Appendix H1c
Beneficial Environmental Effects

Contents

Tables

Figures

H1c.1 Salmonid Tributary Habitat Analysis Methods

Except where described below and in Section 13.5, *Beneficial Environmental Effects*, methods for this analysis were identical to those used in the Scientific Basis Report Supplement (Appendix G2) for estimation of tributary habitat area (Section 5.1, *Tributary Habitat Analysis*). Most analyses were focused on fall-run Chinook salmon, but some were focused on spring-run. Results tables and figures identify fall-run and spring-run results only for tributaries for which spring-run were evaluated; all other tributaries represent only fall-run results. Methods for existing tributary habitat area were used for the baseline and 55 w/WSAs scenarios and methods for VA habitat area were used for the VA scenario.

H1c.1.1 Temperature

Temperature analyses for the American River, Feather River, Mokelumne River, and Sacramento River use data and methodology as described in the Scientific Basis Report Supplement. For the Yuba River, temperature data are derived from the Yuba River temperature model as described in Appendix H1b, *Water Temperature Modeling and Fish Assessment for the Sacramento, Feather, American, and Yuba Rivers*. Temperatures are derived from Long Bar for spawning and Below Daguerre for rearing.

The temperature analysis method for tributaries not included in the VAs differs. Temperature data used in these analyses are from the Central Valley Project Improvement Act (CVPIA) Decision Support Model (DSM) input called "DSMtemperature" (Gill et al. 2022a). Details about the methods used for each tributary are provided by Gill et al. (2022b). Data from DSMtemperature are available at a monthly timestep for 1980–2000. As this does not cover the entire Sacramento Water Allocation Model (SacWAM) modeling period, a subsampling approach, similar to what was used in the Scientific Basis Report Supplement analysis for VA tributaries, was used. Additionally, as data are at a monthly timestep, the "proportion suitable" metric could not be calculated as is done in the Scientific Basis Report Supplement. Rather, habitat was considered suitable if the temperature for the given month and year was below the temperature thresholds.

H1c.1.2 Habitat Data

The habitat analyses follow a similar methodology as described in the Scientific Basis Report Supplement. For tributaries included in the VAs, the data sources are the same as in the Scientific Basis Report Supplement. Methods and data sources for existing tributary habitat area were used for the baseline and 55 w/WSAs scenarios and methods and data sources for VA habitat area were used for the VA scenario.

For the tributaries not included in the VAs, habitat-to-flow functions (similar to those described in the Scientific Basis Report Supplement) needed to be developed to apply to the regulatory pathway scenarios. All habitat data for these tributaries are from the Central Valley Project Improvement Act

(CVPIA) Decision Support Model (DSM) input called "DSMhabitat" (Rodriguez et al. 2023). DSM habitat compiles data from multiple sources. The specific data sources for each tributary are noted in Table H1c.1-1 and listed in Section H1c.3, *References Cited*.

Table H1c.1-1. Spawning, Instream Rearing, and Floodplain Habitat Data Sources

River	Existing Habitat Source	VA Habitat Source
Antelope Creek	Spawning and Instream rearing – No watershed-specific data available. Used a regional approximation method (Gill and Tompkins 2020a). Floodplain – Scaled from a Deer Creek flow-to-floodplain area relationship generated with a 2D HEC-RAS hydraulic model (Hackenjos 2019). Habitat modeling last updated in 2020 (Gill and Tompkins 2020b).	
American River	Spawning – Bratovich et al. 2017; Gill and Tompkins 2020c Instream Rearing – (Hammersmark pers. comm.) Floodplain – (Hammersmark pers. comm.)	Spawning – (Hammersmark pers. comm.) Assumptions: • Hammersmark pers. comm. provided the number of suitable acres for a number of flows, including minimum (34% of committed acres suitable at 500 cubic feet per second [cfs]), maximum (70% of committed acres suitable at 2,000 cfs), and target (75% of committed acres suitable at 1,500 cfs) flow. Added to existing spawning habitat. Instream Rearing – (Hammersmark pers. comm.) Assumptions: • Hammersmark pers. comm. provided the number of suitable acres for a number of flows, including minimum (19% of committed acres suitable at 500 cfs), maximum (17% of committed acres suitable at 10,000 cfs), and target (37% of committed acres suitable at 4,000 cfs) flow. Added to existing instream habitat. Floodplain – *No floodplain habitat committed*.
Battle Creek	Spawning and Instream rearing – Thomas R. Payne and Associates 1995 Floodplain – Scaled from a Deer Creek flow-to-floodplain area relationship generated with a 2D HEC-RAS hydraulic model (Hackenjos 2019).	

River	Existing Habitat Source	VA Habitat Source
	Habitat modeling last updated in 2020 (Gill and Tompkins 2020d).	
Bear River	Spawning and Instream Rearing – SSWD 2019 Floodplain – Central Valley Floodplain Evaluation and Delineation (CVFED) HEC-RAS hydraulic model (DWR 2014) Habitat modeling last updated in 2020 (Gill and Tompkins 2020e).	
Big Chico Creek	Spawning and Instream Rearing – No watershed-specific data available. Used a regional approximation method (Gill and Tompkins 2020a). Floodplain – CVFED HEC-RAS hydraulic model (DWR 2014) Habitat modeling last updated in 2020 (Gill and Tompkins 2020f).	
Butte Creek	Spawning and Instream Rearing – USFWS 2003a; FERC Relicensing DeSabla (PG&E 2008) Floodplain – CVFED HEC-RAS hydraulic model (DWR 2014) Habitat modeling last updated in 2020 (Gill and Tompkins 2020g).	
Calaveras River	Spawning and Instream Rearing – FISHBIO Environmental and Thomas R. Payne & Associates 2010. No habitat modeling is available for fall-run Chinook salmon on the Calaveras River. Instream spawning and rearing habitat for steelhead in the Calaveras River is used as a proxy for Chinook. Floodplain – Scaled from a Tuolumne River flow-to-floodplain area relationship generated with a TUFLOW hydraulic model with 1D channel and 2D overbank components (HDR, Inc. and Stillwater Sciences 2015). Habitat modeling last updated in 2020 (Gill and Tompkins 2020h).	
Clear Creek	Spawning – USFWS 2007; USFWS 2011a Instream Rearing – USFWS 2011b; USFWS 2013 Floodplain – Scaled from a Cottonwood Creek flow-to-floodplain area relationship generated with a USFWS /	

River	Existing Habitat Source	VA Habitat Source
	FEMA 1D HEC-RAS hydraulic model (USFWS 2018). Habitat modeling last updated in 2020 (Gill and Tompkins 2020i).	
Cosumnes River	Spawning and Instream Rearing – FISHBIO Environmental, LLC and Thomas R. Payne and Associates 2010; Mokelumne (CDFG 1991). No watershed-specific salmonid habitat data were available for the Cosumnes River. A regional weighted usable area (WUA) and flow relationship was derived for the Cosumnes River by averaging the WUA values on the Calaveras River and the Mokelumne River. Floodplain – CVPIA Annual Progress Report Fiscal Year 2019 (USFWS 2019) Habitat modeling last updated in 2020 (Gill and Tompkins 2020j).	
Cottonwood Creek	Spawning and Instream Rearing – CDFG and U.S. Corps of Engineers 1979; USFWS 2013 (USFWS 2014) Floodplain – USFWS 2017 / FEMA 1D HEC-RAS hydraulic model (USFWS 2018) Habitat modeling last updated in 2020 (Gill and Tompkins 2020k).	
Cow Creek	Spawning – No watershed specific data were available. Used a regional approximation method (Gill and Tompkins 2020a). Instream Rearing – USFWS 2011c Floodplain – Scaled from a Deer Creek flow-to-floodplain area relationship generated with a 2D HEC-RAS hydraulic model (Hackenjos 2019). Habitat modeling last updated in 2020 (Gill and Tompkins 2020l).	
Deer Creek	Spawning, Instream Rearing, and Floodplain – (Gill and Tompkins 2021, Hackenjos 2019) Habitat modeling last updated in 2021 (Gill and Tompkins 2021).	
Elder Creek	Spawning and Instream Rearing – No watershed specific data were available. Used a regional approximation method (Gill and Tompkins 2020a).	

River	Existing Habitat Source	VA Habitat Source
	Floodplain – CVFED HEC-RAS hydraulic model (DWR 2014) Habitat modeling last updated in 2020 (Gill and Tompkins 2020n).	
Feather River	Spawning – DWR 2004 Instream Rearing – DWR 2005; CVFED HEC-RAS hydraulic model. Floodplain – CVFED HEC-RAS hydraulic model DWR 2014 Habitat modeling last updated in 2020 (Gill and Tompkins 2020o).	Spawning – (Kindopp pers. comm.) Assumptions: • Kindopp pers. comm.. provided the number of suitable acres at minimum (70% of committed acres suitable at 650 cfs), maximum (80% of committed acres suitable at 1,100 cfs), and target (90% of committed acres suitable at 850 cfs) flow. Added to existing habitat on the Low Flow Channel. Instream Rearing – (Kindopp pers. comm.) Assumptions: • Kindopp pers. comm. provided the number of suitable acres at minimum (80% of committed acres suitable at 650 cfs), maximum (50% of committed acres suitable at 3,000 cfs), and target (90% of committed acres suitable at 725 cfs) flow. Added to existing habitat on the Low Flow Channel. Floodplain – (Kindopp pers. comm.) Assumptions: • Kindopp pers. comm. provided the number of suitable acres for minimum, target, and maximum flows for three types of project designed for different inundation flows: 3,000 cfs, 4,000 cfs, and 30,000 cfs. The flow-habitat curves for the three projects were added together into a composite curve after applying linear interpolation between points. • A total of 550 acres was expected to be inundated at 3,000 cfs with the following suitability: minimum (75% of total inundated acres [412.5 acres] suitable at 3,000 cfs), maximum (50% of total inundated acres [275 acres] suitable at 10,000 cfs), and

River	Existing Habitat Source	VA Habitat Source
		target (80% of total inundated acres [440 acres] suitable at 4,000 cfs) flows. • A total of 300 acres was expected to be inundated at 4,000 cfs with the following suitability: minimum (80% of total inundated acres [240 acres] suitable at 4,000 cfs), and maximum/target (80% of total inundated acres [240 acres] suitable at 25,000 cfs) flows. • A total of 805 acres was expected to be inundated at 30,000 cfs with the following suitability: minimum (80% of total inundated acres [644 acres] suitable at 30,000 cfs), maximum (50% of total inundated acres [402.5 acres] at 50,000 cfs), and target (90% of total inundated acres [724.5 acres] at 35,000 cfs) flows.
Mill Creek	Spawning and Instream Rearing – No watershed specific data were available. Used a regional approximation method (Gill and Tompkins 2020a). Floodplain – Scaled from a Deer Creek flow-to-floodplain area relationship generated with a 2D HEC-RAS hydraulic model (Hackenjos 2019). Habitat modeling last updated in 2020 (Gill and Tompkins 2020p).	
Mokelumne River	Spawning and Instream Rearing – (Bilski pers. comm.) Floodplain – (Bilski pers. comm.)	Spawning – *No spawning habitat committed*. Instream Rearing – (Bilski pers. comm.) Assumptions: • Bilski pers. comm. provided the number of suitable acres for a number of flows including minimum (35% of committed acres suitable at 100 cfs) and maximum/target flows (85% of committed acres suitable at 1,000 cfs). Added to existing instream habitat. Floodplain – (Bilski pers. comm.) • Bilski pers. comm. provided the number of suitable acres for a number of flows including minimum (50% of committed acres suitable at 800 cfs), maximum (100% of

River	Existing Habitat Source	VA Habitat Source
		committed acres suitable at 1,700 cfs), and target (100% of committed acres suitable at 1,300 cfs) flows. • Inundation beginning at 800 cfs.
Paynes Creek	Spawning and Instream Rearing – No watershed specific data were available. Used a regional approximation method (Gill and Tompkins 2020a). Floodplain – Scaled from a Deer Creek flow-to-floodplain relationship generated with a 2D HEC-RAS hydraulic model (Hackenjos 2019). Habitat modeling last updated in 2020 (Gill and Tompkins 2020q).	
Sacramento River	Spawning – USFWS 2003b Rearing – CVFED HEC-RAS hydraulic model refined for use in the NOAA-NMFS Winter Run Chinook Salmon life cycle model (Hendrix et al. 2017). Floodplain – CVFED HEC-RAS hydraulic model refined for use in the NOAA-NMFS Winter Run Chinook Salmon life cycle model (Hendrix et al. 2017).	Spawning – (Hannon pers. comm.) Assumptions: • VA habitat is all suitable habitat. • A flow-to-area relationship was not provided, and all 113.5 acres of VA habitat were added to existing habitat consistently across all flows. Added to existing habitat at the Red Bluff to Deer Creek reach. Instream Rearing – (Hannon pers. comm.) Assumptions: • Hannon pers. comm. provided flow-habitat curves for two project types. The flow-habitat curves for the two project types were added together into a composite curve after applying linear interpolation between points. • Hannon pers. comm. provided the number of suitable acres of new side-channel habitat (25 acres) at three flow levels (60% of acres [15 acres] suitable below 8,000 cfs; 100% suitable [25 acres] at 8,000 cfs; 80% suitable [20 acres] above 8,000 cfs). • Hannon pers. comm. provided the number of suitable acres of new instream habitat (112.5 acres) at three flow levels (0% of acres suitable below 8,000 cfs; 25% suitable [28 acres] at 30,000 cfs; 100% suitable [112.5 acres] at 15,000 cfs). Added to existing instream habitat.

River	Existing Habitat Source	VA Habitat Source
		Floodplain – *No floodplain habitat committed*.
Stony Creek	Spawning and Instream Rearing – No watershed specific data were available. Used a regional approximation method (Gill and Tompkins 2020a). Floodplain – Scaled from a Cottonwood Creek flow-to-floodplain area relationship generated with a USFWS / FEMA 1D HEC-RAS hydraulic model (USFWS 2018). Habitat modeling last updated in 2020 (Gill and Tompkins 2020r).	
Sutter Bypass and Butte Sink	Floodplain – CVFED HEC-RAS hydraulic model refined for use in the NOAA-NMFS Winter Run life cycle model (Hendrix et al. 2017).	Floodplain – (Bergfeld pers. comm.) Assumptions: • Flow and suitable area were not provided for VA habitat. • Number of suitable acres for VA habitat was assumed to have the same relative flow to suitable area relationship as existing habitat: minimum (3% of committed acres suitable at 10 cfs), maximum (75% of committed acres suitable at 10,000 cfs), and target (100% of committed acres suitable at 5,000 cfs) flows. Assumed habitat is accessible to fish.
Thomes Creek	Spawning and Instream Rearing – No watershed specific data were available. Used a regional approximation method (Gill and Tompkins 2020a). Floodplain – Scaled from a Cottonwood Creek flow-to-floodplain area relationship generated with a USFWS / FEMA 1D HEC-RAS hydraulic model (USFWS 2018). Habitat modeling last updated in 2020 (Gill and Tompkins 2020s).	
Yuba River	Spawning – (Bratovich pers. comm.) Instream Rearing – (Bratovich pers. comm.) Floodplain – (Bratovich pers. comm.)	Spawning – *No spawning habitat committed*. Instream Rearing – (Bratovich pers. comm.) Assumptions: • Includes assumed suitable hydraulic rearing habitat availability in the lower Yuba River including within the grading footprints of the Hallwood, Lower Long Bar, Upper

River	Existing Habitat Source	VA Habitat Source
		Long Bar, and Upper Rose Bar habitat enhancement projects. • Delineation of in-channel and floodplain habitat based on 1,500 cfs wetted extent below Daguerre Point Dam and 1,750 cfs wetted extent above Daguerre Point Dam. • Bratovich pers. comm. provided the number of suitable acres at minimum (39% of committed acres suitable at 300 cfs), maximum (0% of committed acres suitable at 25,000 cfs), and target (71% of committed acres suitable at 2,500 cfs) flow. Floodplain – (Bratovich pers. comm.) Assumptions: • Includes assumed suitable hydraulic rearing habitat availability in the lower Yuba River including within the grading footprints of the Hallwood, Lower Long Bar, Upper Long Bar, and Upper Rose Bar habitat enhancement projects. • Delineation of in-channel and floodplain habitat based on 1,500 cfs wetted extent below Daguerre Point Dam and 1,750 cfs wetted extent above Daguerre Point Dam. • Bratovich pers. comm. provided the number of suitable acres at minimum (0% of committed acres suitable at 300 cfs), maximum (0% of committed acres suitable at 25,000 cfs), and target (41% of committed acres suitable at 10,000 cfs) flow.

Sources identified in this table are included in Section H1c3, *References Cited*.

H1c.1.3 Meaningful Floodplain Event

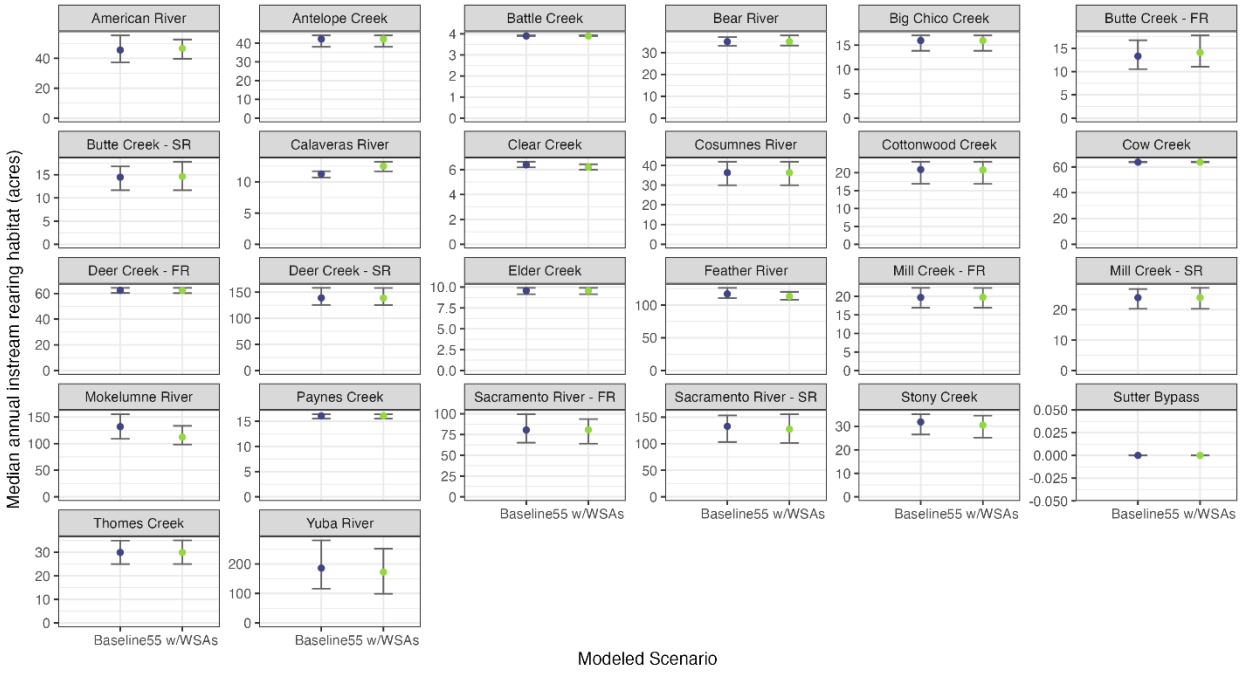
The meaningful floodplain event (MFE) methods used for non-VA tributaries are the same as those described in the Scientific Basis Report Supplement, except in the following cases where a doubling goal[1] does not exist for a watershed: Elder Creek, Stony Creek, and Thomes Creek. In these cases, the magnitude levels for the MFE analysis were set at 25 percent, 50 percent, 75 percent, and 100 percent of the maximum habitat area. MFE analyses were not conducted for the Calaveras River because maximum floodplain habitat is estimated to be less than 1 acre (0.07 acre). MFE analyses have not yet been developed for the Yolo Bypass.

[1] The goal of doubling natural production of chinook salmon from the average production of 1967–1991, consistent with provisions of state and federal law.

H1c.2 Salmonid Tributary Habitat Analysis Supplemental Results Figures

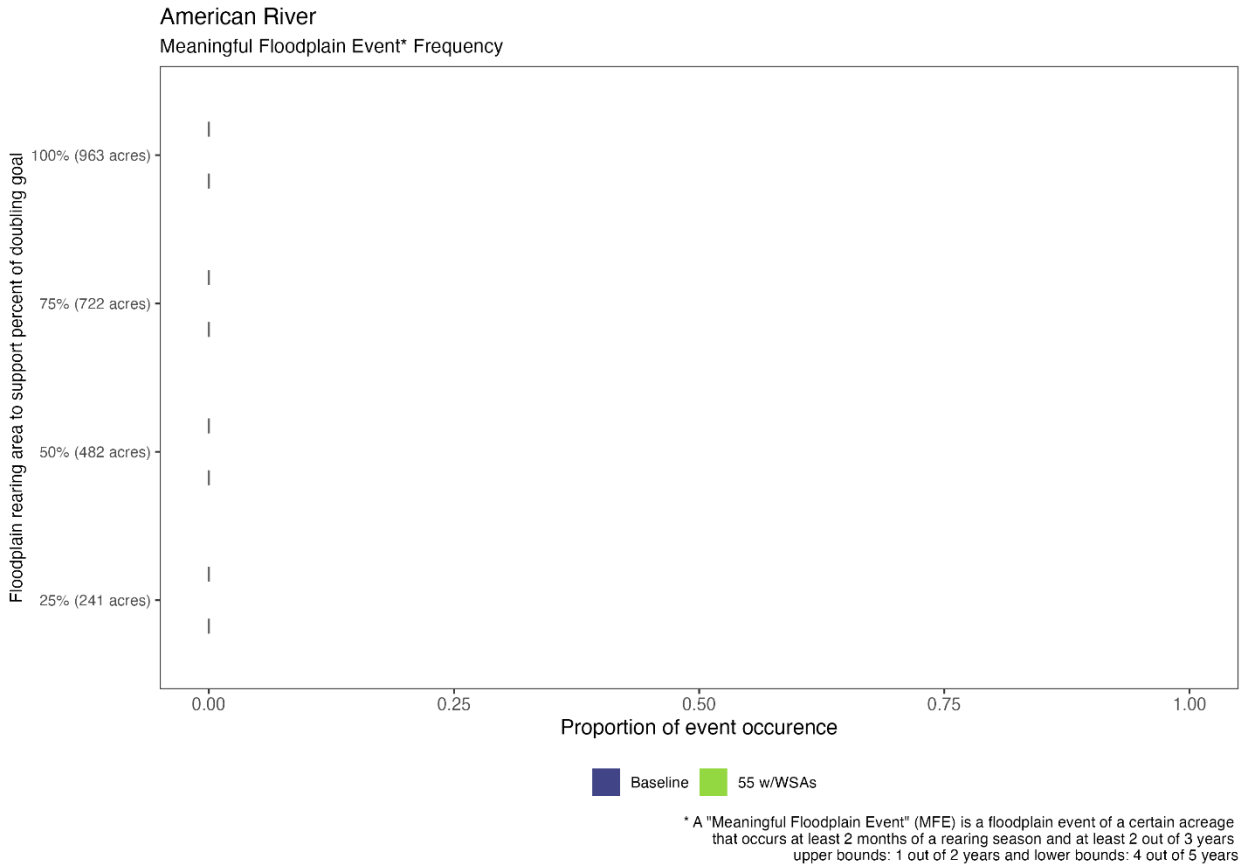
The following figures provide additional detail to the results presented in Section 13.5, *Beneficial Environmental Effects*.

H1c.2.1 Regulatory Pathway



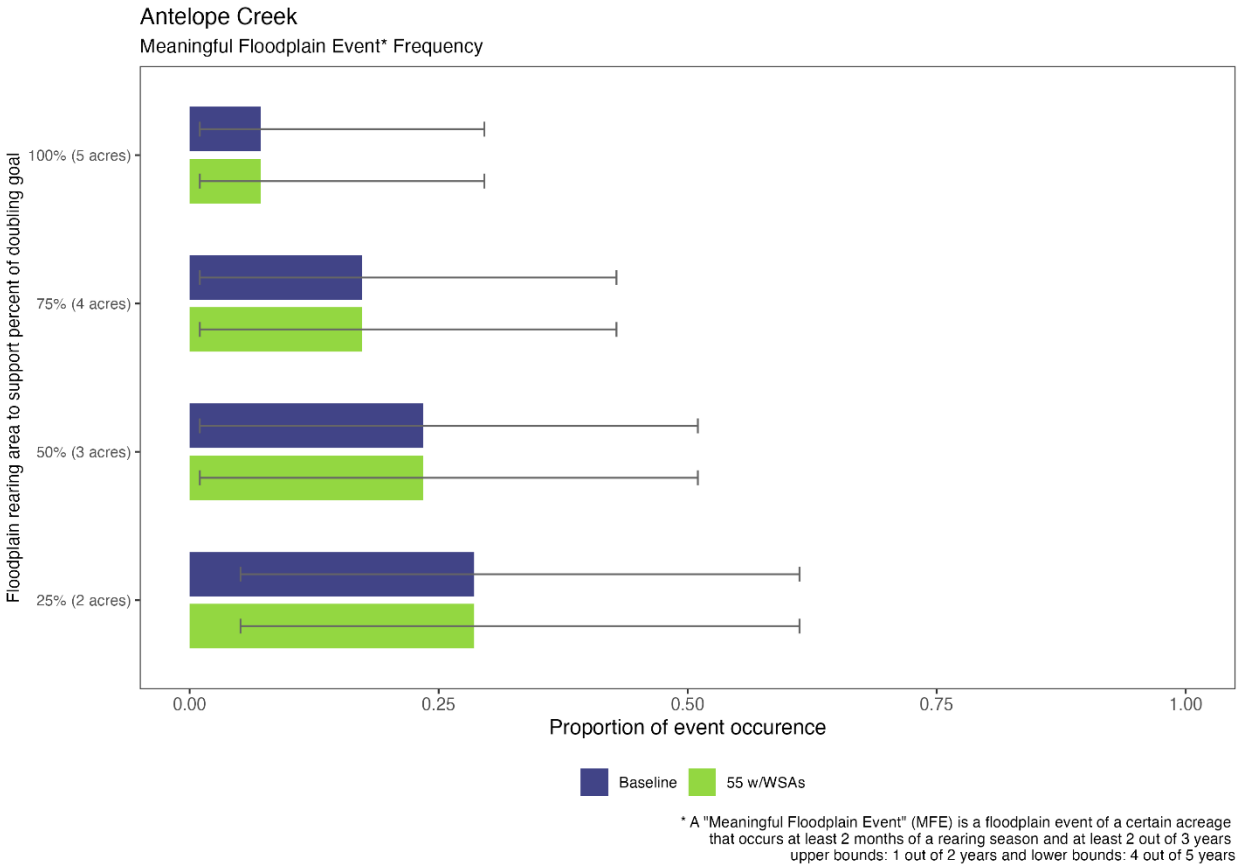
Note: Error bars represent the upper and lower quartiles. Medians and quantiles were calculated across all years; therefore, the quantiles represent year-to-year variability, not the full uncertainty in expected outcomes. FR = fall-run; SR = spring-run.

Figure H1c.2.1-1. Median (across All Years Modeled) Instream Rearing Habitat (acres) for Each Watershed



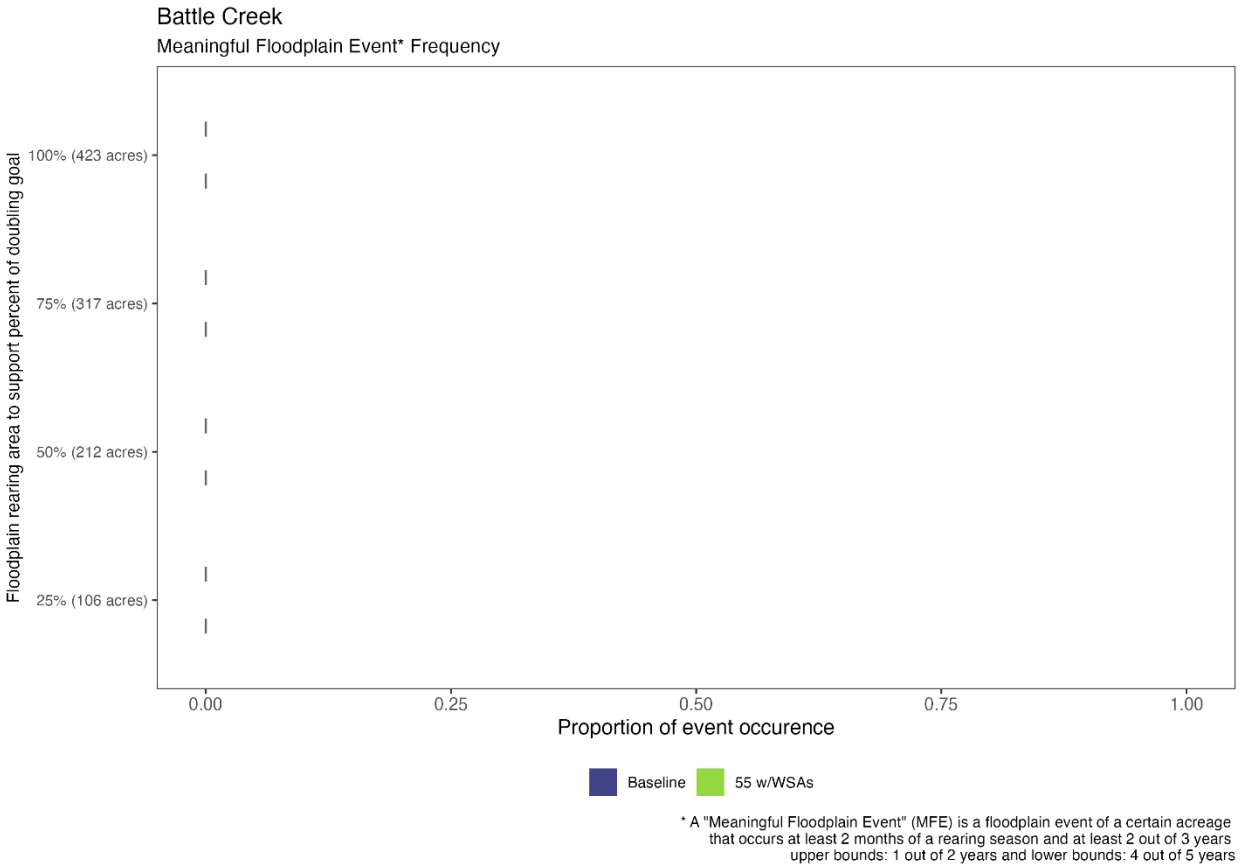
Note: A *meaningful floodplain event* (MFE) is defined as a floodplain event of a certain acreage that occurs at least 2 months of a rearing season and at least 2 out of 3 years. The lower bounds of the error bars represent the proportion of event occurrence when MFE criteria are restricted to require floodplain events 4 out of 5 years. The upper bounds of the error bars represent the proportion of event occurrence when MFE criteria are loosened to require floodplain events 1 out of 2 years. All results are at 0 because there were no MFEs in any scenarios for the American River.

Figure H1c.2.1-2. Proportion of Meaningful Floodplain Event Occurrence for the Baseline and 55 w/WSAs Scenarios on the American River



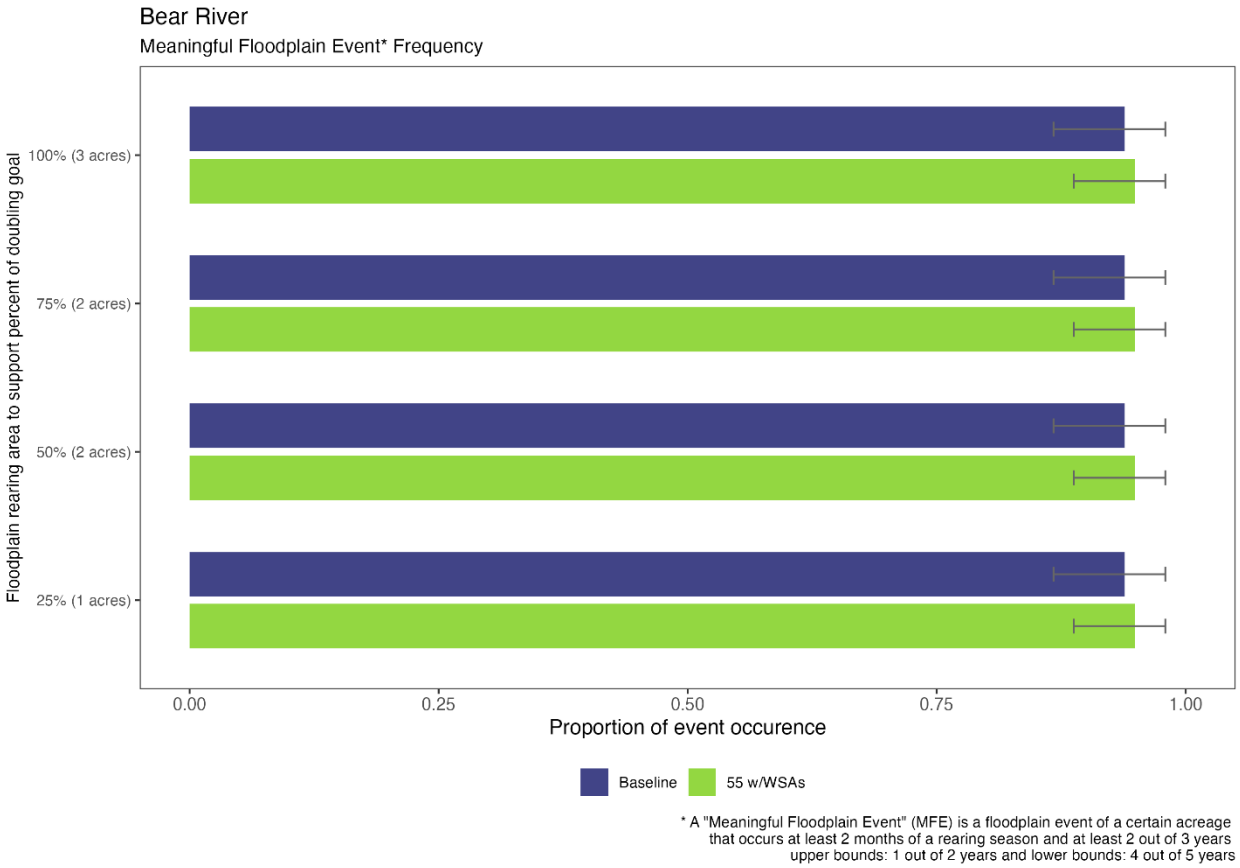
Note: A *meaningful floodplain event* (MFE) is defined as a floodplain event of a certain acreage that occurs at least 2 months of a rearing season and at least 2 out of 3 years. The lower bounds of the error bars represent the proportion of event occurrence when MFE criteria are restricted to require floodplain events 4 out of 5 years. The upper bounds of the error bars represent the proportion of event occurrence when MFE criteria are loosened to require floodplain events 1 out of 2 years.

Figure H1c.2.1-3. Proportion of Meaningful Floodplain Event Occurrence for the Baseline and 55 w/WSAs Scenarios on Antelope Creek



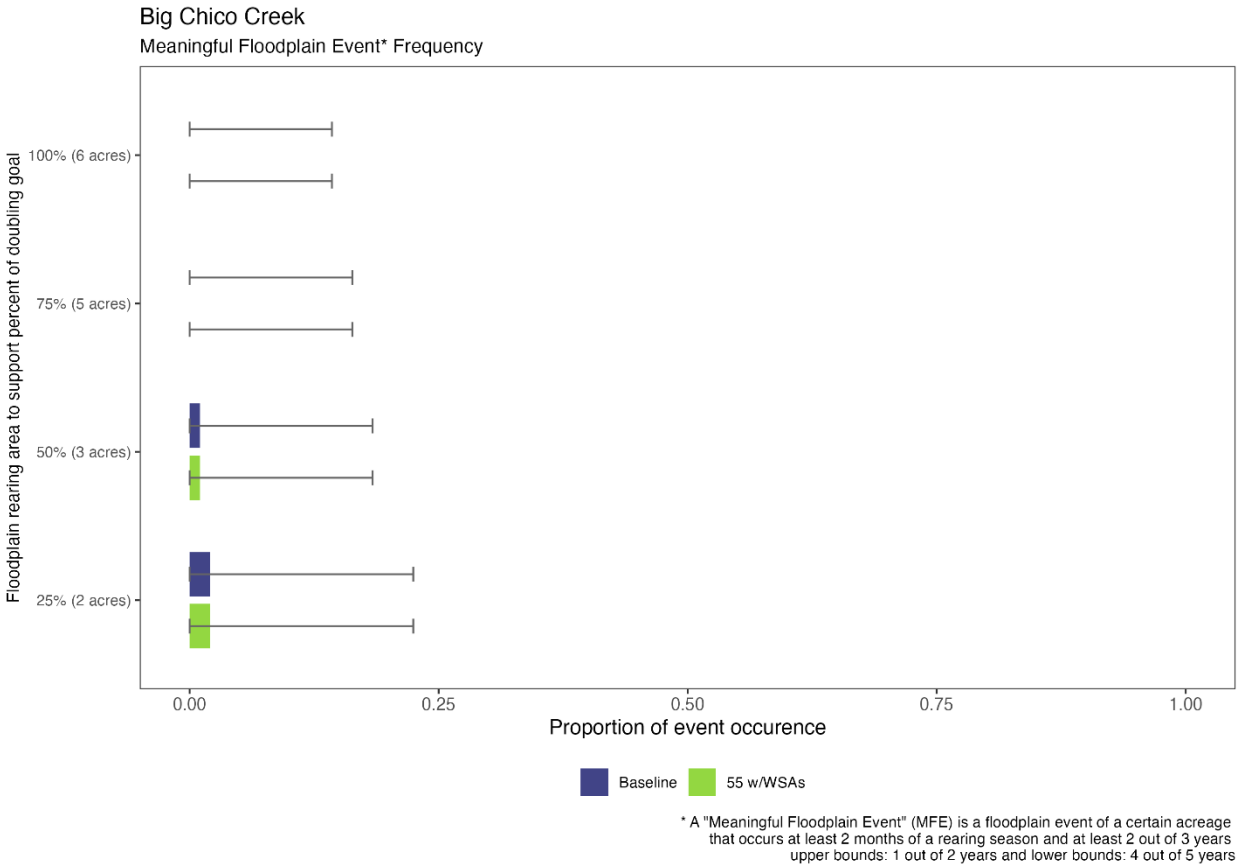
Note: A *meaningful floodplain event* (MFE) is defined as a floodplain event of a certain acreage that occurs at least 2 months of a rearing season and at least 2 out of 3 years. The lower bounds of the error bars represent the proportion of event occurrence when MFE criteria are restricted to require floodplain events 4 out of 5 years. The upper bounds of the error bars represent the proportion of event occurrence when MFE criteria are loosened to require floodplain events 1 out of 2 years. All results are at 0 because there were no MFEs in any scenarios for Battle Creek.

Figure H1c.2.1-4. Proportion of Meaningful Floodplain Event Occurrence for the Baseline and 55 w/WSAs Scenarios on Battle Creek



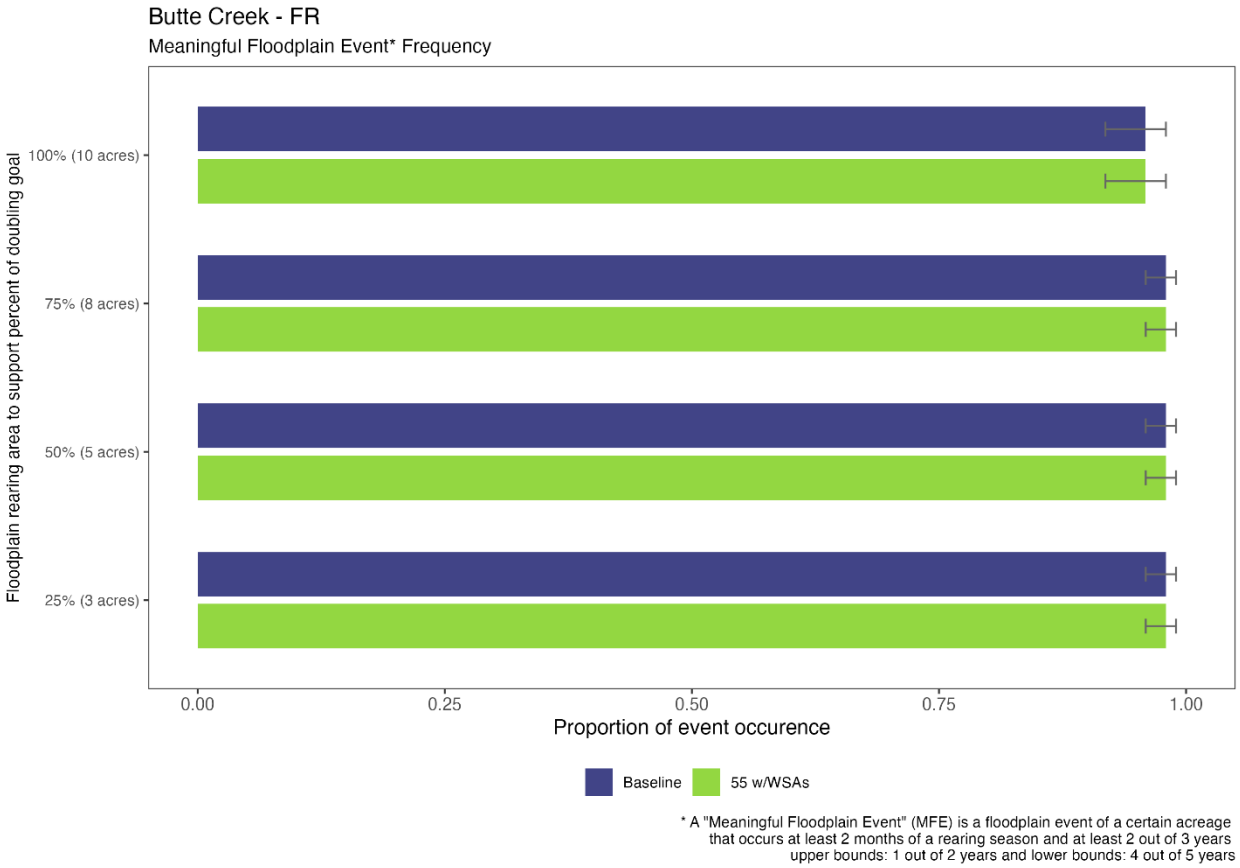
Note: A *meaningful floodplain event* (MFE) is defined as a floodplain event of a certain acreage that occurs at least 2 months of a rearing season and at least 2 out of 3 years. The lower bounds of the error bars represent the proportion of event occurrence when MFE criteria are restricted to require floodplain events 4 out of 5 years. The upper bounds of the error bars represent the proportion of event occurrence when MFE criteria are loosened to require floodplain events 1 out of 2 years.

Figure H1c.2.1-5. Proportion of Meaningful Floodplain Event Occurrence for the Baseline and 55 w/WSAs Scenarios on the Bear River



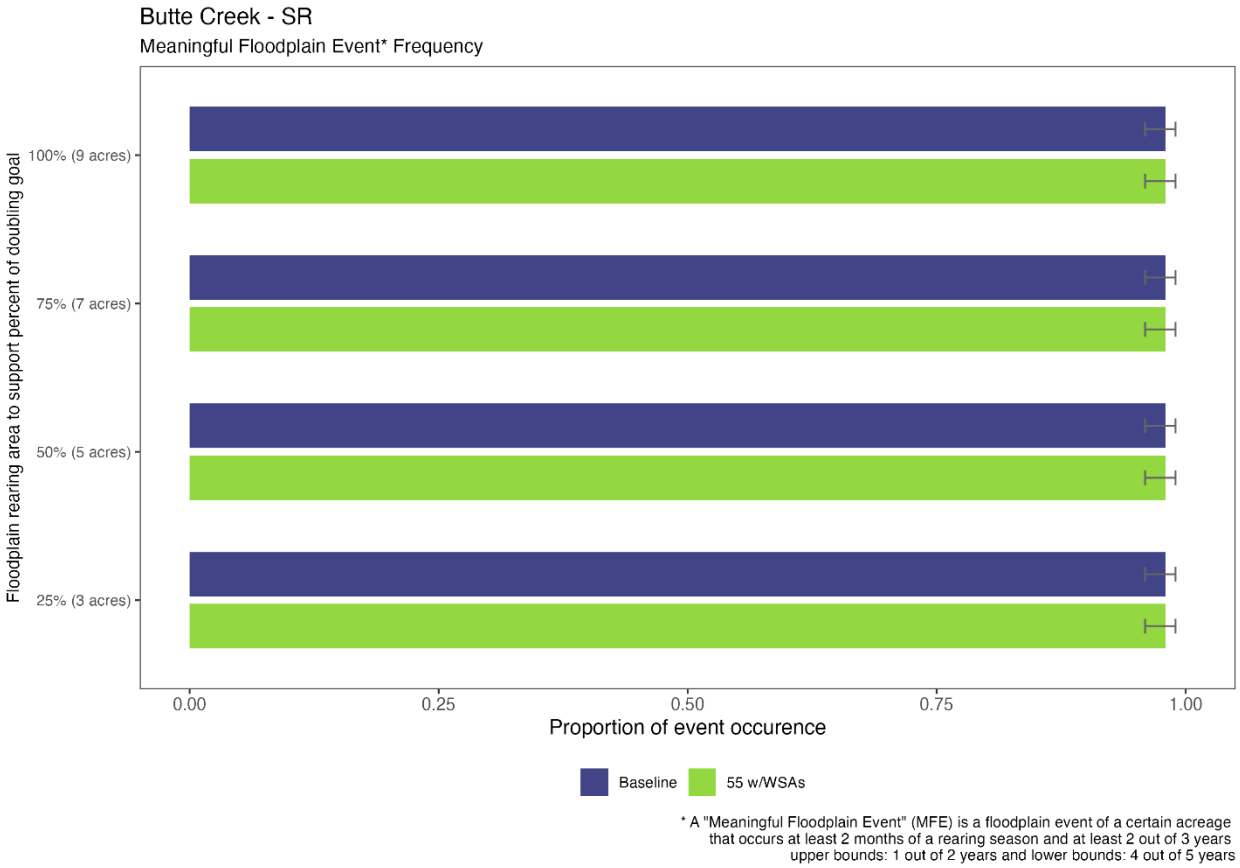
Note: A *meaningful floodplain event* (MFE) is defined as a floodplain event of a certain acreage that occurs at least 2 months of a rearing season and at least 2 out of 3 years. The lower bounds of the error bars represent the proportion of event occurrence when MFE criteria are restricted to require floodplain events 4 out of 5 years. The upper bounds of the error bars represent the proportion of event occurrence when MFE criteria are loosened to require floodplain events 1 out of 2 years.

Figure H1c.2.1-6. Proportion of Meaningful Floodplain Event Occurrence for the Baseline and 55 w/WSAs Scenarios on Big Chico Creek



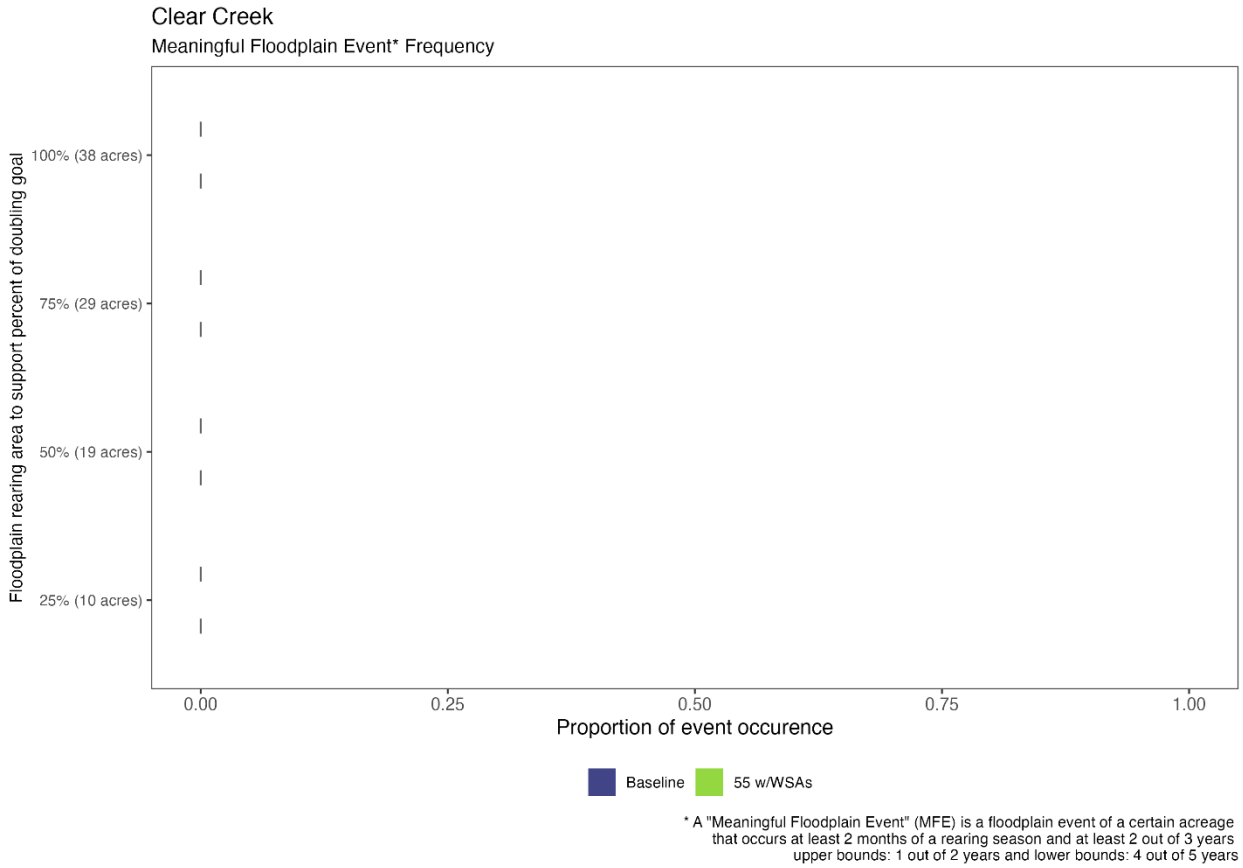
Note: A *meaningful floodplain event* (MFE) is defined as a floodplain event of a certain acreage that occurs at least 2 months of a rearing season and at least 2 out of 3 years. The lower bounds of the error bars represent the proportion of event occurrence when MFE criteria are restricted to require floodplain events 4 out of 5 years. The upper bounds of the error bars represent the proportion of event occurrence when MFE criteria are loosened to require floodplain events 1 out of 2 years.

Figure H1c.2.1-7. Proportion of Meaningful Floodplain Event Occurrence for the Baseline and 55 w/WSAs Scenarios on Butte Creek (Fall-Run)



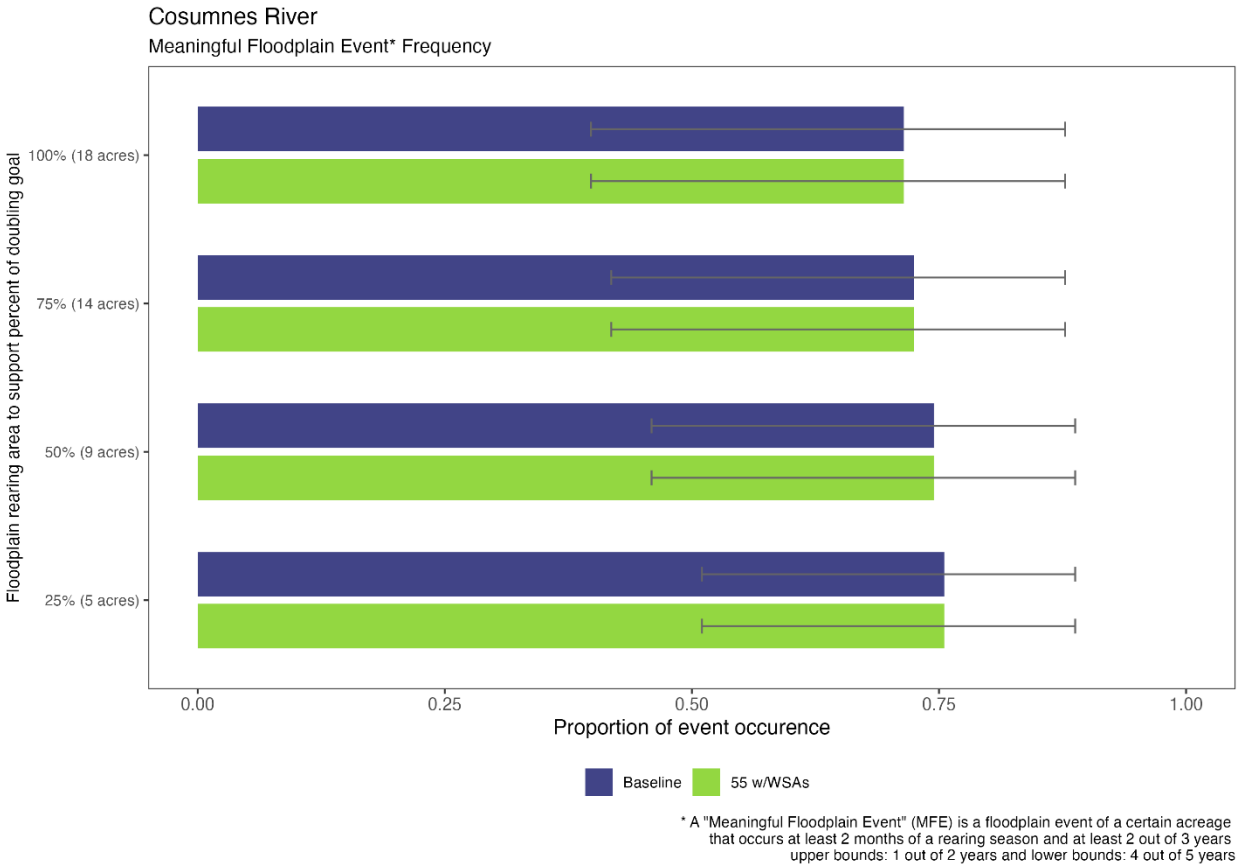
Note: A *meaningful floodplain event* (MFE) is defined as a floodplain event of a certain acreage that occurs at least 2 months of a rearing season and at least 2 out of 3 years. The lower bounds of the error bars represent the proportion of event occurrence when MFE criteria are restricted to require floodplain events 4 out of 5 years. The upper bounds of the error bars represent the proportion of event occurrence when MFE criteria are loosened to require floodplain events 1 out of 2 years.

Figure H1c.2.1-8. Proportion of Meaningful Floodplain Event Occurrence for the Baseline and 55 w/WSAs Scenarios on Butte Creek (Spring-Run)



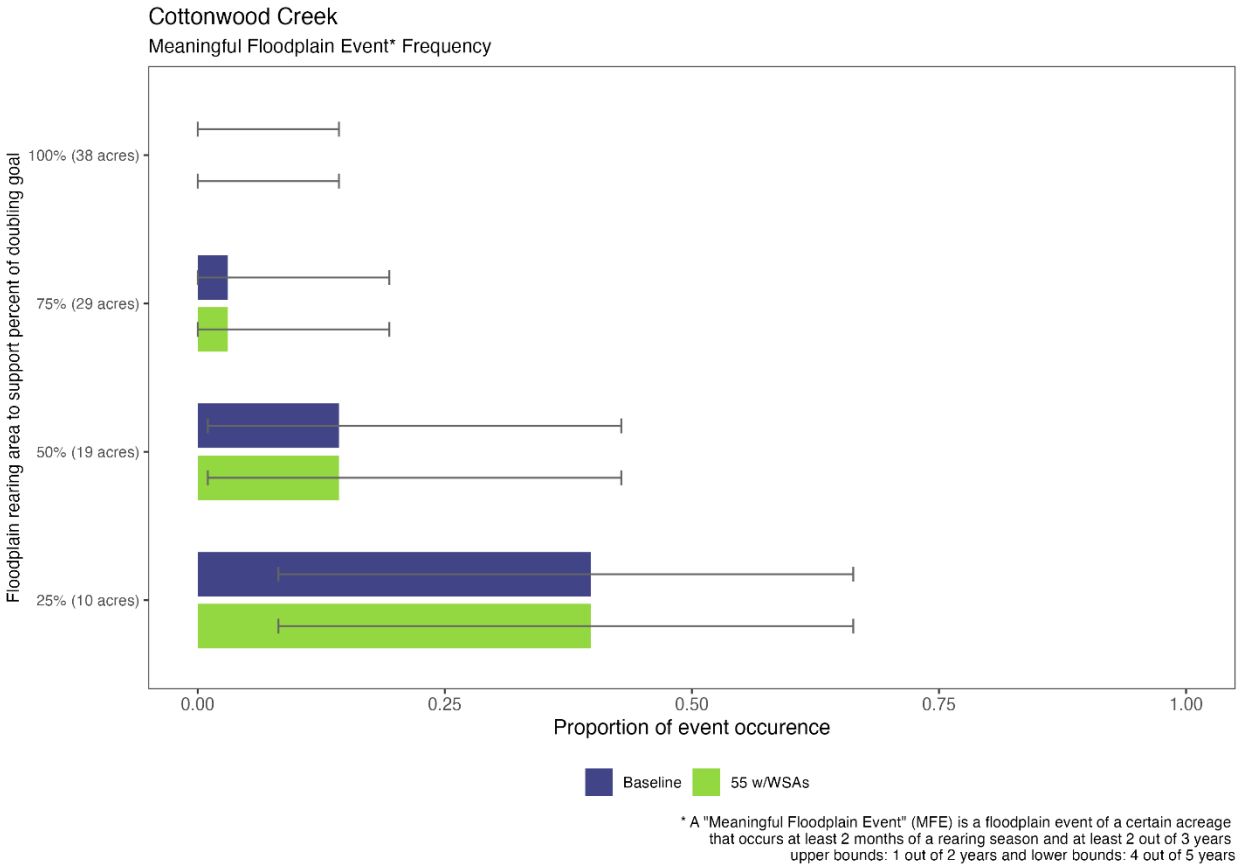
Note: A *meaningful floodplain event* (MFE) is defined as a floodplain event of a certain acreage that occurs at least 2 months of a rearing season and at least 2 out of 3 years. The lower bounds of the error bars represent the proportion of event occurrence when MFE criteria are restricted to require floodplain events 4 out of 5 years. The upper bounds of the error bars represent the proportion of event occurrence when MFE criteria are loosened to require floodplain events 1 out of 2 years. All results are at 0 because there were no MFEs in any scenarios for Clear Creek.

Figure H1c.2.1-9. Proportion of Meaningful Floodplain Event Occurrence for the Baseline and 55 w/WSAs Scenarios on Clear Creek



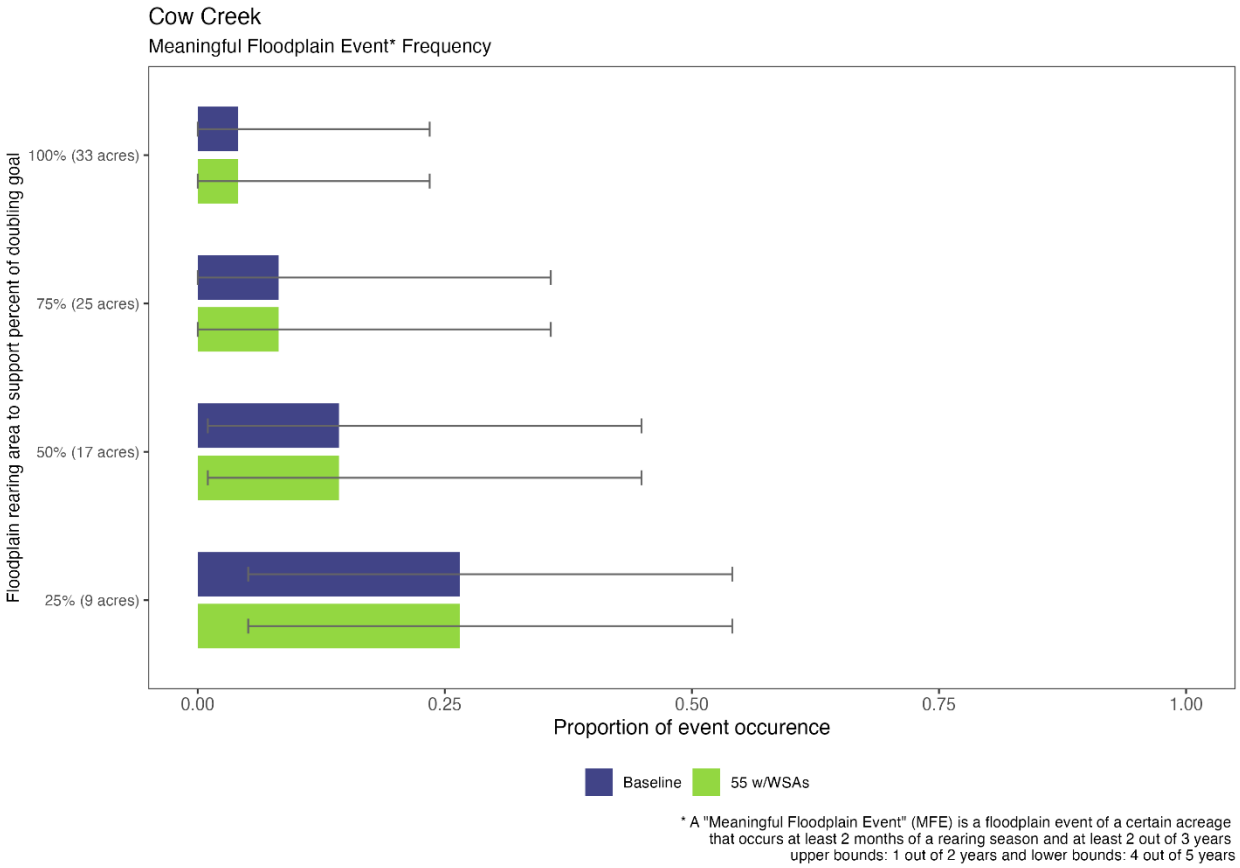
Note: A *meaningful floodplain event* (MFE) is defined as a floodplain event of a certain acreage that occurs at least 2 months of a rearing season and at least 2 out of 3 years. The lower bounds of the error bars represent the proportion of event occurrence when MFE criteria are restricted to require floodplain events 4 out of 5 years. The upper bounds of the error bars represent the proportion of event occurrence when MFE criteria are loosened to require floodplain events 1 out of 2 years.

Figure H1c.2.1-10. Proportion of Meaningful Floodplain Event Occurrence for the Baseline and 55 w/WSAs Scenarios on the Cosumnes River



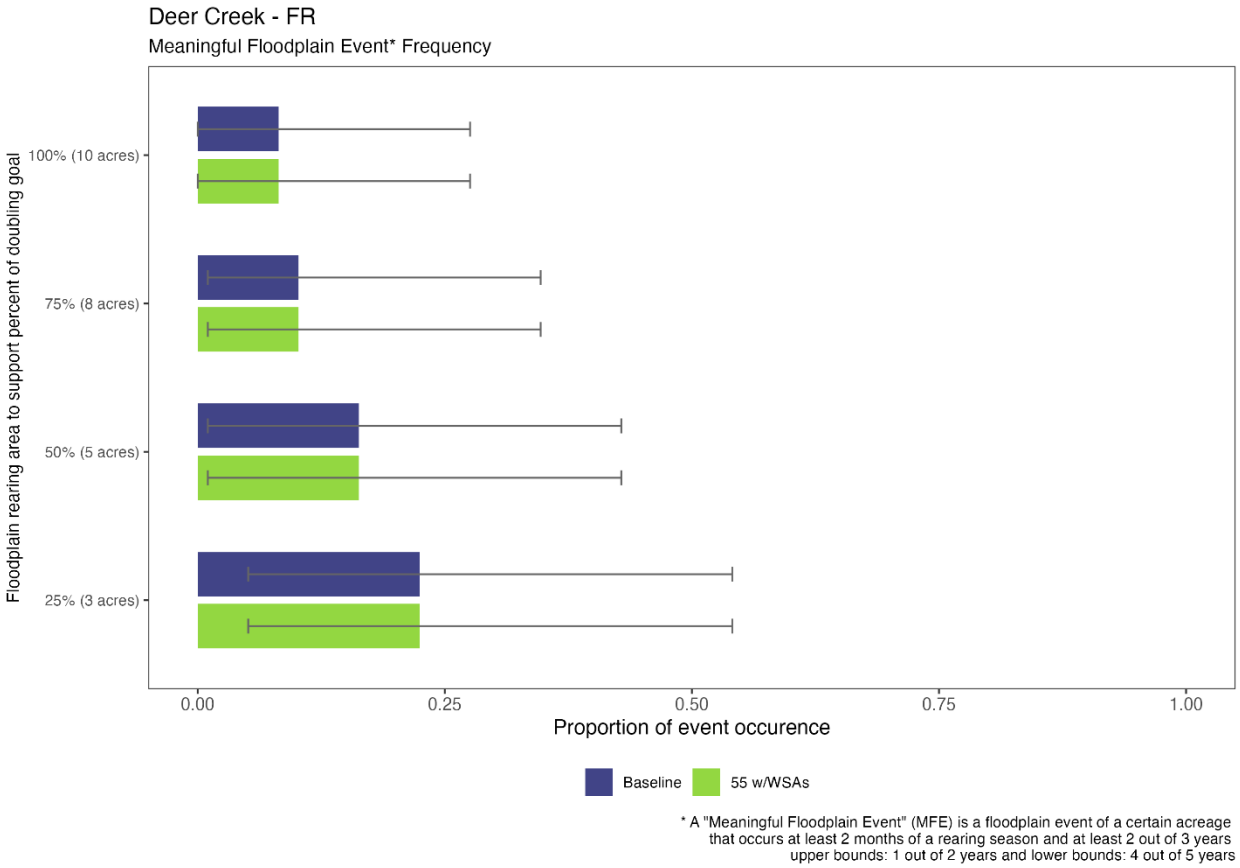
Note: A *meaningful floodplain event* (MFE) is defined as a floodplain event of a certain acreage that occurs at least 2 months of a rearing season and at least 2 out of 3 years. The lower bounds of the error bars represent the proportion of event occurrence when MFE criteria are restricted to require floodplain events 4 out of 5 years. The upper bounds of the error bars represent the proportion of event occurrence when MFE criteria are loosened to require floodplain events 1 out of 2 years.

Figure H1c.2.1-11. Proportion of Meaningful Floodplain Event Occurrence for the Baseline and 55 w/WSAs Scenarios on Cottonwood Creek



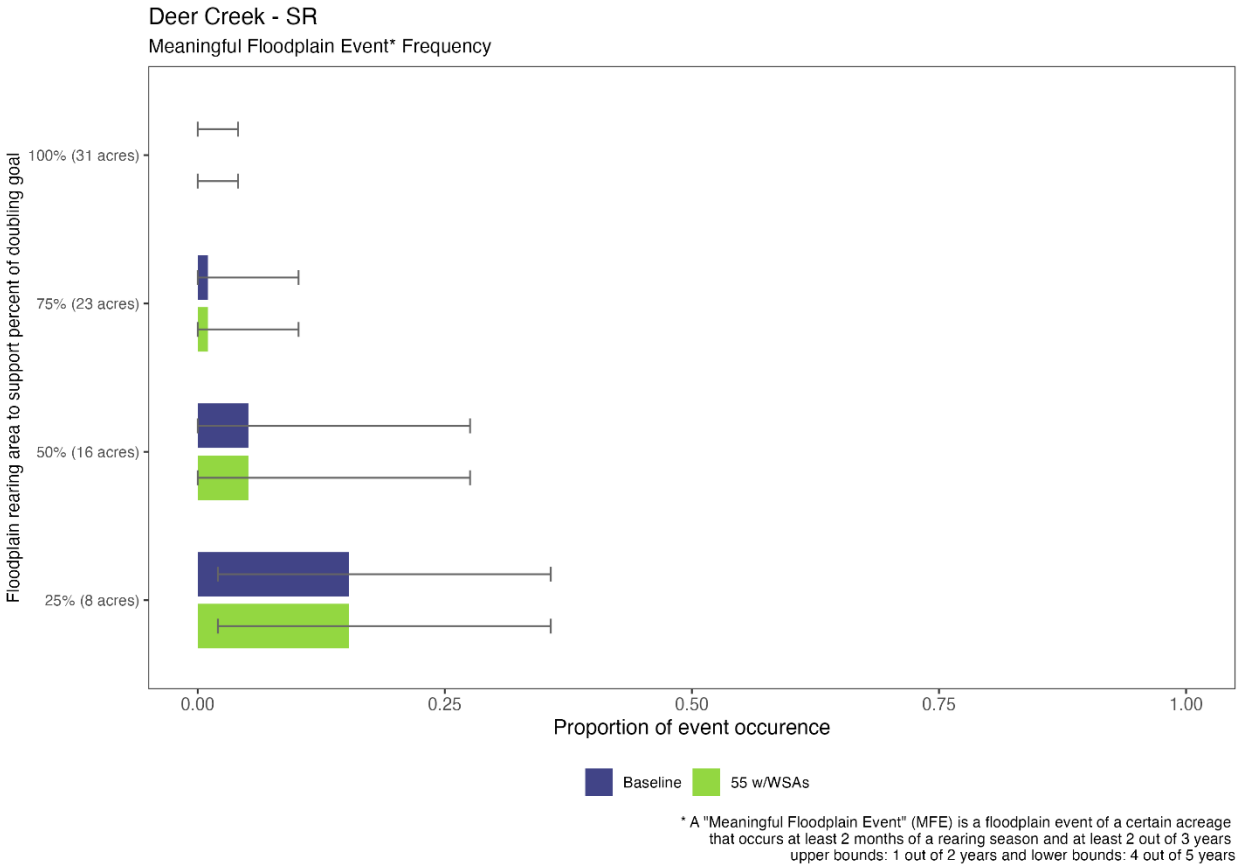
Note: A *meaningful floodplain event* (MFE) is defined as a floodplain event of a certain acreage that occurs at least 2 months of a rearing season and at least 2 out of 3 years. The lower bounds of the error bars represent the proportion of event occurrence when MFE criteria are restricted to require floodplain events 4 out of 5 years. The upper bounds of the error bars represent the proportion of event occurrence when MFE criteria are loosened to require floodplain events 1 out of 2 years.

Figure H1c.2.1-12. Proportion of Meaningful Floodplain Event Occurrence for the Baseline and 55 w/WSAs Scenarios on Cow Creek



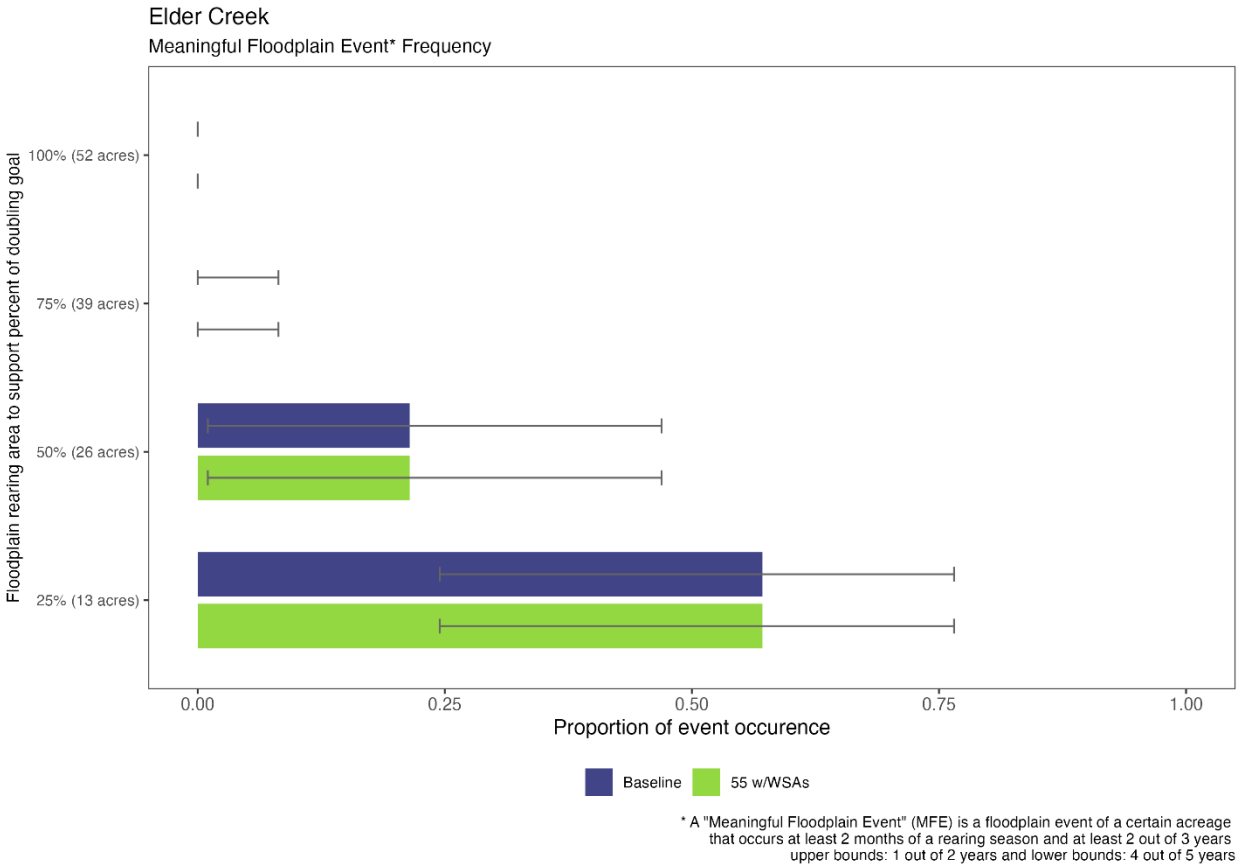
Note: A *meaningful floodplain event* (MFE) is defined as a floodplain event of a certain acreage that occurs at least 2 months of a rearing season and at least 2 out of 3 years. The lower bounds of the error bars represent the proportion of event occurrence when MFE criteria are restricted to require floodplain events 4 out of 5 years. The upper bounds of the error bars represent the proportion of event occurrence when MFE criteria are loosened to require floodplain events 1 out of 2 years.

Figure H1c.2.1-13. Proportion of Meaningful Floodplain Event Occurrence for the Baseline and 55 w/WSAs Scenarios on Deer Creek (Fall-Run)



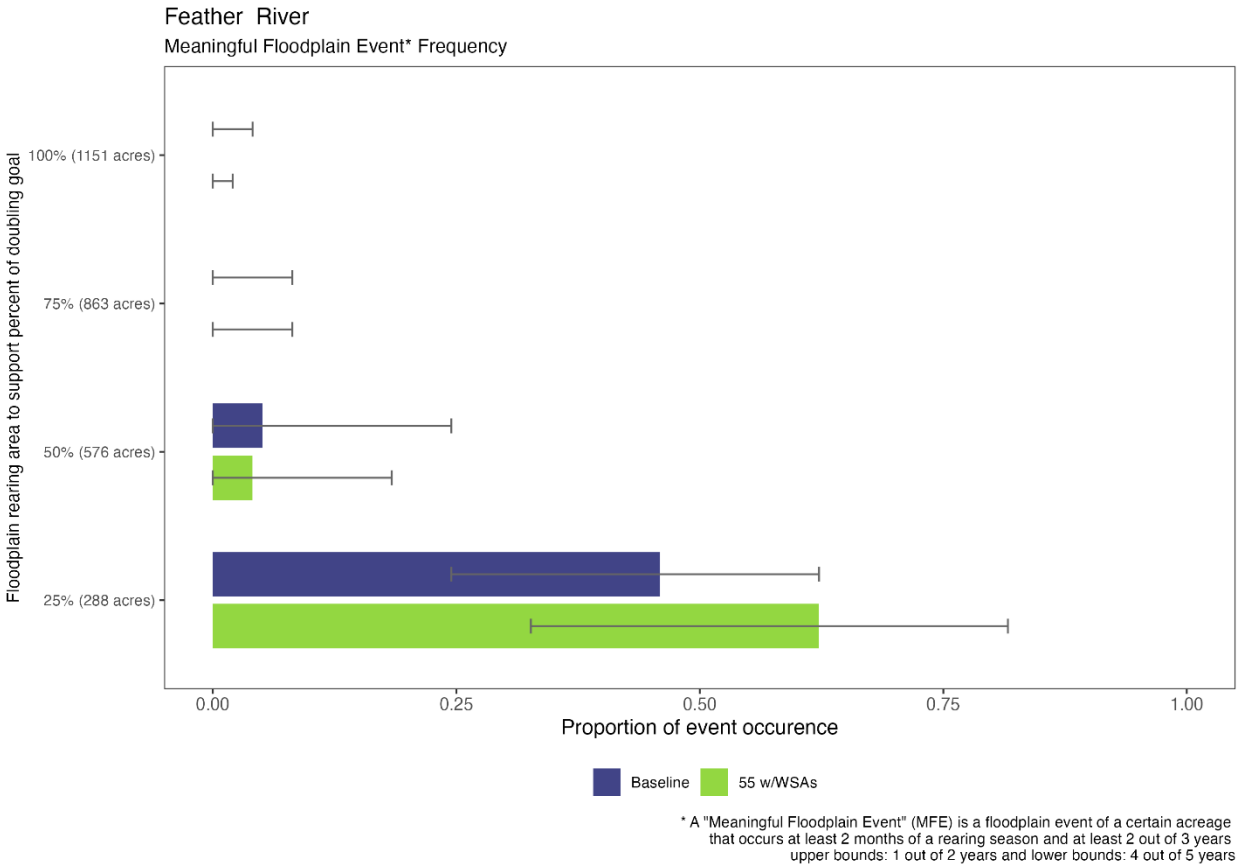
Note: A *meaningful floodplain event* (MFE) is defined as a floodplain event of a certain acreage that occurs at least 2 months of a rearing season and at least 2 out of 3 years. The lower bounds of the error bars represent the proportion of event occurrence when MFE criteria are restricted to require floodplain events 4 out of 5 years. The upper bounds of the error bars represent the proportion of event occurrence when MFE criteria are loosened to require floodplain events 1 out of 2 years.

Figure H1c.2.1-14. Proportion of Meaningful Floodplain Event Occurrence for the Baseline and 55 w/WSAs Scenarios on Deer Creek (Spring-Run)



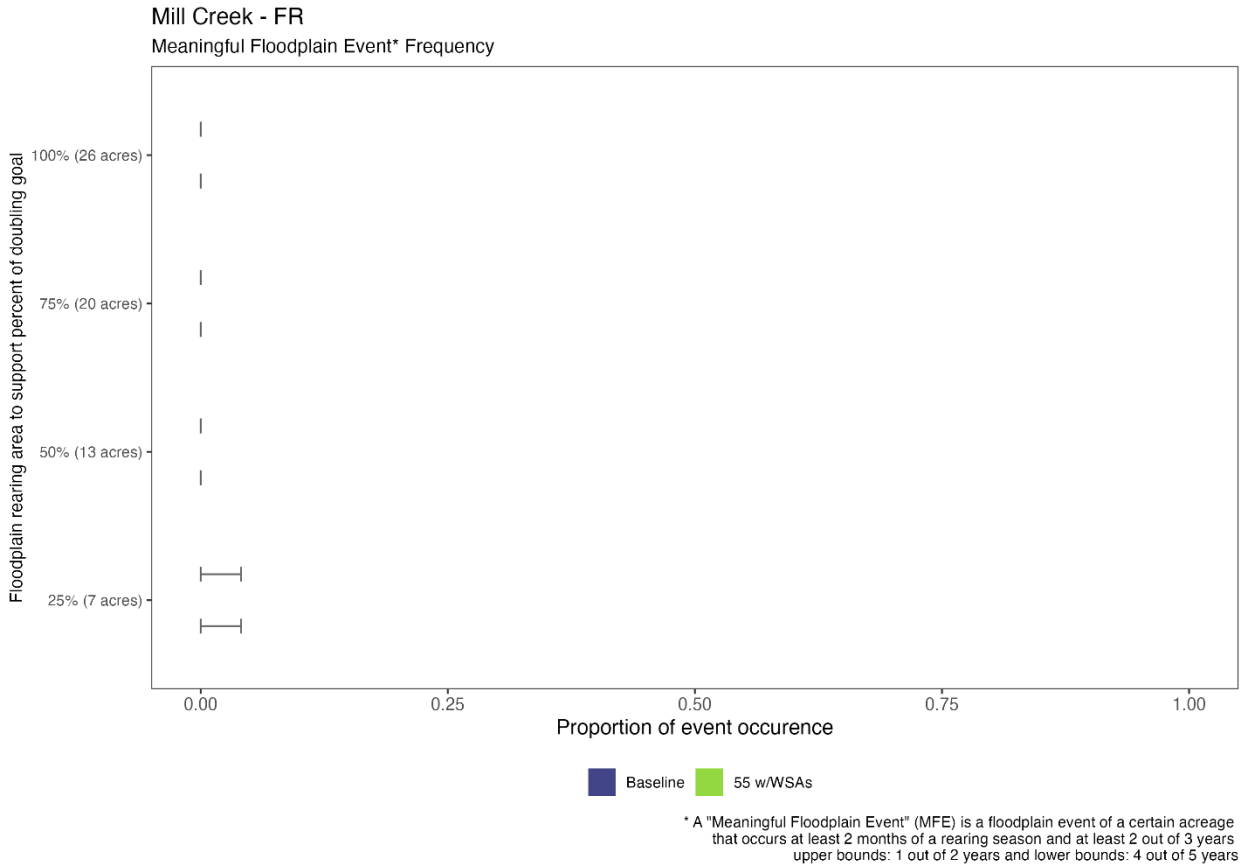
Note: A *meaningful floodplain event* (MFE) is defined as a floodplain event of a certain acreage that occurs at least 2 months of a rearing season and at least 2 out of 3 years. The lower bounds of the error bars represent the proportion of event occurrence when MFE criteria are restricted to require floodplain events 4 out of 5 years. The upper bounds of the error bars represent the proportion of event occurrence when MFE criteria are loosened to require floodplain events 1 out of 2 years.

Figure H1c.2.1-15. Proportion of Meaningful Floodplain Event Occurrence for the Baseline and 55 w/WSAs Scenarios on Elder Creek



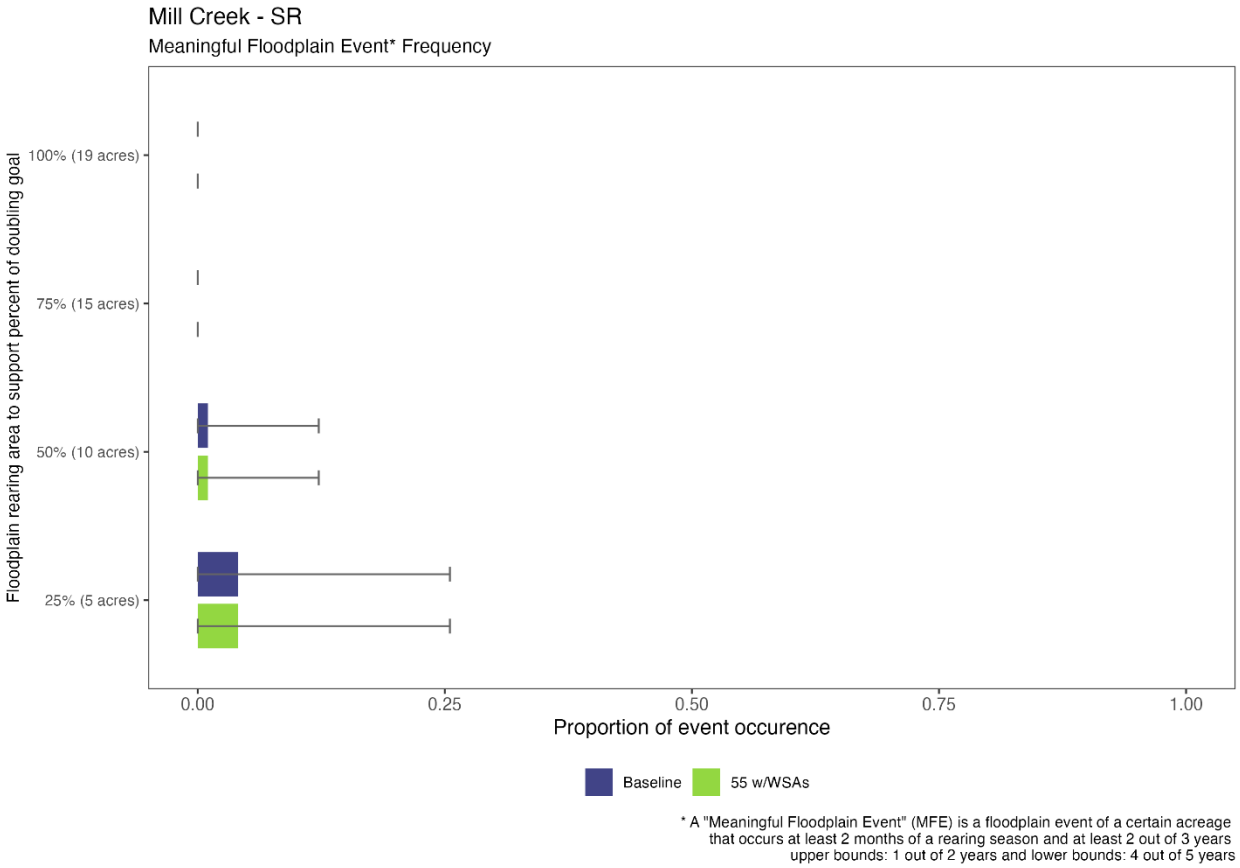
Note: A *meaningful floodplain event* (MFE) is defined as a floodplain event of a certain acreage that occurs at least 2 months of a rearing season and at least 2 out of 3 years. The lower bounds of the error bars represent the proportion of event occurrence when MFE criteria are restricted to require floodplain events 4 out of 5 years. The upper bounds of the error bars represent the proportion of event occurrence when MFE criteria are loosened to require floodplain events 1 out of 2 years.

Figure H1c.2.1-16. Proportion of Meaningful Floodplain Event Occurrence for the Baseline and 55 w/WSAs Scenarios on the Feather River



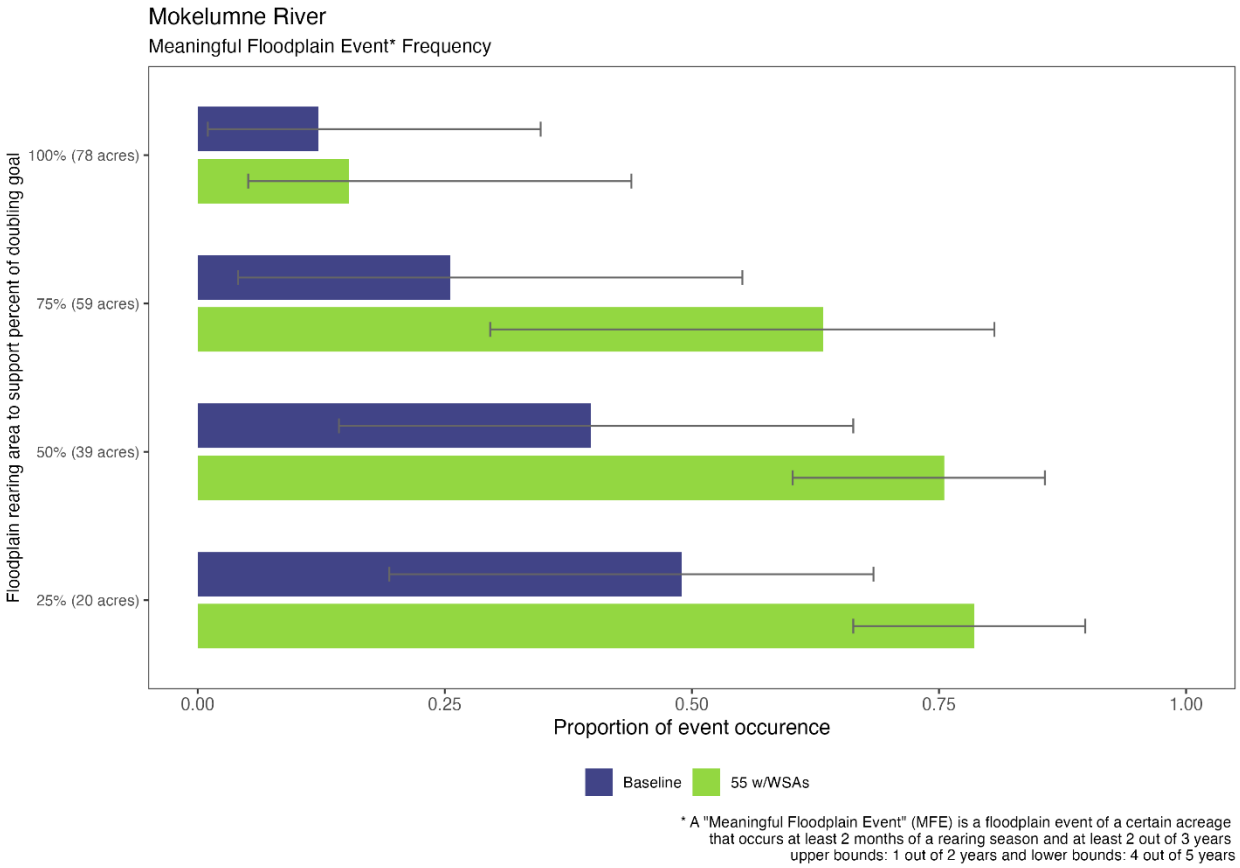
Note: A *meaningful floodplain event* (MFE) is defined as a floodplain event of a certain acreage that occurs at least 2 months of a rearing season and at least 2 out of 3 years. The lower bounds of the error bars represent the proportion of event occurrence when MFE criteria are restricted to require floodplain events 4 out of 5 years. The upper bounds of the error bars represent the proportion of event occurrence when MFE criteria are loosened to require floodplain events 1 out of 2 years. MFEs occur for only 25% of the doubling goal and only in 2% of years.

Figure H1c.2.1-17. Proportion of Meaningful Floodplain Event Occurrence for the Baseline and 55 w/WSAs Scenarios on Mill Creek (Fall-Run)



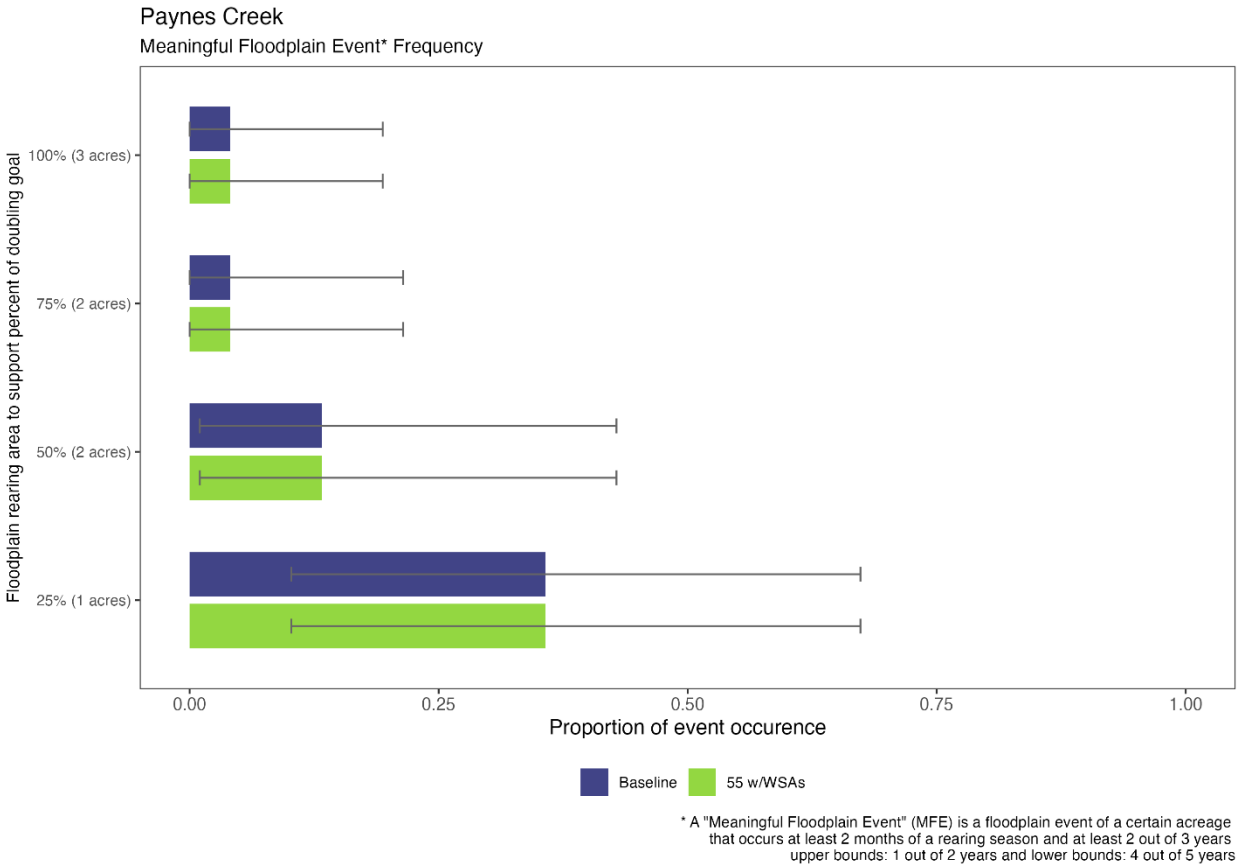
Note: A *meaningful floodplain event* (MFE) is defined as a floodplain event of a certain acreage that occurs at least 2 months of a rearing season and at least 2 out of 3 years. The lower bounds of the error bars represent the proportion of event occurrence when MFE criteria are restricted to require floodplain events 4 out of 5 years. The upper bounds of the error bars represent the proportion of event occurrence when MFE criteria are loosened to require floodplain events 1 out of 2 years.

Figure H1c.2.1-18. Proportion of Meaningful Floodplain Event Occurrence for the Baseline and 55 w/WSAs Scenarios on Mill Creek (Spring-Run)



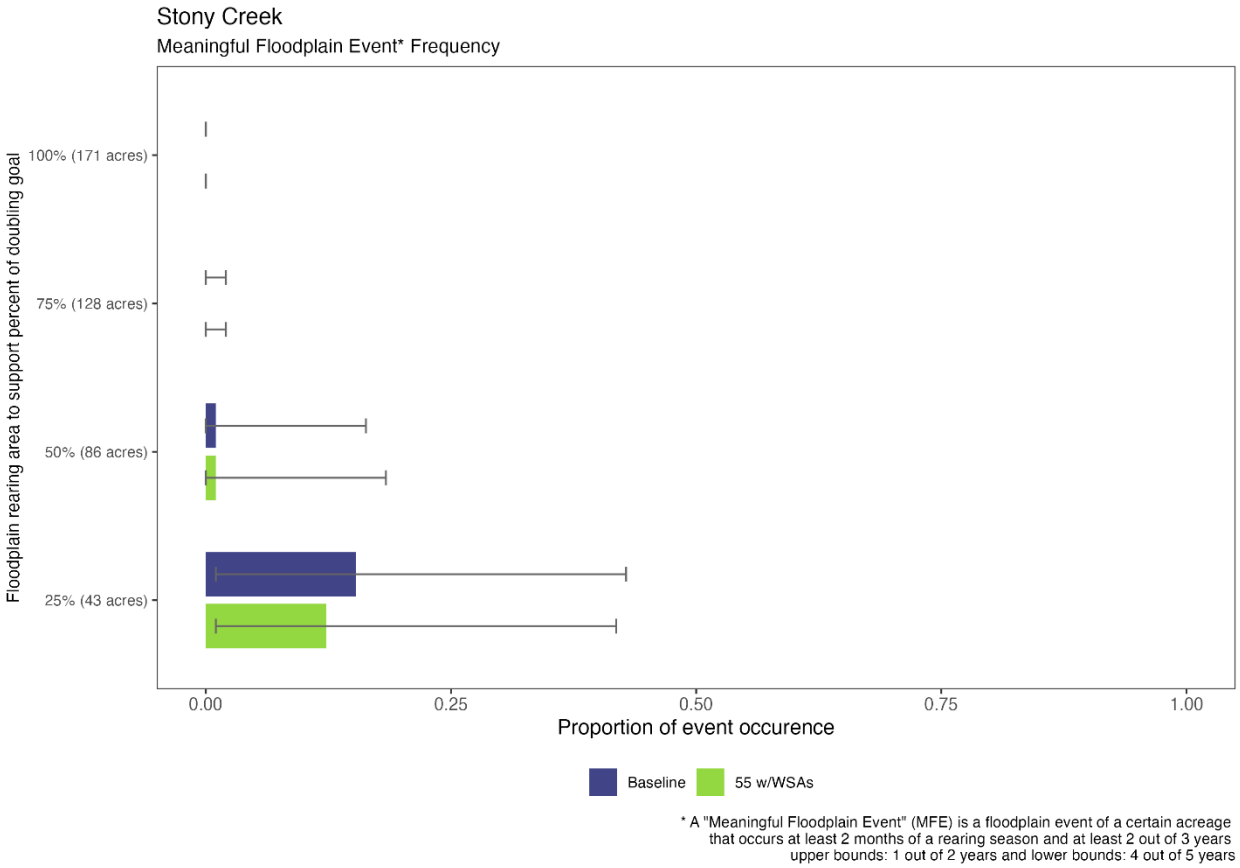
Note: A *meaningful floodplain event* (MFE) is defined as a floodplain event of a certain acreage that occurs at least 2 months of a rearing season and at least 2 out of 3 years. The lower bounds of the error bars represent the proportion of event occurrence when MFE criteria are restricted to require floodplain events 4 out of 5 years. The upper bounds of the error bars represent the proportion of event occurrence when MFE criteria are loosened to require floodplain events 1 out of 2 years.

Figure H1c.2.1-19. Proportion of Meaningful Floodplain Event Occurrence for the Baseline and 55 w/WSAs Scenarios on the Mokelumne River



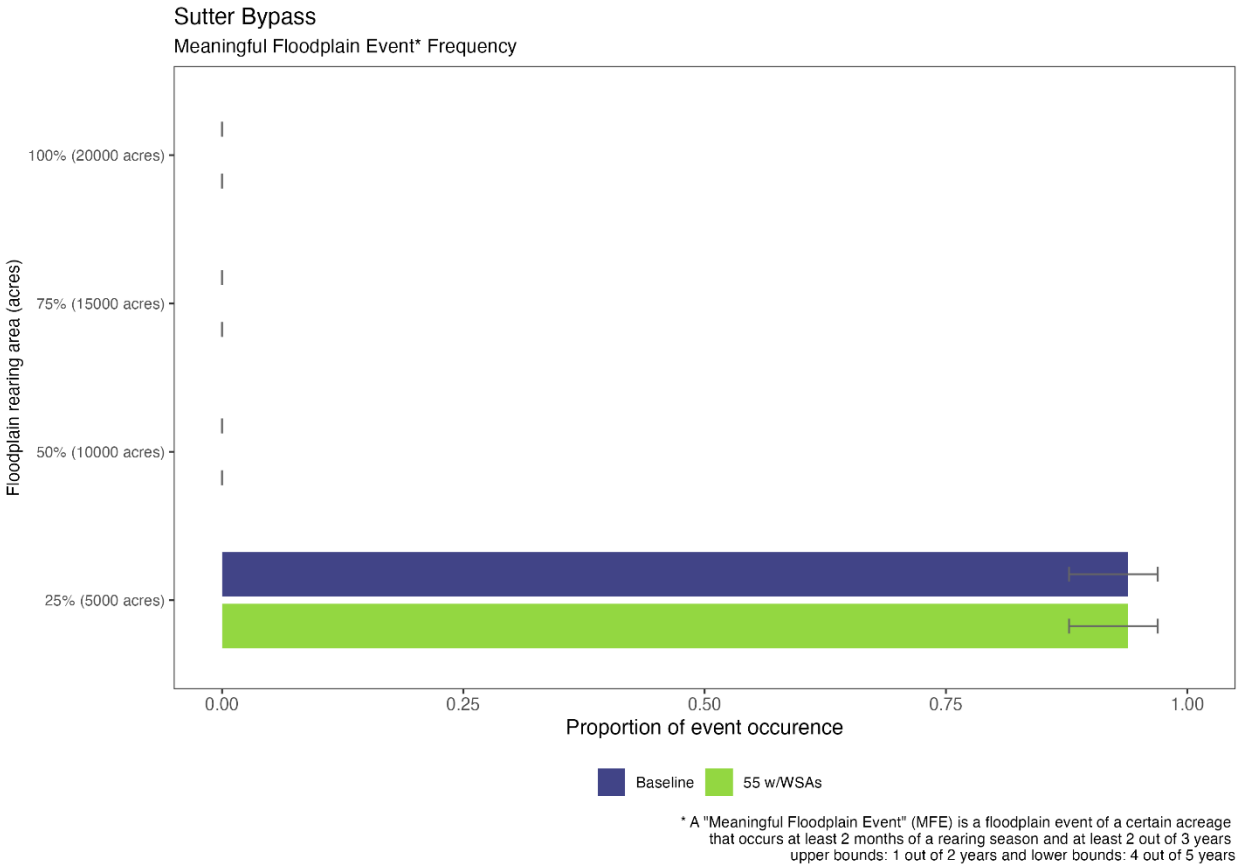
Note: A *meaningful floodplain event* (MFE) is defined as a floodplain event of a certain acreage that occurs at least 2 months of a rearing season and at least 2 out of 3 years. The lower bounds of the error bars represent the proportion of event occurrence when MFE criteria are restricted to require floodplain events 4 out of 5 years. The upper bounds of the error bars represent the proportion of event occurrence when MFE criteria are loosened to require floodplain events 1 out of 2 years.

Figure H1c.2.1-20. Proportion of Meaningful Floodplain Event Occurrence for the Baseline and 55 w/WSAs Scenarios on Paynes Creek



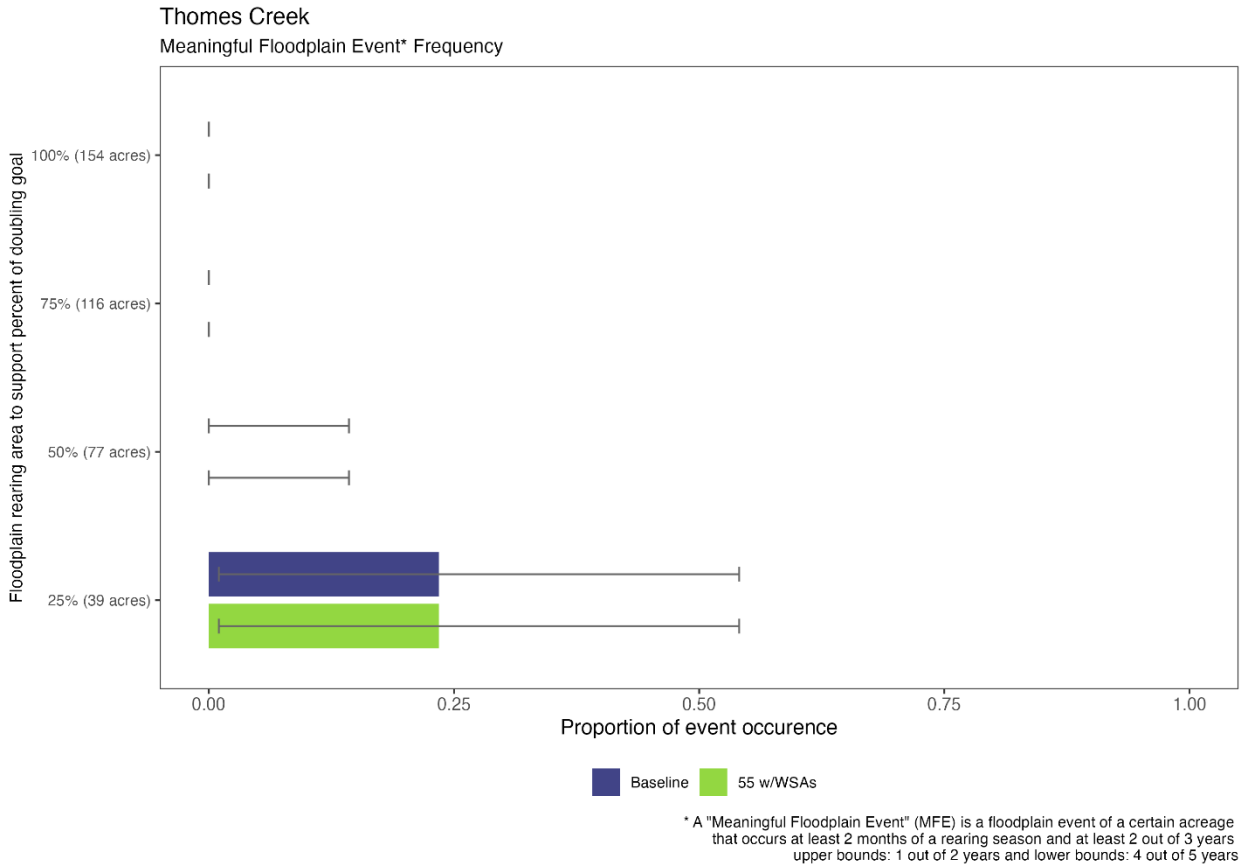
Note: A *meaningful floodplain event* (MFE) is defined as a floodplain event of a certain acreage that occurs at least 2 months of a rearing season and at least 2 out of 3 years. The lower bounds of the error bars represent the proportion of event occurrence when MFE criteria are restricted to require floodplain events 4 out of 5 years. The upper bounds of the error bars represent the proportion of event occurrence when MFE criteria are loosened to require floodplain events 1 out of 2 years.

Figure H1c.2.1-21. Proportion of Meaningful Floodplain Event Occurrence for the Baseline and 55 w/WSAs Scenarios on Stony Creek



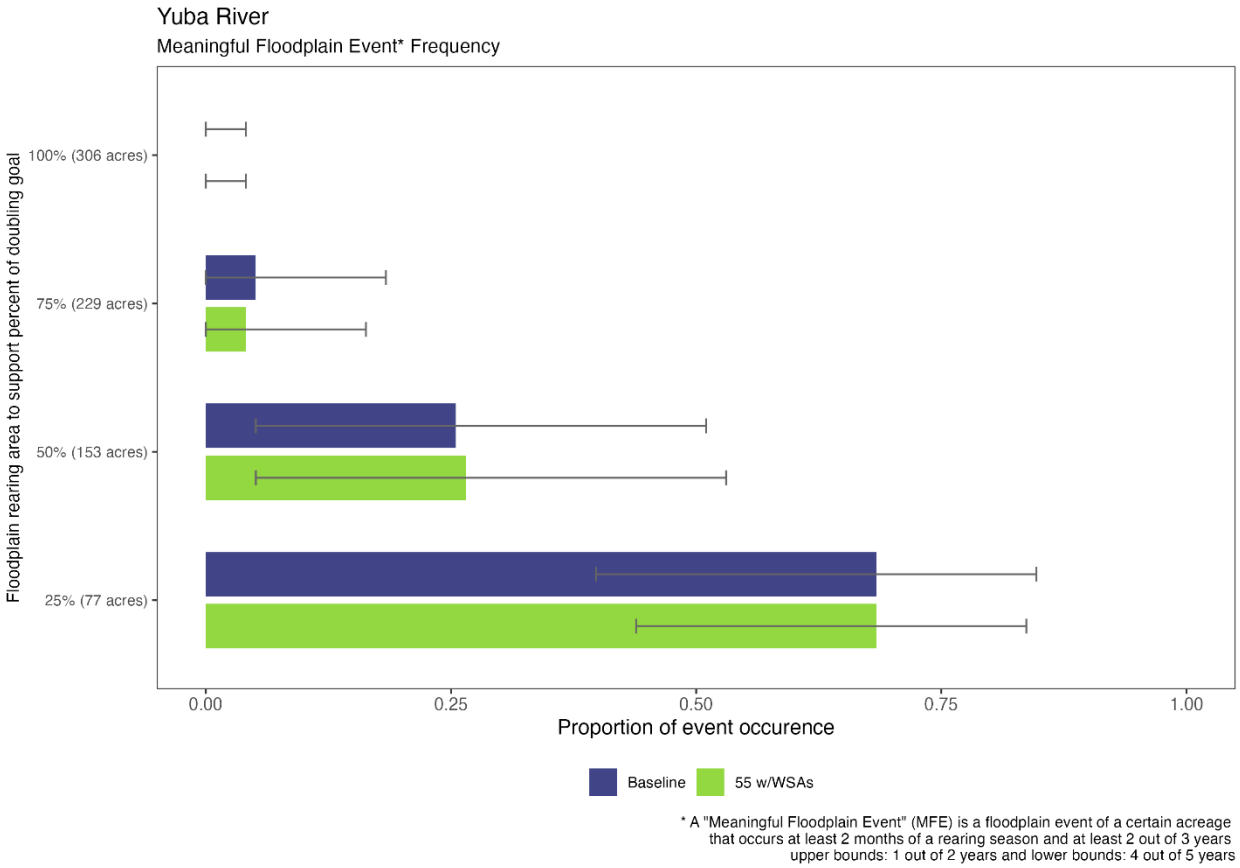
Note: A *meaningful floodplain event* (MFE) is defined as a floodplain event of a certain acreage that occurs at least 2 months of a rearing season and at least 2 out of 3 years. The lower bounds of the error bars represent the proportion of event occurrence when MFE criteria are restricted to require floodplain events 4 out of 5 years. The upper bounds of the error bars represent the proportion of event occurrence when MFE criteria are loosened to require floodplain events 1 out of 2 years.

Figure H1c.2.1-22. Proportion of Meaningful Floodplain Event Occurrence for the Baseline and 55 w/WSAs Scenarios on the Sutter Bypass



Note: A *meaningful floodplain event* (MFE) is defined as a floodplain event of a certain acreage that occurs at least 2 months of a rearing season and at least 2 out of 3 years. The lower bounds of the error bars represent the proportion of event occurrence when MFE criteria are restricted to require floodplain events 4 out of 5 years. The upper bounds of the error bars represent the proportion of event occurrence when MFE criteria are loosened to require floodplain events 1 out of 2 years.

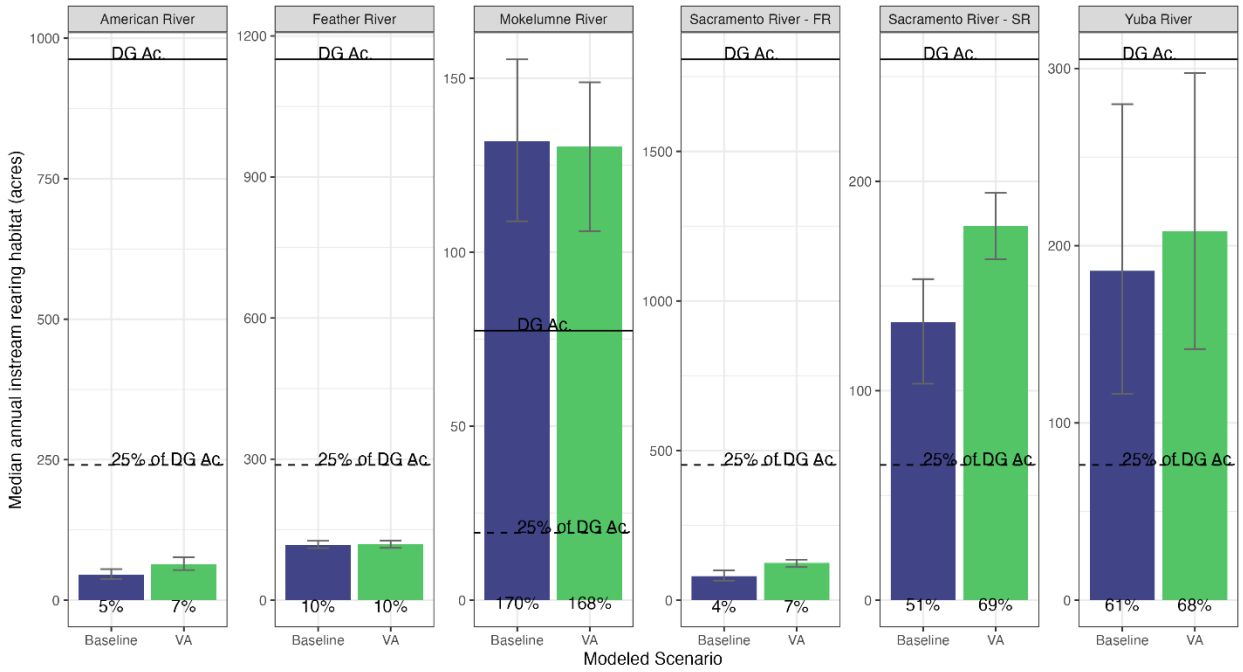
Figure H1c.2.1-23. Proportion of Meaningful Floodplain Event Occurrence for the Baseline and 55 w/WSAs Scenarios on Thomes Creek



Note: A *meaningful floodplain event* (MFE) is defined as a floodplain event of a certain acreage that occurs at least 2 months of a rearing season and at least 2 out of 3 years. The lower bounds of the error bars represent the proportion of event occurrence when MFE criteria are restricted to require floodplain events 4 out of 5 years. The upper bounds of the error bars represent the proportion of event occurrence when MFE criteria are loosened to require floodplain events 1 out of 2 years.

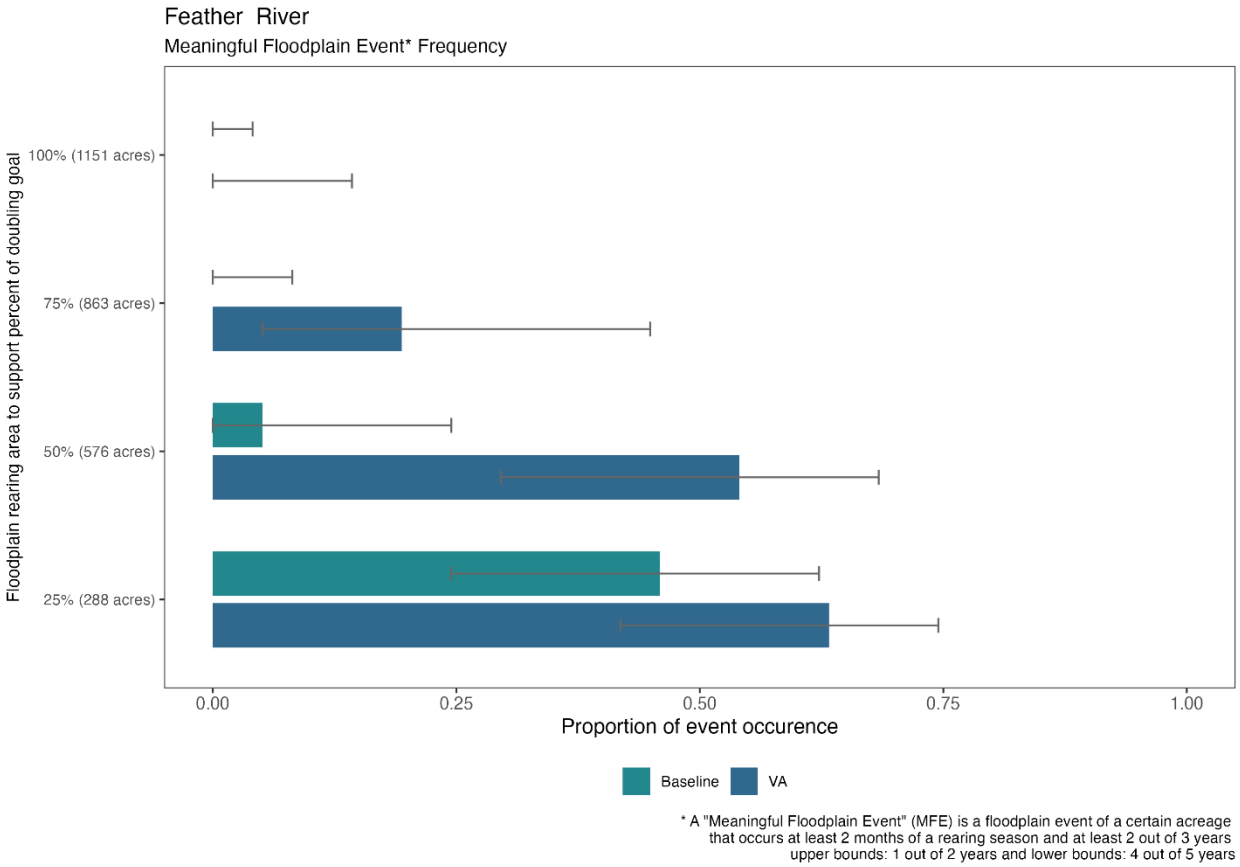
Figure H1c.2.1-24. Proportion of Meaningful Floodplain Event Occurrence for the Baseline and 55 w/WSAs Scenarios on the Yuba River

H1c.2.2 Voluntary Agreement Pathway



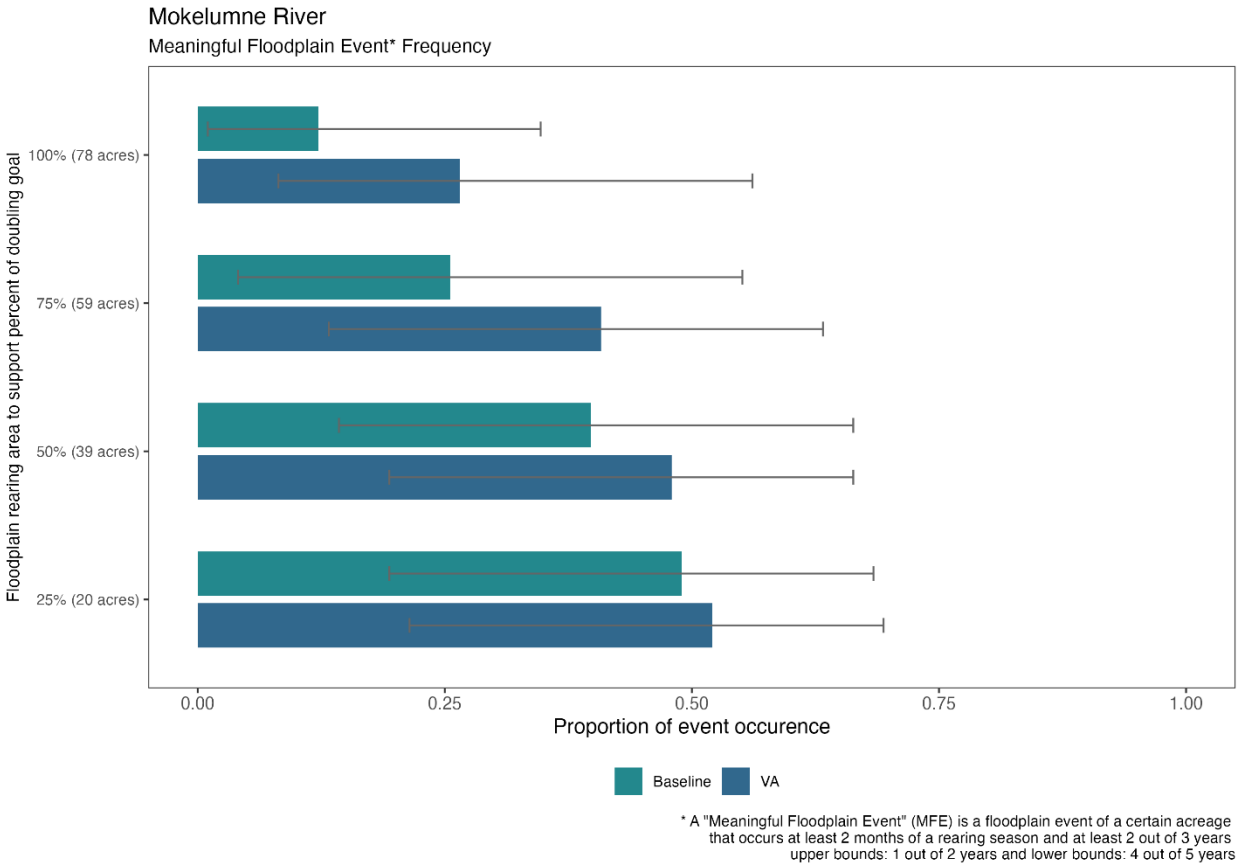
FR = fall-run; SR = spring-run.

Figure H1c.2.2-1. Median (across All Years Modeled) Instream Rearing Habitat (acres) for Each Watershed.



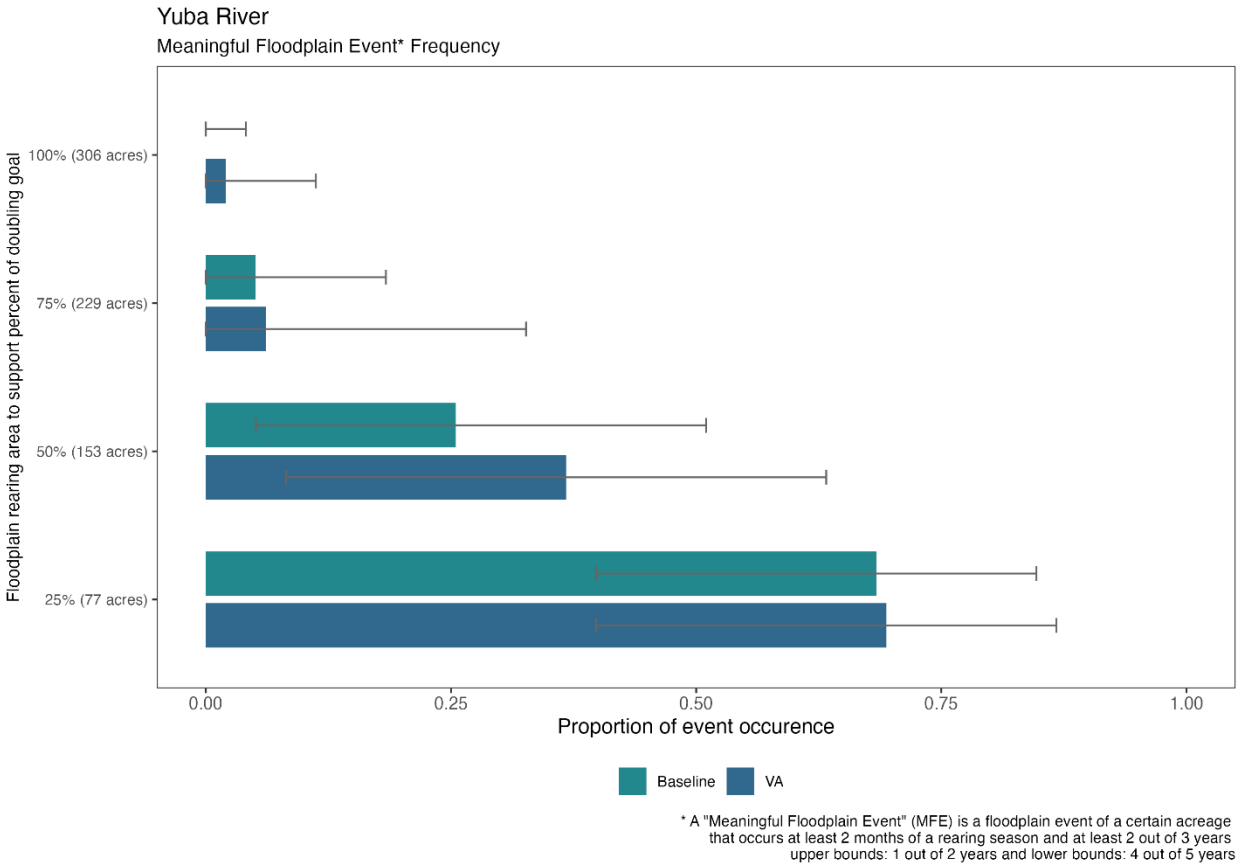
Note: A *meaningful floodplain event* (MFE) is defined as a floodplain event of a certain acreage that occurs at least 2 months of a rearing season and at least 2 out of 3 years. The lower bounds of the error bars represent the proportion of event occurrence when MFE criteria are restricted to require floodplain events 4 out of 5 years. The upper bounds of the error bars represent the proportion of event occurrence when MFE criteria are loosened to require floodplain events 1 out of 2 years.

Figure H1c.2.2-2 Proportion of Meaningful Floodplain Event Occurrence for the Baseline and VA Scenarios on the Feather River



Note: A *meaningful floodplain event* (MFE) is defined as a floodplain event of a certain acreage that occurs at least 2 months of a rearing season and at least 2 out of 3 years. The lower bounds of the error bars represent the proportion of event occurrence when MFE criteria are restricted to require floodplain events 4 out of 5 years. The upper bounds of the error bars represent the proportion of event occurrence when MFE criteria are loosened to require floodplain events 1 out of 2 years.

Figure H1c.2.2-3. Proportion of Meaningful Floodplain Event Occurrence for the Baseline and VA Scenarios on the Mokelumne River



Note: A *meaningful floodplain event* (MFE) is defined as a floodplain event of a certain acreage that occurs at least 2 months of a rearing season and at least 2 out of 3 years. The lower bounds of the error bars represent the proportion of event occurrence when MFE criteria are restricted to require floodplain events 4 out of 5 years. The upper bounds of the error bars represent the proportion of event occurrence when MFE criteria are loosened to require floodplain events 1 out of 2 years.

Figure H1c.2.2-4. Proportion of Meaningful Floodplain Event Occurrence for the Baseline and VA Scenarios on the Yuba River

H1c.3 Flow Threshold Analysis Supplemental Results

The flow thresholds defined in Chapter 3, *Scientific Knowledge to Inform Fish and Wildlife Flow Recommendations*, have been updated as described in Section 13.5.2.3, *Flow Threshold Analysis*. This section provides results of the updated flow thresholds for the 35, 45, 55, and 65 scenarios, using the updated modeling described in Appendix H1a3, *Sacramento Water Allocation Model Results for Updated Unimpaired Flow Scenarios*. Refer to Section 13.5.2.3 for definitions of the flow thresholds.

Table H1c.3-1. Frequency of Exceeding Ecological Flow Thresholds within the Seasons Specified in Table 13.5-1

Threshold (cfs)	MRDO[1]	Baseline	35	45	55	65
Georgiana Slough flow reversal low (17,000)		52%	53%	57%	62%	66%
Georgiana Slough flow reversal high (20,000)		44%	46%	49%	53%	58%
Fall-run outmigration Rio Vista (20,000)		26%	28%	28%	32%	36%
Winter-run outmigration Rio Vista (20,000)		57%	60%	64%	68%	76%
Late fall- and winter-run outmigration Freeport (35,300)		28%	28%	28%	30%	33%
Fall-, winter-, and spring-run outmigration Wilkins Slough (10,700)		29%	30%	30%	34%	42%
Fall-, winter-, and spring-run fry presence (17,700)		51%	52%	57%	62%	67%
Fall-, winter-, and spring-run fry abundance (26,500)		34%	34%	35%	39%	44%
Bay shrimp low (20,000)	0%	52%	59%	68%	73%	81%
Bay shrimp high (25,000)	0%	43%	48%	51%	62%	69%
Longfin smelt (43,000)	0%	30%	30%	31%	32%	34%
Delta smelt (10,200)	0%	22%	22%	26%	34%	42%
Sacramento splittail low (30,000)	0%	39%	44%	51%	54%	62%
Sacramento splittail high (47,000)	0%	25%	26%	27%	29%	31%
Starry flounder (21,000)	0%	45%	49%	52%	63%	72%
Green and white sturgeon (37,000)	0%	16%	16%	16%	19%	23%
Collinsville (7,100)	96%	99%	99%	99%	99%	100%
Chipps Island (11,400)	11%	80%	85%	89%	94%	95%
Port Chicago (29,200)	0%	40%	42%	46%	48%	54%

cfs = cubic feet per second; MRDO = Minimum Required Delta Outflow.

[1] Flows for the MRDO scenario are available only for Delta outflow, and therefore, results for these scenarios are available only for the flow thresholds based on Delta outflow.

H1c.4 References Cited

Bratovich, P., J. Weaver, C. Addley, and C. Hammersmark. 2017. *Lower American River Biological Rationale, Development and Performance of the Modified Flow Management Standard*. Sacramento Water Forum. November.

California Department of Fish and Game (CDFG) and U.S. Corps of Engineers. 1979. *An Analysis of Streamflows for Fishes of Cottonwood Creek, California.* Draft. December.

California Department of Fish and Game (CDFG). 1991. *Lower Mokelumne Fisheries Management Plan*. November.

California Department of Water Resources (DWR). 2004. *Phase 2 Report Evaluation of Project Effects on Instream Flows and Fish Habitat SP F-16: Oroville Facilities Relicensing FERC Project No. 2100.* Prepared by Mills, T., T. Sommer, B. Cavallo, T. Payne, and M. Allen. February.

California Department of Water Resources (DWR). 2005. *Addendum to Phase 2 Report Evaluation of Project Effects on Instream Flows and Fish Habitat SP F-16: Oroville Facilities Relicensing FERC Project No. 2100*. Prepared by Mills, T., T. Sommer, B. Cavallo, T. Payne, and M. Allen. January.

California Department of Water Resources (DWR). 2014. *Central Valley Floodplain Evaluation And Delineation: Subtask 5 Combined Sacramento River System Model Technical Memorandum*. Floodplain Management Branch Floodplain Mapping Section. February.

FISHBIO Environmental, LLC and Thomas R. Payne and Associates. 2010. *Calaveras River Habitat Conservation Plan: Appendix E- PHABSIM Habitat Index Analysis of the Calaveras River between Bellota and New Hogan Dam for Steelhead Fry and Juvenile Rearing and Adult Spawning*. Draft. Stockton, CA. July.

Gill, S. and M. Tompkins. 2020a. *Upper-mid Sacramento Regional Approximation.* July. Available: http://cvpia-habitat-docs-markdown.s3-website-us-west-2.amazonaws.com/watershed/Regional_Approximation.html. Accessed: October 2, 2025.

Gill, S. and M. Tompkins. 2020b. *Antelope Creek.* July. Available: http://cvpia-habitat-docs-markdown.s3-website-us-west-2.amazonaws.com/watershed/antelope_creek.html. Accessed: October 15, 2025.

Gill, S. and M. Tompkins. 2020c. *American River.* July. Available: http://cvpia-habitat-docs-markdown.s3-website-us-west-2.amazonaws.com/watershed/american_river.html. Accessed: October 15, 2025.

Gill, S. and M. Tompkins. 2020d. *Battle Creek.* July. Available: http://cvpia-habitat-docs-markdown.s3-website-us-west-2.amazonaws.com/watershed/battle_creek.html. Accessed: October 15, 2025.

Gill, S. and M. Tompkins. 2020e. *Bear River.* July. Available: http://cvpia-habitat-docs-markdown.s3-website-us-west-2.amazonaws.com/watershed/bear_river.html. Accessed: October 15, 2025.

Gill, S. and M. Tompkins. 2020f. *Big Chico Creek.* July. Available: http://cvpia-habitat-docs-markdown.s3-website-us-west-2.amazonaws.com/watershed/big_chico_creek.html. Accessed: October 15, 2025.

Gill, S. and M. Tompkins. 2020g. *Butte Creek.* July. Available: http://cvpia-habitat-docs-markdown.s3-website-us-west-2.amazonaws.com/watershed/butte_creek.html. Accessed: October 20, 2025.

Gill, S. and M. Tompkins. 2020h. *Calaveras River.* July. Available: http://cvpia-habitat-docs-markdown.s3-website-us-west-2.amazonaws.com/watershed/calaveras_river.html. Accessed: October 20, 2025.

Gill, S. and M. Tompkins. 2020i. *Clear Creek.* July. Available: http://cvpia-habitat-docs-markdown.s3-website-us-west-2.amazonaws.com/watershed/clear_creek.html. Accessed: October 20, 2025.

Gill, S. and M. Tompkins. 2020j. *Cosumnes River.* July. Available: http://cvpia-habitat-docs-markdown.s3-website-us-west-2.amazonaws.com/watershed/cosumnes_river.html. Accessed: October 20, 2025.

Gill, S. and M. Tompkins. 2020k. *Cottonwood Creek.* July. Available: http://cvpia-habitat-docs-markdown.s3-website-us-west-2.amazonaws.com/watershed/cottonwood_creek.html. Accessed: October 21, 2025.

Gill, S. and M. Tompkins. 2020l. *Cow Creek.* July. Available: http://cvpia-habitat-docs-markdown.s3-website-us-west-2.amazonaws.com/watershed/cow_creek.html. Accessed: October 21, 2025.

Gill, S. and M. Tompkins. 2020n. *Elder Creek.* July. Available: http://cvpia-habitat-docs-markdown.s3-website-us-west-2.amazonaws.com/watershed/elder_creek.html. Accessed: October 21, 2025.

Gill, S. and M. Tompkins. 2020o. *Feather River.* July. Available: http://cvpia-habitat-docs-markdown.s3-website-us-west-2.amazonaws.com/watershed/feather_river.html. Accessed: October 27, 2025.

Gill, S. and M. Tompkins. 2020p. *Mill Creek.* July. Available: http://cvpia-habitat-docs-markdown.s3-website-us-west-2.amazonaws.com/watershed/mill_creek.html. Accessed: October 27, 2025.

Gill, S. and M. Tompkins. 2020q. *Paynes Creek.* July. Available: http://cvpia-habitat-docs-markdown.s3-website-us-west-2.amazonaws.com/watershed/paynes_creek.html. Accessed: October 27, 2025.

Gill, S. and M. Tompkins. 2020r. *Stony Creek.* July. Available: http://cvpia-habitat-docs-markdown.s3-website-us-west-2.amazonaws.com/watershed/stony_creek.html. Accessed: October 27, 2025.

Gill, S. and M. Tompkins. 2020s. *Thomes Creek.* July. Available: http://cvpia-habitat-docs-markdown.s3-website-us-west-2.amazonaws.com/watershed/thomes_creek.html. Accessed: October 27, 2025.

Gill, S. and M. Tompkins. 2021. *Deer Creek*. June. Available: http://cvpia-habitat-docs-markdown.s3-website-us-west-2.amazonaws.com/watershed/deer_creek.html. Accessed: October 21, 2025.

Gill, S., Rodriguez, E., and E. Cain. 2022a. DSMtemperature: Modeled Temperature Data for the CVPIA SIT Model. R package version 2.0. Available: https://CVPIA-OSC.github.io/DSMtemperature/.

Gill, S., Rodriguez, E., and E. Cain. 2022b. DSMtemperature: Monthly Mean Water Temperature. Available: https://cvpia-osc.github.io/DSMtemperature/reference/stream_temperature.html.

Hackenjos, B. 2019. *Lower Deer Creek Flood and Ecosystem Improvement Project – 2d Hydrodynamic Model*. April. Prepared for Deer Creek Watershed Conservancy. April.

HDR, Inc. and Stillwater Sciences. 2015. *Lower Tuolumne River Floodplain Hydraulic Assessment Study Report: Don Pedro Hydroelectric Project, FERC No. 2299*. Draft Report. Prepared for Turlock Irrigation District, Turlock, CA and Modesto Irrigation District, Modesto, CA. September.

Hendrix, N., E. Jennings, A. Criss, E. Danner, V. Sridharan, C. Greene, H. Imaki, and S. Lindley. 2017. *Model Description for the Sacramento River Winter-Run Chinook Salmon Life Cycle Model.* January.

Pacific Gas and Electric Company (PG&E). 2008. *DeSabla-Centerville Project, FERC Project No. 803: Attachment 2A: List of Errata – Appendices.* September.

Rodriguez, E., E. Cain, M. Tompkins, and S. Gill. 2023*. DSMhabitat: Estimate Spawning and Rearing Habitat*. R package version 2.0, https://cvpia-osc.github.io/DSMhabitat/.

South Sutter Water District (SSWD). 2019. *Application for New License: Camp Far West Hydroelectric Project, FERC Project No. 2997*. Exhibit E – Environmental Report. June.

Thomas R. Payne and Associates. 1995. *Battle Creek Instream Flow Study Specified Fisheries Investigations on Battle Creek, Shasta, and Tehama Counties*. Draft. June. Arcata, CA. Prepared for California Department of Fish and Game, Redding, CA.

U.S. Fish and Wildlife Service (USFWS). 2003a. *Flow Habitat Relationships For Spring-Run Chinook Salmon Spawning in Butte Creek.* Final. August. Prepared by The Energy Planning and Instream Flow Branch, Sacramento, CA.

U.S. Fish and Wildlife Service (USFWS). 2003b. *Flow-Habitat Relationships for Steelhead and Fall, Late-Fall, and Winter-Run Chinook Salmon Spawning in the Sacramento River between Keswick Dam and Battle Creek.* Prepared by staff of the Energy Planning and Instream Flow Branch, Sacramento, CA. February.

U.S. Fish and Wildlife Service (USFWS). 2007. *Flow-Habitat Relationships for Spring-Run Chinook Salmon and Steelhead/Rainbow Trout Spawning in Clear Creek Between Whiskeytown Dam and Clear Creek Road*. Prepared by staff of The Energy Planning and Instream Flow Branch, Sacramento, CA. August. Available: https://s3-us-west-2.amazonaws.com/cvpiahabitat-r-package/cvpia-sit-model-inputs/FWS2007-2013_ClearCreekInstream.pdf. Accessed: October 20, 2025.

U.S. Fish and Wildlife Service (USFWS). 2011a. *Flow-Habitat Relationships for Fall-Run Chinook Salmon and Steelhead/Rainbow Trout Spawning in Clear Creek Between Clear Creek Road and the Sacramento River.* Final. Prepared by staff of The Restoration and Monitoring Program, Sacramento, CA. January.

U.S. Fish and Wildlife Service (USFWS). 2011b*. Flow-Habitat Relationships for Juvenile Spring-Run Chinook Salmon and Steelhead/Rainbow Trout Rearing in Clear Creek Between Whiskeytown Dam and Clear Creek Road*. Final. Prepared by staff of The Restoration and Monitoring Program, Sacramento, CA. September.

U.S. Fish and Wildlife Service (USFWS). 2011c. *South Cow Creek Habitat Assessment*. Prepared by staff of the Anadromous Fish Restoration Program, Sacramento, CA. July.

U.S. Fish and Wildlife Service (USFWS). 2013. *Flow-Habitat Relationships for Juvenile Spring-Run and Fall-Run Chinook Salmon and Steelhead/Rainbow Trout Rearing in Clear Creek Between Clear Creek Road and The Sacramento River. Final*. Prepared by staff of The Restoration and Monitoring Program, Sacramento, CA. January.

U.S. Fish and Wildlife Service (USFWS). 2014. *Identification of the Instream Flow Requirements for Anadromous Fish in the Streams Within the Central Valley of California and Fisheries Investigations: Annual Progress Report, Fiscal Year 2013*. Prepared by staff of The Restoration and Monitoring Program Sacramento, CA. January. Accessed: October 20, 2025.

U.S. Fish and Wildlife Service (USFWS). 2018. *Central Valley Project Improvement Act Fisheries Investigations: Annual Progress Report, Fiscal Year 2017*. Prepared by staff of the Anadromous Fish Restoration Program, Lodi, CA. February.

U.S. Fish and Wildlife Service (USFWS). 2019. *Central Valley Project Improvement Act, Fisheries Investigations: Annual Progress Report, Fiscal Year 2019*. Prepared by staff of the Anadromous Fish Restoration Program, Lodi, CA. November.

H1c.4.1 Personal Communications

Bergfeld, Lee. Principal Engineer. MBK Engineers. Sacramento, CA. November 11, 2020, e-mail correspondence with Mark Tompkins and Sadie Gill, Principal Engineer and Data Scientist, FlowWest, LLC, Oakland, CA.

Bilski, Robyn. Fisheries Biologist. East Bay Municipal Utility District. Oakland, CA. May 18, 2019, e-mail correspondence with Mark Tompkins, Principal Engineer, FlowWest, LLC, Oakland, CA.

Bratovich, Paul. Managing Principal. Robertson-Bryan. Rancho Cordova, CA. E-mail correspondence on June 27, 2025, with Liz Stebbins, Data Scientist, FlowWest, LLC, Oakland, CA.

Hammersmark, Chris. CBEC Eco Engineering. West Sacramento, CA. E-mail correspondence on August 12, 2025, with Liz Stebbins, Data Scientist, FlowWest, LLC, Oakland, CA.

Hannon, John. Research Hydrologist. U.S. Bureau of Reclamation (USBR). Sacramento, CA. October 16, 2019, phone call with Mark Tompkins and Sadie Gill, Principal Engineer and Data Scientist, FlowWest, LLC, Oakland, CA.

Kindopp, Jason. Senior Environmental Scientist. California Department of Water Resources. Sacramento, CA. May 16, 2019, e-mail correspondence with Mark Tompkins and Sadie Gill, FlowWest, LLC, Oakland, CA.