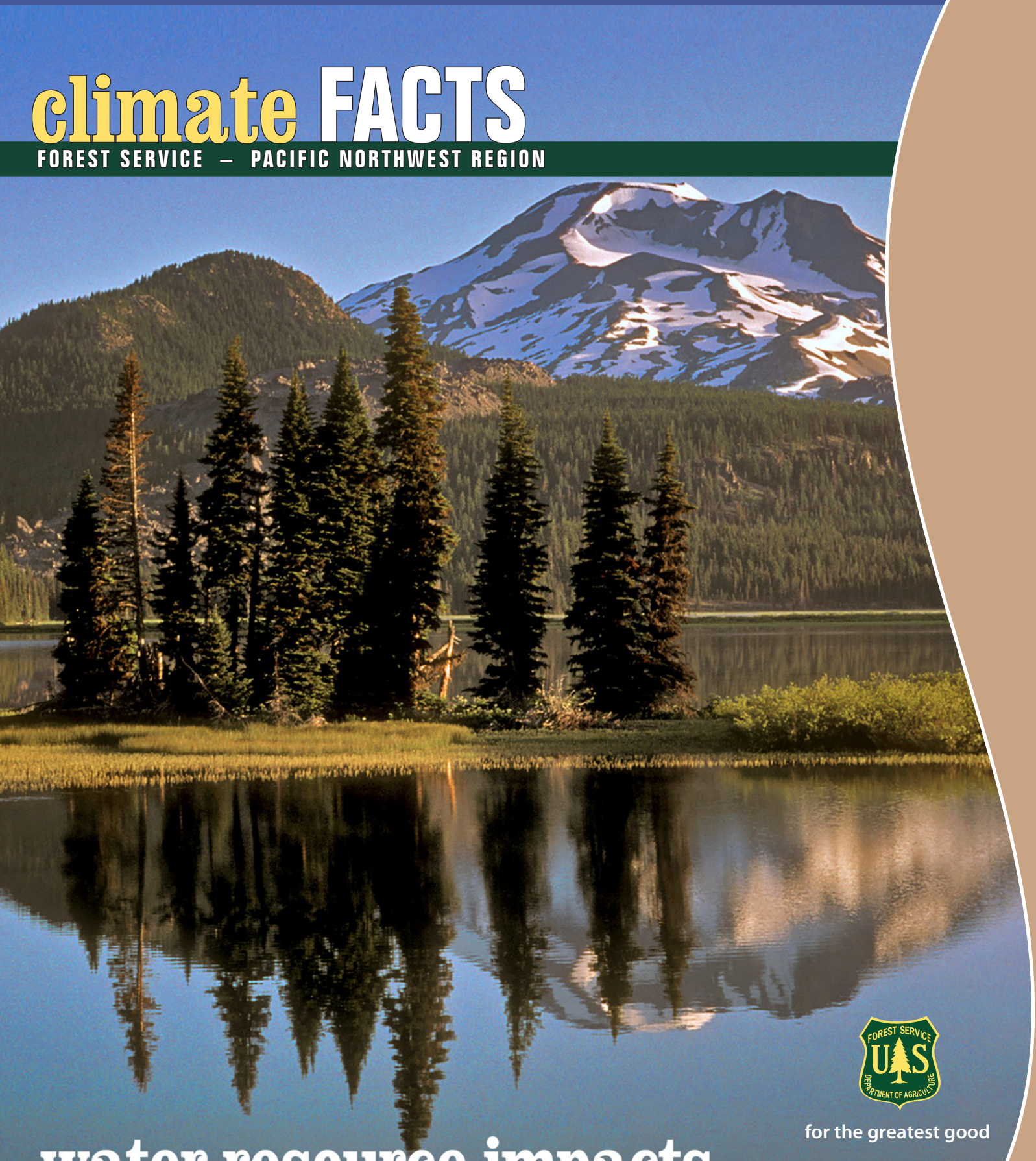
climate FACTS

FOREST SERVICE – PACIFIC NORTHWEST REGION



for the greatest good

water resource impacts IN THE PACIFIC NORTHWEST

Water, Climate Change, and the Pacific Northwest

It is difficult to overstate the importance of water, a fundamental requirement for all forms of life. In the Pacific Northwest, National Forests play a critical role in water management by protecting and managing lands that are sources for the majority of the region's freshwater.[1] Headwater forests sustain stream networks that support unique riparian (stream-side) plant communities, and a variety of fish and wildlife species. In both the populous western and arid eastern sides of the region, water is sourced and diverted from National Forests for livestock, irrigation, and municipal supplies, thus contributing a vital ecosystem service, or a benefit provided to people by nature.[2]

What happens when the amount and timing of water in a stream changes? When water users' expectations are not met, hardship and conflict may result, especially since water managers are already struggling to meet the demands of a growing population. Climate change will affect both the timing and quantity of stream flow in the Pacific Northwest, which is why water resource management is considered one of the most significant and far-reaching climate-related issues facing the region today.

Projected Changes for Pacific Northwest Forests

Simulating the region's hydrologic response to modeled future climate is useful for showing potential changes. Several broad level projections have emerged from research.

- As the region's climate warms, more precipitation falls as rain rather than snow. Watersheds that were historically characterized by a mix of rain and snow in winter will likely become more rain-dominated, and watersheds that were historically dominated by snowfall in winter may become more transitional, experiencing a mix of rain and snow (Figure 1).[3,4,5]
- Historic records show a declining trend in snowpack for the region in the 20th century, and a subsequent shift to earlier peak streamflow.[6,7] These trends will likely continue in the next century. Snowpack will decline and melt earlier. More water will be released from snow earlier in the year, resulting in higher peak streamflows in winter and early spring.[3,4,7,8,9,10]
- Earlier snowmelt means that less water is available later in the year, leading to a subsequent decrease in summer low flows.[2,7,8,9] Some places on the landscape are more sensitive to these changes than others.[11,12]
- Water temperatures in the region's streams and rivers will likely increase by the end of the century.[2,8,9]
- Intensity of extreme precipitation events may also increase.[11]

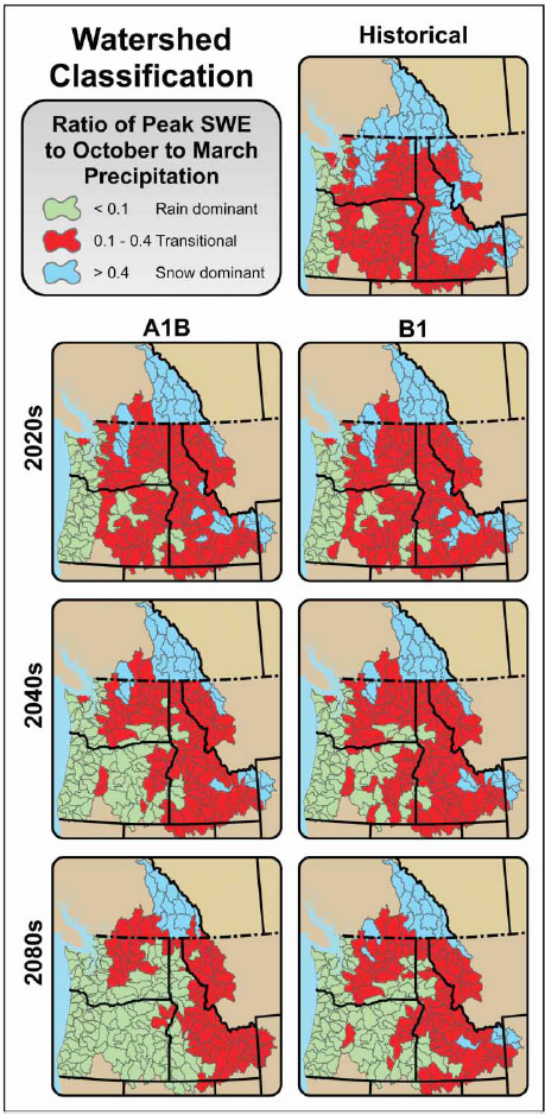


Figure 1: Projected changes in hydrologic regime in Northwest watersheds for high (A1B) and moderate (B1) greenhouse gas emission scenarios. Snow water equivalent (SWE) is a measure of water content in snowpack. This figure displays a gradual shift from snow dominant to rain dominant watersheds over the next century. In both scenarios, snow becomes a minor contributor to annual water yield in Oregon (Source: Hamlet et al., 2013).[7]

Infrastructure & Hydrology

- Flooding will likely become more frequent with changing climate.[2,7]
- Older forest road culverts were built to withstand historically infrequent floods (e.g. 25-yr). Stream-adjacent roads in particular will be vulnerable to increased flooding (Figure 2).[9]
- Wetter soils will increase landslide risks.[2,8,9]
- With more flooding, culverts will be subject to more plugging and filling by sediment and debris.[9]
- Transportation systems will be more vulnerable to damage and blocked access (Figure 3).[2,8,9]
- An indirect effect of climate change is increased public access to forest resources earlier in the year when exposure to hazards is potentially higher.[2,9]

Figure 2: Examples of road damage and loss due to high streamflow events on the Wallowa-Whitman National Forest in northeastern Oregon (Photos Courtesy of Dave Salo, Wallowa-Whitman National Forest).

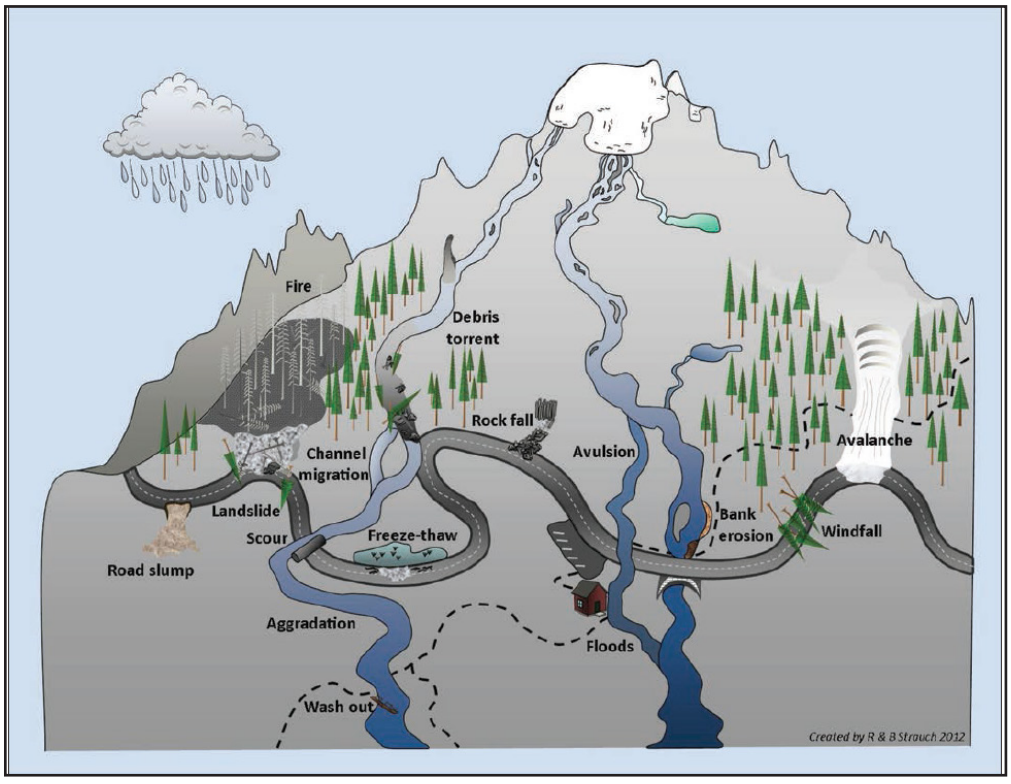


Figure 3: Hazards to transportation infrastructure with climate-related causes (Source: Strauch et al. In: Raymond et al., 2014).[9]

Streamflow Sensitivity

- Watershed hydrology will respond to climate change but not uniformly throughout the region. Consideration of the landscape context (topography, geology, elevation, etc.) is necessary for assessing a watershed's vulnerability to changes in peak and low flows.[10,12]
- Recent research suggests high-elevation watersheds are most sensitive to increases in winter peak flows and decreases in summer low flows. The majority are located on National Forest lands.[10,12]

Ecosystems & Hydrology

The changes projected for the region's hydrologic systems will have consequences for the structure of ecosystems and species assemblages.

Vegetation & Special Habitats

- Ecosystems and hydrologic systems are linked with changes to one affecting the other. Changes in the timing and amount of available water, especially when combined with increasing temperatures will affect plant productivity and ecosystem processes like disturbance, and changes to vegetative cover can affect streamflow and water quality.[13,14,15,16]
- Special habitats, including riparian areas (stream-side vegetation) and wetlands, comprise small portions of the landscape, but support a disproportionate amount of biodiversity. In most cases, climate change will exacerbate the adverse effects of land uses such as livestock grazing on these special habitats.[2]
- Shifts in amount and timing of streamflow will likely affect riparian area extent and species composition. Aspen, willow, cottonwood, and herbaceous communities dependent on water availability during the growing season may decline along with the ecosystem services they provide.[2]
- Wetlands and groundwater-dependent ecosystems, such as fens*, are an emerging concern. They are potentially vulnerable to climate change because water recharge may be lower with reduced snowpack.[2]

*Wetlands fed by mineral-rich surface and groundwater with a high organic material peat substrate.

Fish & Wildlife

- Native fish species could be sensitive to changing hydrologic regimes. Their response will depend on their habitat requirements, life history, and survival strategy.[2,15]
- Disturbances to stream habitat have different effects on fish. Flooding deposits fine sediments on salmon nests, causes egg scour, and flushes juveniles to poor habitat. On the other hand, disturbance delivers sediments and debris that add complexity to streams which enhances foraging, spawning, and refugia habitats. Climate change will affect the balance between these positive and negative outcomes.[15]
- Increased stream temperatures will have significant negative effects on cold water-adapted fish species, shrinking the range of potential habitat (Figure 4).[17]
- Lower low flows in summer could reduce habitat and cause migration barriers, exacerbating impacts to sensitive cold water-adapted fish species (Figure 5).[2]
- Climate-induced hydrologic changes will alter how certain habitats function. This will affect the life cycle, survival, and reproductive success of aquatic and semi-aquatic invertebrate and amphibian species.[8,9]

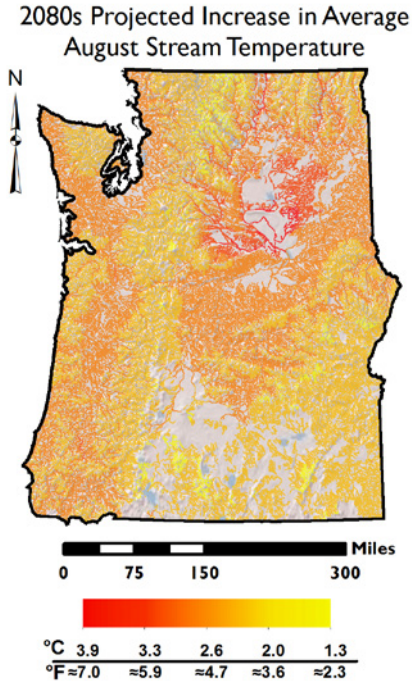


Figure 4: Projected increase in average August stream temperature for U.S. Forest Service Region 6. Calculated as the difference between a 1993-2011 baseline estimate and a 2080s (2070-2099) projection. Compared to current conditions, habitat quality for some sensitive aquatic species is expected to decline. Model and projections developed by the NorWest project, a multi-agency collaborative led by researchers at the U.S. Forest Service Rocky Mountain Station.[17]

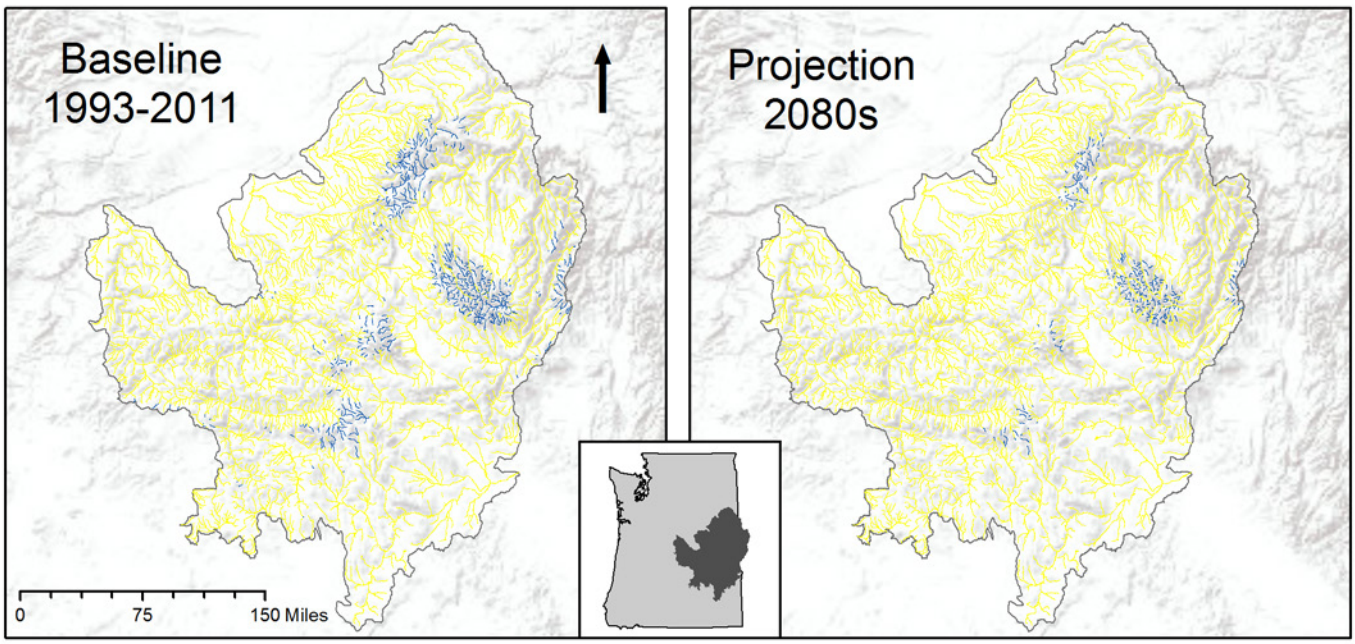


Figure 5: Estimated change in potential suitable habitat for bull trout. Stream reaches with August mean temperatures > 11 °C are warmer than optimal for spawning and juvenile rearing. Stream reaches with < 11 °C are critical to species persistence. NorWest projections estimate 58% of historic bull trout habitat will be over the 11 °C threshold by the 2080s.[17]

Society & Hydrology

Rural communities near national forests are particularly vulnerable to changes in agricultural and recreational resources.[18]

- Balancing irrigation, hydropower, municipal needs, and maintaining ecosystem health with adequate in-stream flows and lake levels will be increasingly difficult.[3,4]
- Warmer and longer growing seasons are projected to cause more frequent shortfalls in water supplies affecting right holders. Subsequent losses in agricultural production puts rural livelihoods at risk.[3,18]
- Culturally and economically important recreational activities tied to the region's hydrological cycle, such as skiing and fishing, will see reductions in suitable areas and season lengths.[18]

Looking for More?

Please see the cited references (located on the back) for more in-depth information about climate change impacts in the region.

The US Forest Service Climate Change Resource Center hosts a wide array of information from basic science to forest impact topics – **www.fs.usda.gov/ccrc**

Climate Facts is produced by the Pacific Northwest Region 6 Climate Change Team. US Forest Service, 1220 SW 3rd Ave., Portland, OR 97205.

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