I do not enjoy writing letters such as this but feel it is necessary.

Please add my name to the list of ACFL trail users who have grown tired of the antics perpetrated by the three knuckleheads (usually seen riding in a group of three), two on gas power dirt bikes and the third on a electric dirt bike who have been tearing up the Little Cranberry Lake trails this spring, summer and now into fall. If I am the first person to email regarding these individuals, I would be very surprised.

Often these individuals can be seen riding recklessly (speeding, riding wheelies, etc) on A Avenue, 37th Street and D Avenue heading to and from the A Avenue trailhead (10 trail), so I figure they must live intown. I have encountered them riding recklessly (speeding, riding off of the established trails, riding on trails designated no motorcycles, intentionally "roosting" other trail users, etc) on the 10, 11, 113, 124, 115, 105 trails with no regards for common sense, trail etiquette, ACFL trail rules or the safety of any other trail user be them hikers or mountain bikers.

I have had the opportunity to address these individuals while on the trails both while hiking with my leashed dog and when I have been mountain biking and have never had a positive encounter, usually the conversation ends with these individuals displaying vulgar hand gestures, cussing, etc.

In the past several weeks, I have noticed what can only be described as intentional trail sabotage that I feel is being done by other regular trail users who also have had enough of these individuals. Begrudgingly, I have undone the trail sabotage as it would not be fair to other trail users to run across intentionally placed loose large rocks, branches and logs placed across the trails in blind corners that are surely intended to slow down wheeled vehicles.

As there really is not any official law enforcement or "park ranger" presence on the ACFL trails, I do not know what could be done to curtail the antics of these individuals. At some point, I am sure someone is going to take matters into their own hands which will not likely end well for any of the parties involved.

Best Regards,

Billy Smith

My comments on the Plan probably reflect what you have already heard, but just in case, here they are:

- The current Plan reflects the desire of our citizens to conserve and responsibly use these resources. I see no need for change to this important statement.
- The goal of the current Plan has two major parts: to conserve and enhance the unique environment and habitats within ACFL, while maintaining recreational opportunities for local residents. By definition, this goal recognizes the conflicting pressures these two parts, but lists conservation and enhancement first consistent with the desire of our citizens. I see no need for change to this important statement.
- Thus, the difficulty is balancing conservation/enhancement of the land with the changing pressures of responsible use, with the recognition that near-term pressures and decisions on use may have unexpected or long-term consequences (i.e., excessive trail erosion, litter, or vandalism).
- My major suggestion is that decisions about use of the ACFL continue to be conducted with a clear and open process, focused on the needs and desires of local residents. The stated goal of

reviewing what is, and what is not working to manage the land, should fairly consider the observational data, but err on the side of conservation and enhancement of the unique environments and habitats.

Thank you for your service and consideration.

Bill Kennedy

I understand you're the person to write with comments regarding the updating of the current ACFL management plan.

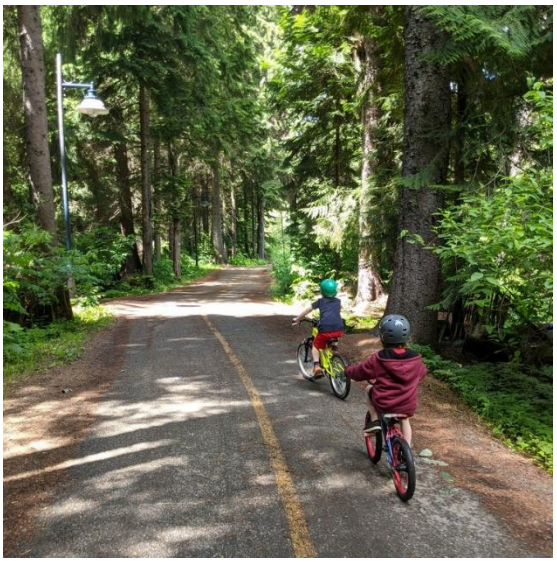
I don't want to stir up a hornets' nest, but I'm curious if there has ever been consideration of a more accessible trail through the forestlands to make it easier for people on the west side to ride their ("non mountain") bikes or walk safely to town without the risk of slipping or tripping on roots, and to avoid riding on the narrow shoulders of Marine Drive or Oakes Ave?

I think there are a lot of people on the west side (Skyline, Marine Heights and Marine Drive area) who would love to bike or walk to town safely for errands or for fun. Perhaps those living "in town" would like to do the same heading toward the west side.

I realize the Guemes Trail may eventually serve that purpose, but my research indicates it may be many many years before all the phases are completed.

As a hiker who enjoys the beauty and serenity of the forestlands several times a week, I think ONE trail made for this purpose would not impact the ecosystem any more than other modes currently permitted, but would significantly improve recreational opportunities for Anacortes residents. Walking through the forestlands on current trails is possible (albeit challenging for our aging population), but riding a bike safely is a challenge currently left to experienced mountain bikers.

Is that an idea that could be brought up for consideration? Perhaps a packed gravel or even a narrow paved trail like the below? (Photo of the Whistler Valley Trail).



Aside from any needed trail maintenance and repairs, don't add anything and keep the forestlands as natural as possible.
Thank you,
Wendy and Hugh Kendrick

Hi I just thought I'd put some of my comments of the management plan in an email as I can not attend the meetings.
First of all I enjoy the ACFL and Mtn bike 4-5 times a week using all areas of the park and know that each area is distinct in its own way.
I am a bit concerned with a local group(s) that are trying to turn the cranberry lake into a sanctuary that we have not seen in decades when in fact it is an urban forest that needs to be managed of course but not restricted by any one group.
One thing I would like to see for sure is the kayak launch. This pond is very peaceful and offers opportunities that are not available without traveling off the island. Whistle lake is beautiful as well but very impractical to carry a small boat from the parking lot whereas cranberry has parking right there.
Unfortunately the Mtn bike practice area was scuttled and moved to the skate park which I feel is a lost opportunity. Not sure how many families will load up the car drive to skate park for 30-45 mins load up and then go to forest to trail ride. So I'm hoping that this same group doesn't eliminate others from enjoying the park as well.

Thank you,
Paul Birch

Comments for the Revision of the ACFL Management Plan
Second set of Comments
from
Martha Hall
Resident of the City of Anacortes

These comments are related to my first set of comments that emphasized the importance of protecting the natural ecosystems found in the ACFL.

The first management goal for the ACFL must be this one:
Protect, preserve and perpetuate the natural ecosystems and all of their parts, including the non-living and living parts. This includes features like the hydrology which involves water tables, water flow and retention, and soils. This also includes the animal and plant species. The many and often connected beaver ponds and the adjacent waterways are one of the most important ecosystems found in the ACFL for wildlife. Protecting the beaver ponds should be the Number One goal.

The value of the beavers as "ecosystem engineers" cannot be over-stated. The beaver ponds and adjacent riparian areas create and maintain provide unique and valuable habitats for plants and animals. This habitat is important for many species of both resident and migratory birds. Bird lists for the beaver ponds are lengthy and include species such as Wilson's snipe, merlin, pied-billed grebe, ring-necked duck, cedar waxwings and hooded mergansers.

Beaver ponds and adjacent riparian areas also provide popular and unique kinds of recreation for hikers/walkers, bird watchers, nature study and research and nature photography. The quality and value of these uses is greater when the beaver ponds and adjacent riparian areas are protected and human disturbance is minimal. This requires adjusting trail networks and uses
and observation areas to limit human disturbance as much as possible.

Below are statements about the value of beaver ponds
copied from various studies of beaver ponds

"Beaver influence on stream morphology is extensive, and their ability to modify their habitat has coined them the name 'ecosystem engineers' (Gurney & Lawton, 1996). Examples of beaver-related alterations include increased ecosystem metabolisms (Wegener et al., 2017), shifts in riparian vegetation (Hayes et al., 2014;Pollock et al., 2007) and increased surface water exposure (Hood & Bayley, 2008). These open water resources provide vital habitats for fish (Schlosser, 1995;Schlosser & Kallemeyn, 2000), birds (Brown et al., 1996;Macfarlane et al., 2017) and herptiles (Russell et al., 1999;Stevens et al., 2007), leading to enhanced biological diversity (Hood & Bayley, 2008;McKinstry et al., 2001). ..."

"The benefits provided for free by beavers include: sediment storage, improved nutrient dynamics and habitat provision, increase in abundance and variety of wildlife , forest fire mitigation [29], greenhouse gas sequestration , regulation of water flows and improved water quality. Additional benefits can be associated with new recreation opportunities, such as nature tourism. "

"Because water storage in the landscape is increased, extreme events such as droughts and floods are moderated, Beaver dams are also known to filter sediments and nitrogen, improving water quality, while boosting biodiversity. Beavers create habitat conditions that benefit many additional species from invertebrates to endangered wetland plants, providing nursing areas for declining fish species and feeding and nesting zones for rare birds. "

"Previous studies have demonstrated that beavers alter important aquatic and riparian attributes such as physical stream conditions (Beier and Barrett 1987, Collen and Gibson 2000, Pollock et al. 2007), macroinvertebrate taxa (Clifford et al. 1993, Washko et al. 2020, stream temperatures (Law et al. 2014, Majerova et al. 2015, Weber et al. 2017, and the vegetative community (Wright et al. 2002, Little et al. 2012.

Strategies to Implement this Goal

The Management Plan for the ACFL must contain strategies that explain how this goal will be implemented. To protect the beaver ponds and adjacent riparian areas, the following strategies are necessary.

Strategy #1. To protect the beaver ponds, trail design and maintenance must comply with standards required in the Anacortes Critical Area Ordinance (CAO) for both wetlands and fish and wildlife habitat areas.

Strategy #2. A stated goal in the Anacortes CAO is to restore riparian areas. This should be a strategy for this goal for the ACFL too. This Restoration is still needed in the ACFL and this work should be a priority, not bike skill courses or more trails.

This work was done by the City without following requirements in the CAO.

A rough trail, user-made trail that leads from the parking area at Heart Lake and runs along the east side was "improved" a few years ago in a manner that violated this CAO. The improvements included destroying vegetation along the edge of the lake and adding fill.
Lake and wetland edges are some of the most valuable habitat for wildlife. Other trails are available very close to this trail and user groups could use these. This short section of trail was not necessary for a good trail network at Heart Lake for all user groups. Many species use the edges when nesting, resting, and foraging. Instead of recognizing this, a member of the Forest Advisory Board praised staff for this work.

A good example of a restoration project.

A good example of one restoration project is the closure of one short trail section that was along the edge of Little Cranberry Lake starting at the bridge on the south end. This trail was on the very edge of the lake and falling into the lake in some places and too close to meet CAO standards for its entire distance. For years, staff maintained this trail by cutting lakeshore vegetation and adding fill in the lake to make the trail wide enough to us. These actions violated the standards in the CAO. Closing this section of trail was the right thing to do. I'm sorry it took so many years of mismanagement before the Anacortes Parks Department acted and did this after being told this trail failed to meet standards in the CAO.

More restoration projects are needed.

Some include trail closures where trails are too close to the edge of beaver ponds, lakes and other riparian areas when other trails are available. When other trails are not available, new trails may need to be constructed away from beaver ponds, lakes, and other riparian areas.

Examples include the long trail along the very edge of the east side of Little Cranberry Lake. This trail is as close to the edge as it can be without having people walk in the water, and in some places, the trail is practically in the lake. After the fire damaged this trail, this was the right time to close this trail. The Anacortes Park Department failed to do this. Instead, this trail was rebuilt and improved. This trail, is creation, maintenance and use, destroy vegetation along the very edge of this lake. This trail is not needed. Trail uses have many other choices in the same vicinity of this lake.

Trails also run too close to the edges of riparian areas between Little Cranberry Lake and Big Beaver. Trails also run too close to the edge of Little Cranberry along the west and southwest sides. Another trail is available and/or these trails could be relocated away from the lake so they will not impact the lake.

Strategy #3: Management must prioritize maintaining beavers and their ponds whenever possible. Cutting notches in beaver dams or removing beaver dams should not be necessary in the ACFL if trails and bridges are designed to accommodate beavers. This requires a trail network that allows water levels to both fluctuate and gradually rise with the build-up of sedimentation. When trails impact these water levels, the trails should be moved and more bridges may be needed.

Beaver ponds and adjacent riparian areas are not static. Neither are their water levels. Rain and snow events change water levels. So do droughts. Water levels also rise as beaver ponds age from the

accumulation of material such as the dead leaves of pond lilies. Trail systems, bridges, and other man-made features must be planned to accommodate changing water levels. These changes should be expected and planned for. They are not "unusual" and they are not "emergencies".

I copied the following articles from the internet about one kind of change in beaver ponds:

Stream life cycle]

Wetland creation

If a beaver pond becomes too shallow due to sediment accumulation, or the tree supply is depleted, beavers will abandon the site. Eventually the dam will be breached and the water will drain out. The rich thick layer of silt, branches, and dead leaves behind the old dam is an ideal habitat for some wetland species.

Meadow creation

As the wetland fills up with plant debris and dries out, pasture species colonize it and the wetland may eventually become a meadow suitable for grazing in a previously forested area. This provides a valuable niche for many animals which otherwise would be excluded. Beaver dam creation also increases the plants the dams were made from (such as willows) to reproduce by cutting, encouraging the growth of adventitious roots.

Riverine forest

Finally the meadow will be colonized by riverine trees, typically aspens, willows and such species which are favoured by the beaver. Beavers are then likely to recolonize the area, and the cycle begins again.

Bottomland

Each time the stream life cycle repeats itself another layer of organic soil is added to the bottom of the valley. The valley slowly fills and the flat area at the bottom widens. Research is sparse, but it seems likely that parts of the bottomland in North America was created, or at least added to, by the efforts of the generations of beavers that lived there. [30]

Friends of the Carp Hills

Article: "Lifecycle of a Beaver Pond

"In the Carp Hills beavers are responsible for enhancing the landscape of wetlands and ponds that benefit many plants and animals. Their dams deepen ponds in natural depressions, create new ponds, and expand biodiverse marshes and swamps.

When a beaver arrives at a new site, it needs the water level to be high enough to swim in, protect its lodge from land predators, and support the plants that it eats like willow and waterlily roots. The beaver is attracted to the sound of running water. Its instinct is to block the flow with a wall of mud, interlaced branches and even stones, thereby creating or enlarging a body of water behind the dam.

The beaver will construct a lodge, raise a family, and live at the pond, sometimes for many years, until its food runs out (or it dies). Then it will move on. Eventually its dam will break and the pond will empty, returning to a stream or small pond or wetland.

Taken between 2016 and 2022, the seven photographs below show the lifecycle of a 4 hectare (9 acre) beaver pond in the Carp Hills. The beavers were active in this pond for many years, repairing the dam when it broke in November 2015, but they abandoned their lodge in 2019 for unknown reasons. The dam – a very old one – quickly breached without regular maintenance and the pond drained.

In 2020 the pond became a beaver meadow, a wetland fed by streams from nearby active beaver ponds. Dormant seeds lying in the pond's sediment or new seeds blown in by the wind quickly germinated and now thrive in the rich, moist soil. Butterflies and other pollinators dance among the wild flowers, an abundant display in the otherwise harsh conditions of the acidic rock barrens.

Beavers returned some time in late 2020 or 2021, raising water levels again, but still one meter below high levels. Shallow water allowed cattails to grow. Cattails and the raised water level attracted muskrats, which built five small lodges in the pond in fall 2021. Cattails are muskrat's preferred food, but they will also eat a variety of other wetland plants and even become carnivorous if edible plant material is scarce.

The cycle has come full circle: the pond water level returned to near pre-2019 levels in late spring 2022."

***

I must end here with these comments because I am out of time, not because I am done. I want to submit these before tonight's public meeting about the ACFL which I will not be attending.

The following pages these: First, several parts of the Anacortes Critical Area Ordinance that apply to the ACFL and Second, studies and articles about beaver ponds and some of the benefits they provide and some of the ways they influence even the climate.

Thank you for having these meetings and for accepting these comments.

Martha Hall, Anacortes, WA

First:

Several Sections from the Anacortes Critical Area Ordinance

19.70.330Specific standards for riparian management zones.

This section was recently amended by Ordinance 4025, codified in November 2022.

A.A riparian management zone (RMZ) is a critical area; specifically, it is a type of fish and wildlife habitat conservation area. A project site's RMZ is associated with each aquatic species upstream and downstream from the project site.

1.The RMZ consists of a watercourse and the area adjacent to the watercourse that has the potential to provide full riparian ecosystem functions for bank stability, shade, pollution removal, contributions of detrital nutrients, recruitment of large woody debris, and wildlife habitat. The width of the RMZ is the height of the tallest 200-year-old site-potential tree ($SPTH_{200}$) or 100 feet, whichever is greater, measured horizontally. The RMZ is measured from whichever of the following features is furthest from the center of the watercourse: (a) the ordinary high-water mark, (b) the top of bank, or (c) the outer edge of the channel migration zone (if one exists). In watercourses with braided channels or alluvial fans, the ordinary high-water mark will include the entire stream feature. The RMZ may exceed the 200-year-old site-potential tree height based on subsection (A)(3) of this section.

2.When a pipe or culvert that has known or potential fish habitat downstream and upstream from the pipe or culvert is daylighted, the watercourse formerly in the pipe or culvert will be regulated as a riparian watercourse, and the area adjacent to that watercourse will be regulated as a riparian management zone, as defined in subsection (A)(1) of this section. This section does not apply when the pipe or culvert is removed to provide a publicly owned facility designed primarily for water quality treatment, flow control, or stormwater conveyance.

3.Activities that may impact an RMZ must provide a critical areas report prepared by a qualified professional describing the functions and values of the RMZ. The report must include the 200-year-old site-potential tree height ($SPTH_{200}$) as determined by WDFW at https://gispublic.dfw.wa.gov/arcgis/rest/services/SPTH/SitePotentialTreeHeightPublic/MapServer.

If $SPTH_{200}$ was also calculated using site-scale data, that information must also be included. The report must describe the inner measurement point (e.g, ordinary high-water mark) and the extent of the RMZ with sufficient detail to allow field delineation. The report must demonstrate that the project will result in no net loss of the ecosystem functions for the RMZ and associated species.

B.*Development Standards for Parcels Containing an RMZ.*

1.*Application of Standards and Regulatory Intent.*

a.The provisions of this section apply to all development on parcels containing an RMZ as defined in subsection (A)(1) of this section.

b.It is the long-term goal of the city to restore the city's RMZs and to protect fish passage where scientifically justified. The city has determined that best available science supports protecting these RMZs as described in this section.

2.*Watercourse.* Development is prohibited within or over the riparian watercourse, except as provided in this subsection. The Director may approve access over the riparian watercourse, if the applicant demonstrates all of the following:

a.No other access is available.

19.70.350Critical area report additional requirements.

This section was recently amended by Ordinance 4025, codified in November 2022.

A.*Additional Report Contents for FWHCAs.* In addition to the minimum report contents required per AMC 19.70.115, Critical area report, FWHCA reports must also include:

1.Documentation of any fieldwork performed on the site, including field data sheets for delineations, water typing and other habitat conservation area classification, baseline hydrologic data, site photos, etc.;

2.A description of the methodologies used to conduct the delineations, classifications, or impact analyses, including references;

3.A discussion of the potential impacts to the critical area or buffer associated with the proposed development including an assessment of cumulative impacts.

B.*Habitat Assessment/Management Plan.* A habitat assessment/management plan is an investigation of the project area to evaluate the potential presence or absence of designated critical fish or wildlife species or habitat. A critical area report for a fish and wildlife habitat conservation area must contain an assessment of habitats including the following site- and proposal-related information at a minimum:

1.Detailed description of vegetation on and adjacent to the project area and its associated buffer;

2.Identification of any species of local importance, priority species, or endangered, threatened, sensitive, or candidate species that have a primary association with habitat on or adjacent to the project area, and assessment of potential project impacts to the use of the site by the species;

3.A discussion of any federal, state, or local special management recommendations, including Washington Department of Fish and Wildlife habitat management recommendations, that have been developed for species or habitats located on or adjacent to the project area;

4.A detailed discussion of the direct and indirect potential impacts on habitat by the project, including potential impacts to water quality;

5.A discussion of measures, including avoidance, minimization, and mitigation, proposed to preserve existing habitats and restore any habitat that was degraded prior to the current proposed land use activity and to be conducted in accordance with AMC 19.70.125, Mitigation requirements;

6.A discussion of ongoing management practices that will protect habitat after the project site has been developed, including proposed monitoring and maintenance programs.

C.*Additional Technical Information Requirements for RMZs.* If no project impacts are anticipated and standard riparian management zone widths are retained, a RMZ delineation report, general critical area report or other reports, alone or in combination, may be submitted as consistent with the specific requirements of this section. In addition to the general critical area report requirements for fish and wildlife habitat conservation areas provided in subsections (A) through (D) of this section, technical information on RMZs must include the following information at a minimum:

1.A written assessment and accompanying maps of the stream and associated hydrologic features on and off site within 300 feet of the project area, including the following information at a minimum:

a.RMZ survey showing the field delineated ordinary high water mark(s);

b.Standard RMZ boundary as determined by AMC 19.70.330, Specific standards for riparian management zones;

c.Vegetative, faunal, and hydrologic characteristics;

d.Soil and substrate conditions; and

e.Topographic elevations at two-foot contours;

2.A detailed description and functional assessment of the watercourse channel and riparian management zone under existing conditions pertaining to the protection of the RMZ functions, fish habitat and, in particular, potential anadromous fisheries;

WAC 220-660-230

Beaver dam management.

(1) **Description:**

(a) A person may need to remove, breach, or modify a beaver dam to prevent damage to private and public land, structures, or other improvements of value from flooding. Beaver dams are normally removed using hand tools or equipment such as backhoes.

(b) An alternative to frequent dam removal is installing a beaver exclusion device. These devices prevent beavers from building a dam that blocks water flow at the mouth or inside of culverts.

(c) Installing a water level (flow) control device may be a preferred alternative to removing or breaching an established dam that maintains a beaver wetland; however, fish passage must be maintained. A person can install a water level control device to maintain a desirable beaver wetland. These devices are installed at the intended depth, extending upstream and downstream of the dam. This preserves the pond's habitat benefits.

(2) **Fish life concerns:**

(a) Beavers play an important ecological role in creating and maintaining ponds and wetlands for fish and wildlife habitat. Ponds also provide surface water storage that improves summer flows, as well as improving water quality through retaining sediment.

(b) Breaching, notching, or removing a dam can negatively affect fish life and the habitat that supports fish life by dewatering the upstream pond, stranding fish life, and releasing large volumes of water (that can be devoid of oxygen) and sediment downstream. Releasing sediment can affect downstream spawning areas. Breaching or removing a beaver dam may not prevent future beaver activity in the area. Persistent breaching or removing a beaver dam can increase the risk of negative impacts to habitat. In these instances, the department may recommend that a person consider other beaver management techniques.

(c) Beaver exclusion devices and water level control devices can create a design challenge for fish passage and the devices can decrease the likelihood for long-term fish passage.

Second,

Studies and Articles about Beaver Ponds

and their Importance

Beavers have an impact on the climate

August 29, 2018, University of Helsinki

:

Summary: A rising water level affects the interaction between beaver ponds, water and air, as well as the carbon balance of the zone of ground closest to water.

———"An increase in the number of beavers has an impact on the climate since a rising water level affects the interaction between beaver ponds, water and air, as well as the carbon balance of the zone of ground closest to water," says Petri Nummi, University Lecturer at the University of Helsinki, Finland.

Current estimates indicate that beaver ponds range from carbon sinks to sources of carbon. Beaver ponds and meadows can fix as much as 470,000 tons of carbon per year or, alternatively, release 820,000 tons of carbon annually. Their overlapping functions as carbon sinks and sources make landscapes moulded by beavers complex.

Quotes from this USFWS Article:

"Beavers Bring Benefits to Partnership Learning to live with beavers offers bonuses"

"Additionally, beaver ponds store groundwater which fuels riverside vegetation. This vegetation, in turn, shades rivers and streams, further cooling the water for native fish. In many cases the stored groundwater also returns to surface flow in downstream reaches, providing important cool water to chill too-warm summer streams. "

"Jaspers explains that beaver “affect our landscape on a big level when it comes to fire and climate resiliency.” Recent research suggests that beavers help to protect people and their property from wildfires. Riverside vegetation fed by beaver ponds acts as a fire break, stopping wildfires from

advancing across the landscape. In 2021, twenty times more land was burned by wildfires in Washington and Oregon than in 2020. With increasing rates of wildfire in the region, beavers may be an important defense against fire-induced property damage and destruction."

State aims to tap beavers to help with water issues and wildfires

Beavers have long been treated as a nuisance for chewing down trees and shrubs and blocking up streams

ByAMY TAXIN Associated Press

July 24, 2023, 9:08 PM

Quotes from this article which is about the recent change in how California manages beavers. Changes were made after years of droughts and wildfires. Many studies show that beavers reduce the negative impacts of both droughts and wildfires.

" "There has been increased motivation to identify and fund the implementation of nature-based climate smart solutions," she said. "Beaver restoration is just that."

Beavers live in family units and quickly build dams on streams, creating ponds. The pools help slow the flow of water, replenishing groundwater supplies, and can also stall the spread of wildfires — a critical issue for a state plagued by fires in recent years, said Emily Fairfax, professor of environmental science and management at California State University, Channel Islands.

"You talk to anyone who has lived near beaver ponds. They'll tell you: These things don't burn," said Fairfax, who has researched beavers and the ponds they build."

"Hydrologic Responses to Beaver Dam Removal in the Knife River Watershed"

A THESIS

SUBMITTED TO THE FACULTY OF THE THE UNIVERSITY OF MINNESOTA

BY EMMA BURGES, SEPTEMBER 2022

LITERATURE REVIEW

Beaver Dam Influence on Hydrology Complex physical and ecological factors influence surface- and subsurface- water flowpaths. In a natural landscape, rainfall that reaches the ground either evaporates, moves downslope across the surface as overland flow, or infiltrates into the ground. Water that infiltrates into the soil can remain stored in the soil or percolate and travel slowly through the subsurface. The water will either continue downward to the water table, laterally toward the stream, or be taken up by vegetation and transpired back to the atmosphere (Figure 1). When beavers are present on a landscape, they build dams with woody debris, rocks, mud, and other available materials, thereby altering the typical hydrologic flow paths. Beaver dams cause surface water to be redirected, forming intricate braided streams and surface ponding (Woo and Waddington, 1990). Newly impounded surface water drowns riparian vegetation and results in increased watersurface area exposed to solar radiation. The enlarged area, coupled with reduced water velocity, leads to greater rates of water lost by evaporation than a free-flowing and shaded stream. In the subsurface, beaver dams increase hydraulic head and elevate water table levels, thereby altering subsurface flow by creating storage and forcing more water through the substrate and back into the stream (Hester and Doyle, 2008; Feiner and Lowry, 2015). The compounding hydrologic changes generated by beaver dams alter the timing, volume, and velocity of peak flows. Beaver dams have a dampening effect on peak flows until the dam is overtopped (Nyssen et al., 2011). The reservoir must first be filled if the level of the pond is below the crest of the dam. This delays the timing of peak flows and reduces peak velocities in flood events downstream (Westbrook et al., 2006; Nyssen et al., 2011).

Evaporation rates and groundwater levels increase post-beaver dam construction, as well as surface and subsurface storage. Low-flow conditions occur during times of little to no precipitation, usually during the same season each year.

In northern Minnesota, periods of low-flow can occur during the summer months when there is little to no precipitation. Instead of rainfall, streams under low-flow conditions are primarily sustained by groundwater inputs via springs and channel connection to the phreatic zone (Smakhtin, 2001).

When water table elevations are above the channel, they maintain a gaining system where water moves from the ground to the channel and thus increases flow in the channel. Water tables decrease over time if they are not recharged by precipitation or hyporheic exchange and eventually become losing systems, where water moves from the channel into the ground and reduces the flow in the stream. Beaver dams attenuate water table declines by creating a surface reservoir that can slowly release water downstream over time (Woo and Waddington, 1990; Westbrook et al., 2006; Green and Westbrook, 2009; Nyssen et al., 2011; Pollock et al., 2014).

…… the surface area of beaver impoundments also dictates the size of the hyporheic zone where groundwater and surface water exchange occurs, as well as subsurface flow paths. The increased area of hyporheic exchange can raise recharge rates and water table elevations near the dam (Lowry and Beschta, 1994; Westbrook et al., 2006) and often attenuate water table 8 declines throughout dry seasons (Westbrook et al., 2006, Nyssen et al., 2011, Majerova et al., 2015). In addition to elevation, the direction of subsurface flow can also be disrupted when a beaver dam is constructed. In low relief watersheds with large floodplain access, the subsurface flow can be forced around the dam and back into the stream in a looping pattern (Janzen and Westbrook, 2011). In steeper channels, the lateral looping pattern away from the pond and back into the downstream channel also occurs (Lowry and Beschta, 1994; Westbrook et al., 2006,). The attenuation of declines in water table elevations and redirection of subsurface flow affect the gaining or losing status of a stream and thus can be a critical source of water during the low-flow period.

Geomorphic changes upstream of beaver dams in Bridge Creek, an incised stream channel in the interior Columbia River Basin, eastern Oregon, July

2007. Earth Surface Processes and Landforms 32(32):1174-1185

Michael M. Pollock, National Oceanic and Atmospheric Administration
Timothy Beechie, National Oceanic and Atmospheric Administration
Chris Jordan, Northwest Fisheries Science Center

Abstract

Channel incision is a widespread phenomenon throughout the dry interior Columbia River basin and other semi-arid regions of the world, which degrades stream habitat by funda-mentally altering natural ecological, geomorphological and hydrological processes. We examined the extent of localized aggradation behind beaver dams on an incised stream in the interior Columbia River basin to assess the potential for using beaver, Castor canadensis, dams to restore such channels, and the effect of the aggradation on riparian habitat. We estimated aggradation rates behind 13 beaver dams between 1 and 6 years old on Bridge Creek, a tributary to the John Day River in eastern Oregon. Vertical aggradation rates are initially rapid, as high as 0·47 m yr − − − − −1 , as the entrenched channel fills, then level off to 0·075 m yr − − − − −1 by year six, as the sediment begins accumulating on adjacent terraces. We found that a 0·5 m elevation contour above the stream channel approximately coincided with the extent of new riparian vegetation establishment. Therefore, we compared the area surrounding reaches upstream of beaver dams that were within 0·5 m elevation of the stream channel with adjacent reaches where no dams existed. We found that there was five times more area within 0·5 m elevation of the channel upstream of beaver dams, presumably because sediment accumulation had aggraded the channel. Our results suggest that restora-tion strategies that encourage the recolonization of streams by beaver can rapidly expand riparian habitat along incised streams.

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Water level variation a ta beaver pond significantly impacts net CO2 uptake of a continental bog

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"Abstract.

The carbon(C) dynamics of northern peatlands are sensitive to hydrological changes owing to ecohydrological feedbacks.We quantified and evaluated the impact of water level variations in a beaver pond (BP) on the CO2 flux dynamics of an adjacent, raisedSphagnum–shrub dominated bog in southern

Canada.We applied the Coup Model to the MerBleuebog, where the hydrological, energy andCO2 fluxes have been measured continuously forover 20years……..

The simulation shows that variation in the BP water level (naturally occurring or due to management) influenced the bog net ecosystem exchange (NEE) of CO2. Over 1998–2004,the BP water level was 0.75 to 1.0 m lower than during 2017–2019. Simulated net CO2 uptake was 55g Cm−2yr−1 lower during1998–2004 compared to 2017 2019 when there was no BP disturbance, which was similar to the differences in measured NEE between those periods.

Peatland annual NEE was well correlated with water table depth (WTD) within the bog, and NEE also shows a linear relation wit the water level at the BP, with a slope of−120g CO2-Cm−2yr−1m−1. The current modelling predicts that the bog may switchfrom CO2sink to source when the BP water levels drop lower than ~1.7m below the peat surface at the eddy covariance (EC) tower, located on thebog surface 250m from theBP. This studyhigh lights the importance of natural and human disturbances to adjacent water bodies in regulating the net CO2 uptake function of northern peatlands"

-Martha Hall