‘Stage Zero’ Restoration of Whychus Creek, Oregon: Monitoring Results and Lessons Learned

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Extended Abstract

Background

Whychus Creek is the focus of multi-year, collaborative restoration efforts that support increased numbers of anadromous and resident fish, improved stream habitat and expanded biodiversity. In 2016, project partners led by the Upper Deschutes Watershed Council (UDWC - https://www.upperdeschuteswatershedcouncil.org), broke ground on the first mile of a six-mile restoration project along Whychus Creek on land owned by the Deschutes Land Trust (DLT - https://www.deschuteslandtrust.org) (Figure 1).

Project proponents are committed and focused on restoring the physical, chemical and biological processes necessary to establish and support a resilient and productive stream ecosystem for the long-terms benefit of fish, wildlife and water quality (Beechie et al. 2013, Bellmore et al. 2013). The approach to restoration adopted by the UDWC and its partners is founded on established principles of process-based stream restoration (Beechie et al. 2010, Roni and Beechie 2012) but also employs key principles of ecological restoration (e.g., McDonald et al. 2016). We focus on addressing the historic root causes of channel and ecological degradation: channel straightening and simplification to support agricultural activites, which led to channel incision and disconnection of the stream from its floodplain. We do this by filling-in the incised channel, re-activating the historical floodplain, and planting the restored reach with native riparian and obligate wetland species. In this approach to stream restoration, we look beyond the channel, to restore natural connectivity within the channel-wetland-floodplain system. The aim is to recover plants and animal assemblages floodplain-wide, and allow natural erosion, deposition, and avulsion processes to create, maintain and support resilient instream, wetland, washland and floodplain habitats that support all life stages of target fish and wildlife species. We intend to recreate ecosystems that are as self-sustaining and as resilient as possible to the impacts of future changes in climate and watershed land-use.

Project design and implementation in Whychus Creek also seeks to explore the degree to which optimum ecologically productive stream conditions can be achieved in practice. Our approach stems from a paper by Cluer and Thorne (2014) in which they propose the Stream Evolution Model (SEM). Their analyses suggest that the highest values for hydro-morphological attributes and ecosystem benefits are associated with ‘Stage 0’ (the pre-disturbance condition) in the incised channel evolutionary sequence. It follows that, when an incised stream is restored, the greatest ecological uplift possible given the remaining site and watershed constraints is attained when the stream is reset to its pre-incision condition – that is, restored to ‘Stage 0’.

Post-project monitoring was designed to: support evaluation of the ecological outcomes of this restoration approach; to inform future phases of restoration at Whychus Creek; and, to establish how well ‘Stage 0’ restoration works in practice.

Project monitoring, ongoing since 2014, includes evaluating a wide range of physical and biological metrics including groundwater, channel morphology, habitat (especially for target and ESA-listed fish species), water temperature, primary productivity, macroinvertebrates, plant community presence/assemblages/extent, and fish usage (Table 1).

Monitoring Results

The pre-restoration, single-threaded, statically-stable channel was incised below the historical floodplain by about 10 feet. It had been relocated along the valley-right toe slope and in Figure 2 it is marked by a line of trees on the far side of the valley floor in the upper photograph. Restoration involved filling-in the incised channel and lowering the valley floor in places, to fully reconnect the stream and its floodplain. Immediately following these actions multiple, dynamically-adjusting anabranches developed (see center photograph in Figure 2). Within 2 years, the post-restoration, braided system had evolved and vegetated into an anastomosing planform, as shown in the lower photograph in Figure 2. This transformation led to very large increases in instream habitat quantity and complexity, with a 187% increase in wetted area at base flow, a 443 % increase in the number of habitat units, and a 429% increase in number of pools. Sediment sampling has revealed a reduction in the percentages of cobbles and boulders (which constituted most of the channel substrate prior to restoration) and increases in the percentages of gravel, sand and silt.

Reconnection of the stream and its floodplain has resulted a rise in the water table from about 7 ft below the valley floor to less than 2 feet - a rise sufficient to create multiple ponds and seasonally flooded areas and support rapid colonization of the project reach by a wide array of riparian and wetland vegetation. Plant assemblages show a predominance of native over non-native and invasive species.

Macroinvertebrate data show abundances in side channels well above that in unrestored reaches with simple, single-thread geometries while EPT taxa richness post restoration remains as high as that in unrestored reaches. The results of measurements of primary productivity reveal the existence of multiple, micro-biological hotspots in side channels that are not found in an unrestored, incised control reach. Anadromous fish usage data collected in Fall 2018 indicate an 321% increase in juvenile steelhead and redband trout (*Oncorhynchus mykiss*) density per unit area over pre-project density, while Chinook (*Oncorhynchus tschawytscha*) juvenile density per unit area was 800% higher in the restored reach than in the adjacent control reach.

Lessons Learned

Monitoring results establish that, to date, the project is either achieving or exceeding 15 out of its 19 success criteria (Table 1). On this basis, only two years after construction, this 'Stage 0' restoration is delivering the physical, habitat, and biological uplift hoped for from a fully connected channel-wetland-floodplain system. Notwithstanding this, four performance parameters appear to be sub-optimal and we are learning lessons about what success looks like in a 'Stage 0' restoration.

Channel bed elevations remain within +/- 2 ft of the Geomorphic Grade Line (GGL) which is the target long profile, but there remains a risk that one anabranch might scour unacceptably - capturing an ever increasing percentage of the overall flow. If monitoring reveals such a trend, adaptive management with partners will identify what potential actions could be taken to prevent renewed degradation so prevent an incised, single-thread channel from disconnecting the stream from its floodplain. One year post-project, the area of riparian and wetland vegetation had increased by approximately 5 acres (or 20%) over that in the pre-project area. It is trending toward the target increase of ≥20 acres. The lesson learned here is that despite riparian planting and recolonization by riparian species, it takes additional time for riparian and wetland plants to become established, mature, and abundant. That said, progress towards this success criterion is substantial and ongoing.

While both the number of pools and the diversity of pool habitats have increased, maximum pool depths are slightly lower than in the control reach. It is anticipated that maximum pool depths will increase through time as anabranches evolve naturally and scour and deposition processes continue to promote pool formation. The finding that the extent of bed substrate dominated by fines (sand and silt) has increased generated concerns amongst some stakeholders, due to the risk of fish eggs being smothered. Despite this concern, gravel redds (depressions in the stream bed created by salmon into which eggs are deposited) have been detected in the 'Stage 0' reach, suggesting the presence of suitable spawning habitat in the project. Also, fine-grained bed materials provide excellent habitat for midges, which are a vital food for fish during their alevin and fry life stages.

A broader lesson learned is that the complexity and valley wall to valley wall extent of fully-connected channel-wetland-floodplain systems created by restoration to 'Stage 0' (see Figure 2) is difficult to adequately describe using conventional, channel-centric, and ground-based monitoring methods. At Whychus Creek, UDWC is expanding the scope of monitoring to capture novel parameters such as 'patch complexity' and, in judging success, we are coming to rely on measures of diversity and variability as much as on traditionally used measures of central tendency. In short, we are interested in parameter ranges and standard deviations as well as spatially- or time-averaged mean, median or modal values.

The findings of our intensive monitoring efforts provide vital insights (reported above) needed to evaluate the benefits and risks of 'Stage 0' restoration and assess whether improvements in long-term productivity, diversity and resilience justify the short-term disruption caused when the fluvial system and valley floor are re-set to their pre-disturbance condition.

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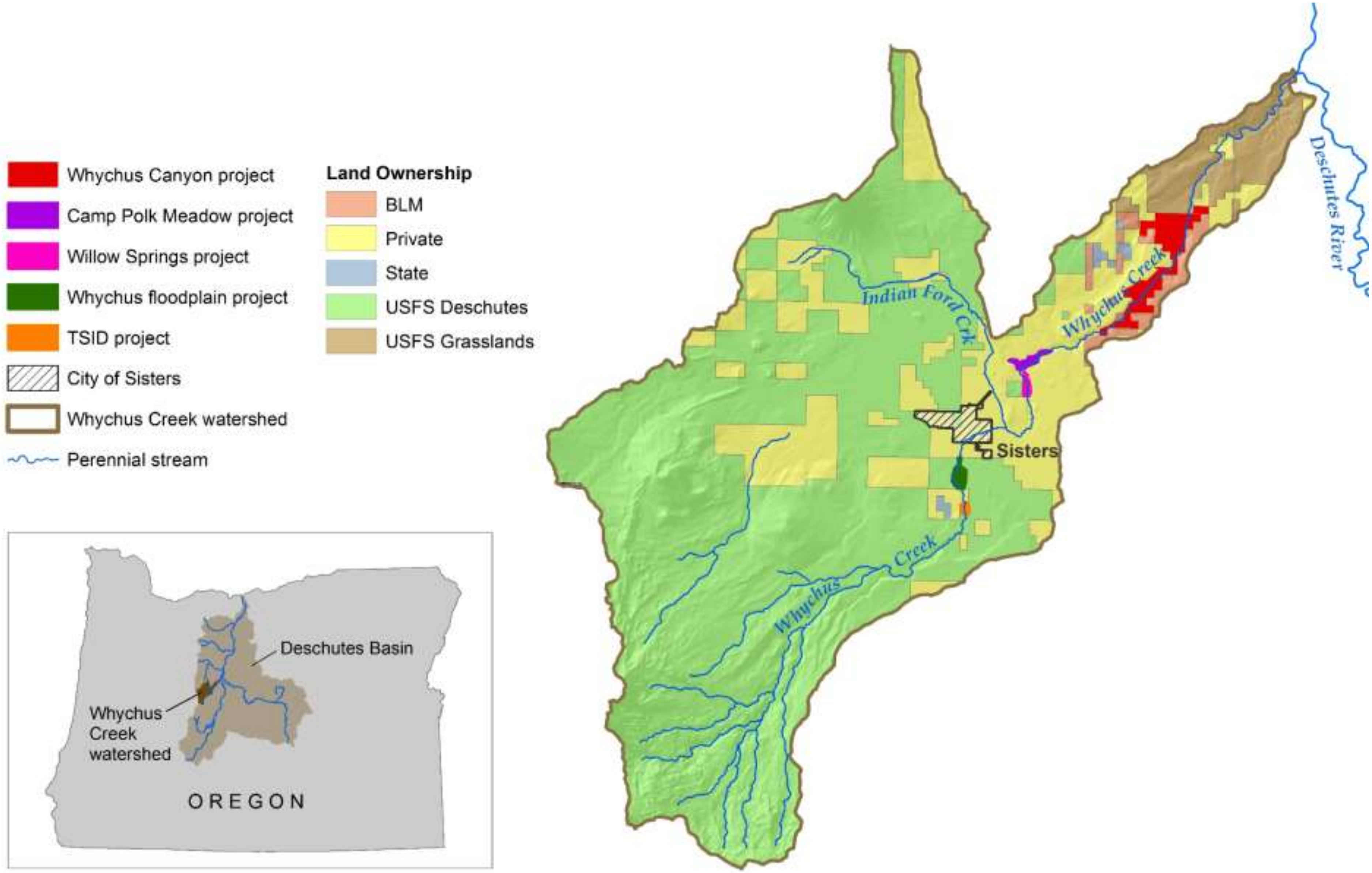

Figure 1. Project location maps.

Figure 2. Project Implementation (pre-restoration (2015), immediately post-construction (2016) and 2-years post-construction (2018).

Table 1. Monitoring outcomes to date. Green crosses indicate outcomes that currently achieve or exceed project success criteria.

Results (at baseflow)

PHYSICAL	Groundwater	Depth	+
PHYSICAL	Channel morphology	Number of channels	+
PHYSICAL	Channel morphology	Channel elevation	+ / -
PHYSICAL	Channel morphology	Total channel length	+
PHYSICAL	Channel morphology	Ratio of primary : secondary	+
PHYSICAL	Channel morphology	Total wetted area	+
PHYSICAL	Stream temperature	July rate of change	+
PHYSICAL	Geomorphic units / habitat	Total number of units	+
PHYSICAL	Geomorphic units / habitat	Number of types of units	+
PHYSICAL	Geomorphic units / habitat	Percent riffle	+
PHYSICAL	Geomorphic units / habitat	Percent pool	+
PHYSICAL	Geomorphic units / habitat	Pool number, types, area, dimensions	+ / -
PHYSICAL	Geomorphic units / habitat	Pieces of wood	+
PHYSICAL	Geomorphic units / habitat	Substrate sizes, proportions	+ / -
BIOLOGICAL	Riparian and wetland vegetation	Area	+ / -
BIOLOGICAL	Riparian and wetland vegetation	Species richness and type	+
BIOLOGICAL	Algae and plankton	Species richness and abundance	+
BIOLOGICAL	Macroinvertebrates	Taxa richness and abundance	+
BIOLOGICAL	Fish	Juvenile density	+