SECTION 4 | LINKED TECHNIQUES

Fig. 4.1 (Above left) Spawning Lost River suckers. Photo: USGS.

Fig. 4.2 (Above right) Algae bloom on Upper Klamath Lake. Photo: Brett Cole.

LINKED TECHNIQUES

Poor water quality in the Upper Klamath Basin is the result of multiple factors, including decades of NPS pollution that has exacerbated naturally elevated phosphorus levels in basin water bodies. Both external and internal sources of phosphorus to Upper Klamath and Agency lakes are important contributors to summertime poor water quality, resulting in excessive seasonal blooms of blue-green algae, low dissolved oxygen, high pH, high ammonia, and problematic levels of algal toxins, primarily microcystin. Water quality conditions have been identified as a significant threat to the long-term survival of endangered Lost River and shortnose suckers in Upper Klamath Lake (see Section 1, pages 3-5).

Given the large scale of the problem, no single technique or approach will be sufficient to improve water quality to the degree that it can support all designated beneficial uses in the Upper Klamath Basin. A recent effort to set theoretical boundaries on expected nutrient removal performance for wetlands in the vicinity of Link River indicated that tens of thousands of acres of treatment wetlands would be needed to reduce phosphorus and nitrogen concentrations by 50% and 15%, respectively.[1] This assumes that all water quality treatment for the basin would occur by diverting water into wetlands at the Link River Dam. While this is not a realistic assumption, the result underscores the importance of treating water at locations further upstream in the Upper Klamath Lake watershed and its tributaries. Another recent modeling effort indicates that water quality improvements in and around Upper Klamath Lake would have a far greater effect on water quality in the Keno Impoundment than treating water in the reservoir or treating water that is discharged to the reservoir by point sources and irrigation drains.[2]

Accordingly, no one technique or treatment approach was singled out by workshop participants or the technical team as a "silver bullet" solution to current water quality problems (Section 2). Rather, implementation of multiple techniques, linked both in time and in space, is key for treating both the symptoms and the causes of Upper Klamath Basin water quality problems.

TREATING THE SYMPTOMS

Short- term projects that treat the symptoms of excessive nutrient loading are focused on addressing acutely low dissolved oxygen concentrations during summer and early fall months and inactivating sediment hot spots for phosphorus recycling. Conceptual designs developed by the project technical team include two types of projects that treat poor water quality symptoms (Figure 4.6):

- Sediment phosphorus sequestration with aeration/oxygenation in the Keno Impoundment
- Targeted dredging in Upper Klamath and Agency lakes with local sediment reuse opportunities for wetland rehabilitation, subsidence reversal, and agricultural soil amendment

Fig. 4.3 (Top right) Grazed pasture in the Wood River watershed. Photo: Damion Ciotti.

Fig. 4.4 (Center right) Tailwater from grazed pasture in the Wood River watershed. Photo: Damion Ciotti.

Fig. 4.5 (Bottom right)The Keno Impoundment and wetlands near the mouth of the Klamath Straits Drain. Source: Chauncey Anderson.

1 CH2MHill 2012

2 Sullivan et al. 2013

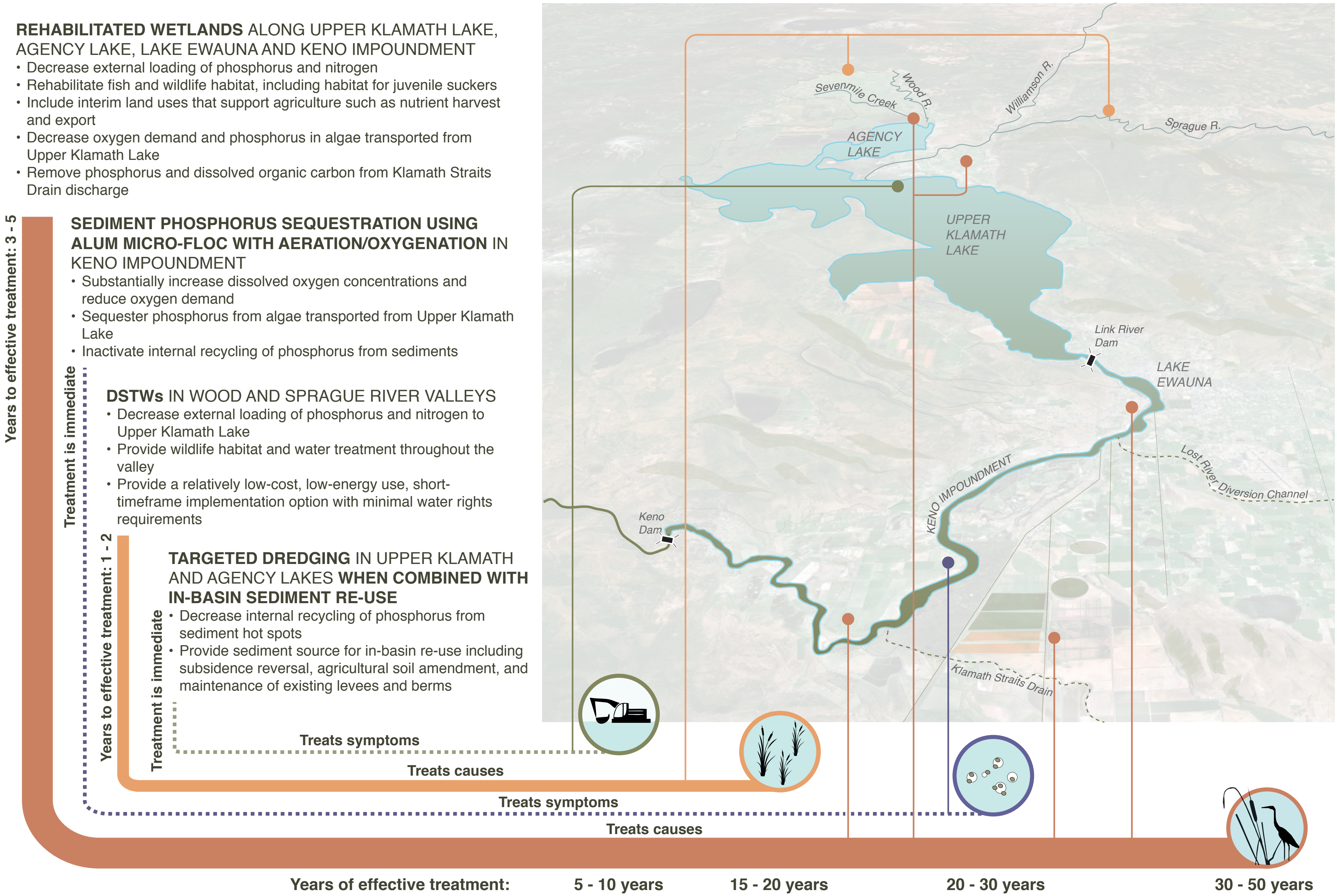

Fig. 4.6 Linked techniques for treating the symptoms and causes of poor water quality in the Upper Klamath Basin over a 50-year timeline.

Algal filtration, another project type that treats the symptoms of poor water quality, was not developed as a conceptual design in this report due to a lack of information on how well this technology can be scaled up to remove large quantities of biomass and improve water quality. However, there is currently momentum for implementing an algal filtration pilot project in the basin, which could shed light on basic questions about harvest efficiency, effects on water quality, and re-use opportunities for harvested material (see Section 2, page 23).

In general, projects that treat poor water quality symptoms have a relatively short implementation timeframe. As soon as they are implemented, water quality and/or sediment conditions improve. However, the longevity of the timeframe for effective treatment tends to be shorter (Figure 4.6). Once treatment stops, poor water and/or sediment quality conditions may return within a relatively short time period (1-3 years). Further, these projects are targeted at specific geographic areas (i.e., the Keno Impoundment, Upper Klamath and Agency lakes) rather than the basin as a whole and they are energy intensive. It is likely that fossil fuels would power the dredge equipment and transfer of sediment to re-use locations and it would run the pumps for dispensing alum and oxygen into the Keno Impoundment. Given climate change, future energy costs may be considerably greater than they are today, increasing the costs of these projects with time.

Therefore, projects that treat the symptoms of poor water quality must be linked with projects that treat the causes. As the sources of water quality problems in the Upper Klamath Basin diminish over time, these projects could be phased out.

TREATING THE CAUSES

Medium- to long-term projects that treat the causes of excessive nutrient loading are focused on external inputs of nutrients to Upper Klamath and Agency lakes. These projects include the following (Figure 4.6):

- DSTWs in Wood River and Sprague River valleys
- Rehabilitated dual treatment and habitat wetlands along margins of Upper Klamath and Agency lakes, Lake Ewauna, and the Keno Impoundment, including the downstream end of the Klamath Straits Drain

Projects that treat the causes of poor water quality have a longer implementation timeframe. From the time that they are implemented, measurable water quality improvements take 1-2 years to occur for DSTWs and 3-5 years for larger wetlands. However, the timeframe for effective treatment tends to be longer (greater than 15 years, see Figure 4.6). These projects have a broader geographic range. DSTWs in particular could be scattered through the Wood and Sprague river valleys, and the larger treatment wetlands could be located at multiple locations along lake or reservoir shorelines. Projects treating the causes are less energy intensive and would therefore be more resilient in the face of climate change and increasing energy costs. These projects would also provide wildlife habitat along with improving water quality (Section 3, pages 41-63).

It is anticipated that linking project types in space and time to treat both the symptoms and causes of poor water quality would result in substantial basin-wide improvements over an approximately 50-year

Fig. 4.7 (Above) Seasonal wet meadows and agricultural areas characteristic of the Sprague River Valley. Photo: Google Earth.

Fig. 4.8 (Below) Farm scene along Sprague River. Photo: Jan Tik.

timeframe (Figure 4.6). Successful implementation of pilot projects presented in Section 3 would help to refine performance estimates for the different conceptual designs.

OTHER POSSIBLE PROJECTS SUPPORTING WATER QUALITY IMPROVEMENT IN THE UPPER KLAMATH BASIN

In addition to the projects discussed above, several other creative ideas were discussed by workshop participants as possible contributors to improved water quality in the Upper Klamath Basin. These include the following:

- Education, outreach and landowner incentive programs to support restoration/rehabilitation goals
- An Upper Klamath Basin Watershed Plan to explicitly state restoration/rehabilitation goals and nutrient targets
- Water diversion into Lower Klamath National Wildlife Refuge from the Klamath Straits Drain and/or the Klamath River via Ady Canal
- Use of wetlands to produce humate[3]
- Harvest algal biomass from the outlet of Upper Klamath Lake (Section 2, page 23)
- Use Biochar or other type of soil amendment to reducenutrient runoff or as a filter media to removenutrients from agricultural drains

In the Sprague River Valley

- Change the point of diversion for agricultural uses and reconnect the groundwater spring system to allow cold groundwater recharge of the river
- Riparian restoration
- Control juniper encroachment at springs and seeps

Further development of these ideas is outside the scope of this report. However, the first two bullets in particular represent critically important steps in the successful implementation of large-scale water quality improvement projects in the basin. Social and cultural factors such as social context, awareness, attitudes, capacities, constraints, and behaviors in a watershed must be considered along with environmental goals.

Research Needs

The remaining bullets could be considered as additional information becomes available. During the development of final pilot project designs, these concepts could be included, as applicable. In particular, a final design for implementation of DSTWs throughout the Sprague River Valley would need to consider how these systems would interact with ongoing efforts for riparian restoration reconnection of groundwater springs (see text box on page 42).

Lastly, there are several ongoing research needs related to nutrient cycling and ecosystem processes in the Upper Klamath Basin. Research needs include continuing data collection and a combination of empirical (based on direct observation) and mechanistic (simulations based on mathematical representations of the processes) models to better describe the following:

- Phosphorus dynamics in Upper Klamath Lake and the Keno Impoundment
- Effects of water flow, temperature, nutrients, and wind circulation on algal blooms in Upper Klamath Lake
- Sucker survival and recruitment in Upper Klamath Lake

These modeling efforts could progress in a coordinated fashion with the recommended pilot projects (Section 3). Information collected during the pilot studies may serve as useful calibration data for the models, or it may help modelers to develop algorithms more appropriate for Upper Klamath Lake conditions.

3 An organic substance that naturally produced in wetlands and is high in humic acids. Humate has been shown to decrease algal bloom density in other locations, although results are mixed for the Klamath Basin for control of *Aphanizomenon flos aquae* blooms in Upper Klamath Lake (Milligan et al. 2009).

Fig. 4.9 West-facing view from a hillside, Upper Klamath Lake. Photo: David Garden.

Fig. 4.10 Shoreline, Upper Klamath Lake. Photo: David Garden.

CONCLUSION

The purpose of the September 2012 Klamath River Water Quality Workshop was to evaluate approaches for improving water quality in the Upper Klamath Basin and to inform decision making on nutrient reduction approaches. The workshop focused on upper basin projects to foster a new, healthier equilibrium condition for basin headwaters, to treat the symptoms as well as the causes of elevated phosphorus and nitrogen levels, and, ultimately, to support water quality improvements in downstream reaches of the Klamath River. Six pollutant reduction technologies or approaches were pre-selected by the project Steering Committee for consideration at the workshop. The pre-selected technologies have demonstrated success in other systems challenged by nutrient pollution, and include the following:

- Wetland restoration (habitat focus)
- Treatment wetlands (water quality focus)
- Diffuse source (decentralized) treatment wetlands
- Algal filtration
- Sediment dredging
- Sediment sequestration of phosphorus and aeration/oxygenation

Feedback from workshop participants was used by the project technical team to develop pilot project conceptual designs for three overarching project types; wetland rehabilitation, sediment removal (dredging), and sediment sequestration of phosphorus with oxygenation/aeration. No single approach to addressing water quality improvements was selected because the current scale of the problems is too large. Instead, the team developed conceptual designs for multiple pilot projects at several locations in the Upper Klamath Basin with an eye toward treating both the symptoms and the causes of water quality problems. Linking both types of projects, in space and time, represents an exciting opportunity to improve water quality and thereby support multiple beneficial uses. Lastly, continuing education, outreach, and incentives for landowners and managers is an important component of the successful implementation of pilot, and ultimately full-scale, water quality improvement projects in the Upper Klamath Basin.