

Purpose of Assessment: To inform and support public agencies and stakeholders in their work to collectively target conservation investments to achieve a healthy, functioning Lower Mokelumne River corridor. This assessment: 1) Quantifies the riparian area in need of restoration along the Mokelumne River; 2) Estimates the costs and benefits (using [Riparian Habitat Quantification Tools](#)) of conducting this restoration; 3) Identifies areas for focused landowner outreach, and provides decision-support information for stakeholders and agencies to make funding decisions.

Results: How much land is left to restore along the Lower Mokelumne River? What would it cost to restore, and what are the benefits? What types of restoration are most cost-effective for the benefits they produce?

Table 1 - Benefits and Costs of Riparian Restoration along the Lower Mokelumne River

Vegetation Types that could be restored to Native Riparian Forest or Shrub	Area (acres)	Implementation Cost (10 Acre Project)	Total Cost ¹ (10 Acre Project)	Total Cost To Treat All Acres	Total Benefit (Functional Acre Unit Uplift ²)	
					Low landscape context ³	High landscape context ³
Annual Grassland	545.97	\$36,938	\$112,806	\$6,158,923	76.44	65.53
Introduced Perennial Grassland	7.72	\$65,834	\$141,702	\$109,396	1.04	0.95
Introduced Riparian Shrub	12.11	\$48,360	\$124,228	\$150,391	1.63	1.49
Introduced Riparian Forest	13.84	\$45,079	\$120,947	\$167,350	1.72	1.38
Riprap	1.12	\$62,337	\$138,205	\$15,466	0.14	0.12
<i>Totals</i>	580.75			\$6,601,527	80.97	69.47

Table 2 - Functional Acre Unit Uplift (per \$100,000)

Vegetation Type	Bird ⁴		Fish ⁴		Flood ⁴		Shade ⁴		Combined Riparian Uplift	
	Landscape context ³ :		Low	High	Low	High	Low	High	Low	High
Annual Grassland	3.77⁵	1.62	0.60	1.99	0.15	0.50	0.44	0.15	1.24	1.06
Introduced Perennial Grassland	2.83	1.21	0.47	1.58	0.17	0.56	0.32	0.12	0.95	0.87
Introduced Riparian Shrub	3.23	1.39	0.54	1.80	0.19	0.64	0.37	0.14	1.08	0.99
Introduced Riparian Forest	3.38⁵	1.45	0.53	1.76	0.02	0.07	0.19	0.02	1.03	0.83
Riprap	2.66	1.14	0.43	1.45	0.08	0.27	0.51	0.19	0.92	0.76

Key conclusions:

- Within the existing landscape, the most benefit (relative to cost) is gained by restoring Annual Grasslands to Native Riparian Forest or Shrub habitats. This is the case from a riparian ecosystem-wide perspective, and when targeting the fish or bird habitat ecosystem functions specifically.
- Annual Grassland makes up the majority of the riparian habitat that could be restored: 94% (546 of 580.75 ac, total). Annual Grassland makes up 29% of the total riparian habitat (1895 ac)⁶ in the study area⁷.
- 69% of the total riparian habitat is currently intact, or not in need of restoration (1314 of 1895 ac). If all Annual Grasslands are restored to Native Riparian Forest or Shrub habitats, this number will increase to 98%.
- 36% (194 ac) of this Annual Grassland is in Reach 2; 31% (169 ac) is in Reach 6; 14% (74.5 ac) is in Reach 5.

¹ We estimate that it will cost ~ \$75,868 to plan and permit a 10 acre project.

² The quality of riparian habitat is measured in “Functional Acre Units” (FAU), defined as fully (100%) functioning areas. If a 10 acre project is assessed to be functioning at 50%, it is considered to provide 10 ac * 0.50 = 5 Functional Acre Units. Uplift is measured relative to baseline conditions before restoration, in which 580.75 acres provide 71.35 FAU in a low landscape context, and 282.01 FAU in a high landscape context.

³ The Landscape Context is considered low when only 30% of the surrounding habitat is intact, and high when 100% is intact. The scope of the surrounding habitat that needs to be considered varies for each function.

⁴ Benefits are reported for four specific ecosystem functions: riparian bird habitat, fish habitat, downstream flood attenuation, and stream shade

⁵ Highest benefit/cost are shown in **bold**, and the second highest are shown in *blue italics*.

⁶ For the purpose of this assessment, riparian habitat is considered all land along the river, excluding agricultural and urban areas.

⁷ Confluence of the Cosumnes River upstream to Camanche Dam (Reach 2 through Reach 6 – see descriptions in **Study Area** below)

- Landscape context makes a big difference in the benefits gained through restoration, and the effects vary for each ecosystem function (see additional information in **Table 3** and **Table 4** below). For example, birds gain more from restoration within a **low functioning** surrounding landscape, while fish gain most from restoration within a **high functioning** surrounding landscape. This context needs to be considered when considering sites for restoration.
- The most benefit for shade ecosystem function results from restoration close to Camanche Dam: Reaches 5 & 6, which together have 45% (243.5 ac) of Annual Grassland. Restoring areas with low-lying vegetation (like Annual Grassland and Riprap) should provide the most benefit for shade, depending on position relative to the river.

Table 3 - Baseline Environmental Condition (% of potential function)⁸

Vegetation Type	Bird		Fish		Flood		Shade		Combined Riparian Baseline Score	
	Low	High	Low	High	Low	High	Low	High	Low	High
<i>Landscape context³:</i>										
Annual Grassland	15.3%	72.7%	5.2%	17.3%	5.5%	18.4%	23.0%	85.5%	12.24%	48.47%
Introduced Riparian Shrub	15.1%	72.6%	6.3%	21.0%	6.0%	19.9%	23.2%	85.4%	12.65%	49.72%
Introduced Riparian Forest	18.4%	74.0%	5.3%	17.5%	6.6%	22.0%	24.2%	86.8%	13.61%	50.08%
Riprap	15.6%	72.8%	8.1%	27.0%	7.2%	24.0%	22.1%	84.3%	13.27%	52.02%
<i>Native Riparian Forest</i>	58.3%	91.1%	11.9%	39.8%	7.2%	23.8%	27.6%	86.9%	26.25%	60.43%
<i>Native Riparian Shrub</i>	53.1%	88.9%	13.5%	44.9%	8.5%	28.2%	26.4%	86.9%	25.36%	62.23%

Table 4 - Percent Uplift from Baseline⁹

Vegetation Type	Bird		Fish		Flood		Shade		Combined Riparian Uplift	
	Low	High	Low	High	Low	High	Low	High	Low	High
<i>Landscape context³:</i>										
Annual Grassland	42.6%	18.2%	6.7%	22.5%	1.7%	5.6%	5.0%	1.7%	14.00%	12.00%
Introduced Riparian Shrub	40.2%	17.2%	6.7%	22.4%	2.4%	7.9%	4.6%	1.7%	13.46%	12.31%
Introduced Riparian Forest	40.9%	17.5%	6.4%	21.3%	0.3%	0.8%	2.3%	0.3%	12.46%	9.98%
Riprap	36.7%	15.7%	6.0%	20.0%	1.1%	3.7%	7.0%	2.6%	12.71%	10.51%

Interpretation of landscape context’s effect on restoration benefits for each ecosystem function:

- To birds, the benefit of restoration on any individual site is higher in a **low functioning** surrounding landscape than in a **high functioning** surrounding landscape. Birds are highly mobile, and if the surrounding landscape is already restored and provides access to quality habitat, they don’t benefit significantly by filling in a single hole in the habitat. In a degraded landscape, the birds gain significantly from the newly improved habitat available to them.
- The benefits that stream shade provides to water temperature and fish habitat are higher in a **low functioning** surrounding landscape than in a **high functioning** surrounding landscape. If the stream is fully shaded, restoring any individual site would not add any significant benefit. In a degraded habitat, it is most effective to focus restoration to keep cold water cool by increasing stream shade closest to the source of the cold water, which in this case is Camanche Dam (Reach 6).
- To fish, the opposite is true. The benefit of restoration on any individual site is higher in a **high functioning** surrounding landscape than in a **low functioning** surrounding landscape. For fish, the entire river is considered

⁸ This table shows the baseline environmental condition (as a percent of full function) of various vegetation communities along the Lower Mokelumne River. These are shown for four separate ecosystem functions and a combined riparian habitat ecosystem function.

⁹ This table shows the environmental uplift (as a percent of full function) as a result of restoring the various riparian vegetation communities to the desired future conditions: native riparian forest or shrub habitat. This is shown for the same four separate ecosystem functions as well as the combined riparian habitat ecosystem uplift.

important habitat, because the river needs to support all life stages of the fish, which require different habitat characteristics. In other words, if one site along the river contains nice habitat, but is surrounded by degraded habitat, fish don't benefit as much.

- The benefits that restoration provides for downstream flood attenuation is higher in a **high functioning** surrounding landscape than in a **low functioning** surrounding landscape. Flood water does not stop moving downstream, and any individual restoration site cannot absorb an entire flood. Instead, the system benefits the most from an individual site being restored when the surrounding landscape is also fully functioning.

Study area:

- This assessment focuses on the area of the Lower Mokelumne River from the confluence of the Cosumnes River upstream to the Camanche Dam (Reaches 2-6, as described by Reeves & Jones [2004]).
 - Reach Two: confluence of the Cosumnes River upstream to Woodbridge Dam
 - Reach Three: Woodbridge Dam upstream to the Highway 99 Bridge
 - Reach Four: Highway 99 Bridge upstream to the Elliott Road Bridge
 - Reach Five: Elliott Road Bridge upstream to the Mackville Road Bridge
 - Reach Six: Mackville Road Bridge upstream to Camanche Dam
- This assessment is based on the vegetation map produced by Reeves & Jones (2004), updated to reflect recent restoration projects (methods included in Lower Mokelumne River Restoration Assessment User Manual **Appendix 1a** as well as map file metadata). The total area mapped includes 100 m on either side of the Mokelumne River from Reach 2 through Reach 6, totaling 3242 acres. We excluded agricultural (1108 ac) and urban areas (239 ac) to determine the total riparian habitat area (1895 ac).

Notes and Constraints:

- We identified five vegetation types that could be restored. We considered the Native Riparian Shrub and Forest habitats described by Reeves & Jones (2004) as the desired future conditions when estimating restoration actions and associated costs. For more information, see full vegetation community descriptions in Lower Mokelumne River Restoration Assessment User Manual **Appendix 2**.
- We only considered restoration actions to improve vegetation, ruling out major changes to the physical structure of the river or floodplain (i.e. no levee setbacks were considered). This explains why we do not see close to 100% function for the fish habitat and flood attenuation ecosystem functions, which require additional aquatic habitat and floodplain connectivity to reach 100% function.
- We did not have potential benefit information for Introduced Perennial Grassland habitats (which consist primarily of *Arundo donax*), and used the benefit estimates for Introduced Riparian Shrub habitats as a proxy.