

Exhibit C

**Supplemental Public
Correspondence received
as of October 12, 2022**

From: [Brian Posewitz](#)
To: [COMMISSION ODFW * ODFW](#)
Subject: Comments on Agenda Item C (Jump Creek Fish Passage Exemptions)
Date: Tuesday, October 11, 2022 10:41:59 PM
Attachments: [221011 WaterWatch Comments on Silvies Valley Ranch.pdf](#)

Greetings,

Please see the attached comments on the above matter, which is on the Commission's agenda for October 14, 2022. Thank you.

Regards,

Brian Posewitz
Staff Attorney | WaterWatch of Oregon
503.432.8249 (temporary remote office land line)
213 SW Ash St, Suite 208
Portland, OR 97204
www.waterwatch.org

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WaterWatch of Oregon

Protecting Natural Flows in Oregon Rivers

October 11, 2022

Oregon Fish and Wildlife Commission
4034 Fairview Industrial Drive SE
Salem, OR 97302

Re: Fish Passage Exemptions on Jump Creek

Chair Wahl and Members of the Commission:

WaterWatch of Oregon is a nonprofit river conservation organization dedicated to protecting and restoring natural flows in Oregon's rivers and streams. WaterWatch also works to protect and restore the free-flowing character of Oregon's rivers and streams and has led several successful efforts to remove high-profile fish passage barriers, including Savage Rapids Dam, Gold Hill Dam, Gold Ray Dam.

Regarding the above matter, WaterWatch appreciates the Commission's decision in January to not approve the requested fish passage exemptions without additional information. WaterWatch also appreciates the additional investigation by the Department and the additional information provided.

While the additional information may bolster the case for fish passage exemptions, the proposed exemptions should still be denied or at least deferred until the applicant complies with all laws and regulations affecting the stream and the Department determines then how the stream functions in connection with the Silvies River.¹

WaterWatch also urges the Commission to consider more generally how fish passage exemptions affect the potential for restoration of degraded streams. As discussed below, granting the exemptions in this case will tend to discourage whatever possibility might still exist to reconnect the Silvies River with its historic tributary.

WaterWatch submits the following more detailed comments (in addition to its comments in January):

¹ If the exemptions are denied, the applicant would be required to either provide fish passage at the dams or seek fish passage "waivers." The latter would at least require Silvies to provide mitigation – and a "net benefit" for native migratory fish – in exchange for not providing passage. ORS 509.585(7).

1. The Department previously found:

Under historic conditions, [Jump Creek] would have functioned as spawning and rearing habitat for redband trout and other fish species native to the Silvies watershed.

(Commission Packet, Attachment 3, p. 5.)

2. The downstream impoundment, which was previously cited as the reason native migratory fish could not use the stream, is illegal and should be removed, but it is not clear that Silvies Valley Ranch will do that voluntarily. (Attachments to these comments, pp. 1-4 (documents obtained by public records request to Water Resources Department).) The fish passage exemptions should be denied or deferred until the impoundment is removed or legalized. The fish passage benefit analysis should then be revisited under the new conditions. (For example, if the impoundment is gone, Silvies may need to provide the creek with a path to the river.)

3. Even if water rights now held by Silvies allow it to divert water from Jump Creek, it can do so legally only in specified amounts and only when it is beneficial for irrigation, which is generally March-September. (Silvies River Decree, p. 29 (see “scanned documents” at [this](#) link).) Indeed, the application for the exemptions says water is diverted only “during the irrigation season.” (Commission Packet, Attachment 2, p. 3.)

4. The updated Benefit Analysis by the Department finds that, even with the illegal reservoir removed, Jump Creek would not connect to the Silvies River because it would be blocked by an irrigation canal and a road running perpendicular to the stream. (Commission Packet, Attachment 4, p. 2.) The analysis says the canal is “legally permitted” and implies that the road is, too. However, there is no analysis of how the canal and road are legally permitted to eliminate the historic connection of the stream to the river (under removal-fill laws, for example).

5. The updated Benefit Analysis also suggests Jump Creek does not have enough natural flow to reach the Silvies River, but that appears to be based on anecdotal information (physical observations on two days). There are no estimates of the stream’s natural flow based on flow measurements and consumptive use, or on topography and precipitation (two methods the Water Resources Department uses to estimate natural stream flow). Pictures of the illegal reservoir by the Water Resources Department suggest, from the apparent volume of water stored, that flows of the stream may be sufficient to reach the river at times. (Attachments to these comments, pp. 5-6.)

6. The Department also suggests Jump Creek is too degraded to provide habitat for native migratory fish. (Commission Packet, Attachment 4, pp. 3-5). However, Silvies apparently sees its potential, saying the dams for which it seeks the fish-passage exemptions are to restore the stream, in part by increasing dry season flows. (Commission Packet, Attachment 9, pp. 5-7.) Why do that if there is no potential for it to have native migratory fish again?

7. Jump Creek still supports speckled dace, which are native, even if the Department doesn't consider them "migratory,"² though some apparently do.³ (Commission Packet, Attachment 3, p. 5.)

8. If the dams on Jump Creek are required to provide fish passage, or if Silvies were granted waivers in exchange for mitigation, Silvies' interest in restoration could lead it to reconnect Jump Creek with the Silvies River. However, since fish passage exemptions can be revoked if conditions change, OAR 635-412-0025(6), granting Silvies exemptions for the dams would create a disincentive for restoring the historic connection.

9. Oregon law requires fish passage at "artificial obstructions" in streams "inhabited, or historically inhabited, by native migratory fish." ORS 509.585(2) (emphasis added). The inclusion of "historically inhabited" shows an intent to incrementally restore access for fish even where it has been lost, and to not further impair passage on historic fish streams that could be restored to have fish again. In other words, the language suggests that incremental progress toward restoration, and preservation of passage where it exists on historic fish streams, can be an "appreciable benefit" to native migratory fish even if the stream in question is not presently inhabited by native migratory fish.

For the above reasons, the exemption requests should be denied. At a minimum, the Commission should wait for issues related to the illegal impoundment to be resolved and to see how the stream functions after that. The Commission should also ask staff for additional information on the legality of the road and irrigation canal that may prevent Jump Creek from reaching the Silvies River. Silvies Valley Ranch says it is interested in restoring streams on the ranch. Restoring the connection between Jump Creek and the Silvies River would be a great testament to that.

Thank you for considering our comments.

Sincerely,

Brian Posewitz

Brian Posewitz
Staff Attorney

² "Native migratory fish" are "native fish that migrate for their life cycle needs," whether to the ocean and back or entirely within a local stream system. See ORS 509.580(6); OAR 635-412-0005(32). The Department doesn't name speckled dace in its definition but uses the term "including" to introduce the list, suggesting it is not exhaustive.

³ See <https://www.biologicaldiversity.org/species/fish/pdfs/SASD-petition-5-11-20.pdf> (petition to list subspecies as endangered or threatened and identifying barriers to migration as a reason for population decline).



June 23, 2022

NOTICE OF VIOLATION

Silvies Valley Ranch, LLC
Attn: Scott Campbell
7610 SE 162nd Ave.
Portland, OR 97236

This is to notify you that you are in violation of Oregon Revised Statutes (ORS) 537.130(1) and (2), unlawful appropriation and storage of surface water.

The facts that constitute the violation is that on June 23, 2022, Watermaster staff confirmed the appropriation and storage of surface water from Jump Creek without the benefit of a water right. The property where the storage is occurring is located at approximately Latitude 44.021304, Longitude -118.984188 in Section 10, Township 18 South, Range 31 East, W.M., Grant County. According to Grant County Assessor's office, you are the responsible party in this matter.

You have until November 1, 2022 to correct the violation by discontinuing the appropriation and storage of surface water without a water right. You may not willfully divert or store surface water without a water right issued by the Oregon Water Resources Department. You must remain in compliance with the terms of this order to avoid further notices of violation and civil penalties (ORS 540.710; ORS 536.900).

If the violation is not corrected within the time provided above, you will be subject to further agency action that may include assessment of civil penalties (ORS 536.900). Each day of continued violation may be considered a separate and distinct violation for the purposes of calculating civil penalties (ORS 536.900(2); OAR 690-260-0060(3)). If you receive a notice of assessment of civil penalties, you will have an opportunity to request a hearing (ORS 536.905; ORS 183.745). You may also be liable for the expenses of the Water Resources Department in taking enforcement action related to correcting the violation (ORS 536.930). Such expenses are in addition to any civil penalties that may be assessed.

This Notice of Violation is in effect for three years from the date of service. A similar violation for which a Notice of Violation was issued may be considered a repeat violation for the purpose of calculating civil penalties (OAR 690-260-0055 through 0070). You may contact the Acting District 10 Watermaster, Donald Swindlehurst at (541) 573-2591 for more information regarding this notice.

Sincerely,

Jason Spriet
East Region Manager, OWRD

CC: Donald Swindlehurst, Acting District 10 Watermaster OWRD (Email)
Matt Day, Enforcement Section Manager OWRD (Email)
Dave Banks, District Fish Biologist ODFW (Email)

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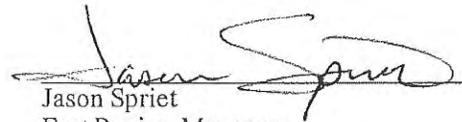
This is a **FINAL ORDER** other than contested case. This final order is subject to judicial review under ORS 183.484. Any petition for judicial review of the final order must be filed within the time specified by ORS 183.484(2). Pursuant to ORS 536.075 and OAR 137-004-0080 you may either petition for judicial review or petition the Director for reconsideration of this order. A petition for reconsideration may be granted or denied by the Director, and if no action is taken within 60 days following the date the petition was filed, the petition shall be deemed denied.

I hereby certify that on June 24, 2022, I mailed a true certified copy of the attached NOTICE OF VIOLATION, by first class mail and certified mail, by depositing the same in the US Post Office, with prepaid postage thereon, addressed to the following:

Silvies Valley Ranch, LLC
7610 SE 162nd Ave.
Portland, OR 97236

and by regular mail to:

Silvies Valley Ranch, LLC
7610 SE 162nd Ave.
Portland, OR 97236


Jason Spriet
East Region Manager
Water Resources Department

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From: SPRIET Jason D * WRD <Jason.D.SPRIET@water.oregon.gov>

Sent: Friday, June 10, 2022 12:04 PM

OWRD-SVR000355

To: BYRD Kristopher R * WRD <Kristopher.R.BYRD@water.oregon.gov>
Cc: SWINDLEHURST Donald S * WRD <Donald.S.SWINDLEHURST@water.oregon.gov>; JOHNSTONE Jake D * WRD <Jake.D.JOHNSTONE@water.oregon.gov>
Subject: Silvies Valley Ranch NOV

Kris –

This link:  [Dist 10](#) contains an NOV for the Silvies Valley Ranch in regard to a storage facility that does not have a water right. Also in the file is a google map screenshot of the location as well as photos Dally took today of the storage facility. We have contacted the ranch manager to see if we could get voluntary compliance and his response, while friendly, was essentially they would not comply.

ODFW has an interest in this as well since the property owner has applied to install environmental restoration weirs on this stream (HB 2298), and would like a copy of any action we take as they have put the project on hold. I assume we can share the NOV once it is final.

Please let me know if you have questions. If we are not able to get this out today, I will ask Marcy to get it mailed early next week and change the certificate of service to reflect such.

Thanks,

Jason

Jason Spriet

East Region Manager

[Oregon Water Resources Department](#)

1995 3rd Street, Suite #180

Baker City, OR 97814

(971) 719-6623

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Jun 23, 2022 at 06:44:27



Jun 23, 2022 at 06:43:09



From: [Jefferson Jacobs](#)
To: [COMMISSION ODFW * ODFW](#)
Subject: Written comments regarding fish passage exemption on Jump Creek
Date: Tuesday, October 11, 2022 4:20:54 PM
Attachments: [SVR-2016 monitoring Report FINAL.pdf](#)
[fish passage exemption comments ONDA.pdf](#)

Hello,

Attached are written comments regarding the fish passage exemption for Jump Creek. I have also attached a report which I reference in the comments.

Thank you,

Jefferson

--



Jefferson Jacobs ([He/Him](#))
Riparian Restoration Manager
MS and Certified Riparian Restoration Professional

Oregon Natural Desert Association
50 SW Bond St, Suite 4
Bend, OR 97702



October 11, 2022

Oregon Fish and Wildlife Commission
Oregon Department of Fish and Wildlife
61374 Parrell Road
Bend, OR 97702

Re: Fish Passage Exemptions on Jump Creek

Chair Wahl and Members of the Commission,

The Oregon Natural Desert Association (“ONDA”) provides these comments in regard to the Fish Passage Exemption proposed for a dam constructed on Jump Creek.

ONDA is a non-profit, public interest organization with more than 10,000 members and supporters dedicated to the conservation of eastern Oregon’s public lands and waters. Founded in 1989, ONDA’s mission is to protect, defend, and restore Oregon’s high desert. ONDA has a long history of monitoring ecological conditions throughout eastern Oregon.

From 2012 through 2016 ONDA was contracted by Silvies Valley Ranch (SVR) to monitor the ecological impacts of the rock dams installed on Paine, Flat and Spring Creeks. The conclusion of that effort was that there was not evidence of ecological improvements in riparian health as a result of the installation of the rock and earth check-dams; and in many cases, conditions had deteriorated as a result of the dam construction. These findings are contrary to the comments on page 5 of Appendix 9 (letter from Elizabeth Howard). Please find attached the final report of those monitoring efforts at SVR. It is important to note that the results of that long-term study also heavily influenced and informed ONDA’s objections to HB 2298, and the comments ONDA made during rule making after HB 2298 was passed. Understanding the impacts, limits and realities of what happens when humans build earthen dams is a discussion I am happy to have with the commission at their convenience.

While the approval of a fish passage exemption for Jump Creek may be a foregone conclusion, it is important for the Commission to appreciate the cautionary tale that Jump Creek provides: That eastern Oregon is losing its limited, precious riparian habitat through the cumulative death from a thousand cuts. That a history of choices that have consistently led to degradation of public resources (water, and wildlife) on public and private lands have resulted in a creek that is now deemed “not worth saving”. Discussions prompted by inflection points such as fish passage permitting are not providing opportunities to work together to reverse the damaging trajectory of these past decisions. Instead they are serving to codify and solidify our cumulative ecological losses. Increasingly, Oregonians are becoming aware of how it is more than just wildlife that is dependent on intact ecological ecosystems: Those that make their living ranching, farming, recreating, or even just dwelling nearby, depend on those intact systems as well.

As you consider your vote to approve or deny SVR their fish passage exemption, please consider not just the loss of Jump Creek itself in its formal conversion to an irrigation ditch, but what the precedent of your decision represents for all the streams which will face similar fates in the future.

Thank you for the opportunity to comment on this important matter. Please feel free to contact me if you have questions or would like additional information.

Sincerely,

Jefferson Jacobs
Riparian Restoration Manager
Oregon Natural Desert Association

50 SW Bond St., Suite 4
Bend, OR 97702
541-330-2638 x313
jjacobs@onda.org



Silvies Valley Stream Monitoring

2016 Final Monitoring Report

Jefferson Jacobs

1/31/2017

Table of Contents

Table of Contents.....	1
Project Background.....	2
Experimental Design	3
Water Temperature	12
Water Temperature Methods.....	12
Water Temperature Results	12
Water Temperature Discussion	17
Changes in Riparian Vegetation:.....	18
Changes in Riparian Vegetation Methods	18
Changes in Riparian Vegetation Results	19
Changes in Riparian Vegetation Discussion	31
Water Tables.....	32
Water Table Methods.....	32
Water Table Results	32
Water Table Discussion.....	38
Aquatic Macroinvertebrate and Fish Surveys.....	39
Aquatic Macroinvertebrate and Fish Survey Methods.....	39
Aquatic Macroinvertebrate and Fish Survey Results.....	41
Aquatic Macroinvertebrate and Fish Survey Discussion	44
Conclusions	46
Recommendations for Future Monitoring.....	47
Literature Cited	49
Appendix I: Monitoring Reach Study Design Diagram.....	52

Project Background

In 2007, the Silvies Valley Ranch (SVR) began implementing the use of earthen check-dams in an attempt to improve riparian conditions along intermittent streams within the ranch. Proposed benefits of the dams included raising the water table and enhancing the growth of riparian vegetation and cattle forage. During 2012 to 2016, the Oregon Natural Desert Association (ONDA) was contracted by SVR to provide objective monitoring to assess the effectiveness of the earthen check-dams as a tool for augmenting riparian restoration in a degraded ecosystem. Monitoring efforts included recording water temperatures and water table depths from surface, as well as photo monitoring to capture landscape-scale changes in factors such as deciduous woody vegetation cover. Concurrent monitoring of changes in forage production was also conducted during this period by the Eastern Oregon Agricultural Research Station (EOARS).

This report constitutes the five-year project's final report, and was provided to SVR on February 1, 2017 with information for a wetlands interpretive sign, as well as copies of all data and photographs collected over the course of the study.

The collaboration between SVR and ONDA has provided a unique and invaluable opportunity to gather data that will help inform future discussions regarding the application of earthen dams as a restoration tool. We thank SVR for taking on the expense and technical challenges of entering into this collaborative project.

Observations and data collection were organized to help gauge the potential effectiveness of earthen dams in improving riparian conditions at SVR in ways which have been documented to occur in natural beaver dam systems. In general the study's areas of inquiry are:

1. Water Temperature: Do the earthen dams at SVR lower water temperatures over the course of the stream, in running sections, and in deep stratified dam pools as has been observed with beaver dams (Castro, Pollock, Jordan, Lewallen, & Woodruff, 2015; Fanelli & Lautz, 2008; Malison, Lorang, Whited, & Stanford, 2014)? Cool water temperatures are critical to the survival of threatened and endangered native fish populations such as bull trout (Selong, McMahon, Zale, & Barrows, 2011) and for discouraging the colonization of streams by invasive, warm water tolerant fish species (McMahon, Zale, Barrows, Selong, & Danehy, 2007). Developing methods for lowering stream water temperatures is therefore of extreme importance in light of climate change (Isaak, Young, Nagel, Horan, & Groce, 2015; Lawrence et al., 2014).
2. Vegetation: Did the amount or health of woody riparian vegetation increase over the course of the study? Woody vegetation plays an important role in contributing towards a healthy stream morphology, temperatures, and forage and habitat for wildlife (Zeedyk and Van Clothier 2009, Lawrence et al., 2014; Penaluna, Dunham, & Noakes, 2016), and often is augmented by the construction of beaver dams in streams (Pollock et al., 2014).

3. **Water Tables:** Are streams reconnecting to flood-plains and resulting in higher, and more extensive water tables? Beaver dams have been shown to increase the exchange between surface and ground water (Majerova, Neilson, Schmadel, Wheaton, & Snow, 2015; Pollock et al., 2014), as well as slow run-off, extend streamflow duration and sub-irrigate downstream riparian zones for the benefit of riparian vegetation (Bird, O'Brien, & Petersen, 2011; Majerova et al., 2015).
4. **Fish and Aquatic Macroinvertebrates:** What species of fish and macroinvertebrates are present over the course of the monitoring project? Fish species can be impacted both positively and negatively by the presence of dams (Kemp, Worthington, Langford, Tree, & Gaywood, 2012). The species diversity and composition of macroinvertebrate populations is often tied to the health of aquatic systems, including the pH, pollution levels, temperature, levels of dissolved oxygen present and streamflow duration (Agouridis, Wesley, Sanderson, & Engineering, 2015; Blackburn & Mazzacano, 2012; Poff et al., 2006).

Experimental Design

Initial experimental design was inspired by the tenets of BACIP (Underwood, 1992) where Before-and-After-Control-Impact (BACI: Eberhardt, 1976) observations are bolstered by observations of concurrent paired (P) locations. Data collected includes stream temperature (every two hours), water table depth from soil surface (two to three times annually), and photo monitoring (annually). Details on the methodology of these three metrics are described in the corresponding report sections below.

Three streams were selected in April 2012 by ONDA in cooperation with SVR staff and Tony Svejcar of the EOARS. The streams selected for the 5-year monitoring project include: Flat Creek, Paine Creek and Spring Creek. All were of a similar size, with an average stream water width of less than two feet and a water depth of less than one foot at maximum seasonal flows. All were free-flowing streams without artificial impoundments. Flat Creek and Paine Creek have similar elevations (4,750-4,900 ft) and gradient (1-3% estimate). Spring Creek is slightly lower in elevation (4,580-4,700 ft), but has a similar gradient (1-3% estimate). Each of the three streams' peak runoff period is from March to May when higher elevations begin snowmelt. At base flows all streams become intermittent.

"Monitoring reaches," composed of three adjacent sections, were mapped out on the three creeks: an "upper control section," "experimental section" and a "lower control section" (Appendix I). Each "section" was roughly 500 meters long. To allow for direct paired comparisons of cause and effect of the presence of dams, experimental and control sections were selected to be as similar as possible besides the presence of dams. SVR staff would construct dams within the experimental sections of each creek after an initial year of data collection. Control sections were to remain undammed. One monitoring reach was located on Flat Creek and one on Spring Creek. Two monitoring reaches were established on Paine Creek.

The study design would allow comparison between experimental sections (dammed) and adjacent controls sections (undammed). It would also allow for the comparison of unforeseen effects between upper and lower controls that may be caused by the upstream influence of an experimental section. By collecting data for a year before dam construction, initial unforeseen relative differences could be observed between control and experimental sections. By collecting data over the course of five years, relative trends over time within each section would also be potentially comparable between experimental and control sections.

Initial conditions existed which precluded the collection of more than one year of “before” data, which limited the ability to capture the natural variability of the systems involved. Limited (one year) “before” data was not seen as fatal to the value of the project owing to: 1) matching each experimental reach with two paired adjacent control reaches; 2) the ability to replicate reaches (N=4); and 3) the general feeling of the parties involved that to be meaningful, the experimental results would have to be “so dramatic as to be clearly visible,” rather than determined purely statistically.

However, several incidents occurring after the monitoring project began necessitated significant modifications to the study design over time, eventually resulting in a more observational approach based on photo monitoring and satellite imagery. The most significant modifications are listed by creek name below:

Paine Creek

- Large-scale removal of the ponderosa forest along the experimental section of upper Paine Creek, and forest thinning of surrounding uplands (Figure 1)
- Filling creek incisions with large woody debris (Figure 2)
- Use of flood irrigation ditches on lower Paine Creek (Figure 3)
- Dams built throughout the lower control section and on a side tributary (Figure 4)

Flat Creek

- Bulldozed gravel into 100 meters of a deep “E” channel within the upper control section (Figure 5)
- Flood irrigation ditches and ponds along the lower half of the experimental section (Figure 6).
- Dams built throughout the lower control section (Figure 7)

Spring Creek

- Dams built throughout lower control section (Figure 8)
- Brush beating (removal of woody upland plants such as sagebrush and rabbitbrush) in experimental section (Figure 9)
- Dams were constructed during the first year of monitoring, precluding the collection of “before” data

Since the modifications listed above were not replicated throughout all monitoring reaches, or between each monitoring reach's control and experimental sections, and have the ability to potentially alter the hydrology of an area, the ability to attribute cause and effect relationship to the dam structures is limited.

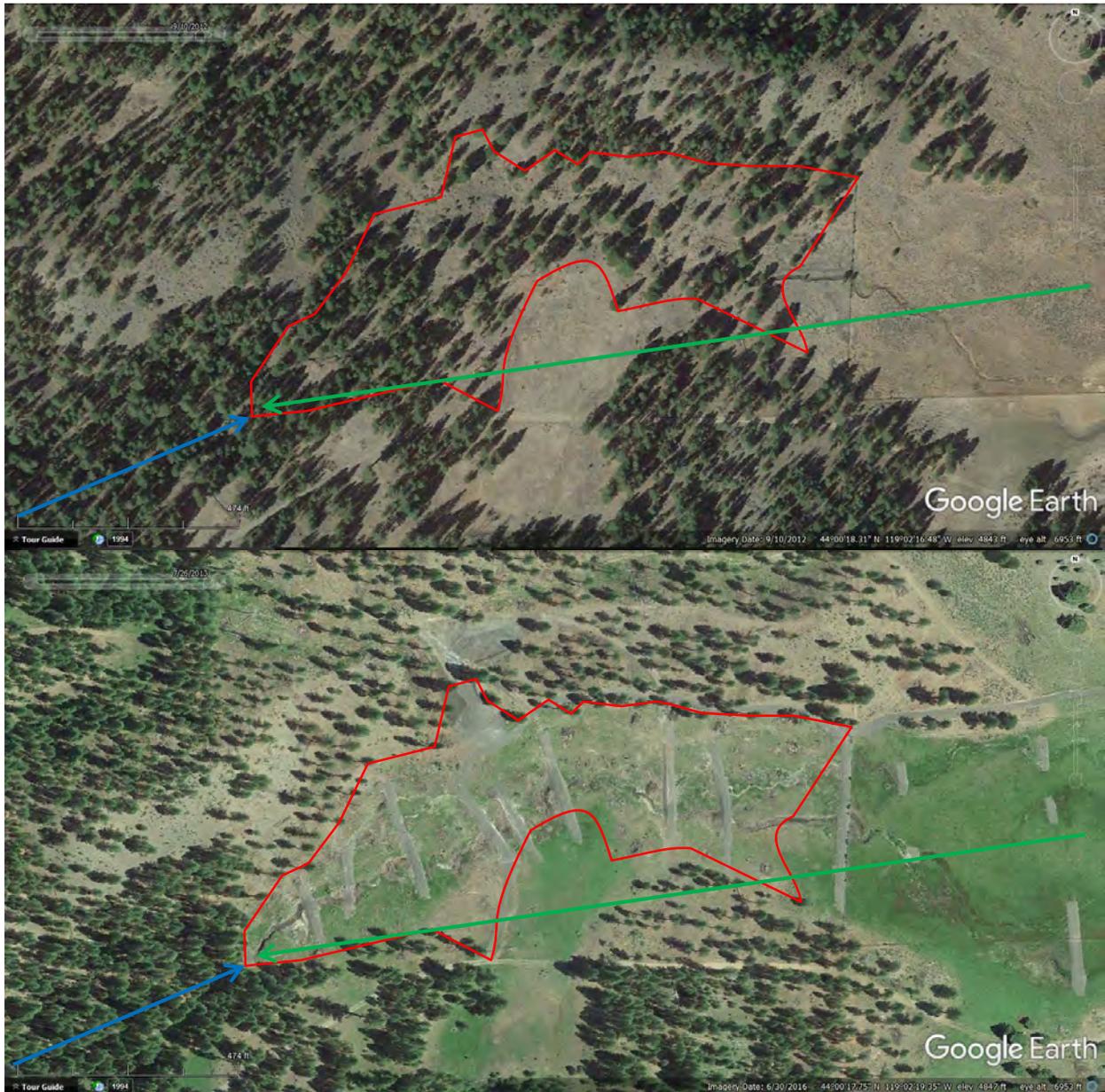


Figure 1. Large-scale removal of the ponderosa forest (within red polygon) and forest thinning of surrounding uplands, along the experimental section (green line) of upper Paine Creek. Before (above) and after (below). Blue line indicates a portion of the upper control section of upper Paine Creek. Stream flows from left to right.



Figure 2. Creek incisions filled with large woody debris and slash within the logged portion (see Figure 1) of the experimental section of upper Paine Creek. Stream flows from left to right.



Figure 3. Use of flood irrigation ditches on both sides of lower Paine Creek (indicated by red arrows). Stream flows from left to right.



Figure 4. Dams constructed throughout length of Paine Creek lower control section (orange line) and on side tributary (blue line). Lower Paine experimental section (Red Line). Upper control for lower Paine (Black line), Upper Paine experimental (Green line). Stream flows from left to right.



Figure 5. Bulldozed gravel in 100 meters of incised E-channel (orange circled area) within the Flat Creek upper control section (black line). Red line indicates a portion of the upper portion of Flat Creek experimental section. Stream flows from left to right.



Figure 6. Flood irrigation ditches and ponds along the lower half of the Flat Creek experimental section (red arrows). Bright green filamentous algae visible in largest pool (blue arrow). Stream flows from left to right.



Figure 7. Dams built throughout the proposed lower control section (orange line) of Flat Creek. Red line indicates initial extent designated for the experimental section. Black line indicates upper control section. Stream flows from left to right.



Figure 8. Dams built throughout proposed lower control section of Spring Creek (orange line). Red line indicates initial extent designated for the experimental section. Black line indicates upper control section. Stream flows from right to left.



Figure 9. Before (above) and after (below) brush beating (removal of woody upland plants such as sagebrush and rabbitbrush) in the experimental section of Spring Creek. Red arrows indicate lateral edge of brush beating area for comparison in both photos. Stream flows from right to left.

Water Temperature

Water Temperature Methods

Autonomous temperature recorders (HOBOS) were placed in the water within the control and experimental sections of each monitoring reach. Temperature was recorded every two hours from early spring through late fall. HOBO placement was replicated each year, with slight modifications each year as stream conditions changed (such as pools expanding behind dams, or other portions of stream drying out). By the final year of the study (2016), HOBO placement throughout the monitoring reaches was increased to include three HOBOS in running water (run), and three HOBOS in dam pools (pool), with both run and pool locations evenly distributed over the length of each monitoring reach. “Run” HOBOS were placed in experimental and control sections. “Pool” HOBOS were placed only in sections where dams were constructed.

Two HOBOS were also hung in willows each year to record air temperature fluctuations at the confluence of Paine and Flat Creeks, and along Spring Creek. When stream HOBO data showed fluctuations in temperature changing to match air temperature fluctuations, it was assumed at that time the stream HOBO was no-longer covered by water in the stream.

There were limited periods of time where synchronized data recording would occur within a monitoring reach due to the fact that runs or pools within the same monitoring reach would often go dry at different times, periodic recorder malfunctions would occur and cattle would sometimes trample HOBOS.

Water Temperature Results

Results are shown (figures 10-14) separately for each year grouped by creek. Data are only shown for years and monitoring reaches that fulfilled the requirements of having at least three data location points (either pools or runs) with concurrent data collection from a submerged HOBO covering a period of time exceeding 18 days.

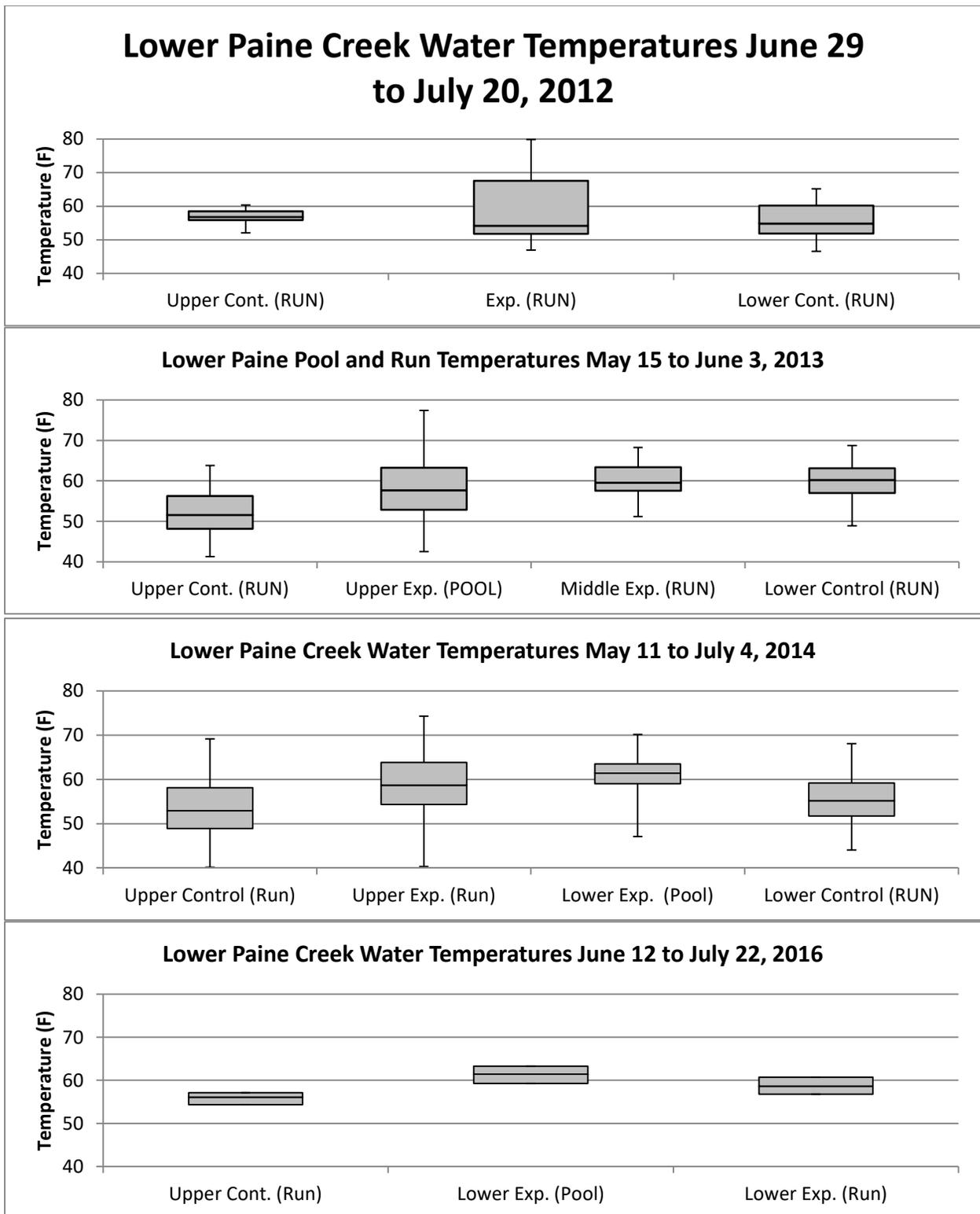


Figure 10. Lower Paine water temperature data for the years 2012, 2013, 2014 and 2016. Vertical axis: temperature in degrees Farenheit. General locations of HOBs (“pool” versus “run”) are listed in order on the horizontal axis with the upstream portion of the creek on the left and the downstream portion of the creek on the right (stream flow is from left to right).

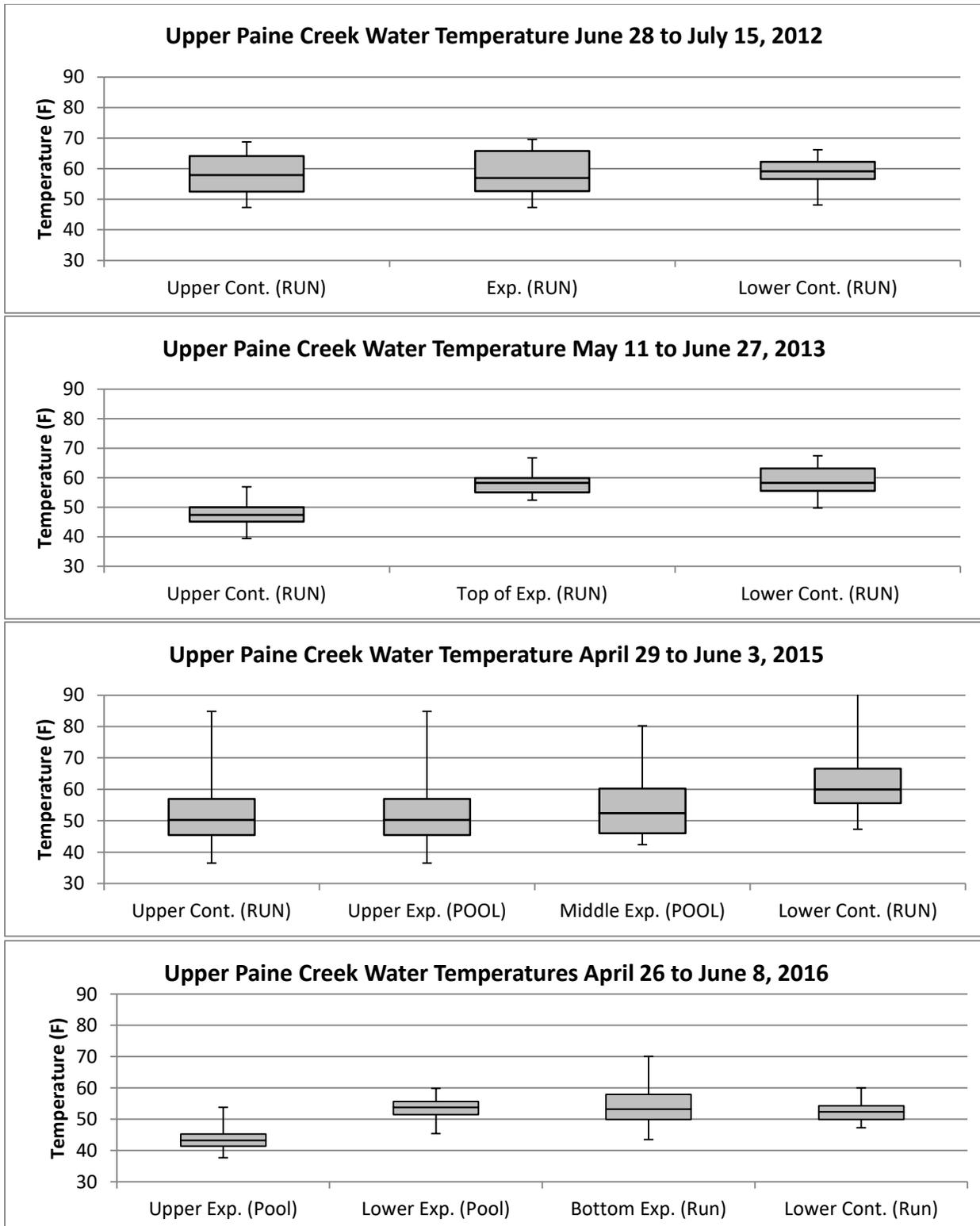


Figure 11. Upper Paine water temperature data for the years 2012, 2013, 2015 and 2016. Vertical axis: temperature in degrees Farenheit. General locations of HOBOS (“pool” versus “run”) are listed in order on the horizontal axis with the upstream portion of the creek on the left and the downstream portion of the creek on the right (stream flow is from left to right).

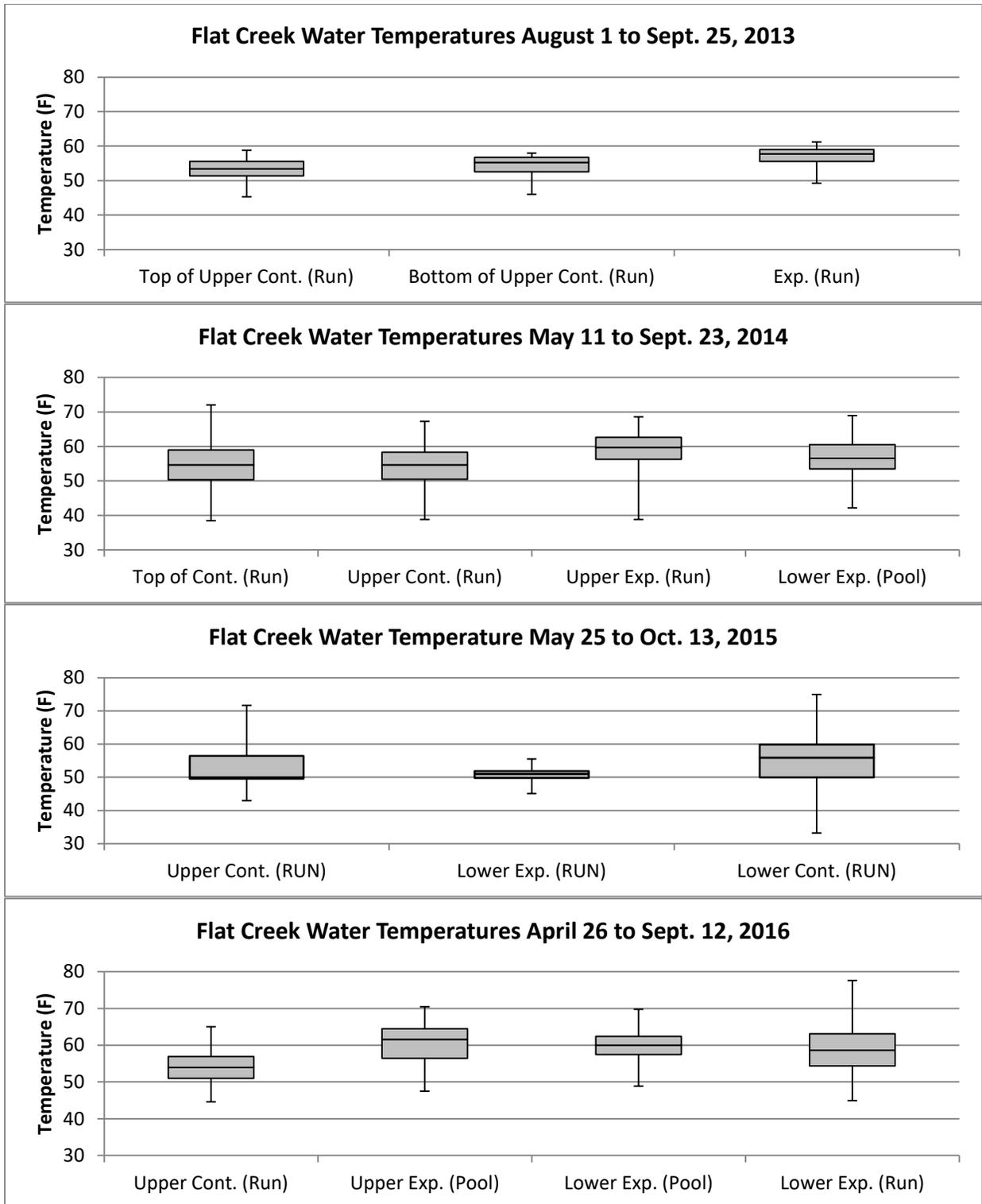


Figure 12. Flat Creek water temperature data for the years 2013, 2014, 2015 and 2016. Vertical axis: temperature in degrees Fahrenheit. General locations of HOBOS (“Pool” versus “Run”) are listed in order on the horizontal axis with the upstream portion of the creek on the left and the downstream portion of the creek on the right (stream flow is from left to right).

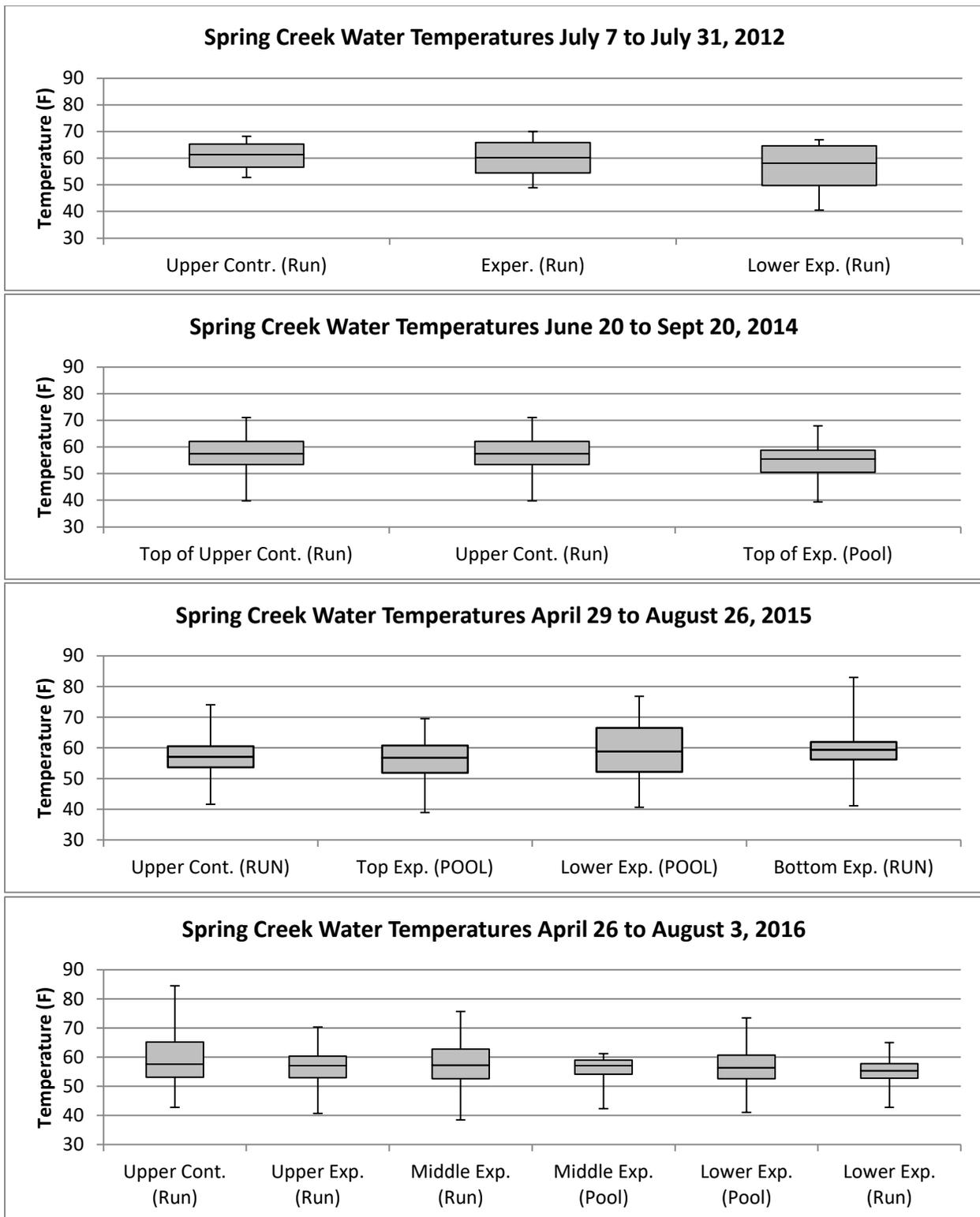


Figure 13. Flat Creek water temperature data for the years 2013, 2015, 2014 and 2016. Vertical axis: temperature in degrees Farenheit. General locations of HOBOS (“pool” versus “run”) are listed in order on the horizontal axis with the upstream portion of the creek on the left and the downstream portion of the creek on the right (stream flow is from left to right).

Water Temperature Discussion

Inter-annual comparisons are not valid due to high annual variation in air temperatures, precipitation rates, temperature changes likely associated with different flow rates and volumes, and the differing time periods/scales over which comparable data was collected.

However, assuming that these inter-annual variations would affect the upper control and experimental reaches equally within the same year, then comparisons in temperature between reaches within the same year and time-period are valid for interpretation. When observing the data in this way we see a repeated pattern in water temperatures of all four monitoring reaches appearing to hold steady (Figure 13) or increase slightly (Figure 10-12) as water moves from the top of the creek through the dammed experimental sections in the years after dam construction (2013 onward). The one seeming exception is on Spring Creek in 2014 (Figure 13). This one exception is a weak indication, since it is only one data point in the pool at the topmost location within the experimental section: in the pool of the topmost dam, which was not deep enough to stratify temperatures.

There is also no indication of cold water temperature refugia occurring within the pools. In three of the four study reaches (Lower Paine, Flat and Spring creeks), pools and runs have similar temperatures, suggesting perhaps that pools are not deep enough to stratify temperatures (Castro et al., 2015). On Upper Paine Creek (Figure 11), the uppermost pool of the experimental reach is unique in that it is formed within a deeply incised channel and heavily shaded by tall mature conifers. It appears that this combination has prevented water temperature increase within the pool as compared to the upstream control immediately above. However, it does not appear that it has contributed to additional cooling beyond initial temperatures suggesting no net benefit.

Overall, pools were observed to be wide and shallow, without significant shade, and often containing large amounts of filamentous algae (Figure 7 and 18); all contributors to or indicators of higher water temperatures and low dissolved oxygen (Belsky, Matzke, Uselman, & Uselman, 1999). These results are not indicative of a strong cooling effect on the overall water temperature profiles in any of the four monitoring creeks as reported for beaver dams in other studies (Castro et al., 2015; Fanelli & Lautz, 2008; Malison et al., 2014).

In arid lands restoration targeting benefits for listed fish species, lowering water temperatures is a typical goal (Isaak et al., 2015; Lawrence et al., 2014). There is no strong or consistent indication that the earthen dams in this monitoring study contributed to the lowering of overall water temperature, or the creation of cold water refugia in deep pools as was achieved in studies monitoring the effects of beaver dams over similar time periods (Anderson, Anderson, Thaxton, & Babyak, 2010; Castro et al., 2015; Gerwing, Johnson, & Alström-Rapaport, 2013).

Changes in Riparian Vegetation:

Changes in Riparian Vegetation Methods

Several hundred photo points were established throughout the four monitoring reaches in 2012 before dam construction began. The majority of photos were re-taken each year. In addition to the creeks where monitoring reaches were established specifically for this project, photo-points were also established, and revisited, on creeks within SVR where dams had been constructed several years before this monitoring project began.

Photo-monitoring was undertaken not as a quantitative analytical tool, but to document individual observations on the ground, to corroborate satellite imagery, and to be used in more effectively describing the observations made to a broader audience. Photo points were included from previously dammed creeks on SVR in attempt to document what may occur on the monitoring reaches in the future.

Satellite imagery from Google Earth was also used to look for or illustrate landscape scale changes in vegetation. Imagery of the monitoring reaches on Flat and Paine creeks is available for June 2016, July 2013, September 2012, August 2011, August 2006 and earlier dates. Imagery for the monitoring reach on Spring Creek is available for June 2016, July 2013, August 2011, August 2007, August 2006 and earlier dates. By using the Google Earth historic imagery slider tool, ocular comparisons in landscape-scale features could be made between years.

Changes in Riparian Vegetation Results



Figure 14. Lower Paine Creek in September 2011 (top) and June 2016 (bottom) showing lack of visible increase in woody riparian vegetation in five years. Stream flows from left to right.



Figure 15. Spring Creek in September 2011 (top) and June 2016 (bottom) showing lack of visible increase in woody riparian vegetation in five years. Stream flows from right to left.



Figure 16. Showing visible vegetation growth in response to beaver dam analogues, lack of large visible pools and lack of vegetation die off on an ungrazed reach of Bridge Creek (near Mitchell, Or.) occurring between July 2011 and July 2014 (2016 imagery not available).



Figure 17. Willow vegetation in a pool on Flat Creek (2015 photo), showing signs of flooding-induced die-off in pool (red circle) versus surviving willows just above the pool (green circle).



Figure 18. Willows dying in lowest pool on Flat Creek. 2013 photo (top), 2016 photo (bottom). Filamentous algae visible in lower photo.



Figure 19. Inundated willows dying in pool of Dam #7 on Flat Creek. Willows on shore behind still alive. 2013 photo (top), 2016 photo (bottom).



Figure 20. Inundated willows and alder dying off in pools in Camp Creek in 2012. Dam #1 (top), dam #16 (below).



Figure 21. Google Earth satellite imagery of Camp Creek showing live woody riparian vegetation in 2006 (top), and die-off (gray clumps) after dam construction 2011 (middle) and 2016 (bottom).



Figure 22. Photos showing vegetation growth at roughly the same location within the enclosure on Flat Creek before it was constructed (2013), and one year after it was constructed (2016). Red circle indicates area of most visible change.



Figure 23. Photos showing lack of new willow growth in an area with existing willows immediately outside the Flat Creek enclosure (foreground, lower photo 2016). Upper photo of same location before enclosure was constructed in 2013. Invasive mullen growing on the dam (lower photo).



Figure 24. Documenting lack of willow regeneration on Spring Creek from 2012 (top photo) to 2016 (bottom).



Figure 25. A dam on Spring Creek showing invasive thistle growth.

Changes in Riparian Vegetation Discussion

In general, very little has changed in regards to riparian woody vegetation in the monitoring reaches, especially those on Spring and lower Paine creeks (Figures 14 and 15). Upper Paine was subjected to significant vegetation modification as part of the forestry work, so is not shown, and Flat Creek is discussed separately below. To demonstrate the validity of the assumption that it would be reasonable to see vegetative change via Google Earth within a 5-year timeline, imagery spanning three years is shown from a similar cooperative project involving beaver dam analogues on Bridge Creek, near Mitchell, Oregon (Figure 16).

The largest changes that were observed in riparian vegetation at SVR were related to the die-off of inundated, previously existing, woody riparian vegetation (Figures 17-21). Satellite data from Google Earth indicate that this seems to be a pattern that was repeated on other dammed creeks within SVR (Figure 21). This may be an indicator, that perhaps for attaining goals related to the restoration of woody riparian vegetation in these low-gradient, already pre-vegetated areas, that more subtle techniques may have been more effective such as much smaller dams or focusing on increasing sinuosity (Bouwes et al., 2016; Castro et al., 2015).

Another pattern observed was the apparent lack of willow regeneration in areas surrounding existing willows. While this was not a direct objective of the study, observations indicate that willow regeneration and expansion is extensive and widespread within the enclosure built in the middle of the experimental section of Flat Creek (Figure 21), and essentially absent on all other monitoring sections (Figures 23 and 24). Figure 23 shows an area immediately outside of the Flat Creek enclosure where pre-existing willow are not regenerating. The Flat Creek enclosure is constructed of 1-meter-high barbed wire and therefore only excludes cattle, and not deer or elk (Figure 23). While deer and elk have shown themselves capable of heavily impacting riparian woody vegetation growth in eastern Oregon and in other western states (Kay, 1994; Marshall, Thompson Hobbs, & Cooper, n.d.; Matney, Boyd, & Stringham, 2005) it appears that cattle may be the largest consumer of riparian vegetation on SVR, and therefore, likely a hindrance to the widespread regeneration of woody riparian vegetation there, as has been found at numerous other locations throughout the West (Belsky et al., 1999; Beschta, Boone Kauffman, Dobkin, & Ellsworth, 2014; Krueper, 1996; Small, Frey, & Gard, n.d.). Therefore, this may indicate that restoration efforts in active grazing areas such as SVR may be more effective if paired with planting efforts and the construction of enclosures.

While previous SVR monitoring reports documented weedy species growing in association with dams and gravel pit areas used to build dams, no landscape scale quantitative study was undertaken to understand if these weed densities and associations were unusual. However, casual observation does suggest that one was more likely to encounter weedy species in areas which were disturbed in the construction of dams than in other areas (Figure 23 and 25).

Water Tables

Water Table Methods

To document relative water table height longitudinally and horizontally, water table wells were installed on control and experimental sections of the four monitoring reaches beginning in the fall of 2012 (Appendix I, Monitoring Reach Study Design). The water table well array design was modeled after Boyd *et al.* (2012). Where soil conditions allowed, three wells were drilled per stream side (“A” and “B”) in each of the experimental and control sections. In each section well #3 was located one meter away from the stream water’s edge. A second well (#1) was located at the farthest edge of the wet meadow habitat in a perpendicular line to the stream, even with well #3. A third well (#2) was located at the midpoint between the first well (water’s edge, #3) and the second well (edge of the wet meadow, #2) forming a line of three wells roughly perpendicular to the stream valley. Where soil conditions allowed, a total of twelve individual wells were therefore located on each stream.

Wells consisted of 60-inch-long, 1-inch perforated PVC pipe with a removable cap on top. Holes were drilled in the ground to a maximum depth of 59 inches using a Bobcat-mounted auger drill.

Water Table Results

Figures 25 through 28 show all water table height measurements taken since project inception in 2012. Three graphs are shown for each creek, grouping together only wells representing equal distances from water’s edge. Graph legends are ordered to show upstream wells at the top of the legend continuing in order to the downstream-most well at the bottom of the legend. Data was collected only at actual “points” indicated on graph: connecting lines do not indicate actual data and are only included as an aid in viewing any annual changes in ordination of water table heights between sections.

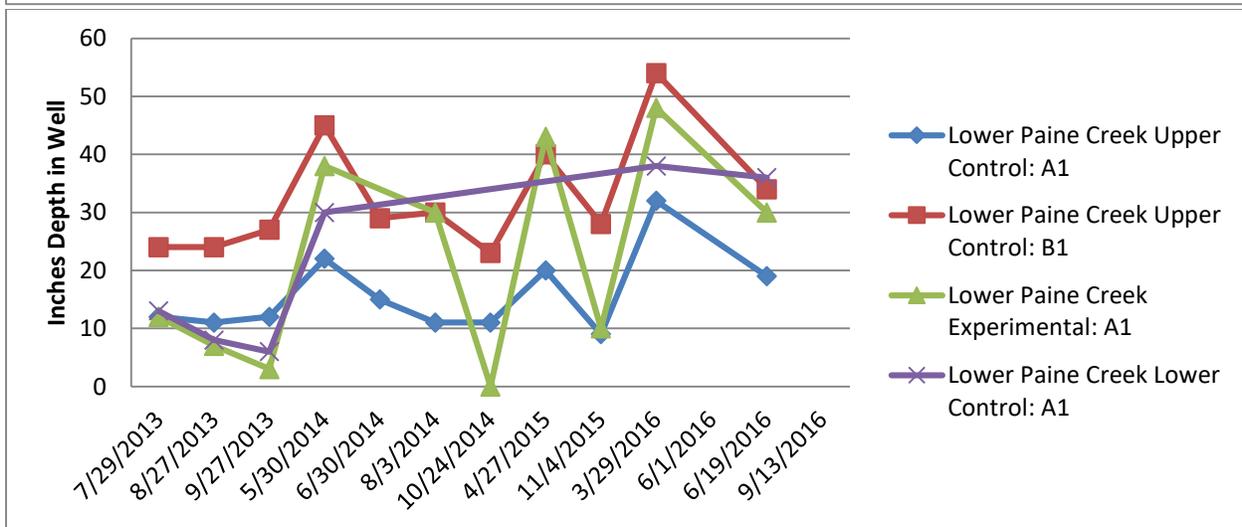
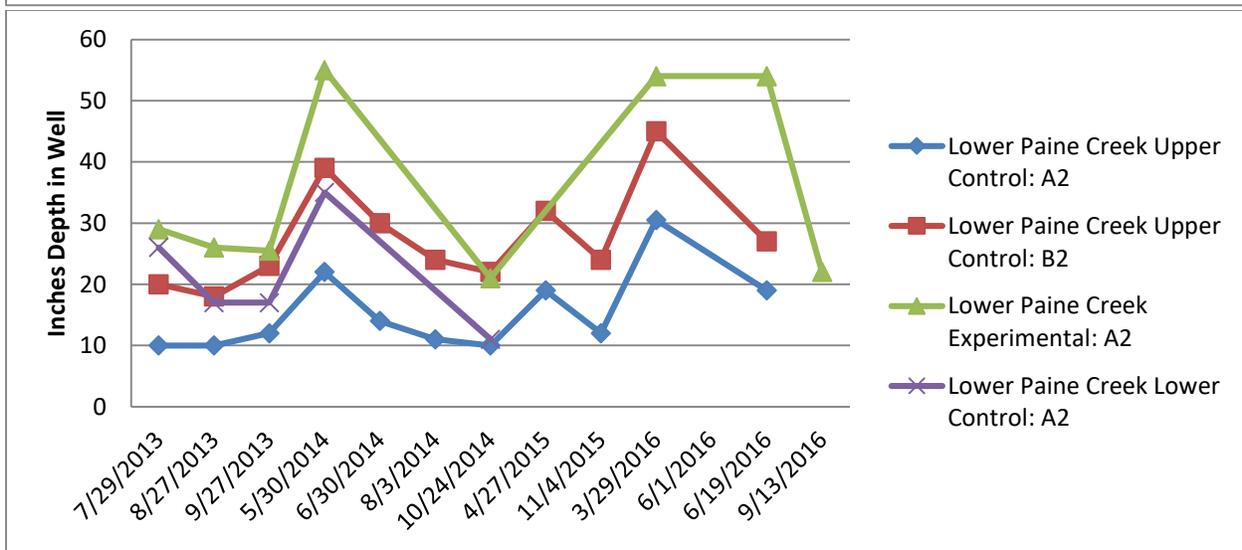
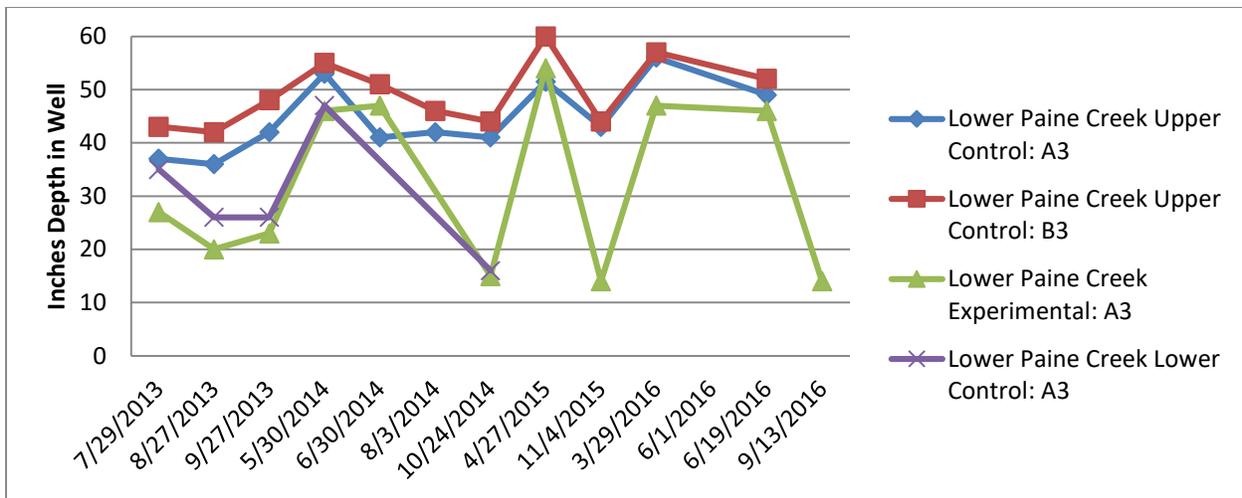


Figure 25. Water table height measured at wells on lower Paine Creek. Wells nearest the creek are in the upper graph, mid distance wells shown in middle graph and wells farthest from the creek are shown in the bottom graph.

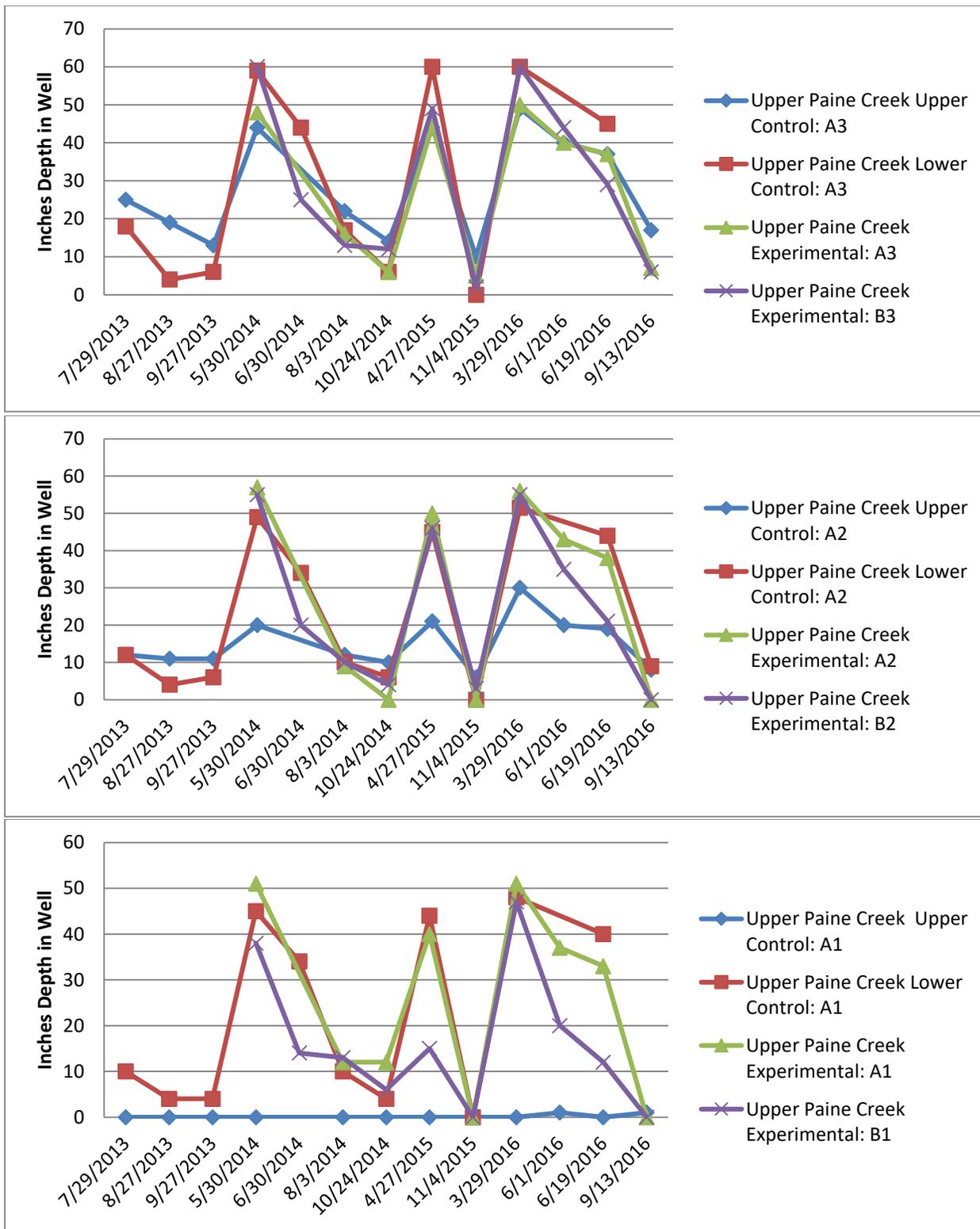


Figure 26. Water table height measured at wells on upper Paine Creek. Wells nearest the creek are in the upper graph, mid distance wells shown in middle graph and wells farthest from the creek are shown in the bottom graph.

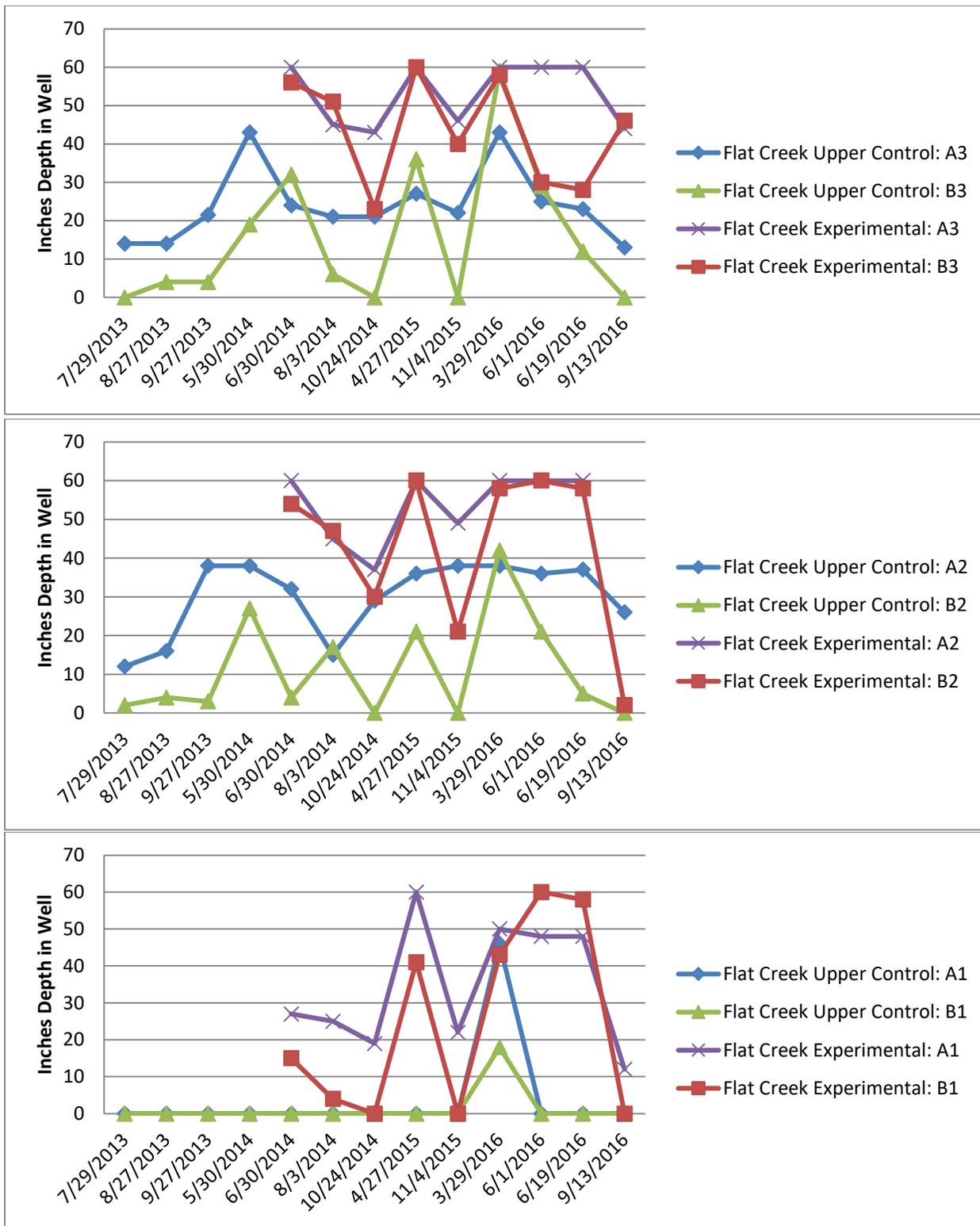


Figure 27. Water table height measured at wells on Flat Creek. Wells nearest the creek are in the upper graph, mid distance wells shown in middle graph and wells farthest from the creek are shown in the bottom graph.

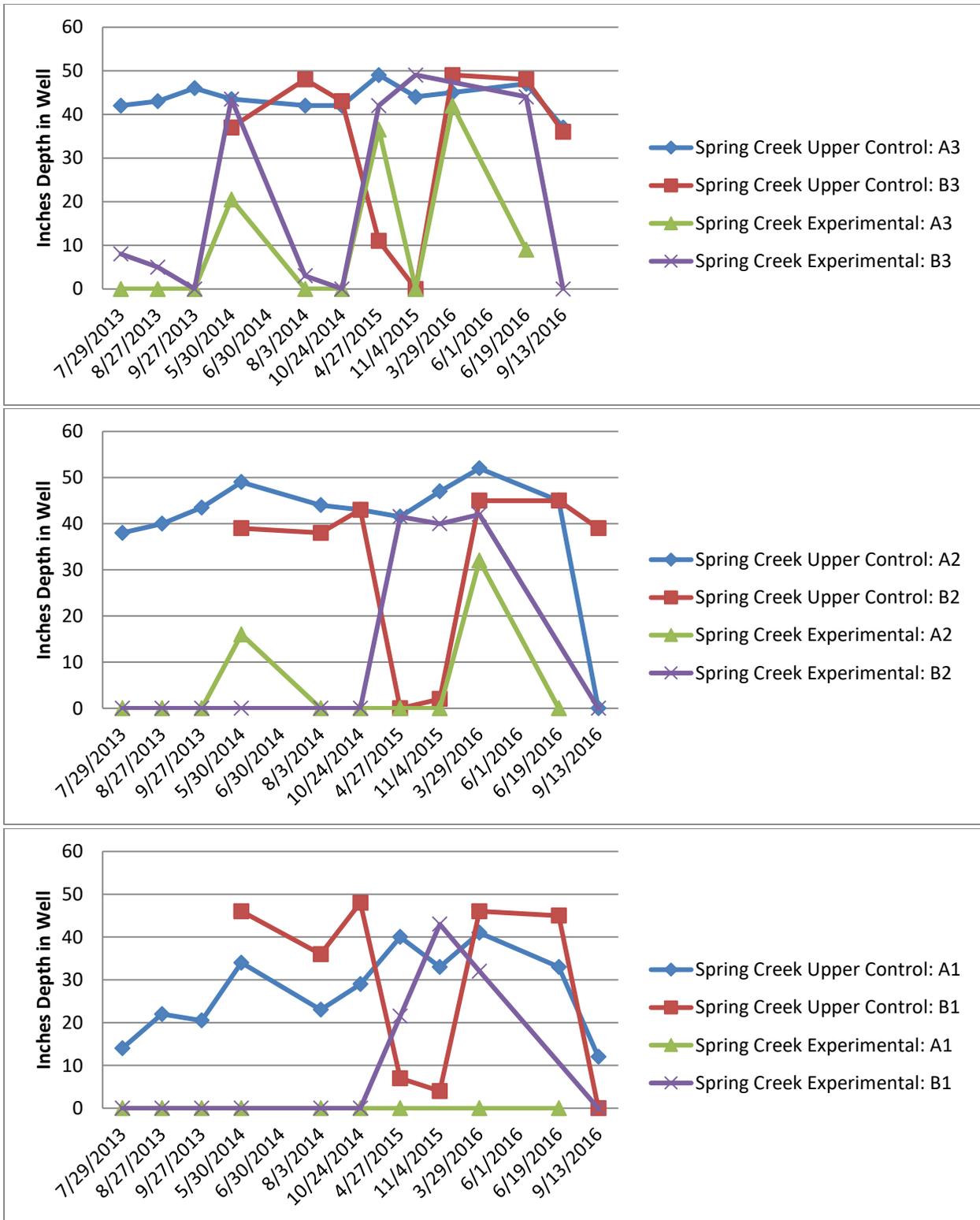


Figure 28. Water table height measured at wells on Spring Creek. Wells nearest the creek are in the upper graph, mid distance wells shown in middle graph and wells farthest from the creek are shown in the bottom graph.



Figure 29. Google Earth images from July 30, 2016 of monitoring reaches on Flat and Paine creeks (top) and Spring Creek (bottom) showing pools behind dams on Flat and lower Paine creeks, and no pools on control reaches, or behind dams on upper Paine and Spring creeks.

Water Table Discussion

High annual variation in precipitation rates and snowpack over the years observed invalidates inter-annual comparisons of *absolute* water table levels. However, one can assume that inter-annual variations would affect the control and experimental reaches equally within the same year; therefore comparisons in relative changes between these reaches within the same year would be valid for interpretation.

In interpreting the water table data it is important to take into account the confounding factors described in the experimental design section (see page 4) and their potential impacts on water table depth. For example:

- Large-scale removal of the ponderosa forest, forest thinning of surrounding uplands and the removal of all shrub cover (brushbeating) could alter water tables by reducing the number of larger trees evapotranspiring water, reducing precipitation interception cover and by changing remaining lower stature plant cover composition.
- Filling creek incisions with large woody debris or gravel could also alter water tables by physically raising the bottom of the creek and creating more head pressure to push the water into, or up onto, the surrounding plain.
- Use of flood irrigation ditches could alter water tables by moving water higher up onto the surrounding valley slopes, where by design it leaks back down over the soil surface forming pools, soaking back into the soil, evaporating or evapotranspiring.
- Dams built on side tributaries could alter water tables by restricting the flow of water into monitoring reaches below or by forcing water into the water table of the monitoring reaches below.

Initial study design involved examining water table data trends to assess if dams holding back water result in water infiltrating the ground and raising the water table level. Such patterns would involve inter-annual changes in ordination of the *relevant* height of water measured between equidistant wells (i.e. all “#3” wells) in the same monitoring reach. For example, upper control wells being consistently higher or the same (relative to experimental sections) in the first year of data collection and then becoming lower (relative to the experimental sections), in later years. However, owing to the confounding factors listed above, attributing the causality of any such patterns would not be valid.

Initial study design also involved assessing water table data patterns for indications that the dams create a horizontal expansion of the water table. Again, owing to the confounding factors listed above, such comparisons are not valid.

Regardless of confounding factors, small changes in water tables may be very difficult to detect owing to the low gradient and significant width of the monitoring reaches. For example, the addition of a large amount of water (200,000 gallons) to the water table over a 13-acre area (such as the upper Paine Creek control section) would only raise the water table less than an inch.

A potentially useful and valid question to examine that was not part of the original design is: Has the amount of visible surface water changed within the study reaches over the course of the study? For the same reasons as have been discussed above, this question cannot address the causality of the changes in visible surface water nor the overall utility of the surface water. The utility (to restoration efforts) of water stored subsurface is that it can act to cool water temperatures, can be slowly released over the drier seasons of the year, and can irrigate riparian vegetation that cannot survive permanent inundation.

To address the question of changes in surface water we looked at Google Earth imagery from June 30, 2016 (Figure 29). These images show large pools of water behind dams on lower Flat Creek and lower Paine Creek. No pools are visible behind dams on upper Paine Creek and Spring Creek. Surface water is not visible in large amounts within any of the control sections. No large pools were present in any of these dammed areas before the inception of monitoring. From these observations, however, it is still not possible to attribute the difference in surface water to dams, since for instance, the pools also occur where there are flood irrigation canals and are absent in areas where there are no irrigation canals.

Aquatic Macroinvertebrate and Fish Surveys

Aquatic Macroinvertebrate and Fish Survey Methods

Reaches were sampled for macro-invertebrate abundance and diversity, and fish presence, in 2012, 2013 and 2016. In September 2012, sampling took place in lower Paine Creek upper control, Flat Creek experimental, Flat Creek lower control, and Spring Creek upper control. The other reaches were not sampled due to lack of water. During the first week of July 2013, sampling occurred on upper Paine Creek upper control, upper Paine Creek experimental, lower Paine Creek upper control, lower Paine Creek experimental, Flat Creek upper control, Flat Creek experimental, Flat Creek lower control, and Spring Creek upper control. In September 2016 sampling took place on lower Paine Creek upper control and experimental sections, Flat Creek upper control and lower control sections and on Spring Creek upper control (Table 1).

A one-foot-square surber net was used to sample all flowing segments of a stream section. A one-foot D-shaped net was used to sample all pooled sections of streams backed up behind dams. For each stream reach, one square foot of stream was sampled at a time. The stream substrate was disturbed for two minutes and all disturbed materials flowed downstream into the surber or D-net. After two minutes, the substrate collected within the nets was placed in a five-gallon bucket and the net was cleaned. This procedure was repeated at even intervals along the entire reach until 8 square feet had been sampled. Once all samples were collected, the sediment was taken to a field lab site where it was thoroughly scanned for macro-invertebrates. Jars were labeled for each reach and insects were stored in a 70% solution of

isopropyl alcohol and shipped to Aquatic Biology Associates in Corvallis, Oregon for a full detailed taxonomic analysis (Robert Wisseman, Senior Scientist 3490 NW Deer Run Street, Corvallis, OR 97330 bob@aquaticbio.com). To assess presence or absence of fish, reaches sampled for macroinvertebrates were also electroshocked for fish (Table 1). Each fish sighted was identified to species and returned to the stream. Small streams reaches were shocked over their entire length.

Sample timing was adaptive throughout the study. In 2012 we sampled in September to allow that year’s weather and stream conditions to influence the macroinvertebrate community. However, many sections of the monitoring reaches were dry at this time of year, precluding sampling, and therefore did not allow for a complete comparative “snapshot” of conditions between those different sections. This gap was remedied by more comprehensive sampling conducted in July 2013. All running sections of monitoring reaches were sampled in 2013. In order to allow for legitimate comparisons between “before” and “after” conditions, final sampling was conducted in September again in 2016. Comparisons between data collected at different times of the year in 2013 and 2016 are not valid.

Table 1. Sections of each monitoring reach and the years that they were sampled for macroinvertebrates and fish: September 2012, July 2013 and September 2016.

Section	Sampling Occurred In:		
	2012	2013	2016
Upper Paine: Upper Control		X	
Upper Paine: Experimental		X	
Lower Paine: Upper Control	X	X	X
Lower Paine: Experimental		X	X
Flat Creek: Upper Control		X	X
Flat Creek: Experimental	X	X	X
Flat Creek: Lower Control/Exp.	X	X	X
Spring Creek: Upper Control	X	X	X

Aquatic Macroinvertebrate and Fish Survey Results

Table 2. Macroinvertebrate sampling summary data for lower Paine Creek experimental and upper control sections and upper Paine Creek experimental and upper control sections for years 2012, 2013, and 2016.

Waterbody Location Date	Lower Paine Experimental 2013-07-02	Lower Paine Upper Cont. 2012-09-10	Lower Paine Upper Cont. 2013-07-01	Lower Paine Upper Cont. 2016-09-27	Upper Paine Experimental 2013-07-01	Upper Paine Upper Cont. 2013-07-01
Total taxa richness	22	26	24	30	10	12
Total abundance	1498.33	2267.67	234.03	316.07	172.16	34.97
EPT taxa richness	2	7	7	6	1	3
EPT abundance	2.69	223.27	13.45	21.52	68.59	12.11
Shannon-Weaver Diversity (loge)	1.47	1.44	2.06	2.67	1.48	2.25
Shannon-Weaver Diversity (log2)	2.12	2.07	2.97	3.86	2.14	3.24
Shannon Evenness Index	0.47	0.44	0.65	0.79	0.64	0.9
Total tolerant taxa richness	12	13	10	14	6	6
Total tolerant abundance	1049.1	2039.02	195.03	169.47	153.33	18.83
Highly tolerant taxa richness	5	3	3	2	1	0
Highly tolerant abundance	958.99	88.77	9.41	2.69	65.91	0
Moderately tolerant taxa richness	7	10	7	12	5	6
Moderately tolerant abundance	90.11	1950.25	185.61	166.78	87.42	18.83
Total intolerant taxa richness	1	1	0	1	0	1
Total intolerant abundance	2.69	5.38	0	1.34	0	4.04
Highly intolerant taxa richness	0	0	0	0	0	0
Highly intolerant abundance	0	0	0	0	0	0
Moderately intolerant taxa richness	1	1	0	1	0	1
Moderately intolerant abundance	2.69	5.38	0	1.34	0	4.04
Semivoltine taxa richness	2	6	5	4	0	2
Univoltine taxa richness	8	14	13	12	4	8
Multivoltine taxa richness	12	6	6	14	6	2
Semivoltine abundance	34.97	266.31	88.77	37.66	0	2.69
Univoltine abundance	133.16	1899.14	127.78	130.47	82.05	29.59
Multivoltine abundance	1330.2	102.22	17.48	147.95	90.11	2.69

Table 3. Macroinvertebrate sampling summary data for Flat Creek experimental and upper control sections for years 2012, 2013, and 2016.

Waterbody Location	Flat Creek Lower Cont.	Flat Creek Lower Exp.	Flat Creek Lower Exp.	Flat Creek Exp.	Flat Creek Exp.	Flat Creek Exp.	Flat Creek Up. Cont.	Flat Creek Up. Cont.
Date	2012-09-26	2013-07-02	2016-09-27	2012-09-28	2013-07-03	2016-09-26	2013-07-03	2016-09-26
Total taxa richness	34	27	33	23	25	26	21	24
Total abundance	856.76	458.64	1824.3	603.9	149.29	6155.23	166.78	16656.48
EPT taxa richness	5	0	1	3	2	2	2	5
EPT abundance	9.41	0	143.65	5.38	25.55	3907.53	4.04	484.2
Shannon-Weaver Diversity (loge)	2.27	2.5	2.71	1.39	2.67	1.65	2.42	1.78
Shannon-Weaver Diversity (log2)	3.28	3.6	3.91	2.01	3.85	2.38	3.49	2.57
Shannon Evenness Index	0.64	0.76	0.78	0.44	0.83	0.51	0.79	0.56
Total tolerant taxa richness	14	11	20	12	13	17	10	8
Total tolerant abundance	594.49	212.51	1120.44	503.03	57.84	5371.42	94.15	12427.8
Highly tolerant taxa richness	2	2	8	3	5	9	4	2
Highly tolerant abundance	9.42	106.25	721.82	5.38	24.21	5014.09	6.72	64.56
Moderately tolerant taxa richness	12	9	12	9	8	8	6	6
Moderately tolerant abundance	585.07	106.25	398.62	497.65	33.62	357.33	87.42	12363.24
Total intolerant taxa richness	4	3	0	2	1	0	2	0
Total intolerant abundance	39	29.59	0	41.7	1.34	0	20.18	0
Highly intolerant taxa richness	0	0	0	0	0	0	0	0
Highly intolerant abundance	0	0	0	0	0	0	0	0
Moderately intolerant taxa richness	4	3	0	2	1	0	2	0
Moderately intolerant abundance	39	29.59	0	41.7	1.34	0	20.18	0
Semivoltine taxa richness	10	4	2	7	4	0	6	1
Univoltine taxa richness	15	12	11	11	8	11	8	9
Multivoltine taxa richness	9	11	20	5	13	15	7	14
Semivoltine abundance	242.1	72.63	25.14	98.19	28.25	0	65.91	96.84
Univoltine abundance	562.21	99.53	420.16	465.37	68.59	553.28	72.63	2453.28
Multivoltine abundance	52.45	286.49	1379	40.35	52.45	5601.95	28.25	14106.36

Table 4. Macroinvertebrate sampling summary data for Spring Creek upper control sections and upper Paine Creek experimental and upper control sections for years 2012, 2013, and 2016.

Waterbody Location Date	Spring Creek Upper Cont. 2012-09-27	Spring Creek Upper Cont. 2013-07-04	Spring Creek Upper Cont. 2016-09-26
Total taxa richness	33	31	38
Total abundance	1023.54	423.67	5450.88
EPT taxa richness	6	9	9
EPT abundance	83.39	63.21	248.64
Shannon-Weaver Diversity (loge)	2.14	2.82	2.14
Shannon-Weaver Diversity (log2)	3.09	4.07	3.08
Shannon Evenness Index	0.61	0.82	0.59
Total tolerant taxa richness	13	9	8
Total tolerant abundance	747.82	186.95	3021.89
Highly tolerant taxa richness	3	2	1
Highly tolerant abundance	490.93	60.52	1654.39
Moderately tolerant taxa richness	10	7	7
Moderately tolerant abundance	256.89	126.43	1367.5
Total intolerant taxa richness	4	1	4
Total intolerant abundance	24.21	10.76	181.7
Highly intolerant taxa richness	0	0	0
Highly intolerant abundance	0	0	0
Moderately intolerant taxa richness	4	1	4
Moderately intolerant abundance	24.21	10.76	181.7
Semivoltine taxa richness	9	6	5
Univoltine taxa richness	17	17	15
Multivoltine taxa richness	7	8	18
Semivoltine abundance	260.93	165.44	2486.37
Univoltine abundance	256.89	125.08	430.33
Multivoltine abundance	505.72	133.16	2534.18

Aquatic Macroinvertebrate and Fish Survey Discussion

In 2012, 2013 and 2016, speckled dace were recorded in Flat Creek and Paine Creek but not in upper Paine Creek or Spring Creek. No other fish species were recorded. Dam construction does not seem to have impacted this species.

Assemblages of benthic macroinvertebrates species can be used to qualitatively compare water temperatures and dissolved oxygen levels of lotic systems (Poff *et al.* 2006). For example, higher richness of Ephemeroptera, Plecoptera and Trichoptera (EPT) taxa, as well as an assemblage of taxa classified as “intolerant,” of warm water temperatures and low dissolved oxygen, together are indicative of cooler water temperatures and more dissolved oxygen present, than in a similar creek with lower counts those species. Higher counts of taxa “tolerant,” of warm water temperatures and low dissolved oxygen, are more commonly found in streams with higher water temperatures and lower dissolved oxygen than in cooler, more oxygenated streams. Lowering temperatures and increasing oxygen levels in the water are often goals in native fish habitat restoration (Isaak, Young, Nagel, Horan, & Groce, 2015; Lawrence et al., 2014).

Paine Creek:

Macroinvertebrate sampling on Paine Creek allowed for comparisons 1) between samples collected in 2012 and 2016 on the lower Paine Creek upper control section, 2) between the lower Paine Creek experimental and the lower Paine upper control sections in 2013 and, 3) between the upper Paine Creek experimental and the upper Paine Creek control sections in 2013 (Table 1).

Water temperatures and dissolved oxygen levels, as indicated by species counts of macroinvertebrates, of the undammed lower Paine Creek upper control section were similar, or warmer and less oxygenated, in 2016 than they were in 2012 (Table 2). More specifically, Paine Creek control sample counts of EPT taxa decreased (seven to six) from 2012 to 2016. Sample counts were higher for total tolerant taxa richness in 2016 than in 2012 (14 and 13 respectively). Highly tolerant taxa richness declined from three to two and moderately tolerant taxa richness increased from ten to 12 from 2012 to 2016 respectively. Sample counts for intolerant taxa richness were the same in 2012 and 2016: no highly intolerant taxa and only one moderately intolerant taxa were observed in samples in both years.

Samples collected in 2013 in the lower Paine Creek experimental section and lower Paine Creek upper control reach allow for a comparison (“snap shot”) between conditions in the control and experimental sections for that year. Lower Paine Creek has no lower control (See Experimental Design page 3). Comparisons of species counts of macroinvertebrates taken in these two sections indicate that the water temperature was cooler and more oxygenated in the control section than in the experimental section (Table 2). More specifically, EPT taxa richness was higher in the control section than in the experimental section (12 and 10 respectively). Total counts for tolerant taxa were higher in the experimental section (12 versus 10 in the control

section). Only one moderately intolerant taxa was collected from the experimental section, and none were collected from the control section.

Samples collected in 2013 in the upper Paine Creek monitoring and upper control reaches allow for a comparison (“snap shot”) between conditions in the control and experimental sections for that year. Comparisons of species counts of macroinvertebrates taken in these two sections indicate that the water temperature was cooler, and more oxygenated in the control section than in the experimental section (Table 2). EPT taxa richness was higher in the control section than in the experimental section (three and one respectively). Total counts for tolerant taxa were the same in the experimental section (6). Only one moderately intolerant taxa was collected from the control section, and none were collected from the experimental section.

Flat Creek:

Macroinvertebrate sampling on Flat Creek allowed for comparisons 1) between samples collected in 2012 on the control and experimental sections before dams were constructed on either of those two sections, 2) between the experimental and the upper control sections in 2013, 3) between the experimental section and the upper control section in 2016, 4) between the lower control section in 2012 (before dams were mistakenly built on it) and the same section in 2016 (renamed “lower experimental”) after dams were constructed, and 5) between the experimental section in 2012 (before dams were built on it) and the same section in 2016 (Table 1).

Water temperatures and dissolved oxygen levels in 2012 were similar in the lower control and pre-construction/undammed experimental section (Table 3). While the Flat Creek lower control sample counts of EPT taxa were higher than in the experimental section (five versus three respectively), and total intolerant taxa richness was higher for the lower control section than the experimental section (4 versus 2), the experimental section had lower tolerant taxa counts than the control section (12 versus 14 respectively). In 2013 (after the construction of dams) the Flat Creek lower control section (renamed “lower experimental”) and the Flat Creek experimental section, counts reversed and were lower for EPT taxa and tolerant species in the lower experimental section (zero versus two and 11 versus 13 respectively). Counts of intolerant taxa remained higher for the lower experimental section in comparison to the experimental section after dam construction (three versus one respectively).

Sample counts collected in 2013 from the Flat Creek lower experimental, experimental and upper control sections indicate that water temperature and dissolved oxygen levels were similar in these sections or perhaps slightly cooler in the control section than in the experimental sections (Table 3). The control section had higher EPT taxa richness than the lower experimental section, but not the regular experimental section (two, zero and two respectively). Tolerant taxa richness was higher in samples collected from the lower and regular experimental sections than from the control section (11, 13 and 10 respectively). Intolerant taxa counts were highest in the lower experimental section (three), lowest in the regular experimental section (one) and intermediate in the control section (two).

By 2016, a more notable difference in the taxa counts between the control and experimental sections was observed, indicating cooler more highly oxygenated water in the control section than in the experimental sections of Flat Creek (Table 3). In 2016, counts for EPT taxa were higher in the Flat Creek control section than in either of the Flat Creek experimental sections (five, and 2 and 1 respectively). Counts of tolerant taxa in the experimental sections were more than double those counted in the control section, and no intolerant species were collected in any of the 2016 Flat Creek samples.

The construction of dams on the lower control section of Flat Creek appears to have increased water temperatures and decreased levels of oxygenation in the water between 2012 and 2016 (Table 3). EPT taxa richness was five before dams were constructed and one in 2016. Total tolerant taxa richness increased from 14 to 20 after dam construction, and intolerant taxa richness dropped from four to zero after dam construction.

Similar patterns were observed on the regular experimental section with data collected in 2012 (before dam construction) and in 2016 (Table 3). EPT taxa richness was higher before dam construction (three versus two respectively). Counts for tolerant taxa increased from 12 to 17 after dam construction and intolerant taxa counts dropped from two to zero.

Spring Creek:

Only the undammed control section of the Spring Creek monitoring reach was sampled in 2012 and 2016. Species counts of macroinvertebrates of this undammed section indicate that the water temperature was similar or cooler, and water was more oxygenated in 2016 than it was in 2012 (Table 4). While this conclusion cannot be used to compare with the adjacent experimental sections of Spring Creek (unsampled due to lack of water), it does provide some corroboration to similar patterns showing limited or no change in water temperature and dissolved oxygen levels in undammed, control sections over the course of the study.

More specifically, Spring Creek control sample counts of EPT taxa increased (six to nine) from 2012 to 2016. Sample counts were lower in all “tolerant” assemblages in 2016 than in 2012. Total tolerant taxa richness sample counts declined from 13 to eight, highly tolerant taxa richness declined from three to one and moderately tolerant taxa richness declined from ten to seven from 2012 to 2016 respectively. Sample counts for “intolerant” taxa richness were the same in 2012 and 2016.

Conclusions

Several patterns may be observed in the data from the monitoring reaches. Due to the numerous significant confounding factors involved in land management surrounding the dams, necessitated by operating a working ranch, we were not able to statistically test for the causality of these trends. However, in general, the sum of our observations and monitoring efforts at SVR suggest the following answers in regard to our original questions:

1. Did earthen dams lower water temperatures? There was no indication in the HOBO data of this occurring. Conversely, the large earthen dams that we monitored created wide, shallow pools on small streams appear to increase overall water temperatures.
2. Did earthen dams increase woody riparian vegetation cover? Large amounts of willow growth and expansion was observed in areas where cattle, but not elk or deer, were excluded. Areas where cattle had not been excluded were observed to either have had no obvious expansion in willow cover or to have had a visible decrease in willow cover.
3. Did earthen dams expand or raise water table levels? There were numerous landscape-scale confounding factors present that may be influencing water table levels and interfering with attributing causality. However, no clear indication was found that water tables levels increased within the experimental reaches versus the control reaches. The exception to this is the obvious increase in surface water (pools) in two of the four monitoring reaches. However, due to other confounding factors present, the causality of the increase in surface water cannot be clearly attributed only to the presence of earthen dams.
4. Did earthen dams lower water temperatures and improve water (as measured by macroinvertebrates)? Dammed creek sections had population assemblages that indicated warmer water temperatures and lower levels of dissolved oxygen in the water than in adjacent undammed sections sampled concurrently. Samples of macroinvertebrates collected before and after dam construction also consistently showed counts of taxa that indicated increases in water temperatures and decreases in dissolved oxygen levels after dams were built. Overall, water temperature and dissolved oxygen on the control sections did not appear to change over the course of the study. These patterns corroborate the HOBO temperature gauge data results. There were no changes observed in fish species occurrence or distribution during the course of the study.

Recommendations for Future Monitoring

It remains unclear if enough time was allowed to see a difference, or improvement, in a situation in which active grazing was occurring. Building on current data could help address this question, and could be conducted at a much lower level of intensity. Based on our experience over the past five years, the most parsimonious approach to continuing data collection to address this question would be: 1) biannually monitoring vegetation conditions by revisiting and photographing representative locations on the creeks and extrapolating those findings using remote sensing or drone imagery to the larger watersheds; 2) using remote sensing or drone imagery to expand assessments of riparian vegetation changes to the numerous creeks at SVR which had dams constructed on them several years before the three reaches monitored in the current study; and 3) documenting continuations of patterns in stream temperatures and dissolved oxygen using aquatic macroinvertebrate samples collected on the original monitoring reaches, biannually in September.

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Appendix I: Monitoring Reach Study Design Diagram

