Reed Canarygrass Research Program

2021 Findings and Results: Irely Creek

10,000 Years Institute

January 2022

Project Coordinator – Celia Thurman
Research Assistants – Lara Hakam, Onyx Yskamp, Miguel Rodriguez
Field Technicians – Seth Miles, Mathew Nichols

Contents

Title Page:
Figure 1. Infestation of reed canarygrass along the left bank of Irely Creek at Transect 2.
Figure 2. Looking upstream from Irely Creek at Transect 4.

Figure 3. Collecting dissolved oxygen at the uppermost reach of the study site, Irely Creek Transect 1.

Overview

The Reed Canarygrass Research Program (RCRP) goals are to observe and quantify the effects of an invasive grass, *Phalaris arundinacea* (reed canarygrass; RCG) on water quality and ecosystem function in small coastal streams of the Olympic Peninsula. RCG threatens aquatic ecosystems with its ability to rapidly colonize streams and wetlands via seed, rhizome, and vegetative fragments. The species acts as an ‘ecosystem engineer’ by creating dense, sod-forming monocultures.[1]

Data collected in the field consists of stream and air temperature, dissolved oxygen (DO), photosynthetic active radiation (PAR), canopy cover, vegetative character, stream velocity, and substrate composition. Regularly scheduled sampling occurred from spring to late fall, as field conditions safely and reasonably allowed. Temperature data is collected year-round. The data summarized in this report was collected between April 6 and November 18, 2021.

In 2021 the RCRP is collected data in two streams: Irely Creek and Wilson Creek. A tributary to the Bogachiel River in the Quillayute watershed (WRIA 20), Wilson Creek was the site of the original pilot study in 2019 and is in the third year of data collection. Lying within the Upper Quinault watershed (WRIA 21), Irely Creek was established as a site in 2020 and is in the second year of data collection. A third order stream, Irely Creek encompasses 1.5 miles (2.4 km) of salmonid spawning area.[2] Results are available for both streams at www.10000yearsinstitute.org/reed-canarygrass-research-program.

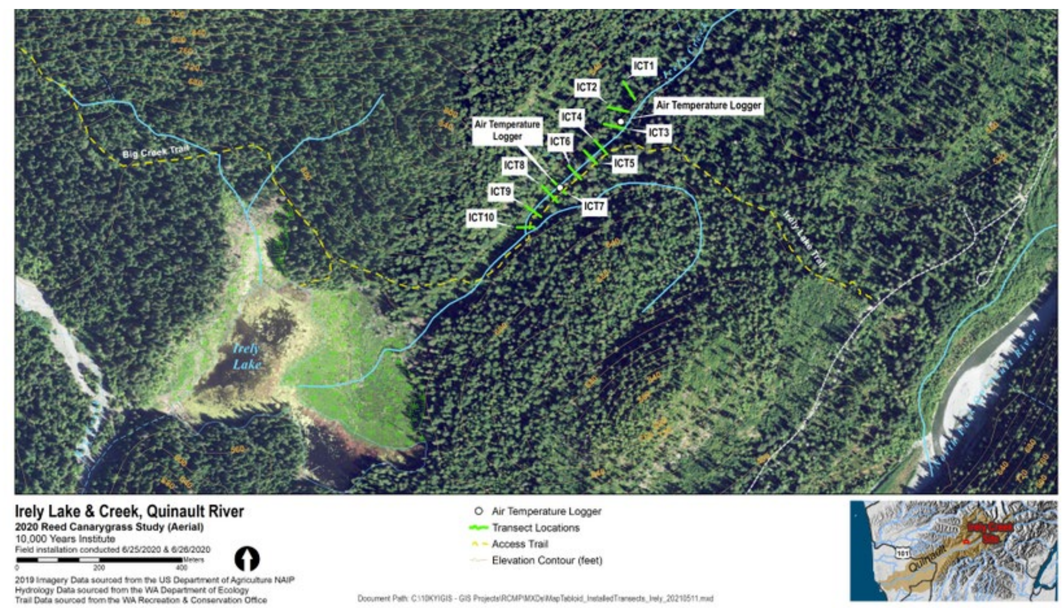


Figure 4. Irely Creek shown in blue, and the ten cross-stream transects are marked in green, with the air temperature loggers marked with white dots.

[1] Maurer D. A., Lindig-Cisneros R., Werner K. J., Kercher S., Miller R., and Zedler J. B. (2003). **The replacement of wetland vegetation by reed canarygrass (*Phalaris arundinacea*)**. *Ecological Restoration, 21* (2), 116-119. http://www.jstor.org/stable/43442677. Accessed Feb. 15, 2018.

[2] Vadas, R. L., Beecher, H. A., Boessow S. N., and Kohr, J. H. (2016). **Coastal Cutthroat Trout Redd Counts Impacted by Natural Water Supply Variations**. *North American Journal of Fisheries Management,* 36, 900-912. DOI: http://dx.doi.org/10.1080/02755947.2016.1173138

Site Conditions

Throughout 2021, conditions in Irely Creek have remained sufficient for most sampling purposes but were affected by two significant factors in 2021: beaver activity and low summer flows. Since the original scouting of the study reach in July 2019, beavers have constructed multiple dams, ponding and rerouting the stream channel. During installation of the monitoring equipment in June 2020, a five-foot high beaver dam was discovered spanning the creek for approximately 200 feet between Irely Creek transects 6 and 7 *(Figure 5)*. During the site visit on July 14, 2021, another beaver dam was discovered immediately downstream of ICT09 *(Figure 6)*. These beaver dams created pools at ICT06 and ICT09, making flow velocity difficult to measure.

Channel response to seasonally low precipitation in July and August 2021 was exacerbated by the 'heat dome' in late June and resulted in a considerable drop in stream discharge by late summer. The low discharge eventually caused sections of the creek to dry out completely. By the September 8 visit, transects 3 to 7 in the middle of the study reach were reduced to disconnected puddles, insufficient for measurements of flow velocity (*Figure 8*). As reported by Vadas et al. in 2016, these low flow events are an increasing trend in mid- to late-summer for Irely Creek, but the occurrence of dry channel segments is especially prominent during increasing climate disruption.[3,4,5]

Figure 5. The beaver dam just upstream of ICT07 on April 6, 2021.

Figure 6. The beaver dam downstream of ICT09 on November 17, 2021.

[3] Vadas, R. L., Beecher, H. A., Boessow S. N., and Kohr, J. H. (2016). **Coastal Cutthroat Trout Redd Counts Impacted by Natural Water Supply Variations**. *North American Journal of Fisheries Management,* 36, 900-912. DOI: http://dx.doi.org/10.1080/02755947.2016.1173138

[4] Gaines, W. L. et al. (2022). **Climate change and forest management on federal lands in the Pacific Northwest, USA: Managing for dynamic landscapes**. *Forest Ecology and Management*, 504(15). DOI: https://doi.org/10.1016/j.foreco.2021.119794

[5] Clifton, C. F. (2018). **Effects of climate change on hydrology and water resources in the Blue Mountains, Oregon, USA**. *Climate Services*, 10, 9-19. DOI: https://doi.org/10.1016/j.cliser.2018.03.001

Site Visits

Crew: Celia Thurman, Miguel Rodriguez, Sarah Watkins, Mathew Nichols, Seth Miles, Onyx Yskamp, Lara Hakam

Site Visits: May 10-11, June 2-3, July 14-15, July 26-27, August 18-19, September 8-9, September 21-22, October 7-8, November 16-17

Nine bi-monthly sampling visits were conducted at Irely Creek this year. Each visit generally consisted of sampling field temperature, dissolved oxygen (DO), flow velocity, and photosynthetic active radiation (PAR) or canopy coverage. These measurements were collected in ten locations throughout the reach, at each of the cross-stream riparian transects.

- Temperature data were uploaded once per month from the HOBO Pendant™ data loggers throughout the field season (*Figure 9*). The equipment remains in Irely Creek for data collection throughout winter 2021-2022.
- Dissolved oxygen data was collected using an optical meter (Hanna Instruments Model 98198) near each temperature logger.
- Flow velocity was measured near each transect, in areas of sufficient depth and minimal flow interference (e.g., no downed wood or sharp curves in the stream). A Swoffer flow meter (Model 3000) was used to calculate depth and flow velocity (ft/s) at numerous intervals across the stream (*Figure 12*). After ten transects were successfully completed, a replicate measurement was collected for quality assurance purposes.
- Light availability was quantified using an Apogee MQ-200™ meter to detect PAR along each riparian transect. This metric was collected at ten equidistant locations along each transect.
- In October 2021, the protocol for estimating canopy cover was updated from measuring PAR to taking hemispherical photos, as described below. This protocol will be fully developed and standardized by the 2022 field season.[6]

Stream and Air Temperature

Stream and air temperature data were collected at each monitoring point by HOBO Pendant™ temperature loggers between January 1 and November 17-18, 2021 and summarized in thermographs (see Appendix A). Differences in sample size for each logger are due to:

- Timing - Deployment date and time of day vary slightly for each temperature logger.
- Environmental conditions - Data was discarded from the stream temperature samples if the streamflow dropped and thermographs were exposed to air, no longer collecting water temperature data.
- Equipment error - There were instances when water loggers required new batteries or replacement.

These differences are reflected by blank space in the thermographs in Appendix A. Minimum, maximum, and average water and air temperature are summarized below for the time period between January 1 and the last site visit of the season on November 17-18, 2021 (*Figure 7, Table 1*).

[6] Andis, A. Z. (2020). "Smartphone hemispherical photography". **A. Z. Andis: Ecology, Evolution, and Conservation**. Web. Accessed 10 Nov 2021. URL: http://www.azandisresearch.com/2020/12/16/smartphone-hemispherical-photography/

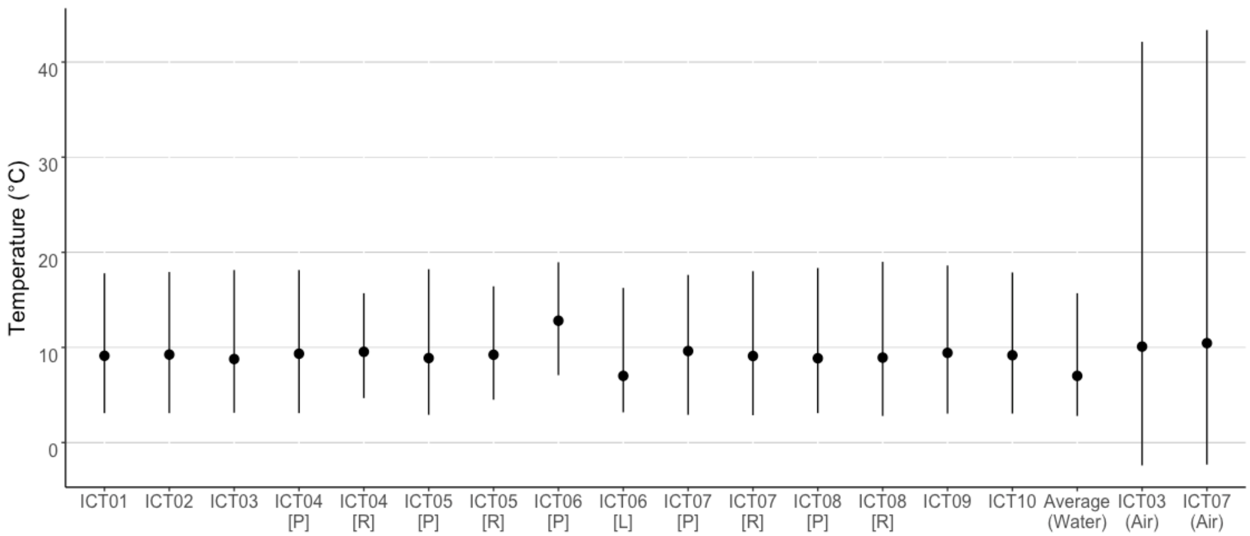


Figure 7. Minimum, maximum, and average stream temperature (°C) for each Irely Creek Transect (ICT). Points represent water temperature averages, while lines represent the range of minimum and maximum for each transect. "Average" is the average water temperature, minimum, and maximum between all ten transects.

Transect	Min Temp. (°C)	Max Temp (°C)	Avg. Temp. (°C)	Std. Dev.	Sample Size (n)	Std. Error
Average (W)	2.81	21.12	9.42	3.84	344484	0.0001
ICT01	3.09	17.80	9.12	3.38	23142	0.0002
ICT02	3.09	17.93	9.25	3.43	23141	0.0002
ICT03	3.13	18.14	8.78	3.65	17202	0.0002
ICT04 [P]	3.09	18.14	9.34	3.60	23141	0.0002
ICT04 [R]	4.67	15.70	9.54	3.36	23138	0.0002
ICT05 [P]	2.91	18.23	8.88	3.43	21547	0.0002
ICT05 [R]	4.5	16.43	9.23	3.24	21939	0.0002
ICT06 [P]	7.08	18.96	12.81	2.42	9465	0.0003
ICT06 [L]	3.17	16.26	7.01	2.68	12597	0.0002
ICT07 [P]	2.91	17.63	9.62	4.21	18477	0.0002
ICT07 [R]	2.87	18.02	9.10	3.69	21483	0.0002
ICT08 [P]	3.09	18.36	8.86	3.58	17465	0.0002
ICT08 [R]	2.79	19.00	8.93	3.61	20198	0.0002
ICT09	3.04	18.62	9.43	3.57	23076	0.0002
ICT10	3.04	17.89	9.18	3.49	20147	0.0002
ICT03 (Air)	-2.41	42.13	10.09	6.56	23139	0.0003
ICT07 (Air)	-2.32	43.37	10.45	6.95	23083	0.0003

Table 1. Summarized stream and air temperature data (°C) for each Irely Creek Transect (ICT).

Figure 8. The logger at ICT05 was out of the water during our site visit on September 5, 2021, due to late summer drought.

Figure 9. Downloading data from the submerged temperature logger at ICT02 on May 11, 2021.

Dissolved Oxygen

Dissolved oxygen (mg/L) was measured and summarized for the seasonal minimum, maximum, and average at each location where data was collected (*Figure 9, Table 2*). Each channel location was sampled eight or nine times between May 5 and November 18, 2021, with the exception of side channels that dried up during the summer drought.

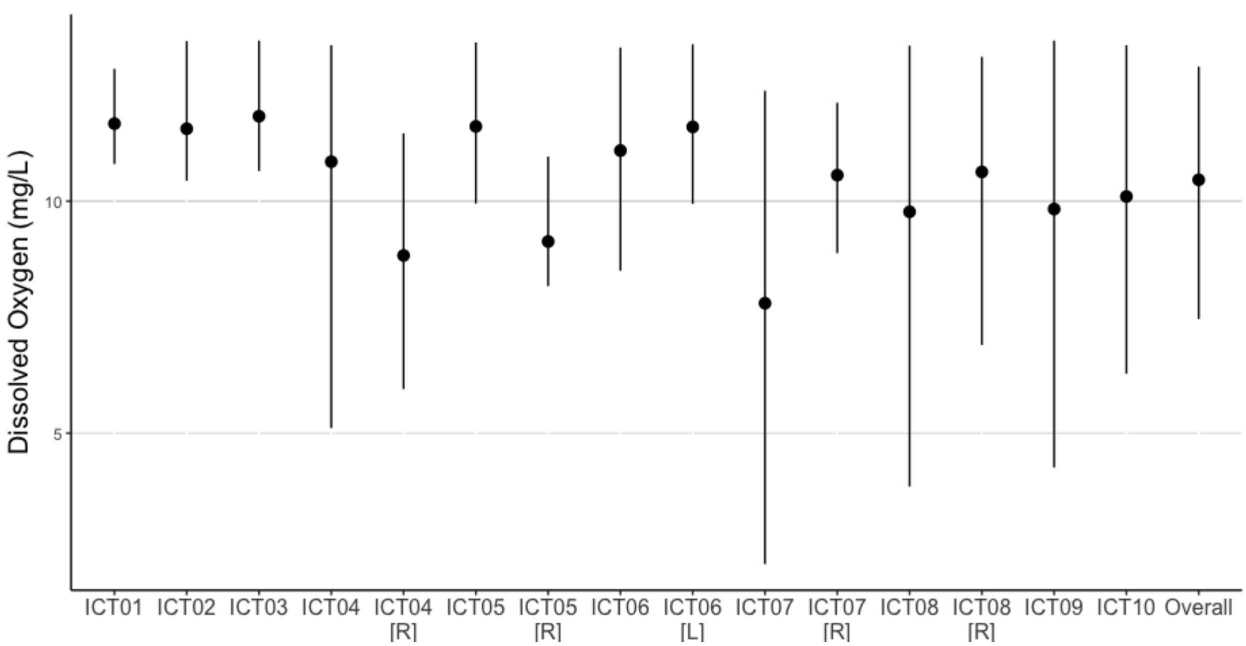


Figure 10. Minimum, maximum, and average dissolved oxygen measurements (mg/L) for each Irely Creek Transect (ICT) within the study reach. Points on the chart represent averages, while lines represent the range of minimum and maximum for each transect.

Transect	Min. DO (mg/L)	Max. DO (mg/L)	Avg. DO (mg/L)	Std. Dev.	Sample Size (n)	Std. Error
Overall	7.46	12.90	10.46	2.24	123	0.02
ICT01	10.80	12.85	11.67	0.81	9	0.09
ICT02	10.44	13.45	11.56	3.95	8	0.49
ICT03	10.65	13.46	11.83	1.00	8	0.13
ICT04 [P]	5.11	11.46	10.85	2.45	9	0.27
ICT04 [R]	5.95	10.96	8.83	1.60	9	0.18
ICT05 [P]	9.95	13.38	11.61	1.28	9	0.14
ICT05 [R]	8.17	12.12	9.13	0.96	8	0.12
ICT06 [P]	8.50	13.11	11.09	1.54	9	0.17
ICT06 [L]	9.94	13.36	11.60	1.72	3	0.57
ICT07 [P]	2.18	13.42	7.80	3.96	9	0.44
ICT07 [R]	8.88	13.31	10.56	3.89	7	0.56
ICT08 [P]	3.85	12.38	9.77	3.04	9	0.34
ICT08 [R]	6.90	13.35	10.63	2.00	8	0.25
ICT09	4.26	13.46	9.83	2.95	9	0.33
ICT10	6.28	13.36	10.10	2.41	9	0.27

Table 2. Summarized dissolved oxygen data (in mg/L) for each Irely Creek Transect (ICT) within the study reach.

Flow Velocity

Flow velocity (ft/s) was measured at each site visit at 13 to 20 intervals across the stream at each transect (*Figure 12).* Measurements were collected and averaged to obtain a representative measure of stream flow (*Figure 11, Appendix C*). Each transect location was sampled between two and eight times throughout the 2021 season, when the water level was deep enough to submerge the sampling equipment, and the stream was wide enough to get a full sample set of 13-20 measurements. The noticeable gap in collected data is a result of low flow conditions of late-summer drought. ICT06 and ICT09 were not sampled in 2021 due to beaver dam construction obscuring measurable flow (*Figure 13)*.

Figure 12. Measuring stream velocity at ICT05.

Figure 13. ICT06 is just above the original beaver dam and lacks sufficient flow to measure stream velocity.

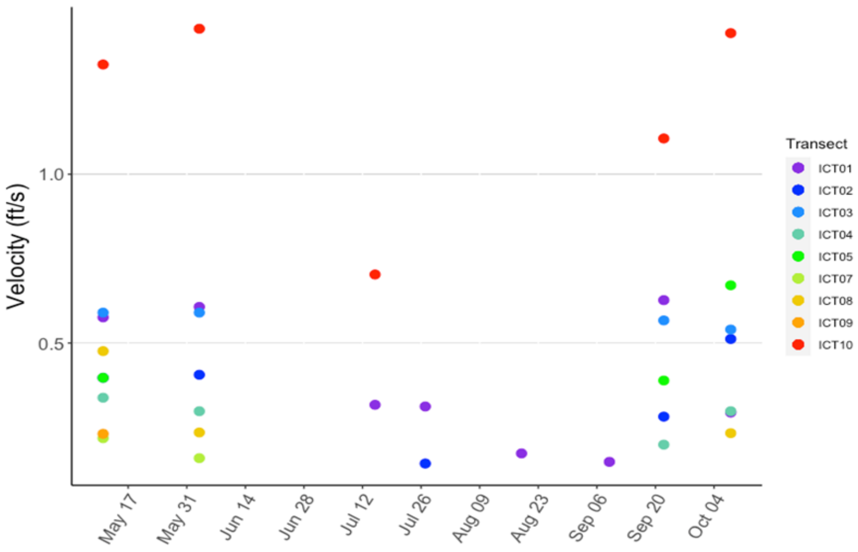


Figure 11. Average flow velocity (ft/s) at each Irely Creek transect. Appendix C depicts each transect separately.

Transect	Min. Flow (ft/s)	Max. Flow (ft/s)	Avg. Flow (ft/s)	Std. Dev.	Sample Size (n)	Std. Error
Overall	0.285	0.608	0.455	0.143	4.75	0.065
ICT01	0.173	0.627	0.382	0.194	8.000	0.069
ICT02	0.143	0.512	0.314	0.150	6.000	0.061
ICT03	0.319	0.590	0.523	0.116	5.000	0.052
ICT04	0.199	0.338	0.283	0.059	4.000	0.030
ICT05	0.389	0.617	0.486	0.160	3.000	0.093
ICT06	N/A	N/A	N/A	N/A	N/A	N/A
ICT07	0.159	0.218	0.188	0.042	2.000	0.030
ICT08	0.194	0.476	0.270	0.116	5.000	0.052
ICT09	N/A	N/A	N/A	N/A	N/A	N/A
ICT10	0.703	1.431	1.200	0.305	5.000	0.136

Table 3. Summarized flow velocity (in ft/s) for each Irely Creek Transect (ICT) within the study reach.

Photosynthetic Active Radiation (PAR)

PAR (µmol m^{-2}) was measured in micromoles per square meter at ten equidistant intervals along each cross-stream transect to quantify riparian solar radiation. PAR measurements were averaged at each transect for each site visit, creating a daily average (*n=10*). These averages were then combined for each transect, representing a total seasonal average (*Figure 14*).

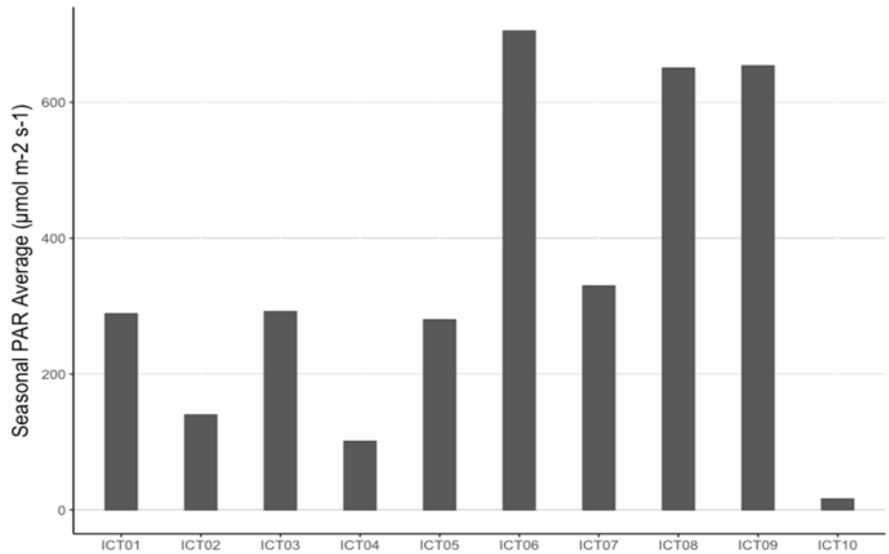


Figure 14. Photosynthetic active radiation (PAR) seasonal average indicating amount of solar radiation along each riparian transect at Irely Creek.

PAR measurements are highly dependent on weather conditions and provide more information about sunlight intensity at a specific time than overall canopy structure. On September 22, 2021, the protocol for estimating canopy cover was changed, and PAR collection was replaced by canopy cover measurements using hemispherical photos *(Figure 15a*). These are taken using the spherical panorama function available on most cameras and then transformed into black and white binary images (*Figure 15b*). From here, the number of dark pixels (canopy) and the number of white pixels (open sky) are extracted to obtain an estimate of canopy coverage (as a percentage). This method is more accurate and more precise than the previous PAR methodology. A standardized methodology is under development, and results will be available in 2022.

Figure 15a. A hemispherical photo in color after it is transformed from the 360° photo taken in the field at ICT01.

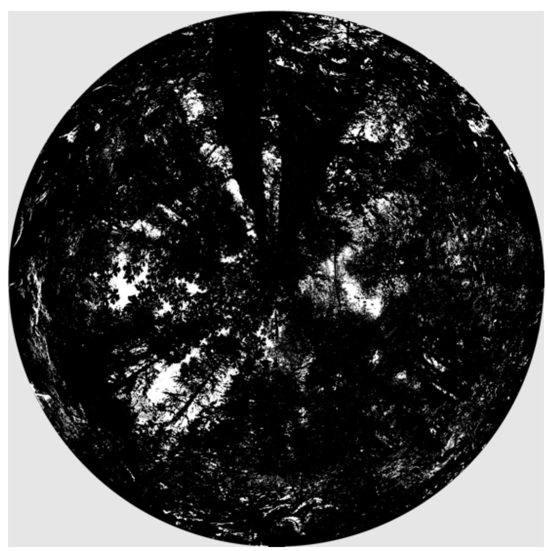


Figure 15b. A binary hemispherical photo where open areas are represented as white pixels and canopy cover as black pixels.

Vegetation Survey

Crew: Celia Thurman, Sarah Watkins
Site Visits: June 21-22, June 29

The 2021 Irely Creek vegetation survey revealed a total species richness of 64 species within the Irely Creek study reach (Appendix B). Percent cover of reed canarygrass was estimated for each of the ten quadrats along each transect of the vegetation survey, with 100 quadrats total in the whole reach. Under the current methodology, in which transects cross the unvegetated stream channel, no significant correlation can be made between RCG percent cover and percent coverage of other species (*Figure 16*).

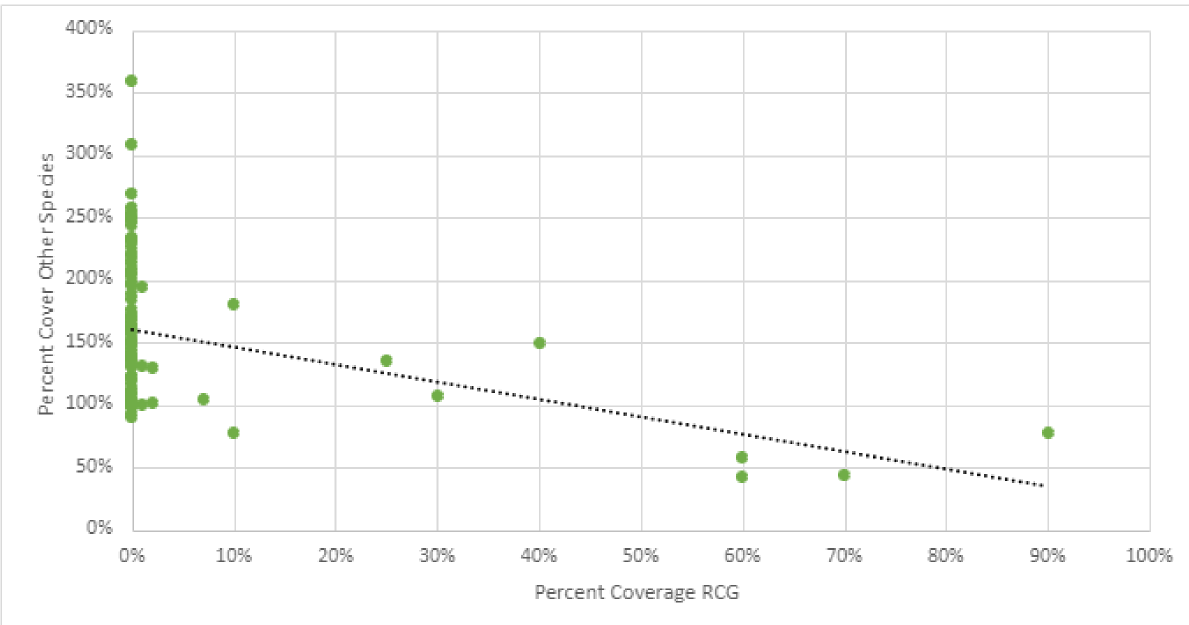


Figure 16. Estimated percent cover of *Phalaris arundinacea* compared to percent cover of other species in each quadrat measured during the 2021 Irely Creek vegetation survey (R^2=0.0331 p=0.07, p<0.05).

Figure 17. The 1m² quadrat placement along the left bank of Irely Creek at ICT06 with native sedge as the dominant species.

Figure 18. This quadrat at ICT08 contained a mixture of reed canarygrass with native lady fern (*Athyrium filixfemina*) and other native grasses.

Upon review of literature, RCG is often associated with the reduction in vegetation diversity, which is contrary to what the RCRP study currently shows. The conclusion was reached that the current methodology is not sufficiently capturing RCG percent cover along the study reach.

For the upcoming 2022 field season, data will be collected in vegetation survey plots along the stream bank, with point-intercept surveys for species diversity starting from the 'greenline' (closest point of rooted vegetation to the stream) so that unvegetated areas in the scoured channel are not included (*Figure 19*).

Figure 19: The transect line at ICT06 falls across the active channel, missing large patches of RCG present in the forefront.

Wolman Pebble Count

Crew: Celia Thurman, Mathew Nichols, Miguel Rodriguez, Seth Miles, Lara Hakam
Site Visits: April 6 and November 17-18

Pebble counts were conducted at each transect at the beginning and end of the 2021 field season (*Figure 20*).

Data collection was conducted near a 'riffle' or 'run' geomorphic habitat unit. The D_{50} (50th percentile measurement) of each sample was determined to represent general substrate composition (*Table 3*).

Due to high flows and safety concerns in mid-November, not all transects were sampled during the end-of-season pebble count.

Transect	April 6, 2021		November 17-18, 2021	
	D_{50} Size Range	Size Class	D_{50} Size Range	Size Class
ICT01	17-32 mm	Coarse Gravel	17-32 mm	Coarse Gravel
ICT02	17-32 mm	Coarse Gravel	33-64 mm	Very Coarse Gravel
ICT03	17-32 mm	Coarse Gravel	33-64 mm	Very Coarse Gravel
ICT04	9-16 mm	Gravel	17-32 mm	Coarse Gravel
ICT05	17-32 mm	Coarse Gravel	17-32 mm	Coarse Gravel
ICT06	9-16 mm	Gravel	--	--
ICT07	17-32 mm	Coarse Gravel	--	--
ICT08	9-16 mm	Gravel	9-16 mm	Gravel
ICT09	9-16 mm	Gravel	--	--
ICT10	9-16 mm	Gravel	17-32 mm	Coarse Gravel

Table 3. D_{50} size range and general size class for each Irely Creek Transect (ICT) pebble count conducted within the study reach.

Figure 20. Measuring sediment size at ICT01 during the end-of-season pebble count on November 18, 2021.

Discussion

The Irely Creek study reach is influenced by several biotic and climatic impacts that complicate the stream response to reed canarygrass, including beaver engineering, extreme drought, and channel avulsions. Under these complex conditions, we have yet to determine whether the current study design can establish a response to reed canarygrass. We're grateful to our recently engaged team of advisors, including Alex Foster (ecologist with the USFS Pacific NW Research Station), Robert Vadas (senior fisheries researcher with WDFW and Irely cutthroat trout study lead) and Gino Lucchetti (retired King County senior ecologist and 10KYI board member). We're also grateful for collaboration with Olympic National Park's senior fisheries biologist, Patrick Crain, chief botanist, Janet Coles, and permit coordination by Matt Dubeau. We will work with all our partners to validate the study methods and design. Data collection will continue at Wilson and Irely Creek in 2022 and additional study sites will be considered.

Acknowledgements

We appreciate your interest and support for this project. The impacts of invasive reed canarygrass on Pacific Northwest cold-water ecosystems require continued investigation. We appreciate the opportunity to conduct this research. Please contact us if you have questions, recommendations, or are interested in partnering with the Reed Canarygrass Research Program, or the work of 10,000 Years Institute:

Jill Silver, Executive Director: jsilver@10000yearsinstitute.org

References

Andis, A. Z. (2020). **Smartphone hemispherical photography**. *A. Z. Andis: Ecology, Evolution, and Conservation*. Web. Accessed 10 Nov 2021.

Bilhimer, D., Stohr, A., and Ward, W. (ed.). (2013). **Standard Operating Procedures for continuous temperature monitoring of freshwater rivers and streams conducted in a Total Maximum Daily Load (TMDL) project for stream temperature, version 3.0**. *Washington Department of Ecology*, Environmental Assessment Program. Web. Accessed 9 Dec 2021.

Clifton, C. F. (2018). **Effects of climate change on hydrology and water resources in the Blue Mountains, Oregon, USA**. *Climate Services*, 10, 9-19. DOI: https://doi.org/10.1016/j.cliser.2018.03.001

Dunham, J., Chandler, G., Rieman, B., and Martin D. (2005). **Measuring stream temperature with digital data loggers: a user's guide**. US Department of Agriculture, Forest Service, Rocky Mountain Research Station. Web. Accessed 9 Dec 2021.

Gaines, W. L. et al. (2022). **Climate change and forest management on federal lands in the Pacific Northwest, USA: Managing for dynamic landscapes**. *Forest Ecology and Management*, 504(15). DOI: https://doi.org/10.1016/j.foreco.2021.119794

Lavergne, S. and Molofsky, J. (2004). **Reed Canary Grass (*Phalaris arundinacea* as a Biological Model in the Study of Plant Invasions**. *Critical Reviews in Plant Sciences*, 23(5), 415-429. DOI: https://doi.org/10.1080/07352680490505934.

Maurer, D. A., Lindig-Cisneros, R., Werner, K. J., Kercher, S., Miller, R., and Zedler, J. B. (2003). **The replacement of wetland vegetation by reed canarygrass (*Phalaris arundinacea*)**. *Ecological Restoration, 21*(2), 116-119. DOI: http://www.jstor.org/stable/43442677.

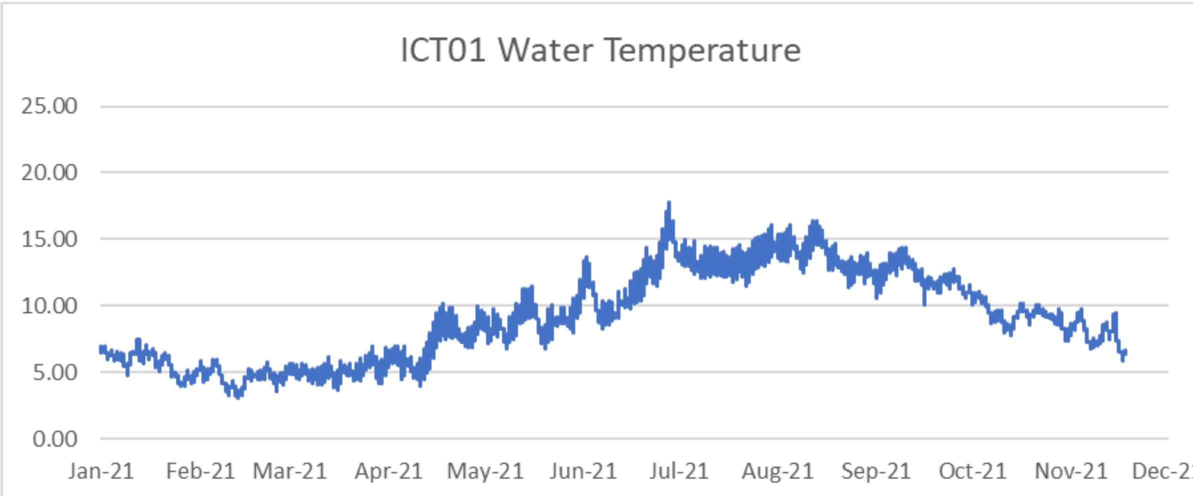
Minkova, T. and Foster, A. (2017). **Status and Trends Monitoring of Riparian and Aquatic Habitat in the Olympic Experimental State Forest: Monitoring Protocols**. *Washington State Department of Natural Resources*, Forest Resources Division, (7) 7-8. Web. Accessed 9 Dec 2021.

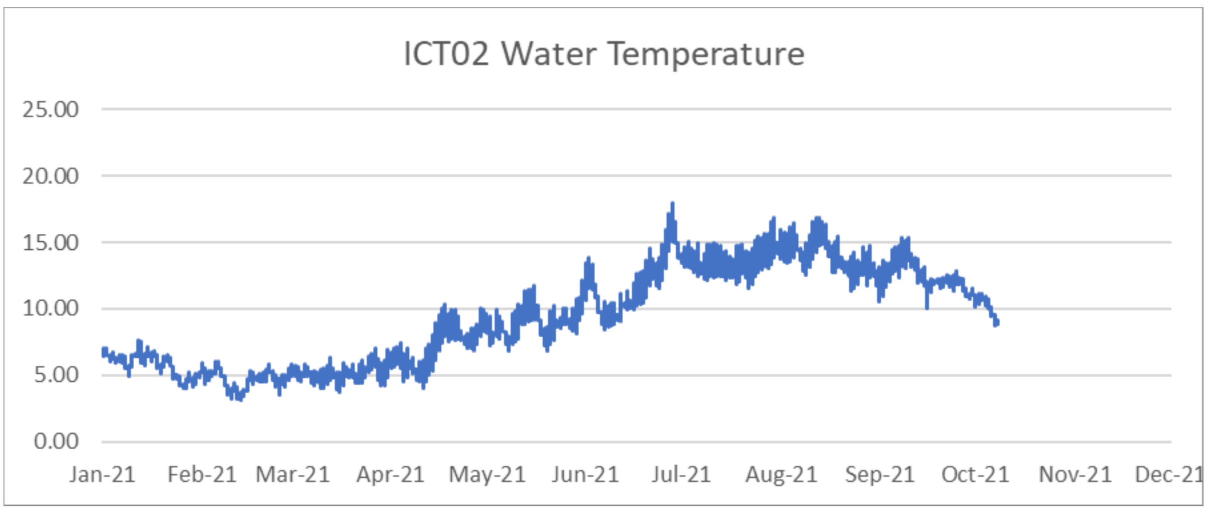
[Thurston Co. EHD] Thurston County Environmental Health Division. (2009). **Integrated Pest Management Prescription: Reed Canarygrass**. Web. Accessed 13 Jan 2019.

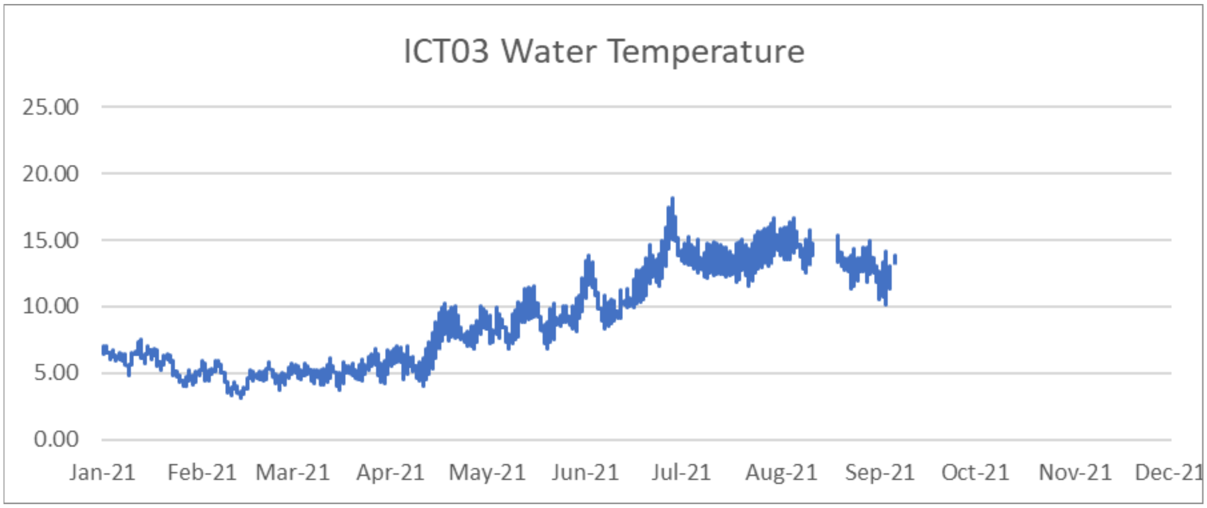
Vadas, R. L., Beecher, H. A., Boessow S. N., and Kohr, J. H. (2016). **Coastal Cutthroat Trout Redd Counts Impacted by Natural Water Supply Variations**. *North American Journal of Fisheries Management,* 36, 900-912. DOI: http://dx.doi.org/10.1080/02755947.2016.1173138

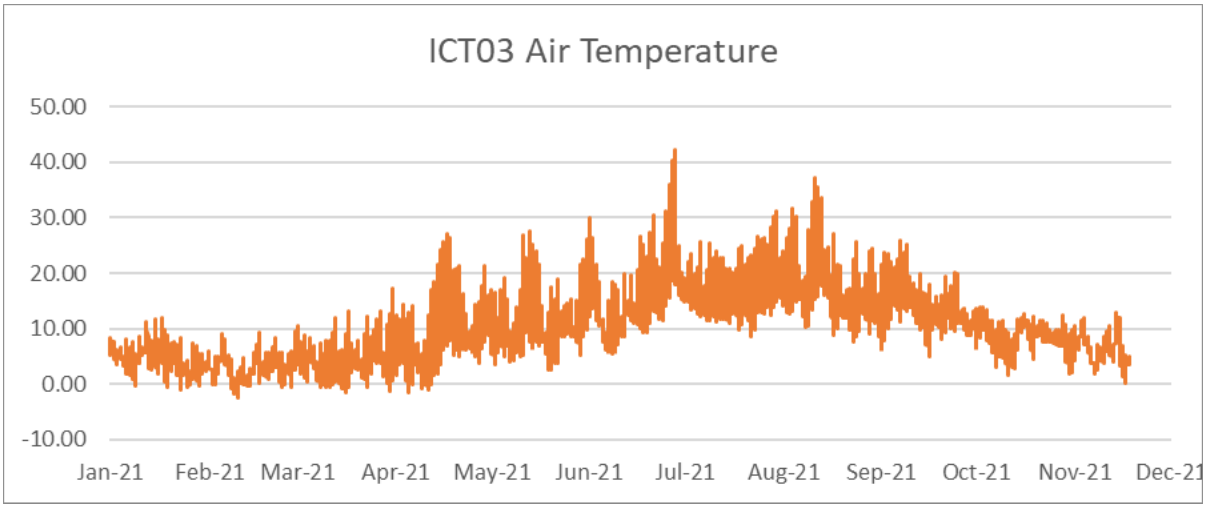
Appendix A

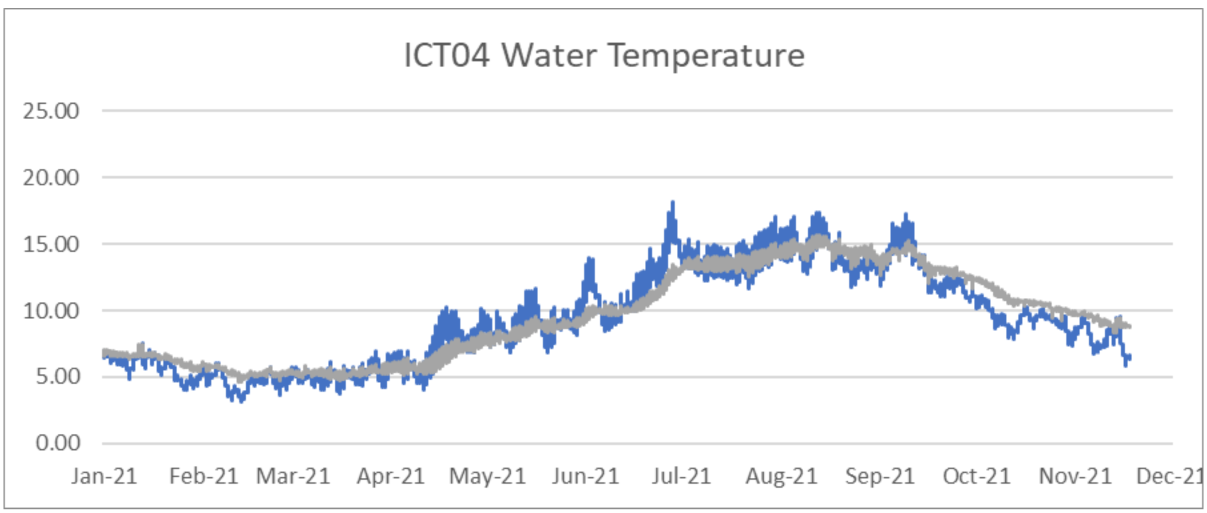
Stream and air temperature summaries for each Irely Creek Transect (ICT) temperature logger location. Side channel logger data are indicated in grey.

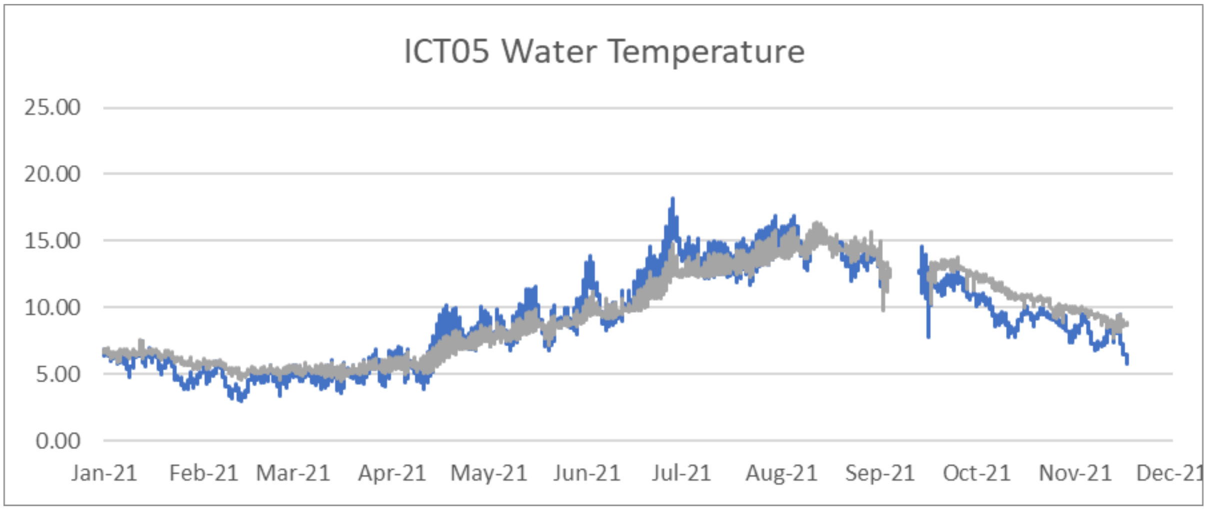


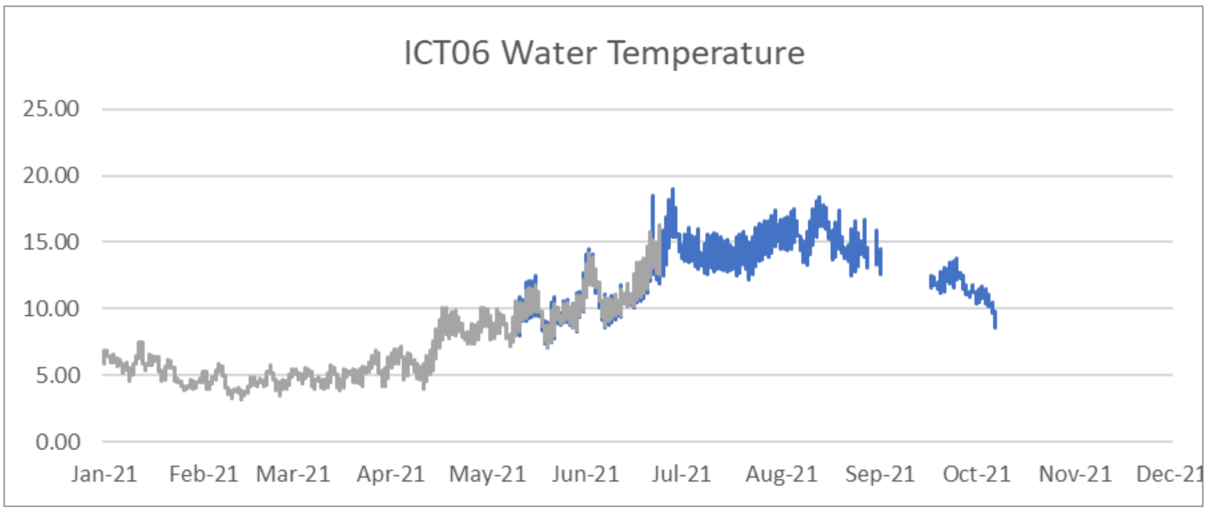


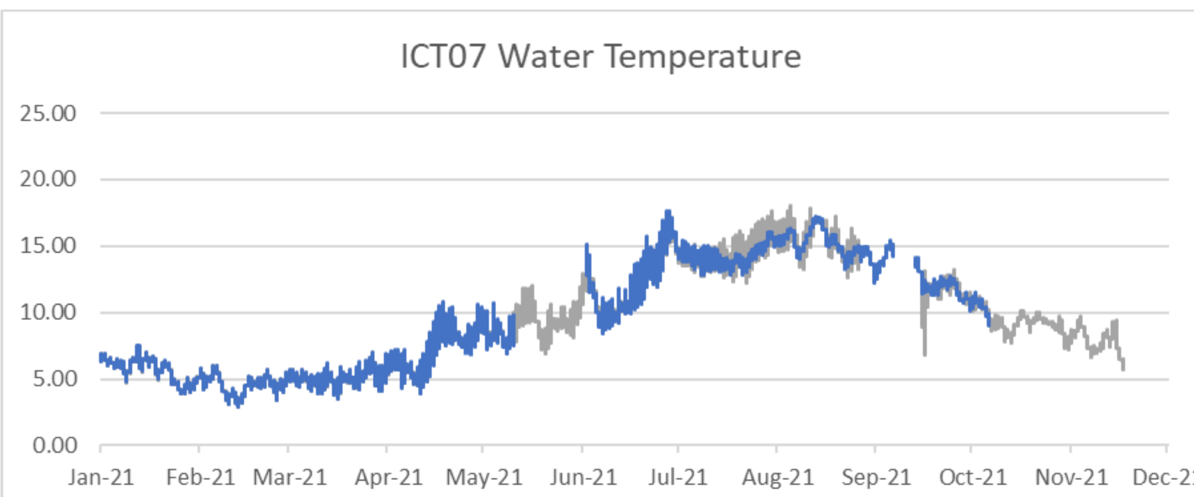

ICT03 Water Temperature
25.00
20.00
15.00
10.00
5.00
0.00
Jan-21
Feb-21
Mar-21
Apr-21
May-21
Jun-21
Jul-21
Aug-21
Sep-21
Oct-21
Nov-21
Dec-21

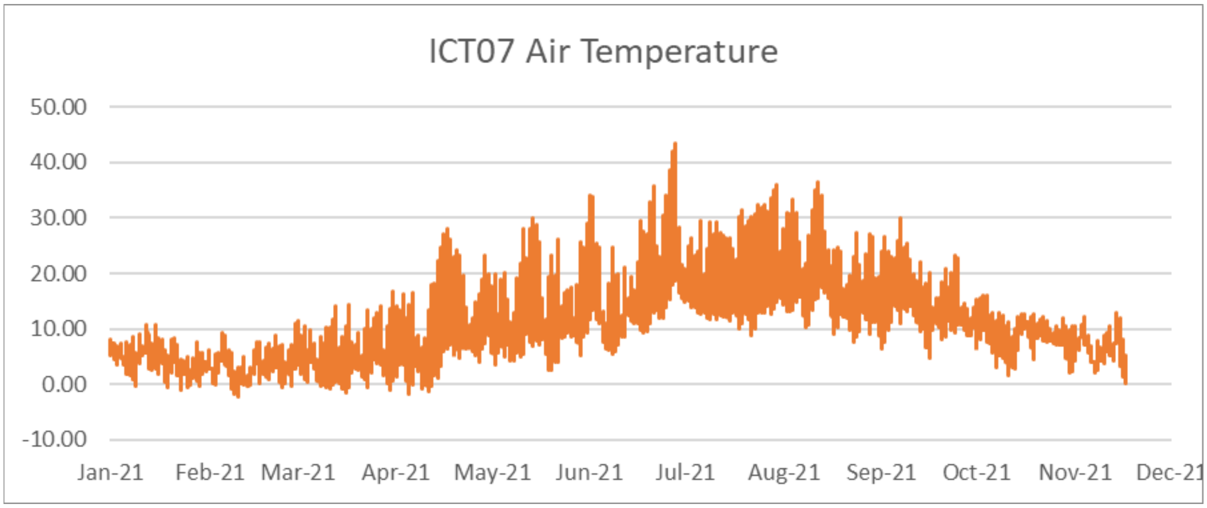

ICT03 Air Temperature
50.00
40.00
30.00
20.00
10.00
0.00
-10.00
Jan-21
Feb-21
Mar-21
Apr-21
May-21
Jun-21
Jul-21
Aug-21
Sep-21
Oct-21
Nov-21
Dec-21

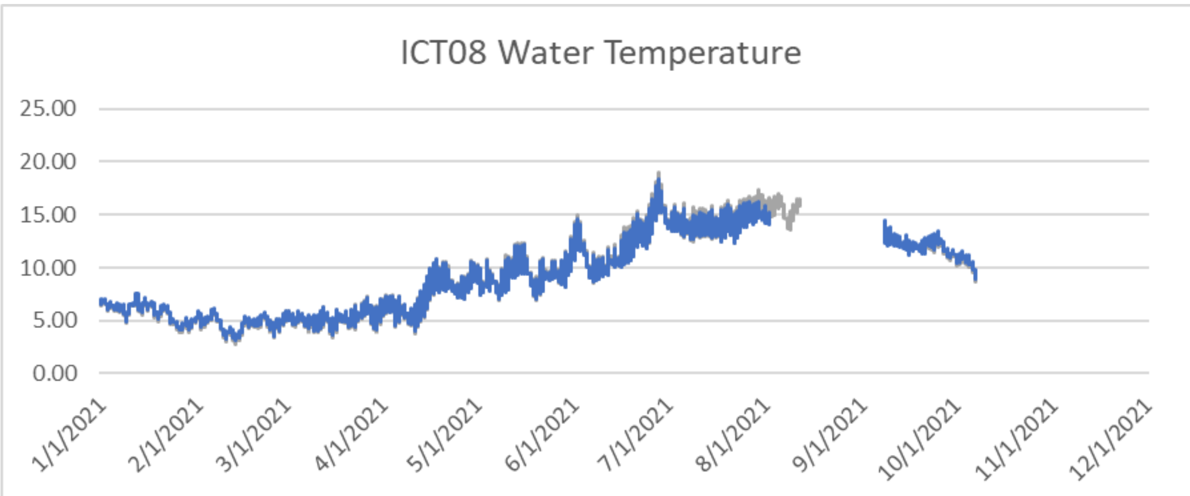

ICT04 Water Temperature
25.00
20.00
15.00
10.00
5.00
0.00
Jan-21
Feb-21
Mar-21
Apr-21
May-21
Jun-21
Jul-21
Aug-21
Sep-21
Oct-21
Nov-21
Dec-21

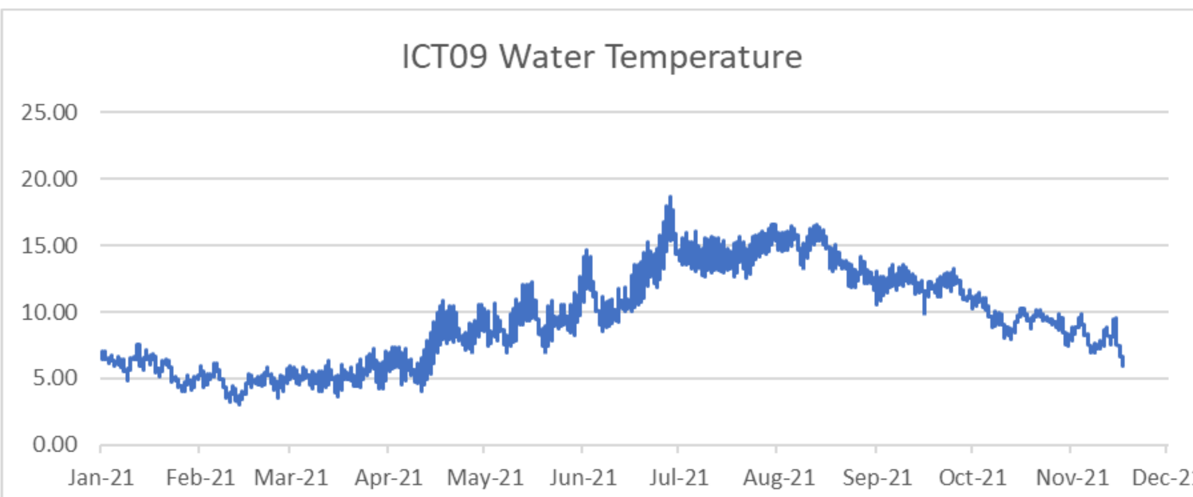

ICT05 Water Temperature
25.00
20.00
15.00
10.00
5.00
0.00
Jan-21
Feb-21
Mar-21
Apr-21
May-21
Jun-21
Jul-21
Aug-21
Sep-21
Oct-21
Nov-21
Dec-21

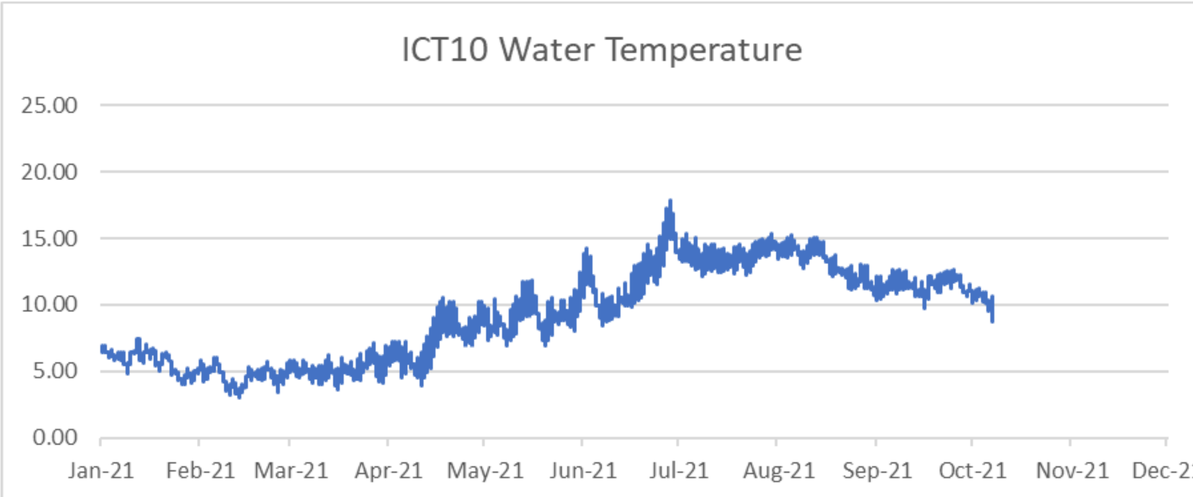

ICT06 Water Temperature
25.00
20.00
15.00
10.00
5.00
0.00
Jan-21
Feb-21
Mar-21
Apr-21
May-21
Jun-21
Jul-21
Aug-21
Sep-21
Oct-21
Nov-21
Dec-21


ICT07 Water Temperature
25.00
20.00
15.00
10.00
5.00
0.00
Jan-21
Feb-21
Mar-21
Apr-21
May-21
Jun-21
Jul-21
Aug-21
Sep-21
Oct-21
Nov-21
Dec-21


ICT07 Air Temperature
50.00
40.00
30.00
20.00
10.00
0.00
-10.00
Jan-21
Feb-21
Mar-21
Apr-21
May-21
Jun-21
Jul-21
Aug-21
Sep-21
Oct-21
Nov-21
Dec-21


ICT08 Water Temperature
25.00
20.00
15.00
10.00
5.00
0.00
1/1/2021
2/1/2021
3/1/2021
4/1/2021
5/1/2021
6/1/2021
7/1/2021
8/1/2021
9/1/2021
10/1/2021
11/1/2021
12/1/2021


ICT09 Water Temperature
25.00
20.00
15.00
10.00
5.00
0.00
Jan-21
Feb-21
Mar-21
Apr-21
May-21
Jun-21
Jul-21
Aug-21
Sep-21
Oct-21
Nov-21
Dec-21


ICT10 Water Temperature
25.00
20.00
15.00
10.00
5.00
0.00
Jan-21
Feb-21
Mar-21
Apr-21
May-21
Jun-21
Jul-21
Aug-21
Sep-21
Oct-21
Nov-21
Dec-21

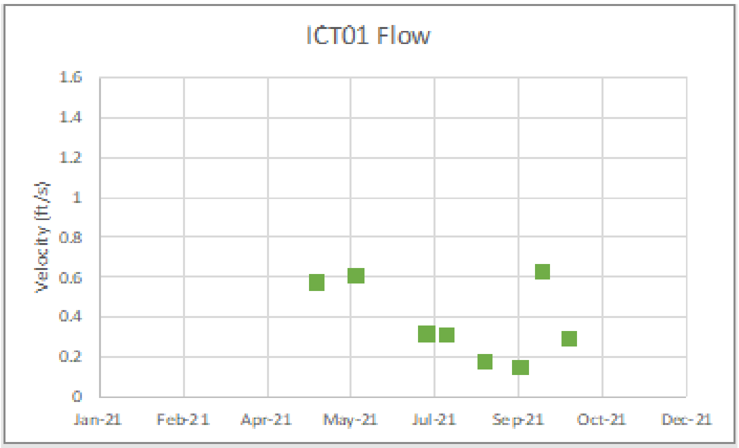
Appendix B

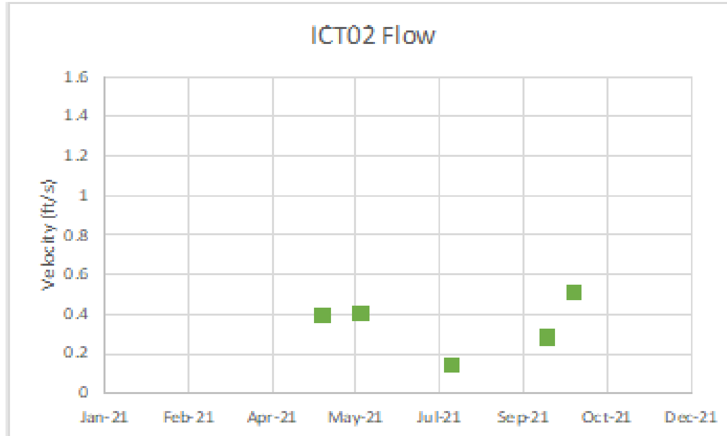
Plant species list for the Irely Creek 2021 vegetation survey. Updated 11/11/2021.

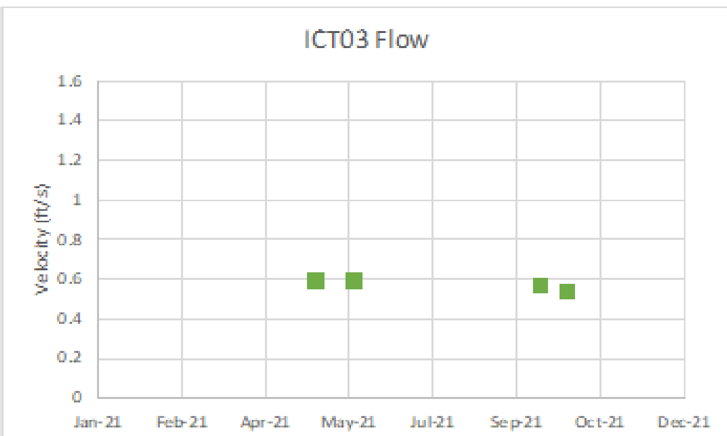
Acer circinatum (Vine maple)
Acer macrophyllum (Big leaf maple)
Adiantum pedatum (Northern maidenhair fern)
Alnus rubra (Red alder)
Angelica genuflexa (Kneeling angelica)
Athyrium filix-femina (Lady fern)
Blechnum spicant (Deer fern)
Boykinia occidentalis (Boykinia)
Bromus sitchensis (Alaska brome)
Bromus vulgaris (Columbia brome)
Cardamine hirsute (Hairy bittercress)
Carex leptoda (Slender-footed sedge)
Cerastium fontanum (Mouse-ear chickweed)
Circaea alpine (Enchanter's nightshade)
Claytonia sibirica (Siberian miner's lettuce)
Elymus hirsutus (Hairy wild rye)
Epilobium ciliatum (Fringed willow herb)
Equisetum arvense (Common horsetail)
Erythranthe guttata (Seep monkeyflower)
Frangula purshiana (Cascara)
Galium aparine (Cleavers)
Galium triflorum (Fragrant bedstraw)
Gaultheria shallon (Salal)
Glyceria elata (Tall mannagrass)
Gymnocarpium dryopteris (Oak fern)
Holcus lanatus (Velvet grass)
Lactuca muralis (Wall lettuce)
Luzula parviflora (Small-flowered woodrush)
Lysichiton americanus (Skunk cabbage)
Maianthemum dilatatum (False lily-of-the-valley)
Malus fusca (Pacific crab apple)
Melica harfordii (Harford's melic)
Mitella ovalis (Oval-leaf bishop's cap)
Oenanthe sarmentosa (Water parsley)
Oxalis oregano (Redwood sorrel)
Petasites palmatus (Western sweet coltsfoot)
Phalarus arundinacea (Reed canarygrass)
Physocarpus capitatus (Pacific ninebark)
Picea sitchensis (Sitka spruce)
Polypodium glycyrrhiza (Licorice fern)
Polystichum munitum (Western sword fern)
Prosartes hookeri (Hooker's fairybells)
Prunella vulgaris (Self-heal)
Pteridium aquilinum (Western bracken fern)
Ranunculus repens (Creeping buttercup)
Ribes bracteosum (Stink currant)
Rubus parviflorus (Thimbleberry)
Rubus pedatus (Five-leaved bramble)
Rubus spectabilis (Salmonberry)
Rubus ursinus (Trailing blackberry)
Rumex obtusifolius (Broad-leaved dock)
Scirpus microcarpus (Smallfruit bulrush)
Stachys mexicana (Mexican hedge nettle)
Stellaria calycantha (Northern starwort)
Stellaria crispa (Crisp sandwort)
Streptopus amplexifolius (White twisted-stalk)
Tiarella trifoliate (Foam flower)
Tolmiea menziesii (Piggyback plant)
Tsuga heterophylla (Western hemlock)
Vaccinium ovalifolium (Oval-leaf huckleberry)
Vaccinium parviflorum (Red huckleberry)
Veronica americana (American speedwell)
Viola glabella (Stream violet)
Viola palustris (Marsh violet)

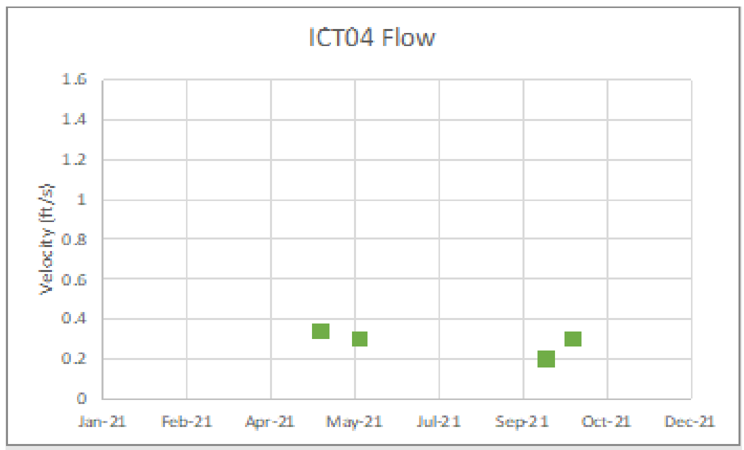
Appendix C

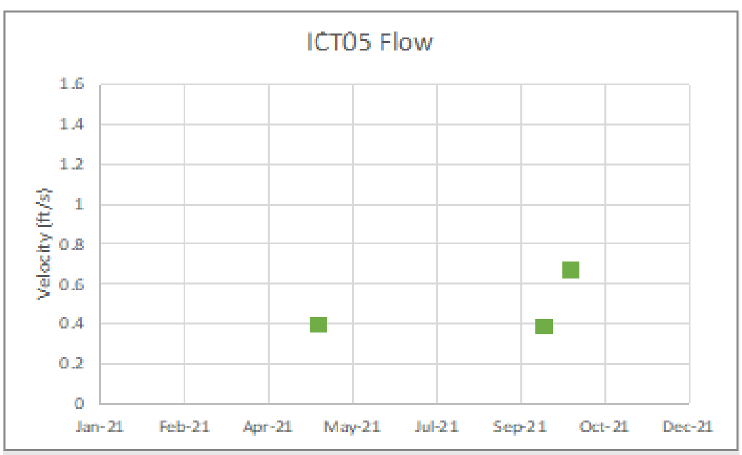
Stream flow velocity averages collected at each site visit in 2021. There is one figure for each Irely Creek Transect (ICT) except for ICT06 and ICT09, where no flow measurements were taken in 2021.

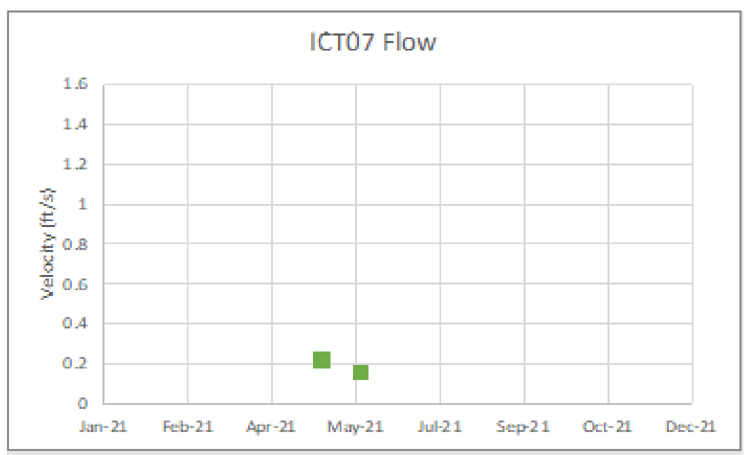


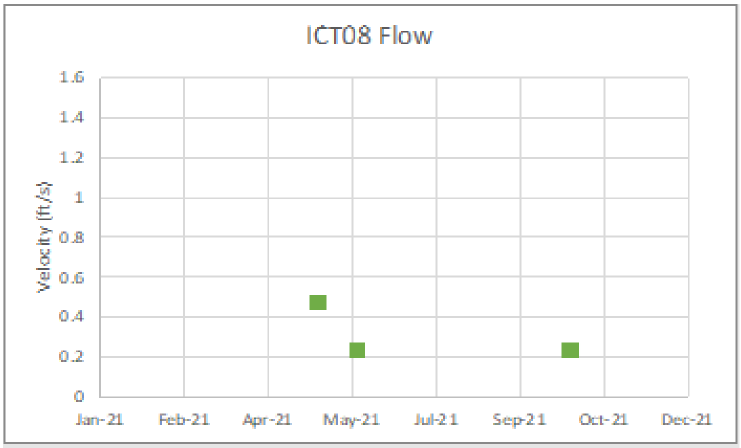


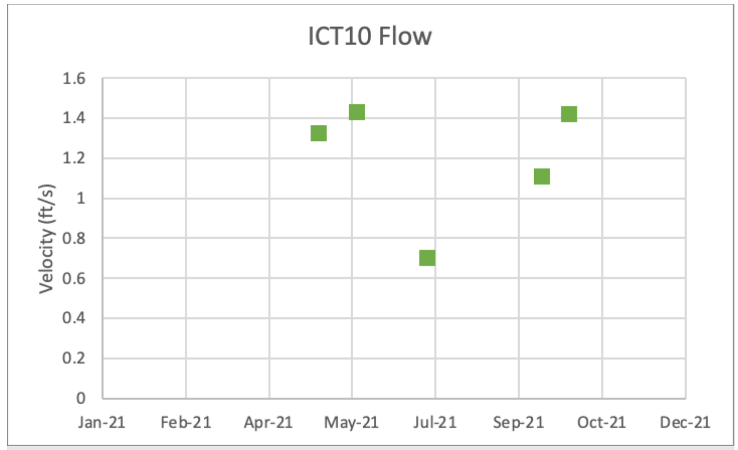









ICT08 Flow
Velocity (ft/s)
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Jan-21
Feb-21
Apr-21
May-21
Jul-21
Sep-21
Oct-21
Dec-21


ICT10 Flow
Velocity (ft/s)
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Jan-21
Feb-21
Apr-21
May-21
Jul-21
Sep-21
Oct-21
Dec-21