Minutes

Meeting	**Regular Council**
Date	**6 August 2019**
Time	**7:00 PM**
Place	**Municipal Hall - Council Chambers**

Present
Mayor Martin Davis
Councillor Bill Elder
Councillor Sarah Fowler (by phone)
Councillor Lynda Llewellyn

Regrets
Councillor Josh Lambert

Staff
Mark Tatchell, Chief Administrative Officer
John Manson, P.Eng, Project Manager
Janet StDenis, Finance & Corporate Services Manager

Public
1 member of the public

A. Call to Order

Mayor Davis called the meeting to order at 7:00 p.m.
Mayor Davis acknowledged and respected that Council is meeting upon Mowachaht/ Muchalaht territory

B. Introduction of Late Items and Agenda Changes

2 late items. Under Correspondence as "L14" an email regarding the public boat launch & washdown station and under New Business as "M5" a FCM Demonstration Projects Grants Application.

C. Approval of the Agenda

Llewellyn/Elder: VOT 358/2019

THAT the Agenda for the August 6, 2019 Regular Council meeting be adopted as amended. **CARRIED**

D. Petitions and Delegations

None.

E. Public Input # 1

None.

F. Adoption of the Minutes

1 **Minutes of the Regular Council meeting held on July 2, 2019**

Llewellyn/Elder: VOT 359/2019

THAT the Regular Council meeting minutes of July 2, 2019 be adopted as amended. **CARRIED**

2 **Minutes of the Committee of the Whole meeting held on July 2, 2019**

Llewellyn/Elder: VOT 360/2019

THAT the Committee of the Whole meeting minutes of July 2, 2019 be adopted as presented. **CARRIED**

3 **Minutes of the Committee of the Whole meeting held on July 4, 2019**

Llewellyn/Elder: VOT 361/2019

THAT the Committee of the Whole meeting minutes of July 4, 2019 be adopted as presented. **CARRIED**

G. Rise and Report

None.

H. Business Arising

1 **Code of Conduct Policy No. 2015**

Llewellyn/Elder: VOT 362/2019

THAT this draft Code of Conduct Policy be received. **CARRIED**

Llewellyn/Elder: VOT 363/2019

THAT this Code of Conduct Policy be approved **CARRIED**

2 **Report to Council Re: 2019 Condition Assessment of the Municipal Wharf**

John Manson, P Eng, Project Manager, spoke to his Report to Council on the Condition Assessment of the Wharf and the proposed options for the siting of the new SAR wharf facility.

Llewellyn/Elder: VOT 364/2019

THAT the Report to Council and the Report on the Condition Assessment of the Municipal Wharf be received. **CARRIED**

Council requested a meeting with the Coast Guard to receive a presentation on the CG's proposed trestle and float option and to discuss the option of utilizing the existing municipal wharf site. Council also requested that the RCMP, DFO and MMFN be invited to attend.

3 **McElhanney Ltd: Final Report Tahsis Flood Risk Assessment**

https://dl.mcelhanney.com/2019/07/23_uRzB/23_G5JetG1/49140TahsisFloodRiskAssessmentFinalReportComplete.pdf

Llewellyn/Elder: VOT 365/2019

THAT the Tahsis Flood Risk Assessment Report be received. **CARRIED**

4 **Report to Council Re: Recreation Centre 2019 Q2 attendance and revenue report**

Llewellyn/Elder: VOT 366/2019

THAT the Report to Council be received. **CARRIED**

5 **Tahsis Roads Project Status Report - Report to Council**

John Manson, P Eng, Project Manager, provided Council with an update on the Roads Project and responded to Council's questions.

Llewellyn/Elder: VOT 367/2019

THAT the Report to Council be received. **CARRIED**

J. Council Reports
Mayor Davis

No Report

Councillor Elder
No report

Councillor Fowler (verbal report)

I have just submitted the "M5" "New Business" so that is my draft application that I have written for the FCM Demonstration Project. The only thing that is missing from my application is a formal resolution that would show the Village of Tahsis' full support for the FCM application. The deadline is in a week, August 15th. So, I was hoping that we can have some kind of resolution to the effect which we can talk to in "M5".

Councillor Llewellyn (verbal report)
I was very impressed with the organization of Tahsis Days.

Llewellyn/Elder: VOT 368/2019
THAT these Council reports be received. **CARRIED**

Bylaws
None.

L. Correspondence

1 **Tahsis Council letter to Hon. Claire Trevena Re: Meeting with Tahsis' Council on May 21st, 2019**

2 **City of Richmond letter Re: Lobbyist Registration**

3 **City of Richmond letter Re: Proposed UBCM Resolution- Conflict of Interest Complaint Mechanism**

4 City of Richmond letter Re: Proposed UBCM Resolution - Statement of Disclosure Updates

5 City of Port Moody letter Re: Support for Property Assessed Clean Energy Enabling Legislation for BC

6 City of Prince George Letter Re: Proceeds of Crime; Clean-Up of Needles and Other Harm Reduction Paraphernalia

7 Municipality of North Cowichan Re: UBCM Resolution- Regional Management of Forestry

8 Katrine Conroy, Minister of Children and Family Development Re: Childcare BC New Spaces Fund

9 Honourable Bernadette Jordan, P.C. M.P. Minister of Rural Economic Development letter Re: Council's letter of March 6th regarding cellular service on Vancouver Island.

10 UBCM Re: Gas Tax Agreement Community Works Fund Payment

11 UBCM Re: Completion of FireSmart Project (SWPI-887: Tahsis Wildfire Prevention 2018)

12 Sierra Club BC Re: Request for Letter of support for the Sierra Club's grant application to the Real Estate Foundation for their forest conservation work with municipalities and Indigenous Nations in the Nootka Sound/ Tahsis region.

13 **Rita Aedan, McKelvie Matters Re: Petition to the Legislative Assembly Province of B. C.**

14 **Email from Allen Carter Re: Public Boat Launch & Washdown Station**

Llewellyn/Elder: VOT 369/2019
THAT these correspondence items received. **CARRIED**

Llewellyn/Elder: VOT 370/2019
THAT item numbers **1, 12, and 14** be pulled for discussion. **CARRIED**

L1 **Tahsis Council letter to Hon. Claire Trevena Re: Meeting with Tahsis' Council on May 21st, 2019**

Council had a question on this letter to which staff responded.

L12 **Sierra Club BC Re: Request for Letter of support for the Sierra Club's grant application to the Real Estate Foundation for their forest conservation work with municipalities and Indigenous Nations in the Nootka Sound/ Tahsis region.**

A brief discussion followed.

Fowler/Elder: VOT 371/2019

THAT Council send a letter of support as drafted by the Sierra Club BC. **CARRIED**

L14 **Email from Allen Carter Re: Public Boat Launch & Washdown Station**

A discussion on options and associated costs followed.

Llewellyn/Elder: VOT 372/21019

THAT Council consider options and associated costs for better boat launch access and a washdown station in time for next year's season. **CARRIED**

M. New Business

1 **Grant-in-Aid Re: Culture Days**

Llewellyn/Elder: VOT 373/2019
THAT the Grant-in-Aid application be received. **CARRIED**

Fowler/Elder: VOT 374/2019
THAT the Grant-in-Aid application be approved. **CARRIED**

2 **UBCM ORV (Off Road Vehicle) Working Group for Rural Communities**

Llewellyn/Elder: VOT 375/2019
THAT this information be received. **CARRIED**

Llewellyn/Elder: VOT 376/2019

THAT Councillor Sarah Fowler be designated as the Tahsis representative on the UBCM ORV Working Group for Rural Communities. **CARRIED**

3 **Report to Council Re: Municipal Insurance Association of BC (MIABC) Voting Delegate and Alternate**

Llewellyn/Elder: VOT 377/2019
THAT this Report to Council be received. **CARRIED**

Llewellyn/Elder: VOT 378/2019

THAT Mayor Martin Davis be selected as the Village of Tahsis Voting Delegate for the MIABC 2019 Annual General Meeting and future annual general meetings. **CARRIED**

Llewellyn/Elder: VOT 379/2019

THAT Councillor Sarah Fowler be selected as the Village of Tahsis Alternate #1 for the MIABC 2019 Annual General Meeting and future annual general meetings. **CARRIED**

4 **Report to Council Re: Dike Maintenance Act – Local Government Diking Authority**

Llewellyn/Elder: VOT 380/2019
THAT this Report to Council be received. **CARRIED**

Llewellyn/Elder: VOT 381/2019

THAT to protect the public interest and safety of life and property that the Village of Tahsis become the diking authority and be fully responsible for the operation and maintenance of existing dikes, improvements to those dikes and new dikes and that the Village secure legal access to the lands on which all dikes are constructed. **CARRIED**

Llewellyn/Elder VOT 382/2019

THAT Council approve submitting a grant application to the Structural Flood Mitigation 2019 program. **CARRIED**

5 FCM Demonstration Project Grants Application

Councillor Fowler spoke to her grant application. A discussion followed.

Llewellyn/Fowler: VOT 383/2019

THAT this grant application and supporting information be received. **CARRIED**

Fowler/

Whereas inclusion is part of the new code of conduct **THEREFORE** it be resolved to support Councillor Fowler's draft application to the FCM towards parity demonstration project. **FAILED**

N. Public Input #2

A member of the public spoke about the history of the Government Wharf and the flood wall.

Recess

Llewellyn/Elder: VOT 384/2019

THAT the Regular Council meeting recess to go in to the Closed meeting for the adoption of the closed minutes. **CARRIED**

Reconvene:

Llewellyn/Elder: VOT 391/2019

THAT the Regular Council meeting reconvene at 9:08 p.m.

Rise and Report

None.

Adjournment

Llewellyn/Elder: VOT 392/2019

THAT the meeting be adjourned at 9:09p.m. **CARRIED**

Certified Correct this

3rd Day of September 2019

Chief Administrative Officer

F1

Minutes

Meeting	**Regular Council**
Date	**2 July 2019**
Time	**7:00 PM**
Place	**Municipal Hall - Council Chambers**

Present Mayor Martin Davis
Councillor Bill Elder
Councillor Sarah Fowler
Councillor Lynda Llewellyn

Regrets Councillor Josh Lambert

Staff Mark Tatchell, Chief Administrative Officer
Janet StDenis, Finance & Corporate Services Manager

Public 9 members of the public

A. Call to Order

Mayor Davis called the meeting to order at 7:01 p.m.
Mayor Davis acknowledged and respected that Council is meeting upon Mowachaht/ Muchalaht territory

B. Introduction of Late Items and Agenda Changes

Delegation "D1" to be removed.

C. Approval of the Agenda

Fowler/Elder: VOT 342/2019

THAT the Agenda for the July 2, 2019 Regular Council meeting be adopted as amended. **CARRIED**

D. Petitions and Delegations

1 **Josie Miladinovic, Tahsis Community Paramedic Re: Community Paramedic Program**

Good Evening Mayor, Council and staff,
Thank you for the opportunity to share information with you tonight about the Community Paramedicine in Tahsis.

My name is Josie Miladinovic, I am a Tahsis paramedic and I am the newly certified community paramedic for Tahsis and here with me tonight is my mentor Rachelle Cole, the community paramedic attached to the Uculet Station which was also 1 of 9 first prototype communities in BC over 3 years ago. We are now 1 of 99 rural and remote communities to receive a community paramedic.

Community Paramedicine is not a new concept as it has been practiced for decades in many provinces and countries around the world. However in BC we are just over 3 years into establishing our program and are 95% to capacity in our first phase as an addition to rural and remote care.

Our mandates are community education, outreach and awareness, health promotion, wellness checks and clinics. Although Community Paramedicine is in the infancy stage for our organization we already have many tools under our belts including home health monitoring and we are always expanding and updating our knowledge to include not only chronic health issues but more recently we have added palliative care training and as with all paramedics in BC mental health.
We are looking forward to an expansion of our scope to even further serve our communities in the months and years to come.
I look forward to collaborating with all the disciplines and services providers in our community along with all interest groups, stake holders and partners.
Thank you,

Fowler/Llewellyn: VOT 343/2019
THAT this presentation be received. **CARRIED**

E. Public Input # 1
Members of Ecologic Environmental Consultants introduced themselves to Mayor, Council and Staff and gave an update on the McKelvie Watershed Assessment Project.

A member of the public complained about the words used by a council member at the previous meeting.

F. Adoption of the Minutes
1 **Minutes of the Regular Council meeting held on June 18th, 2019**

Llewellyn/Elder: VOT 344/2019
THAT the Regular Council meeting minutes of June 18, 2019 adopted as presented. **CARRIED**

G. Rise and Report
None.

H. Business Arising

1 **Island Coastal Economic Trust (ICET) - Economic Infrastructure and Innovation Program (Stage 2) Grant Application**

A brief discussion followed.

Llewellyn/Fowler: VOT 345/2019

THAT this Report to Council and draft grant application be received. **CARRIED**

Fowler/Elder: VOT 346/2019

THAT option # 1 be approved. **CARRIED**

2 **Municipal Finance Authority of BC (MFABC) Re: Updating List of Authorized Signers**

Llewellyn/Elder: VOT 347/2019

THAT this information be received. **CARRIED**

Llewellyn/Elder VOT 348/2019

THAT Randy Taylor and Jude Schooner be removed from list "A" as signing authorities for the Village of Tahsis. **CARRIED**

Llewellyn/Elder: VOT 349/2019

THAT Mayor Martin Davis, Deputy Mayor Sarah and CAO Mark Tatchell be added to list "A" as signing authorities for the Village of Tahsis. **CARRIED**

3 **Service Provider Agreement for Climbing Wall Volunteers**

Llewellyn/Fowler: VOT 350/2019

THAT Council agree to provide liability insurance for contract volunteers who form the Climbing Wall Volunteers, through the Municipal Insurance Association's Associate Member Program;

AND THAT Council authorize the Director of Finance to enter into Service Provider Agreements with individual volunteers for the provision of liability insurance through the Village's liability insurance held with the Municipal Insurance Association of British Columbia. **CARRIED**

J. Council Reports

Mayor Davis (verbal Report)

I did attend a webinar regarding Powell River and their interactions with the community of Powell River and the local First Nations there. It was very interesting. I was looking for insight into how they work their community forests there and apparently they are two separate community forests so they have not exactly integrated them. First Nations want to buy Power River's Community Forest. That's all I got from that.

We had a Canada Day celebration which was wonderful. I got to give a speech and hand out cake.

Councillor Elder

No report

Councillor Fowler (written Report)

My report July 2, 2019 is heavy with academic reports from scientific journals. But first, this is summer! We had our annual Canada Day Trivia Contest and sing-a-long.

It was a honour to attend the delicious dinner put together by Sally for VIHA`s Rural Site Visit Project. My big take away was that Cortes Island is doing some private care called home care plus. I think we could try to explore here. The summary of a report released February 13, 2019 read `it has been identified that relationships are a foundation part of rural health.`

Secondly, I received the following information from Uu-a-thulk fisheries program with respect to the drought conditions due to low water flow.

Please include the documents for the minutes of public record of fishery sensitive watersheds

These Pacific Northwest papers demonstrate forestry effects and ask larger questions about water demand.

Mathew Bayly of Ecofish research group, a environmental consultant with a specialist in fish habitat modeling.

`I`ve seen increasing evidence of current FRPA legislation failing to identify, monitor and manage cumulative effects to fish habitat at the watershed scale.`

	Leiner river,	Perry river,	Tahsis River
area km square	116	49	77
average elevation meter's	744	712	691
H60 Elevation meter's	860	819	838
average slope %	71.8	69.1	68.5
road density for entire FSW km 1.19 0.20			0.67
road density <100m from a stream km2	0.35	0.64	0.07
road density on slopes >60% km2	0.16	0.34	0.01
stream crossing density #/km square	2.41	5.13	0.08
portion of stream disturbed km/	0.04	0.06	0.00
portion of fish bearing streams	0	0	0

(5 attachments)

Councillor Tuesday attachments

HYDROLOGICAL PROCESSES
Hydrol. Process. (2015)
Published online in Wiley Online Library
(wileyonlinelibrary.com) DOI: 10.1002/hyp.10726

A 477-year dendrohydrological assessment of drought severity for Tsable River, Vancouver Island, British Columbia, Canada

Bethany Coulthard* and Dan J. Smith

University of Victoria Tree-Ring Laboratory, Department of Geography, University of Victoria, Victoria, BC, Canada

Abstract:

Summer streamflow droughts are becoming more severe in many watersheds on Vancouver Island, British Columbia, as a result of climate warming. Small coastal basins that are the primary water source for most communities and essential to Pacific salmon populations have been particularly affected. Because the most extreme naturally occurring droughts are rarely captured within short instrumental records water managers likely underestimate, and are unprepared for, worst-case scenario low flows. To provide a long-term perspective on recent droughts on Vancouver Island, we developed a 477-year long dendrohydrological reconstruction of summer streamflow for Tsable River based on a network of annual tree-ring width data. A novel aspect of our study is the use of conifer trees that are energy limited by spring snowmelt timing. Explaining 63% of the instrumental streamflow variability, to our knowledge the reconstruction is the longest of its kind in British Columbia. We demonstrate that targeting the summer streamflow component derived from snowmelt is powerful for determining drought-season discharge in hybrid runoff regimes, and we suggest that this approach may be applied to small watersheds in temperate environments that are not usually conducive to dendrohydrology. Our findings suggest that since 1520, 21 droughts occurred that were more extreme than recent 'severe' events like those in 2003 and 2009. Recent droughts are therefore not anomalous relative to the ~400-year pre-instrumental record and should be anticipated within water management strategies. In coming decades, worst-case scenario natural droughts compounded by land use change and climate change could result in droughts more severe than any since 1520. The influence of the Pacific Decadal Oscillation on instrumental and modelled Tsable River summer streamflow is likely linked to the enhanced role of snowmelt in determining summer discharge during cool phases. Copyright © 2015 John Wiley & Sons, Ltd.

KEY WORDS dendrohydrology; drought; low flows; water management; Vancouver Island; British Columbia

Received 4 May 2015; Accepted 21 October 2015

INTRODUCTION

British Columbia's (B.C.) temperate rainforest coast is considered water-rich, but seasonal water scarcity and streamflow drought often occur during summer when demand for water is highest and storage is limited (Stephens *et al.*, 1992). In 2014 and 2015 many streams experienced droughts that were more severe than any on record (B.C. Ministry of Forests, Lands and Natural Resource Operations, 2014; B.C. River Forecast Centre, 2015). Climate warming has triggered earlier, lower, longer, and more frequent low-flows throughout the coastal region (Rodenhuis *et al.*, 2007), and the impact of worsening droughts on human water use, stream ecology, and the survival of Pacific salmon is recognized by the provincial government as a critical environmental management challenge (B.C. Ministry of Environment, 2013).

'Hybrid' runoff regimes are the primary water source for most towns, municipalities, and First Nations communities on Vancouver Island, B.C., and are also the most vulnerable to summer water shortages (Rodenhuis *et al.*, 2007). Both snowmelt and rainfall contribute substantially to annual streamflow in hybrid watersheds (Eaton and Moore, 2010). The likelihood of protracted drought under future climate conditions makes an accurate understanding of worst-case scenario droughts, based on long-term natural variability, crucial for effective water management in these basins (Pike *et al.*, 2010).

The purpose of our research was to develop a multi-century summer discharge (Q) record for a small hybrid watershed on southeastern Vancouver Island, and to interpret the severity of recent droughts within the context of that record. We used a dendrohydrological approach, where climate-sensitive tree-ring (TR) width records serve as proxies for climate in a paleo-hydrological model (Loaiciga *et al.*, 1993). Detection of recent environmental change often requires these long-term records because natural climatic patterns, such as the Pacific Decadal Oscillation (PDO), persist over multiple decades and can obscure climate change effects (Moore *et al.*, 2007).

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While streamflow reconstructions based on TR data have been developed for drought-sensitive regions world-wide, applying traditional dendrohydrological approaches to a small hybrid watershed in a temperate environment is problematic. First, very flashy rainfall-driven runoff is often a major contributor to total annual streamflow in coastal B.C. (Eaton and Moore, 2010). Dendrohydrological models usually target annual discharge in large watersheds where both runoff and annual radial tree growth are relatively unresponsive to 'flashy' rainfall events (Pederson *et al.*, 2001; Boninsegna *et al.*, 2009; Meko and Woodhouse, 2010; Yang *et al.*, 2010; Margolis *et al.*, 2011; Sauchyn *et al.*, 2014). Second, trees on Vancouver Island are rarely moisture stressed, although the radial growth of some species is sensitive to winter precipitation as a result of the energy-limiting role of deep snowpacks (Marcinkowski *et al.*, In press). Dendrohydrological studies are usually conducted in arid environments using trees whose radial growth is limited by rainfall or snowmelt-derived soil moisture, which directly influences runoff (Woodhouse *et al.*, 2006). We circumvent these problems by targeting low-flow season streamflow in our reconstruction, a time of year when runoff is significantly less flashy, is primarily driven by snowmelt, and is most important for drought management (Smith and Laroque, 1998).

We hypothesized that summer discharge in a small hybrid basin on Vancouver Island is driven by regional snowmelt variations to the extent that TR records that are energy-limited by snow could serve as proxies for climate in a dendrohydrological reconstruction of streamflow. To date, paleohydrological efforts in B.C. have explored the utility of annual TR width and density records as proxies for winter and summer temperature and snow water equivalent (SWE) for reconstructing summer-season and mean water year runoff in nival and glacial watersheds (Gedalof *et al.*, 2004; Watson and Luckman, 2005; Hart *et al.*, 2010; Starheim *et al.*, 2013). No prior attempt has been made to develop seasonal reconstructions of the hybrid streams that are most susceptible to drought in coming decades.

We use the term 'drought' to mean streamflow drought, or below-normal stream discharge, a component of hydrological drought that often also coincides with reduced groundwater availability (Van Loon and Laaha, 2015). Consistent with B.C. government management practices, 'drought' refers to below-normal stream runoff persisting over a period of consecutive months (B.C. Ministry of Environment, 2013).

RESEARCH BACKGROUND

Large precipitation and temperature gradients characterize most watersheds on Vancouver Island. Winter storms originating in the North Pacific Ocean bring moisture to the west coast of the island, where orographic lift results in deep snowpacks at high elevation and large quantities of rain in lowland areas (Stahl *et al.*, 2006). Rain shadow effects on the east side of Vancouver Island result in drier conditions in lowland coastal regions (Rodenhuis *et al.*, 2007). Summers are warm and dry, and dominated by persistent high-pressure systems (Rodenhuis *et al.*, 2007). Seasonal hydroclimatic patterns are moderated by synoptic-scale inter-annual and decadal modes of climate variability stemming from ocean–atmosphere interactions in the Pacific Basin, of which the PDO, the El Niño Southern Oscillation (ENSO), and the Pacific North America (PNA) pattern have a particular influence on regional streamflow (Kiffney *et al.*, 2002).

Hybrid streams on Vancouver Island are found primarily in mid-elevation coastal and near-coastal areas where mean watershed elevations are not high enough to be fully nival (Eaton and Moore, 2010). Hybrid streams experience highest mean monthly flows during winter rains, followed by a significant pulse of runoff from snowmelt in spring. Lowest monthly flows occur during summer when discharge is governed by snow meltwater inputs, nominal summer precipitation inputs, and losses related to high summer air temperatures and evaporation (Eaton and Moore, 2010). Snowmelt can significantly recharge deep groundwater flow pathways to augment summer baseflow in the study region, even if only a small snow fed headwater is present (Moore *et al.*, 2007; Beaulieu *et al.*, 2012). Above average minimum summer discharge is therefore often coincident with deep snowpacks that develop during cool and wet La Niña years, especially when enhanced by cold phases of the PDO (Fleming *et al.*, 2007). The proportion of rainfall-derived *versus* snowmelt-derived runoff varies from year to year in accordance with fluctuations in winter temperature, so that annual flows in hybrid regimes can be 'more pluvial' or 'more nival' in any given year (Moore *et al.*, 2007). A high between-year range in monthly flow totals is typical (Moore *et al.*, 2007).

In the south coastal region of B.C., annual minimum streamflow has decreased in hybrid watersheds over the last 30 years, with low-flow magnitudes projected to decline by up to 50% by the end of the century as a result of seasonal climate trends (Rodenhuis *et al.*, 2007; Mantua *et al.*, 2010). Winters have become milder and wetter, with less winter precipitation falling as snow and more as rain, and more frequent rain-on-snow events. As a result, less snow meltwater is available to buffer low stream discharge during the dry summer months (Pike *et al.*, 2010). Projections suggest that nival flow contributions will weaken or become non-existent, eventually shifting many hybrid systems to more pluvial regimes (Eaton and Moore, 2010). Summers have become warmer and drier additionally drawing-down summer flows (Pike *et al.*, 2010).

STUDY SITE

The Tsable River watershed is a small ($113\,km^2$) hybrid basin located on the eastern slopes of the Beaufort Range on central Vancouver Island, in the rainshadow of the Vancouver Island Ranges (Figure 1). With a maximum basin elevation of around 1500 m asl, a significant portion of precipitation within the watershed falls as snow above 1000 m asl (Eaton and Moore, 2010). Tsable Lake ($\sim 1\,km^2$) and several smaller lakes are located with the basin. Draining east to the Strait of Georgia, the lower reaches of the watershed are located within the dry Coastal Douglas Fir Zone, transitioning from the Coastal Western Hemlock Zone, to the Mountain Hemlock Zone and Alpine Tundra Zone with increasing elevation (Klinka *et al.*, 1991). At high elevation (1000–1500 m asl) the growing season is short and cool, with very deep snowpacks often persisting into the spring and summer. Mountain hemlock (TM; *Tsuga mertensiana* (Bong.) Carrière) trees are dominant, with subalpine fir (*Abies lasiocarpa* (Hook.) Nutt.) and amabilis fir (AA; *Abies amabilis* (Doug.) ex. Louden) trees occasionally co-dominant. Industrial logging is the main land use in the watershed.

Highest total monthly discharge in Tsable River occurs from November through January, with spring snowmelt causing a distinct pulse of runoff in May (Figure 2; Eaton and Moore 2010). Analysis of annual hydrographs provides a comparison between years dominated by winter rainfall- *versus* summer snowmelt-derived runoff (Figure 2). Lowest flows occur in July through September (Figure 2). In recent years, Tsable River summer baseflow has been far below optimum for the river's populations of chum, coho, and pink salmon, and resident and anadromous steelhead and cutthroat trout (B.C. Conservation Foundation 2006). Despite conservation efforts, low-flows have degraded stream habitat to the extent that the wild steelhead stock has likely been extirpated since the early 2000s (Lill, 2002; Silvestri, 2004).

DATA AND METHODS

Hydrometric and climate data

Only three hybrid streams on Vancouver Island have >50 years of natural and continuous instrumental data. Tsable River was selected for this study because it is the hybrid stream with the longest continuous natural hydrometric record (1960–2009), and the watershed does not contain large natural water storage features such as lakes and wetlands. We downloaded monthly discharge data for Tsable River from the Water Survey of Canada (http://www.wsc.ec.gc.ca/applications/H2O/index-eng.cfm). Missing values (1% of the data) were replaced with long-term monthly means (station code 08HB024; gauge location latitude: 49.517, longitude: −124.841, elevation: 1 m asl). We used the average flow from July to August for our reconstruction because the regional hydrological literature suggests that stream discharge is significantly correlated with previous winter SWE during that season (Rodenhuis *et al.*, 2007; Eaton and Moore, 2010). The July–August streamflow data, hereinafter 'summer

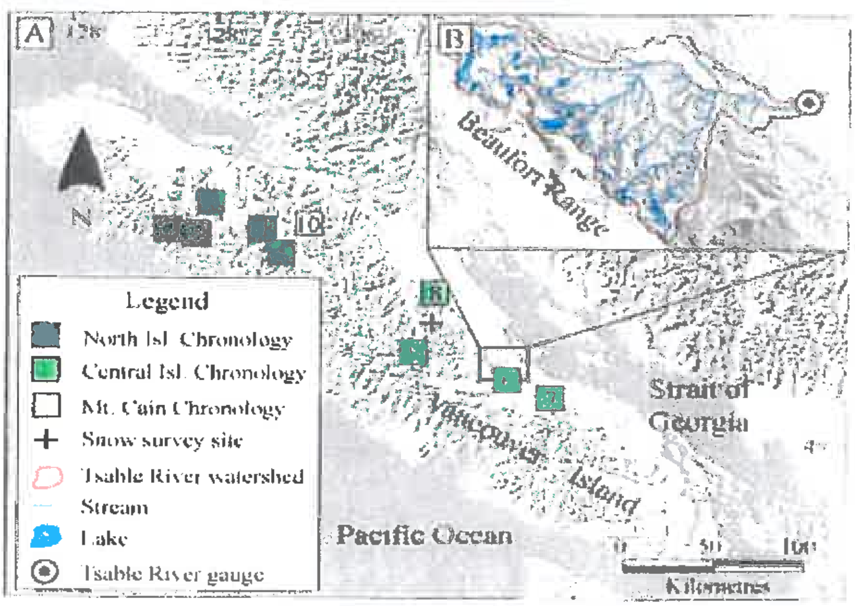

Figure 1. Map of the study area. (A) Vancouver Island. (B) Tsable River watershed 263 × 186 mm

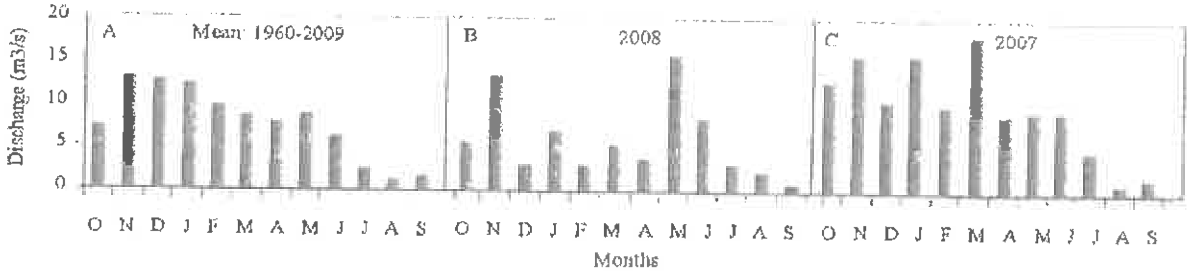

Figure 2. Tsable River water-year hydrographs. Dark bars indicate the reconstruction season (July–August). (A) Gauged mean monthly discharge over the length of record used (1960–2009); (B) mean monthly discharge in a 'more nival' year when runoff during spring snowmelt outweighed rain-derived runoff during winter; (C) mean monthly discharge in a 'more pluvial' year when runoff from winter rains outweighed runoff from spring snowmelt

streamflow' data, span the interval 1960–2009 and were normalized using a log10 transformation.

May 1 SWE records collected at the Forbidden Plateau manual snow survey site (data period February–May 1958–2014; station code 03B01; latitude: 49.653, longitude: −125.207, elevation: 1100 m asl) were retrieved from the Water Survey of Canada (http://a100.gov.bc.ca/pub/mss/stationdata.do?station=3B01). May 1 is generally the maximum annual SWE measurement in the Forbidden Plateau dataset. We estimated monthly maximum temperature and total precipitation anomaly records on the coordinates of the Tsable River hydrometric gauge site using the programme ClimateWNA, ver. 4.83 (Wang *et al.*, 2006; 2012). The programme downscales PRISM (Daly *et al.*, 2002) monthly data (2.5 × 2.5 arc min) based on the reference period 1961–1990. We compared the gauged and reconstructed streamflow records with NOAA Multivariate ENSO Index ranks (http://www.esrl.noaa.gov/psd/enso/mei/) and standardized values of the PDO index downloaded from the NOAA Earth System Research Laboratory website (http://www.esrl.noaa.gov/psd/data/climate indices/list/). Winter (averaged October–March) PDO data were used because year-to-year variability in the index is most energetic during those months (Mantua, 2002).

Tree-ring data

Mountain hemlock and amabilis fir TR width data were used for this study. In the northwestern United States and Canada, the annual radial growth of high-elevation conifer trees is often energy limited as a result of variations in snowpack depth (Peterson and Peterson, 1994). Snow may control the timing of the start or end of the growing season and, therefore, total growing season length through its influence on soil temperatures, which warm rapidly after snowmelt (Graumlich and Brubaker 1986). This climate-radial tree growth relationship is well-documented in mountain hemlock trees (Graumlich and Brubaker, 1986; Smith and Laroque, 1998; Laroque and Smith, 1999; Gedalof and Smith, 2001a; Peterson and Peterson, 2001; Zhang and Hebda, 2004; Marcinkowski *et al.*, In press) and field observations suggest amabilis fir trees typically initiate leaf and shoot expansion shortly after snowmelt (Worrall, 1983; Hansen-Bristow, 1986).

TR width data was compiled for one amabilis fir stand and eight mountain hemlock stands located on central and northern Vancouver Island (Figure 1, Table I). These data were selected because they provided the longest potentially SWE-sensitive TR width records. Crossdated amabilis fir TR width measurements collected by R. Parish at Mt. Cain in 1999 were acquired from the International Tree-Ring Data Bank website (http://www.ncdc.noaa.gov/data-access/paleoclimatology-data/datasets/tree-ring). Mountain hemlock samples were collected between 1996 and 1998 by removing two cores with a 5.0-mm increment borer from trees at standard breast height. Ring widths were measured using WinDENDRO Ver 6.1b (WinDENDRO, 1996; Laroque, 2002). In 2014, the measurements were crossdated visually (list method) and statistically verified using the programme COFECHA 3.0 (Holmes, 1983; Grissino-Mayer, 2001). In some cases physical samples were missing from the archived collections. Because crossdating was not possible without physical specimens, only a subset of the original samples could be used for each site. As a result, sample sizes per site were very low in some cases (Table I).

Tree-ring chronologies were developed using the R package dplR (Bunn, 2008). We removed long-term biological growth trend from the TR data by fitting a 100-year cubic smoothing spline with a frequency cutoff of 50 to each TR series (Cook and Peters, 1981). Dimensionless growth indices were produced by dividing ring-width measurements by the expected value of the spline. The majority of the TR data exhibited low-order autocorrelation as a result of the lagged influenced of environmental conditions in previous years (Fritts, 1976). We fit an autoregressive model to the data to remove persistence, with the model order defined by minimization of the Akaike Information Criterion. Only residual

Table I. Tree-ring chronology information. Chronologies in bold font were entered as candidate predictors in the forward stepwise model

Chronology	#	Lat/Long	Elev (m asl)	RBAR[c]	Length (years)	Series (#)	Trees (#)	r_1[d]
Bulldog Ridge[a]	1	50.28 −127.24	1010	0.22	1845–1997	9	6	0.72
Castle Mountain[a]	2	50.45 −127.12	1150	0.32	1845–1997	10	7	0.75
Colonial Creek[a]	3	50.28 −127.46	990	0.29	1940–1997	7	5	0.76
Silver Spoon[a]	4	49.98 −126.67	1100	0.37	1955–1996	11	8	0.66
N. Isl. Regional[a]		—	—	**0.26**	**1630–1997**	**37**	**28**	**0.72**
Mt. Apps[a]	5	49.44 −124.96	1340	0.29	1795–1996	40	22	0.63
Mt. Arrowsmith[a]	6	49.24 −124.59	1460	0.33	1575–1997	11	8	0.72
Mt. Washington[a]	7	49.75 −125.30	1470	0.42	1795–1996	15	12	0.68
Cream Lake[a]	8	49.48 −125.53	1340	0.36	1525–1995	29	18	0.68
C. Isl. Regional[a]		—	—	**0.30**	**1510–1997**	**95**	**61**	**0.68**
Mt. Cain[b]	**9**	**50.22 −126.35**	**1005**	**0.31**	**1520–1999**	**64**	**34**	**0.83**

[a] Mountain hemlock.
[b] Amabilis fir.
[c] Mean correlation coefficient among TR series, calculated from the detrended residual chronology.
[d] Mean first-order autocorrelation calculated using programme COFECHA, prior to autoregressive modelling.

chronologies estimated by this procedure were used in the subsequent analysis (Cook and Holmes, 1986). Series were combined into single representative 'site-level' chronologies using a bi-weight robust mean estimation (Mosteller and Tukey, 1977). Where two or more series were included from one tree, we averaged them prior to mean chronology estimation in order to weight individual trees equally. We determined the adequacy of the sample size for capturing the hypothetical population growth signal by calculating the expressed population signal (EPS; Wigley *et al.*, 1984), and truncated the chronologies where EPS < 0.80. Because of the low number of samples per site, we aggregated the records into regional chronologies where site-level chronologies were significantly intercorrelated. This significantly extended the lengths of our TR records by enhancing signal-to-noise ratios in the early part of the record. The methods used to estimate site-level chronologies were also used to estimate regional chronologies.

The Pearson correlation coefficient was used to summarize the strength of linear relationships between various time series in this study. All tests of association were conducted over the longest common interval between datasets. We used correlation tests to determine whether the site-level and regional TR chronologies were significantly linearly correlated with the gauged summer streamflow data, with Bonferroni corrections applied for repeated testing (Dunn 1961). The temporal stability of relationships in non-overlapping data subperiods was tested using a difference-of-correlations test that employs a Fisher's Z transformation of correlations (Snedecor and Cochran, 1989). Long chronologies that were significantly ($p < 0.01$) correlated with summer streamflow over the full length of the streamflow record were retained as candidate model predictors.

Hydroclimate relationships

To determine the climatic variables controlling summer discharge in Tsable River, and to justify a SWE-based reconstruction model of the river, we tested correlations of the gauged summer streamflow data with various monthly and seasonal climate data records. Effective sample sizes (Dawdy and Matalas, 1964) were used as needed in testing the correlations for significance, to adjust for persistence in the individual time series.

To assess the influence of snow on runoff, we tested the correlation of gauged summer streamflow data with current and previous year May 1 SWE values. We applied the previously described difference-of-correlations test (Snedecor and Cochran, 1989) to determine if there is a significant change in the relationship between streamflow and SWE before and after the 1976/77 PDO shift (Mantua, 2002). Because high summer streamflow is usually associated with enhanced snowmelt in hybrid streams (Eaton and Moore, 2010), we checked that low summer streamflow years are also influenced by meltwater by sorting the gauged summer streamflow data into lowest, middle, and highest terciles, and calculating Pearson's correlations between the summer streamflow and May 1 SWE values within each tercile.

Correlations of gauged summer runoff with monthly and seasonally aggregated temperature and precipitation data were calculated using the programme Seascorr (Meko *et al.*, 2011). Seascorr estimates confidence intervals on the sample correlations and partial correlations by a Monte Carlo simulation of the flow data by exact simulation (Meko *et al.*, 2011). Correlations of the gauged summer streamflow data with maximum temperature data were tested in 1- to 6-month intervals, with intervals ending in each month of the 14-month period beginning in July of the previous year and ending in August of the current year. Partial correlations were then calculated to determine if annual, and especially summer, precipitation makes a significant contribution to summer runoff that is independent of the temperature influence. We also tested monthly and seasonal correlations between the temperature and precipitation data in the same seasonal and monthly groupings. Relationships to climate in the previous year were evaluated because we were curious whether they influence current-year summer runoff as a result of hydrological lag effects in the groundwater system.

Model estimation

The reconstruction model was estimated by forward stepwise multiple linear regression of the summer streamflow data in year t on the pool of candidate predictor variables in years t, $t+1$, and $t+2$. Lagged predictors were entered to allow TR information in subsequent years to inform on climate conditions in the given year (Cook and Kairiūkštis, 1990). We evaluated regression models based on a suite of statistics widely used to evaluate tree-ring based environmental reconstructions. The adjusted R^2 statistic provides a measure of the explanatory power of the models accounting for lost degrees of freedom. Analysis of the model residuals, and the Durbin–Watson (D–W) and variance inflation factor (VIF) statistics, were used to check the model fit and assumptions. The F-ratio gives an estimate of the statistical significance of the regression equation and the standard error of the estimate (SE) a measure of uncertainty of the predicted values of the model calibration. We used leave-one-out (LOO) cross-validation (Michaelsen, 1987) to validate the models against data that were not used in the calibration. This approach allowed us to use the full 37 years of corresponding streamflow and TR data for the validation procedure, which was important given the relatively short calibration interval. We calculated cross-validation statistics by comparing the predictand gauged summer streamflow data with the LOO-estimated values of the predictand. The reduction of error (RE; Fritts *et al.*, 1990) provides a rigorous measure of model skill, with a positive value indicating that the LOO estimates better predict instrumental flow data than the mean of the instrumental data. The root mean square error of cross-validation ($RMSE_v$) gives a measure of the uncertainty of the predicted values over the verification period. The Pearson correlation (r) and R^2 of the observed and LOO-estimated values provide additional measures of accuracy (Cook and Kairiūkštis, 1990). The best model was calibrated over the full instrumental streamflow data record and used to reconstruct historical summer streamflow over the length of the shortest predictor dataset. We back-transformed the reconstructed values (modelled from TRs) to the original flow units for plotting and analysis, and checked that the selected model predictors are linearly correlated with the reconstructed flow data over the full instrumental data interval. To confirm that they operate as proxies for climate in our paleohydrological model we tested whether the model predictors are correlated with May 1 SWE and/or spring/summer maximum temperature. Correlations with temperature were calculated with Seascorr using the procedure described for hydroclimate correlations.

Analysis of the reconstruction

We compared statistical properties of the reconstructed record in the separate pre-instrumental (1520–1959) and instrumental (1960–1997) periods, with those of the gauged summer streamflow data. This comparison allowed us to determine if the pre-instrumental reconstructed record differs from reconstructed record during the instrumental era in any significant way, and also allowed us to assess the capacity of our model to approximate statistical characteristics of actual Tsable River summer streamflow. Extreme single-year droughts were defined based on a bottom fifth percentile threshold of summer streamflow, calculated based on the full reconstruction data period (1520–1997). Drought timing and magnitudes were then plotted as departures from the reconstructed mean summer streamflow calculated from the instrumental period. Comparing reconstructed values in the pre-instrumental and instrumental periods puts extreme historical droughts in the context of recent conditions without making unequal comparisons between TR-modelled streamflow data and gauged streamflow data.

We calculated the return interval of extreme droughts following the equation of Mays (2005) and used Chi-squared analysis to test if the frequency of these events in the gauged summer streamflow record (1960–2009) differed from an expected frequency of five events per 100 years (bottom fifth percentile). High year-to-year summer discharge variance is typical in hybrid watersheds and can make it difficult to identify multi-year stretches of generally low runoff, so we assessed the number of years of below median runoff over a sliding 21- year window. To determine whether reduced summer runoff corresponds with enhanced overall runoff variance, we visually compared extreme drought timing and intervals of generally low discharge with a sliding 21-year average of the standard deviations of the reconstructed summer streamflow values.

The gauged and reconstructed summer streamflow records were compared with instrumental ENSO and PDO records to investigate the influence of large-scale climate modes on droughts and wet episodes. A test of proportions (Newcombe, 1998) was used to determine if the proportion of years with below-median (or above-median) runoff during El Niño years equals the proportion of years with below-median (or above-median) runoff during weak- and non-El Niño years. The strength of El Niño/La Niña in a given year was based on NOAA Multivariate ENSO Index ranks. The same difference-of-correlations test (Snedecor and Cochran, 1989) was used to determine if correlations of the winter PDO data with the gauged and reconstructed streamflow records are significantly different during cool *versus* warm PDO phases. Effective sample sizes (Dawdy and Matalas, 1964) were used as needed to account for autocorrelation in the individual time series. A Morlet wavelet analysis (Torrence and Compo, 1998) was performed on the full reconstructed record to highlight localized fluctuations of power over time that may be associated with climate modes.

RESULTS

Tree-ring data

We developed eight site-level mountain hemlock chronologies and one site-level amabilis fir chronology for this study (Table I). Four significantly intercorrelated (mean $r=0.753$, $p<0.01$) mountain hemlock chronologies were combined into a regional chronology representing northern Vancouver Island, and four significantly intercorrelated (mean $r=0.841$, $p<0.01$) mountain hemlock chronologies were combined into a regional chronology representing the central part of Vancouver Island. Consolidating short site-level chronologies enhanced chronology sample depths to the extent that the regional chronologies could be used for dendroclimatic reconstruction. Chronology lengths for the final chronologies ranged from 367 to 487 years and mean correlation coefficient among TR series (RBAR) ranged from $r=0.26$ to 0.31 (Table I). All chronologies were significantly ($p<0.01$) correlated with the gauged summer streamflow data (r ranging from 0.466 to 0.867). The two regional chronologies and the Mount Cain amabilis fir chronology were retained as candidate model predictors.

Hydroclimate relationships

Of the monthly and seasonal climate data tested, the Tsable River gauged summer streamflow data are most strongly correlated with current-year May 1 SWE (Table II), a positive relationship that is stable over the over the 1976/1977 PDO shift (Mantua, 2002). This relationship is also significant ($p<0.05$) in the lower and upper, but not middle, terciles of the gauged data (lower tercile: $n=17$, $r=0.529$, upper tercile: $n=17$, $r=0.552$). The gauged data are also negatively correlated with maximum temperature in March through August of the current year (Table II, Figure 3) and, independently, with winter precipitation but not summer precipitation (Figure 3). No relationships to climate in the previous year were significant. Panel B in Figure 3 indicates that temperature and precipitation data are significantly negatively correlated in July through October and May through August.

Model estimation and reconstruction

A reconstruction that used the central island regional chronology in time t and Mt. Cain amabilis fir chronology in time t was selected as the best model

$$Q = 2.05 - (0.993^{*}\textit{central island TRs}) - (0.527^{*}\textit{ Mt. Cain TRs})$$

Time plots of the chronologies are presented in Figure 4. Despite similarities between the predictors, the standardized coefficients indicate that the amabilis fir chronology contributes significant additional explanatory power to the model (beta = −0.33) relative to the central island chronology (beta = −0.60). The reconstructed record spans 1520–1997 and explains 63% of the variance in the gauged Tsable River summer streamflow data (1960–2009) accounting for lost degrees of freedom. The reconstructed and the gauged streamflow data are compared in original streamflow units in Figure 5A. Regression and cross-validation statistics are summarized in Table III, and a time plot of

Table II. Hydroclimate correlations

	Central Isl. TM	Mt. Cain AA	SWE	Max T
Q (JA)	−0.75	−0.61	May 0.70	Mar–Aug −0.61
Central Isl. TM	—	0.46	May −0.58	Mar–Apr 0.41
Mt. Cain AA		—	May −0.53	Jul–Aug −0.36

Current year in capital letters.
For all correlations $p<0.01$.

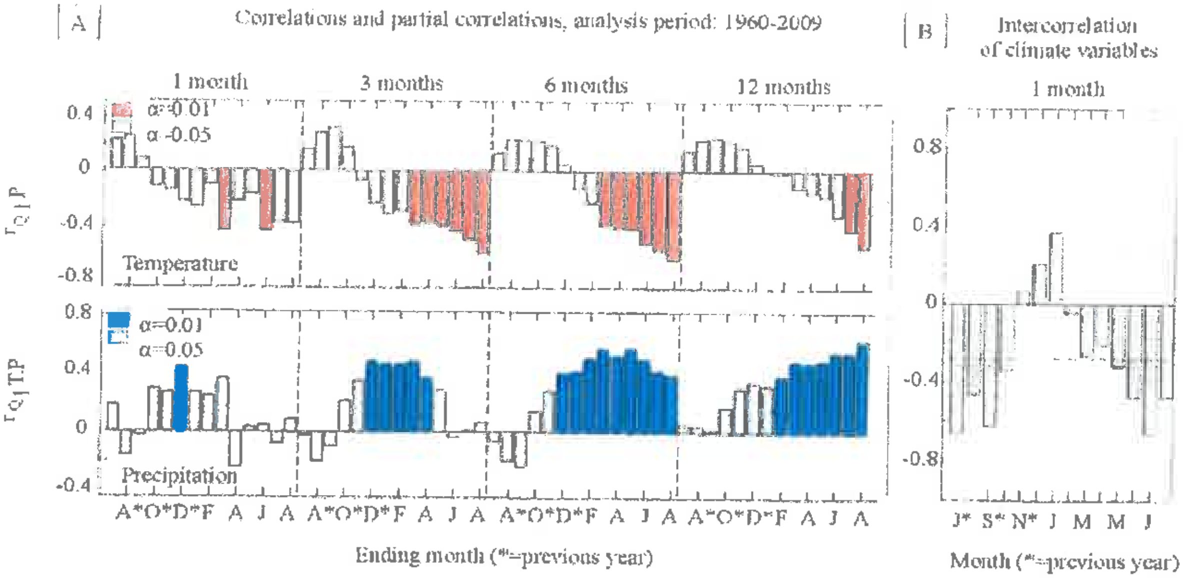

Figure 3. (A) Monthly and seasonal correlations between Tsable River July–August streamflow (Q) and maximum temperature, over 1-, 3-, 6-, and 12-month sliding windows beginning in the previous July through current August (top), and; monthly and seasonal partial correlations between Tsable River flows and precipitation, controlling for the influence of maximum temperature. (B) Monthly correlations between temperature and precipitation, beginning in the previous July through current August. Red-hatched bands represent 95% confidence intervals with the confidence interval set at $0 + 1.96/\sqrt{N}$, where N is the sample size. All tests were calculated using Seascorr

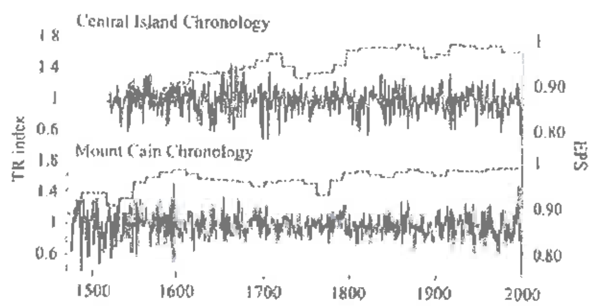

Figure 4. Time plot of tree-ring chronologies used as model predictors. EPS values are plotted with a hatched line

the cross validation is presented in Figure 5B. Collinearity diagnostics indicate that predictors are adequately independent, and the F-ratio indicates a statistically significant regression equation. The positive RE value is very similar to the validation R^2, and the SE value approximates that of the $RMSE_v$, suggesting a well-validated model. The LOO-generated predicted values of the predictand are significantly and strongly ($r = 0.62$, $p < 0.01$) correlated with the gauged summer streamflow data. Analysis of regression residuals indicated that the models do not violate regression assumptions. The chronologies are significantly ($p < 0.01$) correlated with the gauged summer streamflow data over the full period of that record (Figure 5C, Table II).

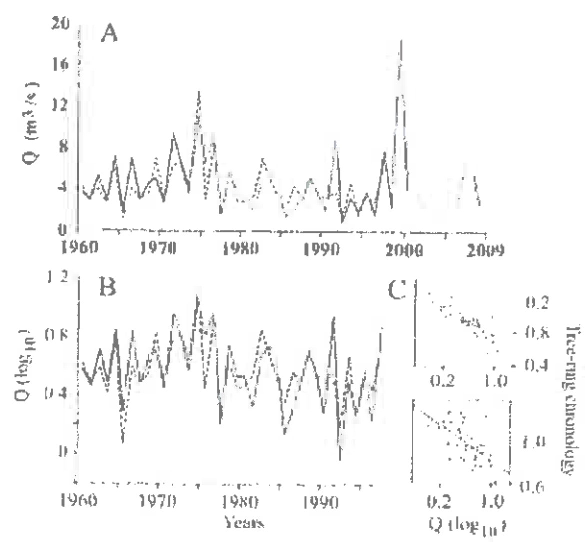

Figure 5. (A) Time plot of the reconstructed (hatched line) and gauged (solid line) summer streamflow data, backtransformed to original flow units, over the model calibration period. The instrumental data extend to 2009. (B) Time plot of the cross validation. The solid line represents the gauged (transformed) streamflow data, and the hatched line represents the LOO estimates. (C) Scatterplots of the linear associations of the central island regional chronology (above: $R^2 = -0.565$) and the Mount Cain chronology (below: $R^2 = -0.373$) with the predictand streamflow data

The central island regional chronology is most strongly negatively correlated with May 1 SWE, and is also weakly positively correlated with maximum temperature

Table III. Reconstruction and cross-validation statistics

Adj. R^2	D–W	VIF	SE	F-ratio[a]	RE	$RMSE_v$[b]	r[c]	R^2[d]
0.63	2.08	1.27	0.16	32.86	0.62	0.16	0.79	0.62

[a] Significant at the 99% level.
[b] Derived from transformed flow (unitless).
[c] Cross-validation r ($p < 0.01$).
[d] Cross-validation R^2.

in March through April (Table II). The Mt. Cain amabilis fir chronology is most strongly negatively correlated with May 1 SWE, and also exhibits a weaker negative correlation with maximum temperature during July and August (Table II, Figure 4).

Analysis of the reconstruction

The cross-validation time plot exhibits strong coherence between the gauged summer streamflow data and the LOO-estimated values (Figure 5B). While the magnitudes of both high and low flows are over and underestimated at times (for example, the magnitudes of the three lowest flows are underestimated), the modelled data track the instrumental data well overall.

Generally, our reconstruction describes very high year-to-year variance typical of a small hybrid streamflow regime that shifts intermittently from more pluvial to more nival states, and where variance is not smoothed by hydrological lag over multiple years (Figure 6). Autocorrelation function plots indicate that neither the gauged or reconstructed summer streamflow data are significantly autocorrelated at lags <15 years. Generally symmetric high-to-low flow variance is punctuated by intervals of enhanced variance driven by high flows (Figure 6). While the mean summer streamflow values and standard variances are similar in the gauged and reconstructed records, the gauged minimum/maximum values are slightly lower/higher than the reconstructed values (Table IV). A scatterplot of the standardized residual values against the gauged summer streamflow data, as well as the width of the reconstruction confidence intervals (Figure 6) suggest that our model most accurately estimates summer streamflow values in low flow years and may underestimate them in high flow years.

The timing and magnitudes of bottom fifth percentile flow years ($Q < 1.67\,m^3/s$) are plotted in Figure 6. Twenty-two extreme droughts occurred prior to the instrumental record, with a 20 year return interval (Figure 6, Table V). The most extreme droughts recorded occurred in 1651, 1660, and 1665, with an unusual cluster of seven drought years occurring between 1649 and 1667. Only once in the last 440 years have drought conditions persisted for three or more years (1665–1667). None of the reconstructed droughts was more severe than the worst instrumental drought in 1992, when summer streamflow was only 21% of the reconstructed instrumental period mean discharge (Table V).

Table IV. Gauged and reconstructed streamflow statistics

Streamflow data	min (m^3/s)	mean (m^3/s)	max (m^3/s)	cv[a]	r_1[b]
Gauged	0.9	4.4	18.6	0.53	−0.11
Reconstructed (instrumental period)	1.3	4.2	13.4	0.69	−0.12
Reconstructed (pre-instrumental period)	0.7	4.1	13.3	0.54	−0.11

[a] Coefficient of variation.
[b] First-order autocorrelation coefficient. None significant ($p < 0.05$) for lags 1–15.

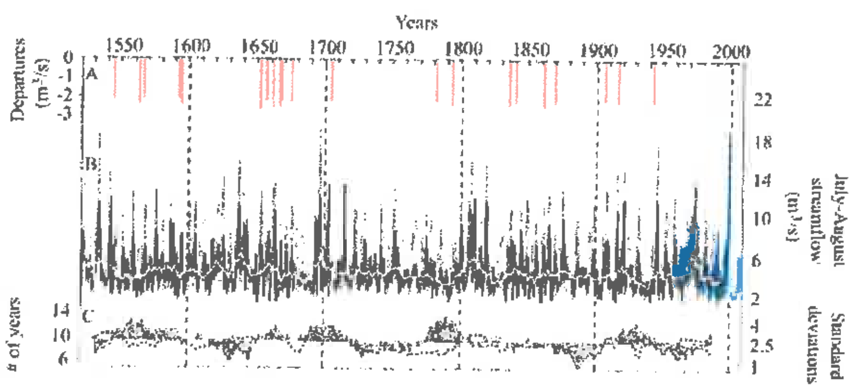

Figure 6. (A) Extreme droughts, plotted as departures from the reconstructed instrumental period mean. Reconstructed droughts are represented with red bars and gauged droughts with red hatched bars. The gauged drought magnitudes are calculated from a threshold derived from the reconstructed record. (B) Time plot of reconstructed Tsable River July–August streamflow (black line) with 5-year running mean (white line), gauged streamflow data (blue line), and 95% confidence intervals calculated from the RMSEv (Weisberg 1985; grey envelope). (C) Line graph of the number of years when July–August streamflow fell below the median value of the full-period reconstruction, plotted over a 21-year sliding window (grey fill) and a sliding 21-year average of the standard deviations of the reconstructed streamflow data (dotted line). For both the median departures and standard deviations, each plotted value represents the central value of the sliding window

Table V. Pre-instrumental bottom fifth percentile low-flow timing and magnitudes (regular font), and gauged flows falling below the reconstructed bottom fifth percentile threshold (bold font). Presented in order of severity

Year	Departure[a] (m^3/s)	Mean July–August flow (m^3/s)	% of reconstructed instrumental period mean Q
1992	**−3.33**	**0.91**	**21**
1651	−3.21	1.03	23
1660	−3.14	1.10	25
1665	−3.11	1.13	26
1860	−2.98	1.30	29
1593	−2.93	1.31	30
1792	−2.92	1.32	30
1834	−2.91	1.33	30
1915	−2.89	1.35	31
1985	**−2.86**	**1.38**	**31**
1562	−2.88	1.40	32
1941	−2.81	1.43	32
1868	−2.76	1.48	33
1839	−2.75	1.49	34
1704	−2.70	1.54	35
1674	−2.69	1.55	35
1780	−2.66	1.58	36
1543	−2.65	1.59	36
1655	−2.65	1.59	36
1977	**−2.65**	**1.59**	**36**
1666	−2.62	1.62	37
1667	−2.62	1.62	37
1905	−2.60	1.64	37
1565	−2.58	1.66	38
1591	−2.58	1.66	38
1996	**−2.58**	**1.66**	**38**
2003	**−2.58**	**1.66**	**38**

[a] Departure from the reconstructed instrumental period mean (4.24 m^3/s).

Gauged summer streamflow values also fell below the bottom fifth percentile threshold in five years (1977, 1985, 1992, 1996, and 2003; Figure 6, Table V). The Chi-squared analysis indicated that the frequency of extreme droughts in the gauged record does not differ from the expected frequency (Chi-squared = 4.69, p = 0.10). We have reported the magnitudes of extreme instrumental droughts in terms of their departure from the reconstruction mean over the instrumental period which is a slightly unequal comparison because the instrumental period was omitted from the calculation of the bottom fifth percentile threshold.

The number of years where summer streamflow fell below the median value of the full-period reconstruction is plotted over a 21-year sliding window in Figure 6. Each value in Figure 6 represents the central value of the sliding window. The plot makes it possible to identify periods of time when summer streamflow was either high or low overall relative to the median, despite the very high year-to-year variance dominating the reconstruction. Periods of overall lower flows occurred from the mid-1560s to late 1500s, 1650–1720, 1770–1810, and 1905–1941. Visual comparison of these periods with intervals of higher year-to-year summer streamflow variance, highlighted in Figure 6 by the sliding-mean standard deviations, does not suggest any relationship of generally higher/lower summer streamflow with higher overall variance.

Neither the gauged or reconstructed summer streamflow records exhibited differences in the number of below (above)-median flows during El Niño *versus* weak- and non-El Niño years (Table VI). Both records were significantly correlated with winter PDO over the full common data interval ($r = -0.47$ and $r = -0.23$ respectively, $p < 0.01$), although the reconstructed record exhibited a weaker relationship. Relationships with winter PDO were stronger during the early/cool phase (1960–1976; $r = -0.57$ and $r = -0.47$ respectively, $p < 0.01$) than the late/warm phase (1977–1997; $r = -0.30$ and $r = -0.11$ respectively, $p < 0.01$), but the difference between correlations in these periods was not statistically significant for either record. The wavelet power spectrum identifies repeating, but not necessarily regular, fluctuations (energy) in the time series over time (Torrence and Compo, 1998). The reconstructed streamflow data (Figure 7) exhibits significant ($p < 0.01$) energy in the approximately 2, 4, and 8-year bands that is intermittent over time, and energy in the approximately 15–30 year band that is more persistent over time, including throughout the mid- 1600s, 1800–1850, and 1960–1980.

Table VI. Test of proportions determining associations of instrumental and reconstructed flow data to El Niño events, calculated over the period 1960–1997. Calculated using function *prop.test* in R. Proportions of years in each streamflow category noted in parentheses. The null hypothesis that both groups have the same true proportions was true for all tests, with p values ranging around 0.32 (average)

Streamflow category	# El Niño years	# non-El Niño years	# El Niño and non-El Niño years
Instrumental flow data			
Below median	9 (40.9%)	10 (62.5%)	19 (50%)
Above median	13 (59.1%)	6 (37.5%)	19 (50%)
Total	22 (100%)	16 (100%)	38 (100%)
Reconstructed flow data			
Below median	8 (36.4%)	11 (68.7%)	19 (50%)
Above median	14 (63.6%)	5 (31.3%)	19 (50%)
Total	22 (100%)	16 (100%)	38 (100%)

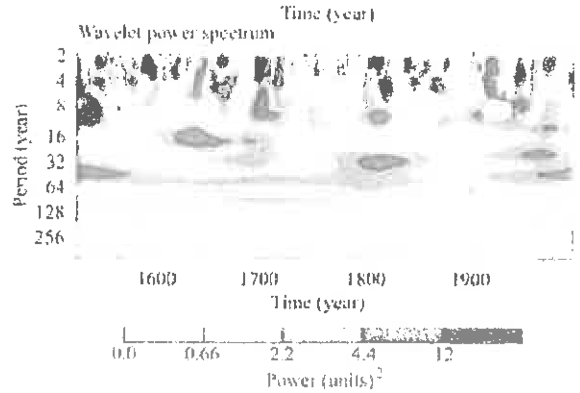

Figure 7. Morlet wavelet power spectrum on the full reconstructed streamflow record. The black contours represent the 95% confidence level based on a white-noise background spectrum. The hatched area represents areas of the spectrum susceptible to the effects of zero padding (Torrence and Compo 1998)

DISCUSSION

Reconstruction model

Our reconstruction effectively estimates July-August streamflow in Tsable River based on two TR-derived proxy records sensitive to regional-scale SWE variability. Correlation analyses indicate that runoff during this season is driven principally by snowmelt, and that the selected TR predictors primarily operate as proxies for that streamflow component in our paleohydrological model. The sensitivity of gauged summer streamflow data to previous winter SWE and spring/summer maximum temperatures supports the interpretation that Tsable River is characterized by a hybrid hydrological regime. Tercile correlations confirm that low streamflow values, not just high streamflow values, are influenced by snowmelt. The gauged streamflow record is also influenced by summer temperature fluctuations which can impact runoff because of the large relative influence of evaporation on small basins (Margolis *et al.*, 2011). Some temperature-related variability may be incorporated into the reconstruction because the two predictor TR chronologies are influenced by temperature in the spring and summer, respectively. The model residuals are correlated with maximum temperature during March (-0.42, $p < 0.01$) but not during summer months, suggesting summer temperature related variability from the Mount Cain TR chronology may influence the model estimates. The negative relationship between TRs and summer temperature means that summer temperature information within the TR chronology serves to weaken the relationship between TRs and streamflow, which may reduce model accuracy (although the TR-temperature relationship is notably weak; $r = -0.36$, $p < 0.01$). Finally, the instrumental streamflow data are influenced by winter rainfall persisting in the groundwater system, and summer rainfall. Neither of these flow components is captured by our model but, because they contribute little to summer runoff, it is not likely this seriously reduces the accuracy of the reconstruction. A possible limitation of our reconstruction is that cross-validation statistics can be biased upward when the cross-validation period is short (Meko, 2006), although the cross-validation time plot indicates a strong model validation.

Our reconstruction is primarily 'tuned' to SWE-driven runoff variations. However, we found that the gauged summer streamflow data are also influenced by spring/summer maximum temperature. The inability of our model to fully capture temperature-driven summer streamflow variability likely contributes to general underestimation of the severity of the lowest gauged flows (3/4 lowest instrumental flow values are underestimated), although low flows are still more precisely estimated than high flows. The incorporation of a summer temperature-sensitive proxy in a similar model may improve the accuracy of low-flow magnitude estimations and, given the non-independence of temperature and precipitation fluctuations during summer, might also enable a model to account for some portion of variability in summer precipitation.

As is typical in TR-based regression, our model does not capture the full range of instrumental streamflow variance (Table IV; Cook and Kairiūkštis, 1990). We emphasize that as a result, the reconstruction likely underestimates the severity of historical lowest summer flows. For example, although the model residuals suggest low flows are generally more accurately estimated than high flows, the magnitudes of the three worst instrumental droughts are all underestimated in the cross-validated and reconstructed data (Figure 5A, B). We have also reconstructed mean, not minimum, July–August streamflow values; actual lowest streamflow values would be lower than those estimated by our model.

Extreme droughts

Twenty-two extreme droughts occurred over the 439-year pre-instrumental record. As a modern analogue, the low-flow magnitudes in all but one of these years were more severe than the gauged values in 2003 and 2009 when severe summer drought throughout southern and coastal B.C. seriously impacted community, irrigation, and hydroelectric water supplies in un-glaciated catchments (B.C. Ministry of Environment, 2010; Puska *et al.*, 2011). Our reconstruction suggests that droughts of the severity of those in 2003 and 2009 are not anomalous relative to the last several hundred years and should be accounted for in water management strategies (in fact, 2009 was not flagged as an extreme drought year based on the long-term threshold). Further, worst-case scenario natural droughts based on hydrometric data records are likely underestimated because more severe events occurred outside the hydrometric data period. It is possible that extreme natural low flows, paired with pressures from land-use and climate change, could result in a drought that is more severe than any since 1520. It is important to consider that very low flows in unglaciated Vancouver Island streams since 2009, especially in 2014 and 2015 (B.C. Ministry of Forests, Lands and Natural Resource Operations 2014; B.C. River Forecast Centre, 2015), may well have surpassed the severity of gauged droughts analysed for this study but could not be accounted for because of unavailable hydrometric data. The instrumental drought in 1992 may be more extreme than any in the reconstructed record, but this should be interpreted conservatively because the reconstructed streamflow variance is somewhat suppressed relative to the gauged record; actual magnitudes of pre-instrumental low flows may be as or more extreme than in 1992.

Our results suggest that relative to the preceding 440 years, the magnitudes of extreme droughts in Tsable River did not generally worsen from 1960 to 2009. Frequencies of lowest flow events also did not increase. A large outlier (high-flow year) in 1999 obscures a significant long-term negative trend in the gauged data (tested using a *t*-test of the slope of a regression of the instrumental flow data on time with 1999 removed) indicating that, with the exception of one year, Tsable River summer runoff has declined overall between 1960 and 2009. Analysis of SWE and precipitation data shows the outlier is related to very high snowfall (July–August precipitation was equal to the long-term 1960–2009 average in that year, while SWE was 217% of the average). This trend is not exceptional compared to the rest of the reconstruction, which suggests long-term streamflow declines of similar length and magnitude began around 1640, 1700, and 1800. Without data for the most extreme recent drought years, it is not possible to assess the unusualness of recent streamflow trends relative to the last few centuries.

Our findings highlight that consecutive years of very low flows have been extremely rare in the Tsable River system, which is consistent with minimal multi-year hydrological lag in small coastal watersheds and is an important hydrological feature for water management. Because the likelihood of extreme droughts is largely unrelated to conditions in the previous year, these events are highly unpredictable compared with large basins where persistent, multi-year drought is typical (Meko and Woodhouse, 2010). From a model-development standpoint, mimicking the zero-autocorrelation structure of the gauged summer streamflow data was critical for developing an accurate reconstruction. The dendrohydrological approach risked introducing 'artificial' persistence related to biological tree growth into our model, but use of residual chronologies guarded against this.

We found no evidence that the timing of below- or above- median streamflow in Tsable River corresponds with El Niño or weak- and non-El Niño years, in either the instrumental or reconstructed flow data. We evaluated El Niño years because they are typically associated with the low flows of interest to this study and which are most accurately estimated by our model. We did not evaluate associations with La Niña events that are typically more strongly associated with annual streamflow in hybrid watersheds, and correspond with enhanced winter precipitation and total runoff (Fleming *et al.*, 2007). In contrast, both the reconstructed and gauged streamflow records are influenced by winter PDO during the common data interval, with the strongest (negative) relationships occurring during the cool phase of the oscillation. This suggests an influence of SWE on summer low flows, consistent with cool PDO phases promoting more snow and higher snowmelt-derived runoff than warm phases (Fleming *et al.*, 2007). That the difference in correlations between the warm and cool phases was not statistically significant may have been because of small effective sample sizes (17 and 21 years). Intermittent ENSO-like power in the reconstructed record is evident in the approximately 2, 4, and 8-year bands of the wavelet power spectrum (Figure 7). PDO-like multidecadal power weakens between 1850 and 1910, as documented in other independent reconstructions of that oscillation (Gedalof and Smith, 2001b, MacDonald and Case, 2005).

Comparison with historical temperature, precipitation, and drought records is made difficult by a lack of relevant high-resolution records in Pacific Canada and the northwestern United States. The most pertinent records, which represent seasonal and/or spatial contexts distinct from those of this study, unsurprisingly yielded no notable similarities to historical Tsable River streamflow variability (Graumlich and Brubaker 1986; Larocque and Smith 2005; Luckman and Wilson 2005; Jarrett 2008; Wiles *et al.*, 2014). Neither does our reconstruction correspond with the few (non-hybrid) streamflow reconstructions developed in B.C. (Gedalof *et al.*, 2004, Hart *et al.*, 2010, Starheim *et al.*, 2013), similar records from Canada's western interior (Case and MacDonald 2003; Axelson *et al.*, 2009), or large-scale historical drought episodes such as the 1929–1940 Dust Dowl, the 1946–1956 drought in the southwestern United States (Fye *et al.*, 2003), or the 16^{th} century megadrought (Stahle *et al.*, 2000). In the instrumental period, recent large-scale droughts in the Canadian Prairie provinces (e.g. 2002; 1999–2005; Canadian Foundation for Climate and Atmospheric Sciences 2010) are not expressed in the Tsable River gauged record, reinforcing the distinct hydroclimatological character of B.C.'s small coastal basins relative to surrounding regions.

CONCLUSION

Long-term perspectives on hydroclimate variability are critical for water management, with small temperate watersheds representing a frontier for paleohydrological modelling (Biondi and Strachan, 2012). We demonstrate that a dendrohydrological approach focused on the SWE-driven streamflow component is appropriate for determining drought-season runoff in small hybrid watersheds in coastal B.C. Tree-ring width records that are energy-limited by spring snowmelt timing were effective proxies for this streamflow component. Our reconstruction of Tsable River suggests that the severity of droughts in the 440 years preceding the instrumental record exceeded modern analogues such as the 2003 and 2009 droughts. The fact that recent 'extreme' events fall within a natural range of multi-century variability means that rather than being considered anomalies, extreme droughts should be expected and incorporated into drought management strategies. Most importantly, our findings suggest that worst-case scenario natural drought estimates based on hydrometric data are likely underestimated. Given projected climate trends and pressures from land-use change and increasing human demand for water in the study area, exacerbation of natural droughts can be reasonably anticipated in hybrid basins in coming decades, potentially resulting in low flows that exceed any since 1520.

There has been a significant decline in Tsable River summer runoff from 1960 to 2009 with the exception of one year. The frequency of extreme droughts did not increase between 1960 and 2009, but we could not account for severe events after 2009 — including the major droughts that occurred in 2014 and 2015 — because of a lack of hydrometric data. Both the gauged and reconstructed streamflow records experienced significantly greater runoff during cool phases of the PDO, which favour deep snowpacks. There was no measurable influence of El Niño on the timing of below-median flows but ENSO-type variability is apparent in the wavelet analysis. This variability may be related to the influence of La Niña on high flows in hybrid systems in the study area. While our reconstruction is primarily 'tuned' to SWE-related flow variability, a model that could account for the influence of spring/summer temperature on summer streamflow may improve drought magnitude estimates.

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LONG-TERM CHANGES IN STREAMFLOW FOLLOWING LOGGING IN WESTERN OREGON AND ASSOCIATED FISHERIES IMPLICATIONS[1]

Brendan J. Hicks, Robert L. Beschta, and R. Dennis Harr[2]

ABSTRACT: The long-term effect of logging on low summer streamflow was investigated with a data set of 36 years. Hydrologic records were analyzed for the period 1953 and 1988 from Watershed (WS) 1 (clearcut logged and burned), WS 2 (unlogged control), and WS 3 (25 percent patch-cut logged and burned) in the H. J. Andrews Experimental Forest, western Cascade Range, Oregon. These records spanned 9-10 years before logging, and 21-25 years after logging and burning. Streamflows in August were the lowest of any month, and were unaffected by occasional heavy rain that occurred at the beginning of summer. August streamflows increased in WS 1 compared to WS 2 by 159 percent following logging in WS 1, but this increase lasted for only eight years following the start of logging in 1962. Water yield in August for 1970-1988 observed from WS 1 was 25 percent less than predicted from the control (WS 2, ANOVA, p=0.032).

Water yield in August increased by 59 percent after 25 percent of the area of WS 3 was patch-cut logged and burned in 1963. In contrast to WS 1, however, water yields from WS 3 in August were consistently greater than predicted for 16 years following the start of logging, through to 1978. For the 10 years, 1979-1988, water yield observed in August from WS 3 was not different than predicted from the control (WS 2, ANOVA, p-0.175).

The contrasting responses of WS 1 and 3 to logging are thought to be the result of differences in riparian vegetation caused by different geomorphic conditions. A relatively wide valley floor in WS 1 allowed the development of hardwoods in the riparian zone following logging, but the narrow valley of WS 3 and limited sediment deposits prevented establishment of riparian hardwoods.

Low streamflows during summer have implications for salmonid survival. Reduced streamflow reduces the amount of rearing habitat, thus increasing competition. Combined with high water temperatures, reduced streamflow can lead directly to salmonid mortality by driving salmonids from riffles and glides, and trapping them in drying pools. Low streamflow also increases oxygen depletion caused by leaves from riparian red alders.

(KEY TERMS: streamflow; logging; salmonids; water use; water storage; evapotranspiration; dissolved oxygen.)

INTRODUCTION

Many studies have shown that removal of vegetation by clearcut logging results in increased annual water yield (e.g., Bosch and Hewlett, 1982; Harr, 1983). This increased streamflow is caused by reduction of the water loss associated with vegetation through interception, evaporation, and transpiration. It is generally assumed that some time after clearcut logging, annual water yields will approach prelogging values as vegetation regrows (Kovner, 1956; Rothacher, 1970). The rate of regrowth and concomitant reduction of water yield depends on a number of factors, among which are climate, plant species, soil, and altitude. Studies at the H. J. Andrews Experimental Forest in the Cascade Range of western Oregon (Figure 1) predicted that return of annual water yield to prelogging levels might take about 27 years in this environment (Equation 1, in Harr, 1983).

Whether water yield actually returns to the prelogging level, or to some level above or below it, has not previously be established in the Pacific Northwest of the U.S. Few studies have sufficiently long periods of observation with which to investigate long-term water yield following clearcut logging. In addition, short-duration studies have covered only the period of increased water yield immediately following logging (e.g., the Alsea Watershed Study, Harris, 1977), being terminated before regrowth of vegetation subsequently reduced logging-related flow increases to pretreatment levels. This study examines the long-term effect of timber harvest, taking into account the period of vegetative regrowth following logging.

In certain environments, water yields might decrease following logging. Instead of the expected increase, a small (<20 mm) decrease in annual water

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yield was observed after 25 percent of a watershed was patch-cut logged at Fox Creek, Bull Run Municipal Watershed, on the western slopes of Mt. Hood, Cascade Range, western Oregon (Harr, 1982). The experimental watersheds at Fox Creek extend in elevation from 840 to 1070 m, where fog is common. Interception of wind-blown fog by 46-55 m-tall conifers is an important source of moisture in the Fox Creek watersheds, and fog interception was reduced by removal of vegetation, thereby reducing the annual amount of moisture available at the soil surface (i.e., precipitation plus fog drip) by up to 30 percent compared to prelogging levels. Fog has also been shown to contribute significantly to annual precipitation in coastal forests in Oregon and northern California (Isaac, 1946; Azevedo and Morgan, 1974).

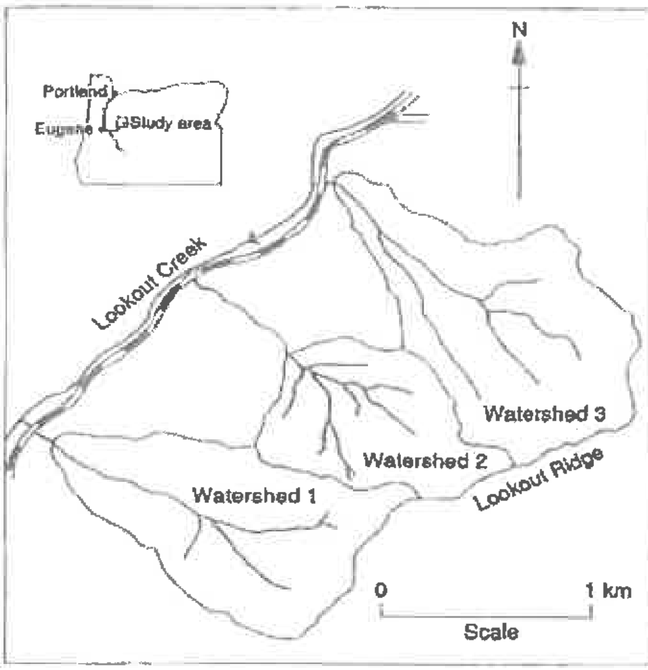

Figure 1. Location of Watersheds 1 and 2 in the H. J. Andrews Experimental Forest, Cascade Range, Oregon (after Rothacher *et al.*, 1967).

Forests have a substantial effect on water yield in environments other than fog zones. Interception of precipitation and transpiration by trees have a pronounced effect on water balance in regions with moderate to high annual precipitation (above about 1500 mm) and dry summers (Pearce and Rowe, 1979). Many of the production forests in western North America occupy such environments, and freshwater resources could be affected as second-growth forest replaces mature forest.

Diminishing water flows from June to September can adversely affect stream inhabitants. Even small reductions in water yield in summer can be detrimental to salmonids. Several studies have suggested that volume of summer rearing habitat is a significant factor affecting fish production (Smoker, 1953; Everest and Sedell, 1984; Elliott, 1985; Hicks, 1990). Also, when flow is reduced, stream temperatures may increase, causing increased stress, disease, and competition among fish. Temperatures preferred by rainbow trout (*Oncorhynchus mykiss*, formerly *Salmo gairdneri*), or optimum for their growth, range from 12 to 22°C. Temperatures of 25°C or above may be lethal (Cherry *et al.*, 1975). Increased yield of coarse sediment following logging can increase the effect of low flows, causing shallowing and widening of stream channels (Lyons and Beschta, 1983; Tripp and Poulin, 1986).

METHODS

Predicting the response of summertime streamflows to forest management activities requires a long period of record, preferably from paired watersheds. One of the few long-term records of changes in water yield from paired watersheds in an environment with moderate to high annual precipitation and dry summers comes from Watersheds (WS) 1, 2, and 3 of the H. J. Andrews Experimental Forest (Figure 1). The study basins have areas of 96 ha, 60 ha, and 101 ha, respectively, and are underlain by volcanic rocks, including andesite and basalt lava flows, and tuff breccias (Rothacher *et al.*, 1967). The watersheds range from 442 to 1082 m, at which elevation the vast majority of precipitation falls as rain (Rothacher *et al.*, 1967). Snow that does fall between 400 and 1100 m elevation in western Oregon is transient, usually melting in 3-4 days during subsequent rain (Harr, 1983), and thus is of little significance to summer streamflows.

Streamflows were calibrated by taking baseline measurements in the unlogged watersheds from 1953 to 1961 for WS 1, and from 1953 to 1962 for WS 3. Logging began in WS 1 in 1962, and continued until 1966. Remaining vegetation and logging slash in WS 1 was burned in October 1966 (Rothacher, 1970). In late 1962 and early 1963, 25 percent of the area of WS 3 was patch-cut logged, and these cleared patches were burned in September 1963. Watershed 2 remained unlogged as a control, with precipitation measured at a climate station in WS 2. Months were grouped by water year (October 1 to September 30) for analysis of streamflow and precipitation.

Water yields for WS 1, 2, and 3, analyzed by Harr (1983), were derived from data transcribed from continuous records using methods that visually estimated instantaneous flow from the water level traces (pers. comm., Don Henshaw, Pacific Northwest Research Station, Corvallis, Oregon). We have reanalyzed results from data digitally transcribed from the original records for part of the prelogging period (1953-1959), and we have added seven more years of data to the analysis of Harr (1983).

Data from the prelogging calibration period were used to relate annual and summer water yields in millimeters from WS 1 and 3 following timber harvest to water yield from the control watershed (WS 2). Calibration periods were nine years for WS 1 (1953-1961) and 10 years for WS 3 (1953-1962). Least-squares regression was used to derive the prelogging relationship between streamflows in WS 1 and 2, and between streamflows in WS 3 and 2. The linear model $Y=a+bX$ was used, where Y=observed water yield from WS 1 or 3 (treated watersheds) and X=observed water yield from WS 2 (unlogged control). Observed water yield from WS 2 was then used to predict water yield expected from WS 1 and 3 before and after logging on the basis of the recalculated regression relationships in Table 1.

RESULTS

Water Yield After Logging

Slope and intercept for regression relationships between WS 1 and 2 from this analysis were very close to those calculated using the same methods by Harr (1983) for July to September (Table 1). The recalculated regressions of prelogging water yields for WS 1 on WS 2 were significant for all months and combinations of months (Table 1). Regression relations for prelogging water yields for WS 3 on WS 2 were also significant for all months and combinations of months, except for July. The regressions of total annual prelogging water yield for both WS 1 and WS 3 on WS 2 were also significant ($p<0.001$, Table 1).

The period of increased summer flow observed following the start of logging in WS 1 compared to the unlogged WS 2 was short-lived (about eight years,

TABLE 1. Results of Least-Squares Linear Regression Analysis of Summer and Annual Water Yields Before Logging for Watershed 1 (1953-1961) and Watershed 3 (1953-1962, depending variables, Y) on Watershed 2 (independent variable, X) in the H. J. Andrews Experimental Forest, Western Oregon Cascades (n=9 for WS 1, n=10 for WS 3). Results from Harr (1983) compared to those from this paper for digitized data. The model used is $Y=a+bX$.

Time Period	Slope (b)	Intercept (a)	r^2	Significance of Regression Model (p)
		WATERSHED 1 – Clearcut Logged (this paper)		
July	0.461	2.06	0.62	0.012
August	0.544	0.14	0.67	0.007
September	1.001	–2.60	0.89	<0.001
July to August	0.513	1.70	0.72	0.004
July to September	0.704	–2.84	0.80	0.001
Annual	0.944	–97.92	0.96	<0.001
		HARR (1983)		
July to September	0.731	–2.74	0.72	0.004
		WATERSHED 3 – 25 Percent Patch-Cut Logged (this paper)		
July	0.629	8.61	0.20	0.198
August	1.018	0.89	0.74	0.001
September	1.275	–0.14	0.92	<0.001
July to August	0.823	8.59	0.43	0.040
July to September	0.861	11.43	0.63	0.006
Annual	0.839	110.63	0.94	<0.001

Figure 2A). After 1970, observed water yield from WS 1 for August was generally less than that predicted from the model; reduced water yield has occurred for 18 of 19 years (1970-1988). In contrast to WS 1, however, water yields from WS 3 in August were consistently above predicted through 1978, 16 years after the start of logging (Figure 2B).

Differences between observed and predicted water yields for WS 1 were compared for three distinct periods of record (Table 2). The three periods were: (1) 1953-1961 (prelogging calibration), (2) 1962-1969 (the period of increased water yield that included logging and burning, and (3) 1970-1988 (the following 19 years of low water yield). Means were compared with single-classification ANOVA. Differences between observed and predicted water yields for WS 1 increased dramatically following clearcut logging for 1962-1969. The increase in water yield for August

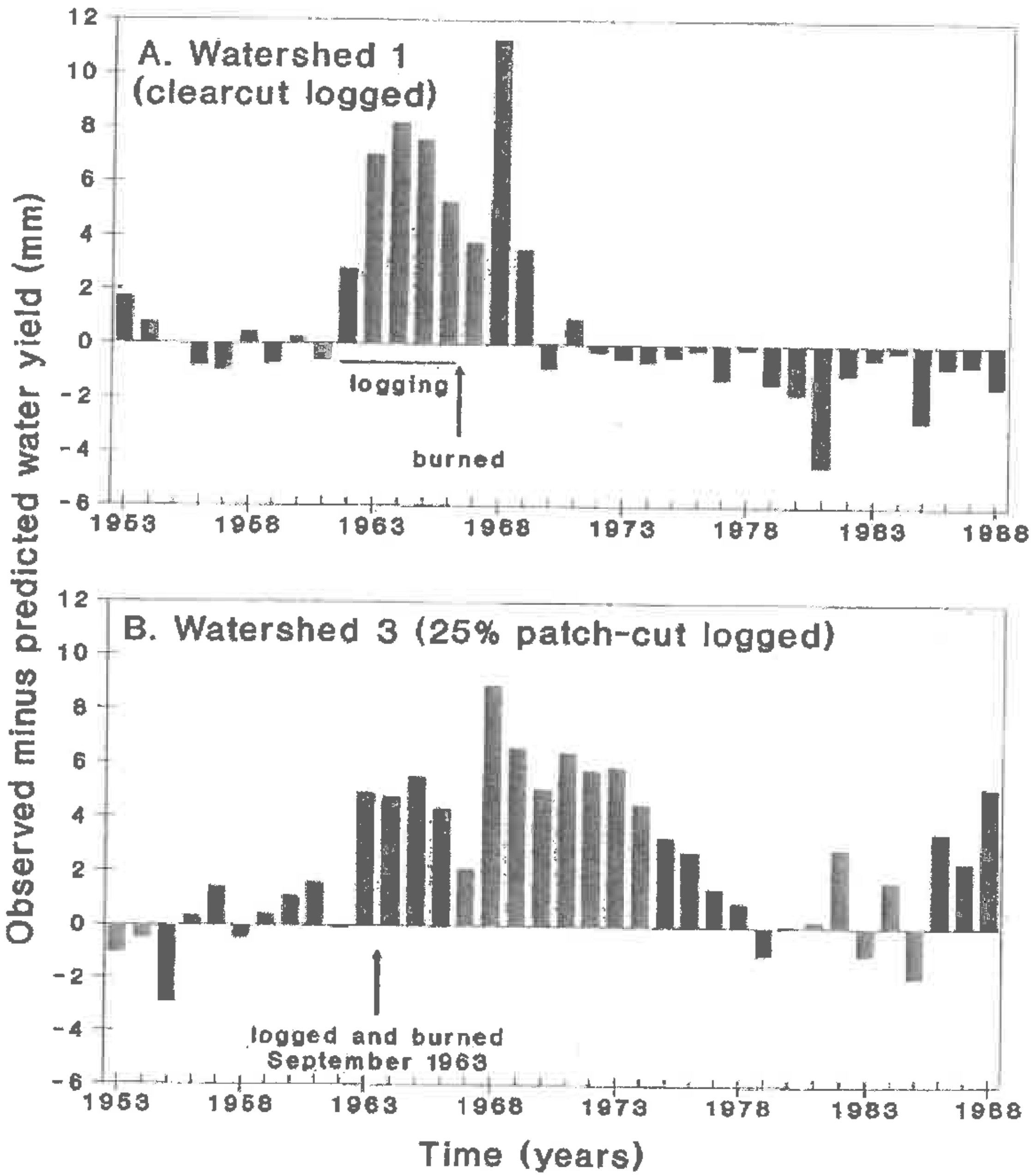

Figure 2. Differences Between Observed and Predicted Water Yield for August from Watershed 1 (A) and Watershed 3 (B) in H. J. Andrews Experimental Forest, Western Oregon Cascades, Before and After Logging (1953-1988).

TABLE 2. Means of Observed and Predicted Water Yields from Watersheds 1, 2, and 3 Before and After Logging (1953-1988) in the H. J. Andrews Experimental Forest, Western Oregon Cascades, for (A) Period of Prelogging Streamflow Calibration, (B) Period of Increased Water Yield During and Immediately Following Logging, and (C) Period of Reduced Water Yield Following Vegetative Regrowth. All water yields increased significantly in the period immediately following logging compared to the prelogging period.

Months	Years of Record	n	Mean Observed Water Yield (mm)	Mean Observed Water Yield ($l/s/km^2$)	Predicted Water Yield (mm)	Mean Observed Minus Predicted Water Yield (mm)	(percent)	mean	se*	Significance of Difference Between Periods A and C** (α)
				WATERSHED 1 – Clearcut Logged						
July	(A) 1953-1961	9	9.1	3.40	9.1	0.0	0	0.00	0.11	
	(B) 1962-1969	8	14.7	5.50	6.7	8.1	121	3.01	0.51	0.200
	(C) 1970-1988	19	7.0	2.63	7.9	–0.8	–10	–0.30	0.15	
August	(A) 1953-1961	9	5.7	2.12	5.7	0.0	0	0.00	0.11	
	(B) 1962-1969	8	10.1	3.78	3.9	6.2	159	2.30	0.36	0.032
	(C) 1970-1988	19	3.0	1.11	4.0	–1.0	–25	–0.37	0.10	
September	(A) 1953-1961	9	7.2	2.79	7.2	0.0	0	0.00	0.21	
	(B) 1962-1969	8	11.8	4.57	4.2	7.7	183	2.95	0.72	0.256
	(C) 1970-1988	19	7.4	2.87	6.3	1.2	19	0.45	0.25	
July to August	(A) 1953-1961	9	14.8	2.76	14.8	0.0	0	0.00	0.08	
	(B) 1962-1969	8	24.9	4.64	10.4	14.4	138	2.74	0.32	0.039
	(C) 1970-1988	19	10.0	1.87	11.8	–1.7	–14	–0.33	0.10	
July to September	(A) 1953-1961	9	22.0	2.77	22.0	0.0	0	0.00	0.09	
	(B) 1962-1969	8	36.7	4.62	13.9	22.8	164	2.90	0.39	0.885
	(C) 1970-1988	19	17.5	2.20	17.2	0.3	2	0.03	0.15	
Annual	(A) 1953-1961	9	1377.9	43.69	1377.4	0.4	0	0.01	0.55	
	(B) 1962-1969	8	1439.3	45.64	1073.2	366.1	31	11.61	1.83	<0.001
	(C) 1970-1988	19	1426.8	45.24	1140.1	286.7	25	9.09	0.42	
				WATERSHED 2 – Unlogged Control						
July	1953-1988	36	12.7	4.74						
August	1953-1988	36	7.8	2.92						
September	1953-1988	36	8.6	3.33						
July to August	1953-1988	36	20.5	3.83						
July to September	1953-1988	36	29.1	3.67						
Annual	1953-1988	36	1358.6	43.08						
				WATERSHED 3 – 25 Percent Patch-Cut Logged						
August	(A) 1953-1962	10	11.2	4.19	11.2	0.0	0	0.00	0.16	
	(B) 1963-1978	16	12.4	4.63	7.8	4.6	59	1.70	0.19	0.175
	(C) 1979-1988	10	9.3	3.47	8.1	1.2	15	0.44	0.27	
September	(A) 1953-1962	10	11.9	4.60	11.9	0.0	0	0.00	0.20	
	(B) 1963-1978	16	14.1	5.43	10.1	4.0	40	1.54	0.25	0.159
	(C) 1979-1988	10	12.4	4.79	11.1	1.3	12	0.51	0.28	
July to August	(A) 1953-1962	10	29.2	5.44	29.1	0.0	0	0.00	0.24	
	(B) 1963-1978	16	28.5	5.32	22.8	5.7	25	1.06	0.21	0.976
	(C) 1979-1988	10	25.9	4.84	26.0	0.0	0	–0.01	0.27	
July to September	(A) 1953-1962	10	41.1	5.17	41.1	0.0	0	0.00	0.17	
	(B) 1963-1978	16	42.6	5.36	33.2	9.4	28	1.19	0.22	0.634
	(C) 1979-1988	10	38.4	4.83	37.2	1.1	3	0.14	0.24	
Annual	(A) 1953-1962	10	1403.7	44.51	1403.4	–0.3	0	0.01	0.59	
	(B) 1963-1978	16	1330.4	42.19	1221.3	109.0	9	3.46	0.48	0.160
	(C) 1979-1988	10	1177.6	37.34	1144.3	33.3	3	1.06	0.40	

*Standard error.
**Means for prelogging calibration period (A) and period of reduced water yield (C) compared with single classification ANOVA.

alone was 159 percent, which corresponds to an increase in specific discharge of 2.3 $l/s/km^2$ (Table 2).

Within three years of the completion of logging and burning on WS 1, regrowth of vegetation had eliminated the increases in summer water yield. Water yields for August over the period 1970-1988 were 25 percent (i.e., 1.0 mm) lower in WS 1 than predicted from WS 2 compared to the prelogging period (1953-1961, $p=0.032$). Water yields for July and August combined were 14 percent (i.e., 1.7 mm) lower for 1970-1988 than for 1953-1961 ($p=0.039$, Table 2). Specific discharge for August was 0.37 $l/s/km^2$ lower than predicted for 1970-1988. The differences in observed minus predicted water yields between the 1953-1961 and 1970-1988 periods for July or September alone, or for July to September combined, were not significant ($p>0.200$).

Water yield in September was extremely variable among years. Rains at the end of summer sometimes began part way through September, and sometimes occurred after the end of September. For the period 1953-1988 the coefficient of variation of streamflow from the control watershed, WS 2, was 62 percent for September, but only 41 percent for August. Variability in streamflow masked the response to logging of September water yield.

There were three distinct periods in the summertime hydrologic record for WS 3 (Figure 2B). These periods were (1) 1953-1962 (prelogging calibration), (2) 1963-1978 (the period of increased water yield following logging and burning), and (3) 1979-1988 (the following 10 years during which water yield appeared to have returned to pretreatment levels). Observed water yield increased compared to predicted by 59 percent for August alone, and by 25 percent for July and August combined, immediately following the start of logging (1963-1978, Table 2). Water yields for 1979-1988 were not significantly different from the 1953-1962 period of prelogging calibration for combinations of July-September yields, or for annual totals (Table 2).

Comparing Figures 2 and 3, it is obvious that the response of annual water yield to logging is not necessarily a good predictor of changes in summer water yield. Differences between patterns of water yield for August and annual water yield are a result of, at least in part, seasonal patterns of precipitation and streamflow for forested watersheds in western Oregon and Washington. About 80 percent of total annual precipitation occurs between October 1 and March 31, leading to low streamflows in late summer. The excess of potential evapotranspiration over precipitation results in a water deficit in the H. J. Andrews Experimental Forest from June to September (Rothacher, 1971). Thus only 2-4 percent of average annual streamflow occurs during July, August, and September (Harr, 1983). For example, streamflow for July 1 to September 30 from WS 2 was 2.4 ± 0.5 percent (mean ± 95 percent confidence intervals, $n=36$) of annual totals between 1953 and 1988.

We examined predictions that the increase in annual water yield caused by logging would return to zero by 1992, 27 years after 1965 (Harr, 1983). Analyzing data for 1953-1981, Harr (1983) derived the model $Y=513.2-19.1X$ for reducing water yield, where Y=observed increase in annual water yield (in inches) compared to control, and X=time since logging ($r^2=0.75$, $n=16$). Adding seven years of record (i.e., 1982-1988 inclusive), we found that the steep decline in annual water yield for WS 1 from 1966 to 1976 flattened out from 1977 to 1988, so that there has been little further reduction in annual water yield (Figure 3A). Water yield from WS 1 for 1970-1988 was still 25 percent greater than for 1953-1961, the prelogging period ($p<0.001$, Table 2). The model calculated from least squares regression for data for 1965-1988 (the period used by Harr, 1983) was $Y=435.9-9.72X$ ($r^2=0.53$, $p<0.001$, $n=24$), indicates that annual water yields (in millimeters) will return to prelogging values 46 years after logging, in 2011. Annual water yield from WS 3 from 1979 to 1988 was not significantly different from prelogging levels ($p=0.160$, Table 2, Figure 3B).

Changes in Vegetation

Before logging, the vegetation of the hillslopes of WS 1 was dominated by old-growth (300-500 year old) and mature (125 year old) Douglas-fir (*Pseudotsuga menziesii* (Mirb). Franco), and western hemlock (*Tsuga heterophylla* (Raf.) Sarg.) of varying age (Dyrness, 1973). Riparian vegetation consisted largely of old-growth conifers and shade-adapted herbaceous species. Tall conifers suppressed establishment and growth of deciduous vegetation along the channel.

After logging and burning, vegetation gradually reestablished in WS 1 and 3. The recovery has been described elsewhere (Halpern, 1988, 1989), and followed the pattern typical for the Pacific Northwest, with forbs, sprouting hardwoods, and miscellaneous pioneer species initially establishing on the hillslopes; Douglas-fir trees now occupy most slopes. Red alder (*Alnus ruba* Bong.) dominates the riparian zone of WS 1 (pers. comm., F. J. Swanson, Pacific Northwest Research Station, Corvallis, Oregon), and willow (*Salix* spp.), and cottonwood (*Populus trichocarpa* Torr. and Gray) are also established in and adjacent to the stream.

Different geomorphic conditions in the valley floors of WS 1, 2, and 3 have determined the development of riparian vegetation. Watershed 1, with a relatively

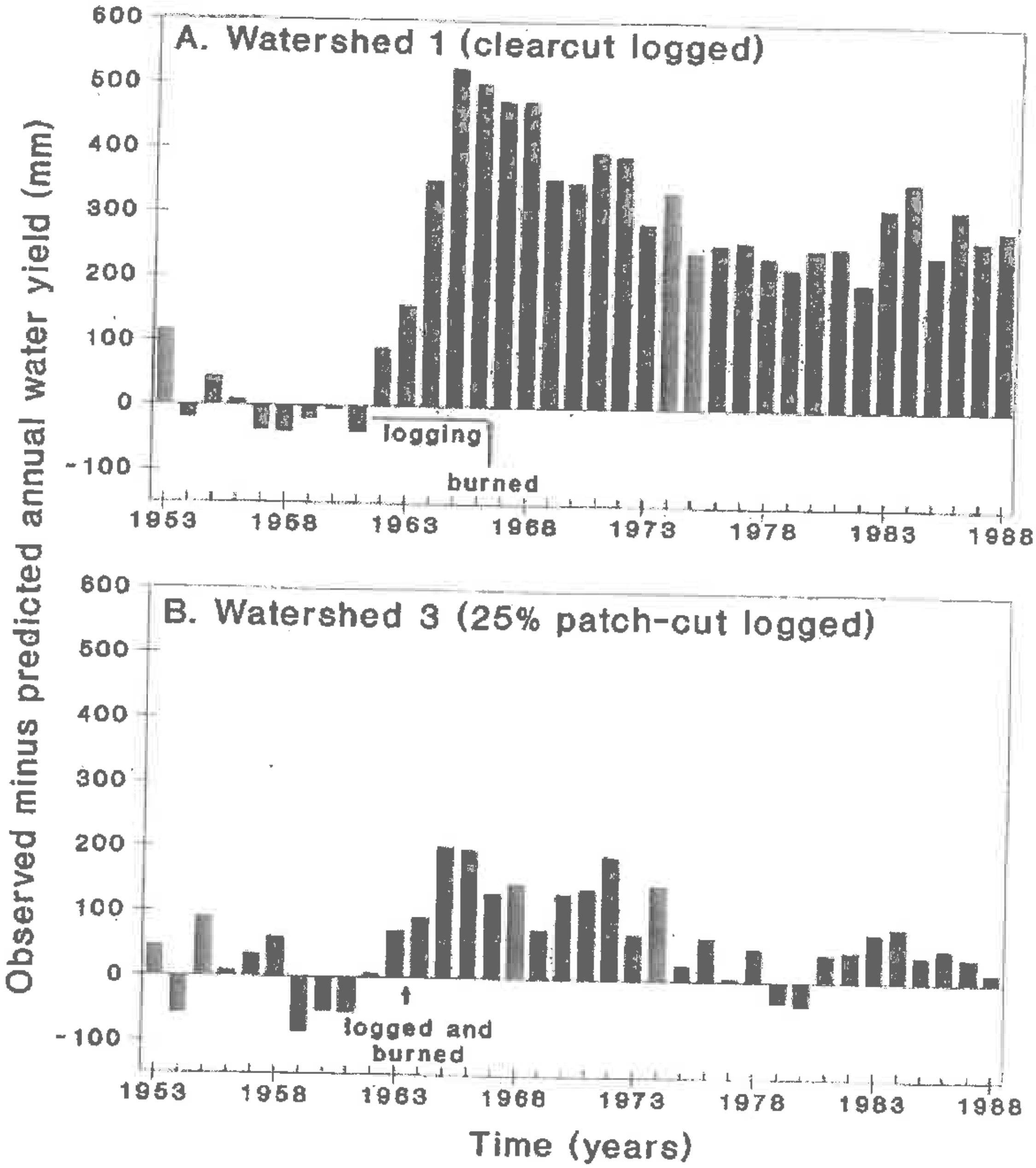

Figure 3. Differences Between Observed and Predicted Water Yield for Watershed 1 (A) and Watershed 3 (B), H. J. Andrews Experimental Forest, Western Oregon Cascades, Before and After Logging (1953-1988).

wide valley floor compared to WS 2 and 3, has well-developed riparian hardwoods. As a consequence of the narrow valley floor in WS 3, there has been little opportunity for hardwoods to establish in the riparian zone following logging. In addition, sediment deposits on which riparian hardwoods might have established have been removed from much of the valley of WS 3 by debris torrents caused by floods in December 1961, December 1964, and January 1965 (Fredriksen, 1963, 1965). Hardwoods are limited in the riparian zone of WS 2 because (1) the small amount of sediment at the channel edge prevents rooting, and (2) conifers rooted on side slopes suppress hardwood establishment along the channel (pers. comm., F. J. Swanson, Pacific Northwest Research Station, Corvallis, Oregon).

DISCUSSION

Significance of Long-Term Trends in Water Yield

Increased annual water yield has been one of the benefits generally attributed to timber harvest, and water yield did increase after logging in WS 1 and 3. Observed annual water yield from WS 1 for 1970-1988 has been 25 percent greater than predicted, after being 31 percent greater immediately following logging (1962-1969, Table 2). However, in streams of the Pacific Northwest most of the increase in annual water yield following logging occurs from October to March, when water is not in short supply (Harr, 1983). Of critical concern to instream biota is water yield in summer.

For WS 1, the period for which increased summer water yield persisted was short, especially considering the proportion of the time that it would represent (8-11 percent) during a rotation time of 70-100 years under intensive forest management. Following the period of increased water yield immediately following logging, timber harvest may actually reduce July and August streamflows for many years. So far the period of reduced yield has been 19 years, or 19-27 percent of the period of a rotation. The actual length of time for which reduced summer flows persist is not known, but they may continue for several decades, until conifers grow large enough to suppress growth of riparian hardwoods. For WS 3, the patch-cut watershed, summertime flows have generally remained at or above prelogging levels (Figure 2B).

The mechanism for different water yield responses of WS 1 and WS 3 following logging and burning is not entirely understood. Reduced evapotranspiration on hillslopes following the start of logging apparently increased delivery of water to the streams for 1962-1969 in WS 1, and for 1963-1978 in WS 3, increasing summer and annual streamflows. However, from 1970 on in WS 1, increased water use by established riparian vegetation may have been responsible for decreased streamflows. An attempt at reducing hardwoods in the riparian zone of WS 1 in 1973 was unsuccessful (pers. comm., F. J. Swanson, Pacific Northwest Research Station, Corvallis, Oregon) and no subsequent increase in water yields was observed. Higher stomatal conductance has been demonstrated in hardwoods such as quaking aspen (*Populus tremuloides* Michx.) in the Rocky Mountains than in conifers (Kaufman, 1984). Thus hardwoods are likely to use more water than conifers in summer for equivalent leaf areas.

Changes in soil moisture in WS 3 were only partly consistent with changes in streamflow. Summer soil moisture in the upper 120 cm of the profile along a transect at a logged site was greater than predicted following logging compared to a transect at an unlogged site from 1963 to 1965. From 1966 to 1980, however, soil moisture in summer was less than predicted at the logged site (Adams *et al.*, in press), even though streamflow was consistently greater than predicted in WS 3 until 1978 (Figure 2B). This suggests that water stored at depths of >120 cm was responsible for the increased streamflows during summer following logging. If changes in riparian vegetation were at least partially responsible for the reduced streamflows in WS 1, then replacement of conifers in the streamside zone with hardwoods could have important consequences for aquatic life and downstream users.

Effects on Salmonid Survival

Summer is a time of stress for juvenile salmonids rearing in streams in the Pacific Northwest. Furthermore, streamflows and water temperature can be factors limiting the survival of aquatic life in streams. Although salmonids do not use the stream in WS 1, we can infer that similar impacts of logging on streams elsewhere, such as in the Oregon Coast Range, would be detrimental. Although hardwoods such as red alder in the riparian zone may eventually shade a stream, they may also bring about detrimental changes in water quality as well as quantity. Leafdrop from hardwoods in dry conditions during late summer and early fall can contribute to low dissolved oxygen concentrations in coastal streams, which may reduce growth and survival of fish and invertebrates (Slack, 1955; Hicks, 1990). The extent of oxygen depletion was related inversely to streamflow, and was greater under red alder than under a mixed canopy of bigleaf and vine maple (Hicks, 1990).

Increased temperatures and low dissolved oxygen can have direct effects on fish, causing stress, disease, and consequent mortality. Reduced streamflow can increase the severity of changes in temperature and dissolved oxygen, and also can have direct and indirect effects on fish by reducing volume of stream habitat. Fish may die as a direct result of reduced streamflow as stretches of stream become dry. As an indirect effect, reduced flows may increase competition among fish. Riffle volumes are affected by reduced flows more than glides, and glides are affected more than pools (Hicks, 1990). Species such as age 0 steelhead (fry to fingerling-sized *Oncorhynchus mykiss*) often occupy riffles when in the same stream as pool-adapted fish such as age 0 coho salmon (*Oncorhynchus kisutch*) (Hartman, 1965; Bisson *et al.*, 1988). Thus, with reduced flows juvenile steelhead could be forced out of drying riffles and into pools, where they would face increased competition with the more aggressive coho salmon; this is likely to lower the survival of steelhead. In combination with other logging-related habitat changes, such as habitat simplification, decreases in pool habitat, increases in riffle habitat and channel widening (Lyons and Beschta, 1983; Bisson and Sedell, 1984; Tripp and Poulin, 1986; Hicks *et al.*, in press), reduced flows following forest harvest represent another factor that may seriously reduce survival of salmonids.

CONCLUSIONS

Many previous studies of changes in water yield following timber harvest have not fully considered changes in low summer flows. Analysis of logging-related water yield experiments often have looked only at annual water yields, ignoring the critical summer period when evapotranspiration is greatest and water is potentially in short supply. Furthermore, many studies have insufficient periods of record on which to draw conclusions about the long-term effects of logging on water yield (for example, Harris, 1977; Harr *et al.*, 1979; Harr, 1980).

Long-term records from WS 1 (clearcut logged) and WS 2 (unlogged control) in the H. J. Andrews Experimental Forest, spanning nine years before logging and 26 years after logging, show that the relatively large increases in water yield for August following logging were short-lived, existing for only about eight years. After this period, August water yields were less than normal for 18 of 19 years of record. We hypothesize that as a canopy of conifers closes over hardwoods in the riparian zone of WS 1 over the next few decades, the reductions in summer low flow will be eliminated and summer streamflow will return to prelogging levels, possibly 40-60 years after harvest. If the establishment of hardwoods in the riparian zone following clearcut logging has caused water yields in WS 1 to drop below predicted yields, as we suggest, then future forest harvest practices should protect conifers in the riparian zone during logging to suppress hardwood growth and thereby maintain summertime water yields. In view of the importance of the existing hydrological records from WS 1, 2, and 3 in the H. J. Andrews Experimental Forest, continued collection of hydrologic data from these watersheds is imperative.

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3

Seasonal and successional streamflow response to forest cutting and regrowth in the northwest and eastern United States

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[1] This study examined daily streamflow response over up to four decades in northwest conifer forest and eastern deciduous forest sites in the United States. We used novel methods to analyze daily observations of climate and streamflow spanning more than 900 basin years of record at 14 treated/control basin pairs where forest removal and regrowth experiments were underway in the period 1930–2002. In the 1 to 5-year period after forest removal, maximum daily increases ranged from 2 to 3 mm at deciduous forest sites, to 6 to 8 mm at conifer forest sites. Significant spring surpluses persisted for up to 35 years in conifer forest basins, but winter and spring streamflow deficits appeared after 10 to 15 years of forest regrowth in eastern deciduous forest basins. In all 5-yr posttreatment periods, absolute changes in daily streamflow were significantly more likely during moist, warm seasons, or during snowmelt seasons, but relative changes were more likely during warm seasons irrespective of moisture status. Both relative and absolute streamflow changes in the 1 to 5 and 15 to 25-year periods after forest removal were significantly positively related to the age of the forest at the time it was cut. Eastern deciduous forests had been disturbed by logging or hurricane 12 to 56 years prior to forest removal, while Pacific Northwest conifer forests had been not experienced logging or wildfire for 90 to 450 years. Paired basin experiments provide a continuous, and continuously changing, record of vegetation structure, composition, and climate, and their effects on streamflow. *INDEX TERMS:* 1860 Hydrology: Runoff and streamflow; 1803 Hydrology: Anthropogenic effects; 1863 Hydrology: Snow and ice (1827); *KEYWORDS:* Caspar Creek experimental forest, Coweeta experimental forest, Coyote Creek, Fernow experimental forest, H. J. Andrews Forest, Hubbard Brook experimental forest

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1. Introduction

[2] Paired-basin forestry experiments are a major source of data on climate, streamflow, and vegetation for testing of theoretical propositions in hydrology. Yet to date, the hydrologic implications of paired basin experiments have been largely examined for individual experiments, or in reviews or meta-analyses [e.g., *Bosch and Hewlett*, 1982; *Robinson et al.*, 2003] combining results from studies using disparate methods. Hydrologic modeling efforts frequently employ paired-basin data, but inferences are limited by uncertainty about many parameters, including vegetation-climate-soil interactions [*Beven*, 2002].

[3] Studies of eco-physiology, global change, and stream ecology are providing hydrologists with challenging hypotheses about vegetation and climate coupling to hydrology. Eco-physiology studies argue that forest structure and composition develop during succession to reduce stress on plants and optimally use resources, including moisture [*Eagleson*, 2002]. Studies of global change, including climate change, indicate that streamflow responds to changes in temperature and rainfall [*Hodgekins et al.*, 2003] with concurrent changes in vegetation cover and species composition [e.g., *Shafer et al.*, 2001]. Stream ecologists advocate restoration policies based on streamflow variability [*Poff et al.*, 1997], as well as habitat structure. Results from paired-basin experiments can contribute to these issues, by revealing the coupling among vegetation, atmosphere, soil, and streamflow at spatial and temporal scales intermediate between plot- and reach-scale studies characteristic of eco-physiology and stream ecology, and the coarse scales of climate and land use change modeling.

[4] In paired basin experiments, both increases and decreases in streamflow may occur in both relative and absolute terms at different seasons or time periods after treatment, providing clues about causal mechanisms, and geomorphic and ecological consequences, of vegetation change. In published studies, the largest relative changes in streamflow occurred in summer months after removal of eastern deciduous forest [*Douglass and Swank*, 1972, 1975; *Swank et al.*, 2001; *Hornbeck et al.*, 1997; *Martin et al.*, 2000] and western conifer forest [*Rothacher*, 1975; *Harr et al.*, 1979, 1982]. However, in conifer sites, the largest absolute streamflow increases occurred during wet winter months [*Rothacher*, 1970; *Lewis et al.*, 2001]. Lags of

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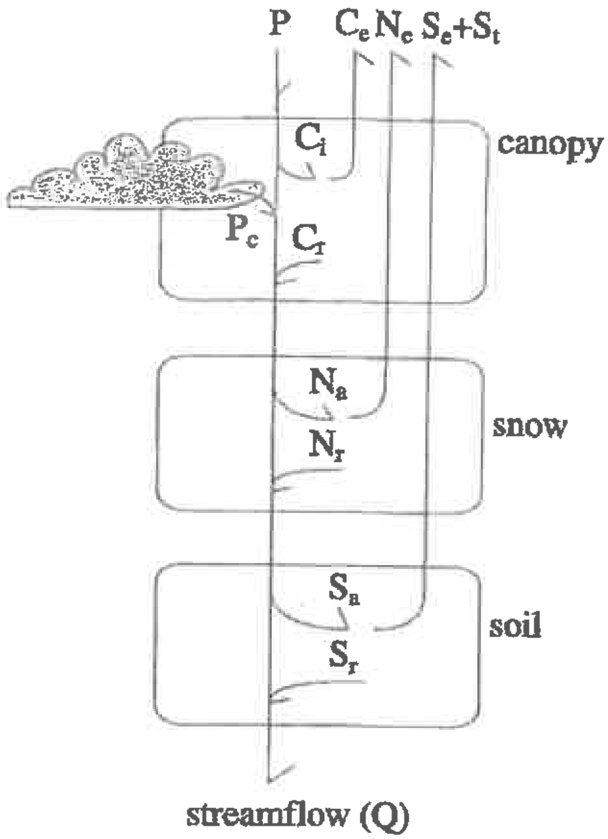

Figure 1. Ten fluxes involving moisture storage reservoirs (boxes) in vegetation canopies, snowpacks, and soils in forested basins. Inputs to the system are from precipitation (P) and cloudwater interception (P_c); output is streamflow (Q). Fluxes into and out of the canopy are interception (C_i), throughfall (C_r) and evaporation (C_e). Fluxes into and out of the snowpack are snow accumulation (N_a), sublimation and evaporation (N_e), and snowmelt (N_r). Fluxes into and out of the soil are soil water accumulation (S_a) and release (S_r), evaporation (S_e) and transpiration (S_t).

several months between periods of vegetation water use and streamflow responses have been reported from southeastern deciduous forest sites [*Swank et al.*, 1988].

[5] Both hydrologic and ecological causal mechanisms have been invoked to explain varied streamflow responses in paired basin experiments. In the northwestern United States, conifer forest removal may modify cloudwater interception [*Harr*, 1982] as well as snowpack dynamics [*Harr*, 1981; *Berris and Harr*, 1987] during wet (winter) seasons. In the eastern United States, vegetation species in early succession may be higher water users per unit leaf area than the species removed, reducing summer streamflows [*Hornbeck et al.*, 1997; *Swank et al.*, 2001]. Also, conifers may use more water over greater periods of the year than deciduous forests, reducing fall, winter, or spring flows [*Swank and Douglass*, 1974; *Swank et al.*, 1988].

[6] Differences among basins where forest removal experiments have been conducted lend themselves to testing the generality of hypotheses about causes and consequences of vegetation change for streamflow. The eastern US has a mesic climate with wet summers whereas the northwestern US has a xeric climate with dry summers. Northern and high-elevation basins have seasonal snow, but basins at lower latitudes or elevations have transient snowpacks or no snow. Basins in the eastern US have deciduous forests mostly regenerating from logging or other disturbances in the early 20th century, whereas basins in the northwestern US have conifer forests that have been protected from logging and wildfire since at least 1900. Thus season, forest type, and forest age, both time since treatment and age of the forest when it was removed, all may influence streamflow response to forest removal.

[7] Technological developments also lend themselves to a broad analysis of paired-basin forest removal experiments [*Jones and Swanson*, 2001]. Records of up to sixty years of continuous streamflow and associated measurements now are available from many sites [*Post et al.*, 1998]. Many of these records are available through online data harvesters (e.g., hydro-DB [*Baker et al.*, 2000]). New methods are being developed for testing hypotheses with long-term streamflow data sets [e.g., *Jones and Grant*, 1996; *Jones*, 2000; *Post and Jones*, 2001]. Finally, increased computer power and growth of the Internet now permit data sets from many sites to be readily compiled and analyzed in one location.

2. Conceptual Model

[8] Hydrologic responses to forest canopy removal and regrowth can be predicted from the hydrologic cycle (Figure 1). Because forest vegetation is coupled to the atmosphere, the snowpack, and the soil, three major classes of hydrologic responses to forest removal and regrowth involve changes in forest canopy interactions with: (1) the atmosphere and soils (i.e., cloudwater interception P_c, canopy interception C_i, evaporation from the canopy and soils C_e and S_e, and transpiration S_t, Figure 1), (2) snowpack accumulation and melt (i.e., snow accumulation N_a, sublimation N_e, and snowmelt N_r, Figure 1), and (3) soil moisture storage (i.e., additions and losses S_a and S_r, Figure 1).

[9] We tested the following hypotheses.

[10] H1. Forest vegetation affects streamflow through evapotranspiration, interception, and soil moisture storage. Therefore streamflow responses to forest removal should occur when temperature is conducive to evapotranspiration, or during periods of snowmelt. Evapotranspiration effects are large in absolute terms at times of year when soils are moist (S_e, S_t, S_a and S_r are large), but they are large in relative terms at times of year when temperature is conducive to transpiration irrespective of soil moisture (S_e and S_t are large but S_a and S_r are small). Snow interception effects are large in absolute terms at times of year when soils are moist and snowmelt is occurring (S_a, S_r, and N_r are large). In sites with cold snowpacks, young deciduous forests produce smaller snowpacks (N_a, N_e, and C_e increase) compared to older deciduous forests, but in sites with warm snowpacks, young conifer forests produce larger snowpacks (N_a, N_e, and C_e decrease) compared to older conifer forests. Alternatively, streamflow responses to forest removal may occur during times of year when neither evapotranspiration nor snowmelt is occurring, because soil moisture storage reservoirs exert a lagged effect.

[11] H2: The forest vegetation effect on streamflow depends upon forest structure and composition, which vary with the age of vegetation. Two measures of forest age are relevant: the age of the forest in the treated basin (time since treatment) and the difference in ages of the forests between the treated and control basins (which is equivalent to the time since most recent pre-treatment forest disturbance). Young forests use more water than older forests at times of year when temperature is conducive to transpiration, irrespective of soil moisture (S_c and S_t are larger relative to S_a and S_r for young than older forests). Therefore streamflow response will decline rapidly in the first few decades of forest regrowth, and forests aged 10 to 30 years will produce summer streamflow deficits relative to older forests. However, as forests age, structure and composition change so as to better utilize water available at times of year when transpiration is temperature- or moisture-limited. Therefore streamflow responses will be positively related to the difference in forest age between the treated and control basins.

3. Study Sites

[12] Study sites were located in six experimental forests, three in the Pacific Northwest of the United States, and three in the eastern United States (Table 1). As of 2002, Pacific Northwest sites (the Andrews, Coyote Creek, and Caspar Creek Experimental Forests) had conifer forests up to 500-yrs old and dry summers. Eastern sites (the Hubbard Brook, Fernow, and Coweeta Experimental Forests) had <100 yr old deciduous forests and wet summers. The northernmost sites (Andrews, Hubbard Brook) had seasonal snowpacks. Mean annual precipitation ranged from 1000 mm to over 2000 mm at both conifer and deciduous sites (Table 1).

[13] Forest age was determined as the time since the most recent severe disturbance documented at that site (Table 1). The most recent disturbances included wildfire and logging in conifer forests, and hurricane and logging in deciduous forest (Table 1). Conifer forest types included western hemlock (Andrews), mixed-conifer (Coyote Creek) and redwood forests (Caspar Creek). Deciduous forest types included northern hardwoods (Hubbard Brook) and oak-hickory forests (Fernow, Coweeta) (Table 1).

[14] Each site consisted of one or more paired-watershed experiments in which 100% of forest cover had been harvested and an unharvested control basin exists (Table 1). Forest harvest treatments at the fourteen treated basins occurred over more than half a century, from the 1930s to 1990 (Figure 2). In ten of these cases forest harvest occurred in a single year, but in four cases harvest occurred over several years (Table 1, Figure 2). Treatment involved logging (removal of wood products) in ten treated watersheds. In four cases wood products were not removed, and in two of these four cases herbicide was applied for several years after logging (Table 1). Because of differing disturbance histories, 90 to 450 yr-old forests were removed in the conifer sites, but 12 to 56 yr-old forests were removed in the deciduous forest sites (Table 1).

[15] Long-term records of streamflow and climate have been collected at 26 basins (14 treated, 12 control) from the six study sites. Basin size ranged from 9 to 96 hectares, and streamflow and climate records span periods ranging from 17 years to 63 years (Figure 2). Pre-treatment records were 6 or more years in length in all but one treated basin, and posttreatment records ranged from 11 to over 40 years (Figure 2). Most of the basins ranged in size from 20 to 50 ha, and the ages of most harvested forest ranged from 30 to 125 years (Table 2, Figure 2).

4. Methods

4.1. Datasets and Data Collection

[16] Mean daily streamflow, precipitation, minimum and maximum temperature, and snowpack data from five of the six sites are publicly available on the worldwide web and were collected electronically through Hydro-DB, an automated data harvester http://www.fsl.orst.edu/hydrodb/). Data from the sixth site (Coweeta Experimental Forest) are not publicly available, but they were provided by U.S. Forest Service scientists (L. Swift and W. Swank) for periods of record through 1995. The resulting primary data set consisted of over 750,000 observations spanning more than 900 watershed-years of streamflow records. Original streamflow data in units of L/s were converted to mm/day (unit area discharge):

$$\frac{mm}{day} = 8.64 \cdot \frac{L}{s} \cdot A$$

where A is basin area in hectares. We used a water year from 1 October to 30 September. For Caspar Creek many values from late April to early November were missing values.

[17] The initial data set comprised records from 26 basins (14 treated, 12 control). We present results from 14 treated/control pairs (Table 2). In 11 of these 14 pairs we used the treated/control pairs established by the original researchers. In three cases, we used an alternative to the original control basin (Table 2). In these three cases, Coweeta 7/34 (7/2), Coweeta 13/14 (13/18), and Andrews 10/2 (10/9), the original control basins (in parentheses) were less than 15 ha in size. The average standard deviation of daily flow at control basins in mm (y) was significantly negatively related to basin size in hectares (x) ($y = 2.29 \exp(-0.034x)$; $r^2 = 0.84$; $n = 12$). Therefore streamflow changes were not detectable using the original (<15 ha) basins, but they were detectable when the same treated basins were compared to larger, nearby control basins. Moreover, in one case (Andrews 10/9) the original treated/control relationship was suspect because a flume change 15 months prior to the treatment produced significant changes in streamflow at the control basin (Andrews 9).

4.2. Calculating Streamflow Responses to Forest Removal and Regrowth

[18] The change in streamflow in the treated basin relative to the pretreatment treated/control relationship was calculated by day of year and averaged for 5-yr periods after forest removal, following *Jones and Grant* [1996] and *Jones* [2000]. The treated/control relationship was

$$c_{ij} = \ln\left[\frac{(b_{ij})}{(a_{ij})}\right]$$

where c_{ij} = the (ln-transformed) ratio of streamflow at the treated and control basins, day i, year j; a_{ij} and b_{ij} = unit area

Table 1. Vegetation Cover, Disturbance History, Treatments, and Ages of Forest in Fourteen Treated/Control Basin Pairs in This Study

Basin Pair	Disturbance	Treatment		Age[a]		MAP,[a] mm
		Type	Date	Treated[b]	Control[c]	
		Western Hemlock[d]				
Andrews 1/2	severe wildfire in 1500s	100% clearcut, logged, burn	1962–66	450	500	2270
Andrews 6/8	wildfire in 1500s, 1850s	100% clearcut, logged, road	1974	125	150	2178
Andrews 10/2	"	100% clearcut, logged	1975	125	500	2282
		Mixed Conifer[e]				
Coyote 3/4	wildfire in 1500s, 1850s	100% clearcut, logged	1970	120	145	984
		Redwood[f]				
Caspar C/I	clearcut, logged 1860–1904	96% clearcut, logged	1991	90	100	1190
Caspar E/I	"	100% clearcut, logged	1991	90	100	1190
		Northern Hardwood[g]				
Hubbard Brook 2/3	logged 1800s–1910, hurricane/salvage 1938	100% clearcut, herbicide	1965	27	64	1312
Hubbard Brook 4/3	"	100% clearcut, logged	1970–74	32	64	1312
Hubbard Brook 5/3	"	100% clearcut, logged	1983	45	64	1312
		Oak-Hickory[h]				
Fernow 1/4	logged 1905–1910	100% clearcut, logged	1957	50	95	1438
Fernow 7/4	"	100% clearcut, herbicide	1963	56	95	1450
		Oak-Hickory[i]				
Coweeta 7/34	grazing, burning 1840–1906; logged 1919–27	100% clearcut, logged	1977	50	75	1962
Coweeta 13/14	"	100% clearcut	1939	12	75	1934
Coweeta 37/36	"	100% clearcut	1963	35	75	2191

[a]Age of forest (time since last forest disturbance) and mean annual precipitation (mm) at the control basin for the period of record used in the analysis. Forest ages are based on *Weisberg and Swanson* [2003] (Andrews), *Lewis et al.* [2001] (Caspar Creek), *Douglass and Hoover* [1988] (Coweeta), *Harr et al.*, [1979] (Coyote), Fernow Experimental Forest website (http://www.fs.fed.us/ne/parsons/fefhome.htm), *Schwarz et al.* [2001] (Hubbard Brook). Ages of 500-year old forest have error margins of ±25 years due to uncertainty in dating prehistorical events. Forest ages were log-transformed in analyses in part to account for increasing uncertainty of dates with forest age..

[b]Age (time since last forest disturbance) of forest in treated basin at time of treatment.

[c]Age (time since last forest disturbance) of forest in control basins in 2002.

[d]Forests dominated by Douglas-fir (*Pseudotsuga menziesii*) with western hemlock (*Tsuga heterophylla*) and red cedar (*Thuja plicata*) [*Rothacher et al.*, 1967].

[e]Forests dominated by Douglas-fir (*Pseudotsuga menziesii*), ponderosa pine (*Pinus ponderosa*), and sugar pine (*Pinus lambertiana*) [*Harr et al.*, 1979].

[f]Forests dominated by coast redwood (*Sequoia sempervirens*), Douglas-fir (*Pseudotsuga menziesii*), grand fir (*Abies grandis*) and western hemlock (*Tsuga heterophylla*) [*Lewis et al.*, 2001].

[g]Forests dominated by American beech (*Fagus grandifolia*), sugar maple (*Acer saccharum*), and yellow birch (*Betula alleghaniensis*) [*Schwarz et al.*, 2001].

[h]Forests dominated by northern red oak (*Quercus rubra*), sugar maple (*Acer saccharum*), and tulip poplar (*Liriodendron tulipifera*) (Fernow web site).

[i]Forests dominated by chestnut oak (*Quercus prinus*), scarlet oak (*Quercus coccinea*), northern red oak (*Quercus rubra*), red maple (*Acer rubrum*), and tulip poplar (*Liriodendron tulipifera*) with abundant rhododendron (*Rhododendron maximum*) [*Day et al.*, 1988].

streamflow (mm) at the control basin and the treated basin, respectively, on day i, year j. The period of record was divided into periods k = 1, 2,. . .n, such that the pretreatment period was noted 1, and 5-year posttreatment periods were noted 2 and higher. The average treated/control relationship was

$$c_{ik} = \overline{c_{ij}}$$

for years j in period k = 1, 2, .n. The percent change in the treated/control relationship in a given posttreatment period relative to the treated/control relationship in the pretreatment period, for each period k, was

$$d_{ik} = \left(\exp^{(c_{ik} - c_{i1})} - 1\right) \cdot 100$$

for periods k = 2,. . .n and where d_{ik} = percent change on day i, years j in period k, c_{ik} = treated/control relationship on day i, years j in 5-yr posttreatment period k, c_{i1} = treated/control relationship on day i, years j in the pretreatment period. The mean of (log-transformed) daily flow at the control basin on day i for period k was:

$$e_{ik} = \sum_{j \in k} \ln(a_{ij})/n_k$$

where n_k = number of years in period k. The absolute change in streamflow (back-transformed to units of mm/day) in the treated basin relative to the control basin on day i of 5-yr posttreatment period k was:

$$f_{ik} = d_{ik} \cdot \exp(e_{ik})$$

The detection of change in paired-based experiments depends fundamentally upon ratios, whose interpretation can be problematic when the denominator (flow at the control basin) is a small number. Several measures were taken in the analysis and presentation of results to protect

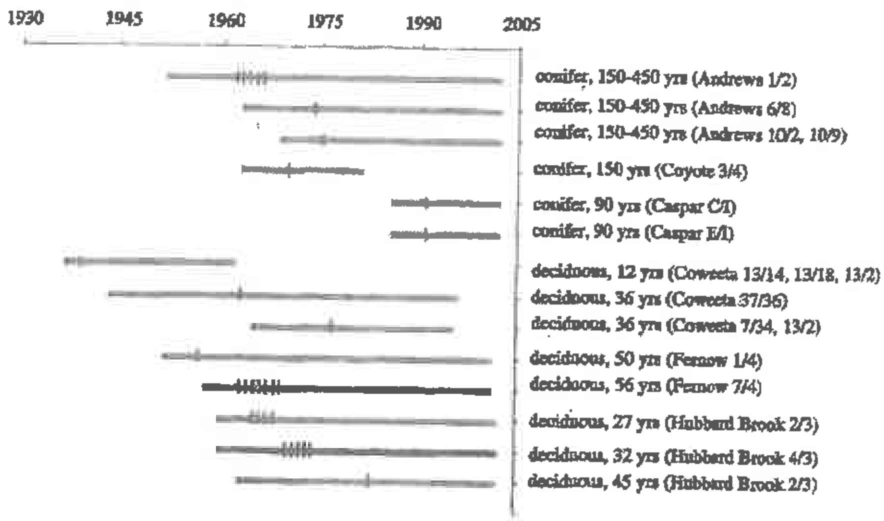

Figure 2. Periods of record of the fourteen small paired-watershed experiments examined in this study. Vertical lines indicate dates of forest harvest and herbicide treatments (where relevant). Experiments are arranged by forest type (conifer, deciduous) in the treated/control pair and age (time since most recent forest disturbance) of the treated watershed. Vertical lines indicate the date of forest removal. Some treatments lasted for multiple years: forests were harvested over 5 yrs at Andrews 1, Fernow 7 and Hubbard Brook 4; herbicide was applied for 3 years at Hubbard Brook 2 and Fernow 7. Some treated watersheds (Andrews 10, Coweeta 7, Coweeta 13) were compared to more than one control watershed.

against misleading interpretations from ratios. Streamflow data were filtered before analysis to remove very low flows. Days with streamflow less than 0.01 mm were treated as missing values, and streamflow changes were calculated only for days with less than two missing values in any five-year posttreatment period. Both absolute and relative changes were calculated to identify instances where very large relative changes were small in absolute terms. Relative changes (d_{ik}) and absolute changes (f_{ik}) were smoothed with a 15-day window to reduce the effect of large changes on any given day, and figure axes were restricted to exclude the occasional values that are improbably large. Statistical analyses were either non-parametric tests based on counts of days exceeding some threshold of d_{ik} and f_{ik}, or regressions of average percent changes by season rather than daily values.

4.3. Hypothesis Tests

[19] Hypotheses involving seasons were tested using chi-squared tests of independence of streamflow changes by season [*Ramsay and Schaefer*, 1996]. Days with absolute streamflow changes were tested for independence to (1) moist periods when temperatures are conducive to evapotranspiration, and (2) snowmelt periods. Days with

Table 2. Eighteen Treated/Control Basin Pairs Examined in This Study

Treated/Control Basin Pair	Basin Size, ha		Streamflow Record, Years		
	Treated	Control	Total	Pretreatment	Posttreatment
Andrews 1/2[a]	96	60	1953–2002	9	41
Andrews 6/8[a]	15	22	1964–2002	10	28
Andrews 10/2[a]	10	60	1969–2002	6	27
Andrews 10/9	10	9	1969–2002	6	27
Caspar C/I[a]	26	21	1986–2002	6	11
Caspar E/I[a]	27	21	1986–2002	6	11
Coyote 3/4[a]	49	50	1964–81	6	11
Coweeta 7/2	59	13	1965–96	12	20
Coweeta 7/34[a]	59	33	1965–96	12	20
Coweeta 13/2	16	12	1937–62	2	23
Coweeta 13/14[a]	16	61	1937–62	2	23
Coweeta 13/18	16	13	1937–62	2	23
Coweeta 37/36[a]	44	49	1944–96	20	43
Fernow 1/4[a]	30	39	1951–2001	6	44
Fernow 7/4[a]	29	39	1957–2001	6	38
Hubbard Brook 2/3[a]	16	42	1958–96	7	31
Hubbard Brook 4/3[a]	36	42	1958–96	12	26
Hubbard Brook 5/3[a]	22	42	1958–96	25	13

[a]Results from fourteen basin pairs are examined in detail.

Table 3. Seasons, Defined by Dates, Discharge, Runoff Ratio, Minimum and Maximum Temperatures From Control Basins*

	Moist				
Control Basin	Cool	Snow Accumulation	Snowmelt	Dry or Moist Warm	Water Year
		Andrews 2			
Dates	10/1–12/7	12/8–2/8	2/9–6/12	6/13–9/30	10/1–9/30
Discharge, mm	230	525	546	44	1344
Runoff ratio, %	36	74	72	28	59
Min temperature, °C	3	−1	3	10	4
Max temperature, °C	9	4	13	25	14
		Andrews 8			
Dates	9/11–12/6	12/7–2/10	2/11–6/24	6/25–9/10	10/1–9/30
Discharge, mm	178	434	524	23	1160
Runoff ratio, %	28	67	70	24	53
Min temperature, °C	4	−1	4	11	5
Max temperature, °C	12	5	14	26	14
		Andrews 9			
Dates	9/12–12/2	12/3–3/2	3/3–3/27	3/28–9/11	10/1–9/30
Discharge, mm	190	690	128	213	1222
Runoff ratio, %	31	70	66	45	54
Min temperature, °C	4	−1	−1	8	4
Max temperature, °C	11	4	6	21	14
		Coyote 4			
Dates	11/5–12/25	12/26–2/4	2/5–5/20	5/21–11/4	10/1–9/30
Discharge, mm	124	162	201	24	511
Runoff ratio, %	51	115	57	10	52
Min temperature, °C	1	0	3	9	5
Max temperature, °C	7	6	12	22	15
		Caspar 1			
Dates	11/23–4/24	–	–	4/25–11/22	10/1–9/30
Discharge, mm	32	–	–	415	447
Runoff ratio, %	12	–	–	46	38
Min temperature, °C	10	–	–	6	8
Max temperature, °C	19	–	–	12	16
		Hubbard Brook 3			
Dates	–	10/1-3/16	3/17–5/15	5/16–9/30	10/1–9/30
Discharge, mm	–	346	348	144	837
Runoff ratio, %	–	58	171	28	63
Min temperature, °C	–	−7	0	11	−3
Max temperature, °C	–	2	10	21	6
		Fernow 4			
Dates	10/11–4/30	–	–	5/1–10/10	10/1–9/30
Discharge, mm	486	–	–	156	642
Runoff ratio, %	63	–	–	23	44
Min temperature, °C	−2	–	–	11	4
Max temperature, °C	8	–	–	23	15
		Coweeta 14			
Dates	10/17–4/17	–	–	4/18–10/16	10/1–9/30
Discharge, mm	578	–	–	385	962
Runoff ratio, %	57	–	–	49	54
Min temperature, °C	0	–	–	12	6
Max temperature, °C	14	–	–	26	20
		Coweeta 34			
Dates	10/17–4/17	–	–	4/18–10/16	10/1–9/30
Discharge, mm	658	–	–	509	1167
Runoff ratio, %	59	–	–	58	59
Min temperature, °C	0	–	–	12	6
Max temperature, °C	14	–	–	26	20
		Coweeta 36			
Dates	10/17–4/17	–	–	4/18–10/16	10/1–9/30
Discharge, mm	1100	–	–	587	1687
Runoff ratio, %	89	–	–	61	77
Min temperature, °C	0	–	–	12	6
Max temperature, °C	14	–	–	26	20

Table 4. Numbers of Treated/Control Basin Pairs by Basin Type[a]

	>100 Year-Old Conifer Forest, Dry Summer	<95 Year-Old Deciduous Forest, Wet Summer	Number of Pairs
Seasonal snowpack	Andrews 1/2 Andrews 6/8	Hubbard Brook 2/3 Hubbard Brook 4/3 Hubbard Brook 5/3	5
Transient snow or no snow	Andrews 10/2 Coyote 3/4 Caspar C/I Caspar E/I	Fernow 1/4 Fernow 7/4 Coweeta 7/34 Coweeta 13/14 Coweeta 37/36	9
Number of pairs	6	8	14

[a]Types are conifer, no seasonal snow; conifer, seasonal snow; deciduous, no seasonal snow; deciduous, seasonal snow. Basin types are based on vegetation type and forest age in control basin as of 2002 (time since most recent forest disturbance), summer precipitation, and presence/absence of a seasonal snowpack. A seasonal snowpack persists throughout the winter, whereas a transient snowpack may persist for only a few days to a few weeks [*Harr*, 1981]. Snow seasonality is based on long-term records (snow data at Hubbard Brook) and modeling [*Perkins*, 1997].

relative streamflow changes were tested for independence to warm periods. For each period k, absolute streamflow changes were defined as all days i for which the 15-day smoothed values of

$$f_{ik} > s[\ln(a_{ij})]$$

where $s[\ln(a_{ij})]$ was the back-transformed, smoothed standard deviation of a_{ij} for all years j in the period of record. Thus $n_{abs,k}$ is the count of days i in the water year for which f_{ik}, the absolute change in the treated/control relationship days in period k, exceeds the variation in the entire record of streamflow on that day at the control watershed. Relative streamflow changes were defined as all days i for which the 15-day smoothed values of

$$d_{ik} > 25$$

Thus $n_{rel,k}$ is a count of days i in the water year on which the treated/control relationship in streamflow in period k changed by more than 25%.

[20] Counts of days with absolute and relative changes ($n_{abs,k}$, $n_{rel,k}$) were subdivided by season. Every day of the water year at each control basin was classified into one of four seasons based on soil moisture, temperature, and snowmelt (Table 3). Two seasons occurred at basins lacking snowpacks: (1) warm (and dry at conifer basins, moist at deciduous basins), and (2) moist, cool. Basins with snowpacks had two additional seasons: (3) moist, snow accumulation and (4) moist, snowmelt. Seasons were defined based on mean values over the entire period of record at each control basin for each day i of minimum and maximum temperatures ($T_{min,i}$, $T_{max,i}$), precipitation (P_i), streamflow (Q_i), and snow water equivalent (S_i). Warm, moist periods were defined as all days i for which $T_{min,i} > T^*_{min}$, $P_i > P^*$, and $Q_i > Q^*$, where T^*_{min} is a temperature threshold of 5°C for deciduous forests and 0.1°C for conifer forests, and P^* and Q^* are moisture thresholds of 2 mm and 0.5 mm, respectively. Warm periods were defined as all days i for which $T_{min,i} > T^*_{min}$, and (for warm, dry periods at conifer basins) $P_i < P^*$ and $Q_i < Q^*$. Periods in which snowpacks were present were divided into days for which $S_i > S_{i-1}$ (accumulation) or $S_i < S_{i-1}$ (melt).

[21] Hypotheses involving succession were tested by linear regression [*Ramsay and Schaefer*, 1996]. Response variables were the sum of daily streamflow changes f_{ik} by season and for the whole water year, and these sums as percents of seasonal or annual streamflow (Table 3). The independent variable was the difference in age between the control and treated basin (Table 1). Data points in regressions were coded by basin types: (1) conifer, seasonal snow; (2) conifer, transient or no snow; (3) deciduous, seasonal snow; (4) deciduous, transient or no snow (Table 4).

5. Results

5.1. Summer Precipitaton and Snowmelt Effects on Daily Streamflow

[22] Daily streamflow responds to summer precipitation and snowpack characteristics of the basins. The Pacific Northwest (conifer forest) has dry summers, whereas the east (deciduous forest) has wet summers (Tables 3 and 4, Figure 3). In conifer forest basins with transient or no snow (Andrews 9, Coyote 4, Caspar I), smoothed daily streamflow peaks in January or February and declines rapidly starting in March, as precipitation declines and minimum temperatures rise above 0°C. In deciduous forest basins with transient or no snow (Fernow, Coweeta), streamflow peaks in March, just before leafout, and declines rapidly, despite constant precipitation, after minimum temperatures rise above 5°C. In conifer basins with seasonal snow (Andrews 2, Andrews 8), streamflow remains elevated after snowmelt in March, April, and May (Figure 3). In the deciduous forest basin with a seasonal snowpack (Hubbard Brook), streamflow declines after December as the snowpack forms, rises to a maximum in mid-April during snowmelt, begins to decline in late April, and continues to decline rapidly after minimum temperatures rise above 5°C in May (Figure 3).

5.2. Seasonal Effects

[23] Large streamflow changes, in both absolute and relative terms, were associated with vegetation change, but they occurred during different seasons and time periods in various basin pairs. Absolute changes in daily streamflow after 100% forest removal were strongly seasonal, and ranged from slight decreases of up to −2 mm/day, to no change at all, to increases of as much as 8 mm/day (Figure 4). In conifer forest basins, daily streamflow increased by as much as 6 to 8 mm during the fall, and 2 to 6 mm in the winter and spring, in the 1 to 5-yr period after forest removal. Some increases persisted for up to 35 years. In deciduous forest basins, streamflow changes were both positive and negative, and occurred during summer, snowmelt, and other periods. Except in one herbicided basin where initial increases were larger

Note to Table 3

[a]Dates are given in month/day. Seasons are defined in the text. Runoff ratio is streamflow/precipitation × 100. The warm season is moist in eastern forests, and dry in Pacific Northwest forests.

Table 5. Absolute Streamflow Changes in Warm, Moist Seasons After Forest Removal and During Forest Regrowth at Fourteen Pairs of Small Experimental Basins in Pacific Northwest Conifer and Eastern Deciduous Forests, USA[a]

Hypothesis/Season	Treatment	Years After Forest Removal 1 to 5	6 to 10	11 to 15	16 to 20	21 to 25	26 to 30	31 to 35	36 to 40	41 to 45
					Conifer Forests					
Andrews 1/2										
Change (mm)	318	414	293	229	246	238	197	152		
Odds ratio	5[b]	203[d]	8[d]	7[d]	13[d]	6[d]	6[d]	4[c]		
Andrews 6/8										
Change (mm)		421	237	240	268	205	104			
Odds ratio		1	2	43[d]	2[b]	2	7[b]			
Andrews 10/2										
Change (mm)		108	95	91	−16	−30	−31			
Odds ratio		4[c]	7[d]	10[d]	3[b]	4[b]	2			
Coyote 3/4										
Change (mm)		265	284							
Odds ratio		5[d]	8[d]							
Caspar C/I										
Change (mm)		196	274							
Odds ratio		–	–							
Caspar B/I										
Change (mm)		124	520							
Odds ratio		–	–							
					Deciduous Forests					
Hubbard Brook 2/3										
Change (mm)	661	262	51	−17	−21	−25	−59	4		
Odds ratio	7[d]	3[b]	0.4	0.4	0.1	0.2	0.2	0.2		
Hubbard Brook 4/3										
Change (mm)		101	79	37	−36	−61	−61	−51		
Odds ratio		0.1	0.1	–	0.1	0.1	0.3	0.2		
Hubbard Brook 5/3										
Change (mm)		131	87	0	−27					
Odds ratio		0.4	0.3	0.2	0.3					
Fernow 1/4										
Change (mm)		156	16	16	27	34	52	2	−8	
Odds ratio		48[d]	0.1	–	0.1	4	1.6	0.1	–	
Fernow 7/4										
Change (mm)	66	149	60	9	−16	−5	8	−38		
Odds ratio	–	–	–	–	–	–	–	–		
Coweeta 7/34										
Change (mm)		105	1	−57	86					
Odds ratio		0.2[c]	0.1[b]	4[b]	3[b]					
Coweeta 13/14										
Change (mm)		17	14	−28	−39	−63				
Odds ratio		0.8	0.5	0.2[d]	0.6	4[c]				
Coweeta 37/36										
Change (mm)		164	61	55	–	−28	−46	−47		
Odds ratio		13[d]	2	3[b]	–	0.1[b]	0.5	0.3[b]		

[a]Change and odds ratios are shown for each basin pair and postharvest time period. Blanks indicate no data for that time period. Dashes indicate that no chi-squared test could be conducted, because one or more cells of the 2 × 2 table contained no observations. An odds ratio >1 means that days with an absolute streamflow response were more likely to occur during the warm, moist season, and an odds ratio <1 means that days with an absolute streamflow response were less likely to occur during the warm, moist season.

[b]Chi-squared tests of independence between absolute streamflow changes and the warm, moist season were significant at $p < 0.05$.

[c]Chi-squared tests of independence between absolute streamflow changes and the warm, moist season were significant at $p < 0.001$.

[d]Chi-squared tests of independence between absolute streamflow changes and the warm, moist season were significant at $p < 0.0001$.

(Figure 4g), daily streamflow in deciduous basins increased by no more than 2 to 3 mm in the 1 to 5-yr period after forest removal. After a decade of forest regrowth, streamflow surpluses became deficits in several deciduous basins.

[24] Relative changes in daily streamflow after 100% forest removal also were strongly seasonal, and ranged from initial increases of a few tens to hundreds of percent (Figure 5). In conifer forest basins, daily streamflow increased by several hundred percent during the late summer/early fall (and late spring, at Caspar Creek, but results are affected by missing data) in the 1 to 5-yr period after forest removal. By 25 to 35 years after forest removal, maximum summer deficits ranged from −30 to −50% (Figure 5). In deciduous forest basins, daily streamflow increases ranged from more than several hundred percent (in herbicided basins), 200–300% (at Hubbard Brook and Fernow), to a few tens of percent (Coweeta), in late summer and early fall in the 1 to 5-yr period after forest removal. By 25 to 35 years after forest removal, maximum summer streamflow deficits ranged from −50% (Hubbard Brook and Fernow) to −30% (Coweeta) (Figure 5).

[25] Seasons were accurate predictors of when streamflow change occurred. Absolute streamflow change was significantly associated with warm moist periods in three of

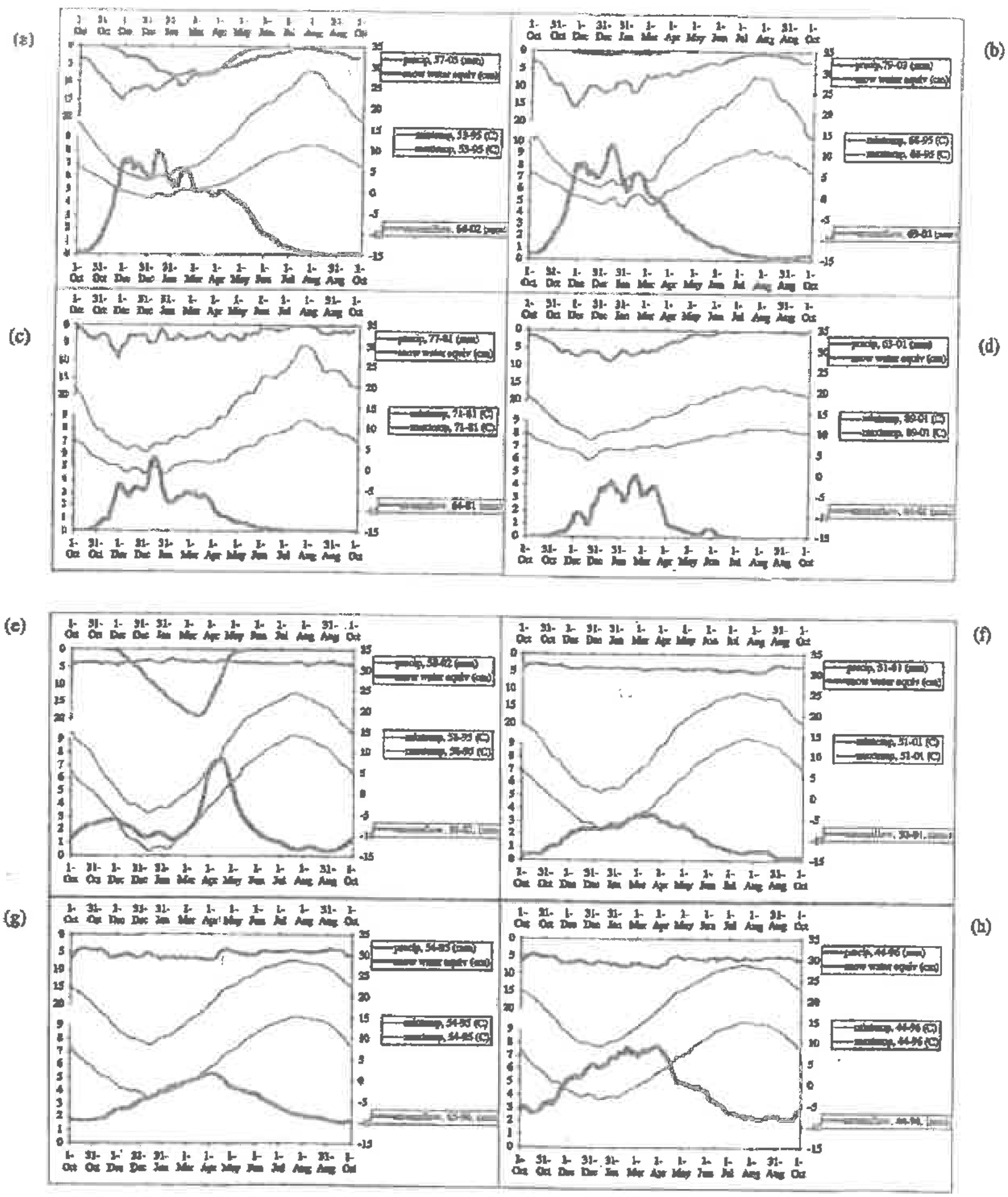

Figure 3. Mean daily precipitation (mm), snowpack (mm of snow water equivalent), streamflow (mm), maximum and minimum temperatures (°C) in ten control basins used in this study. Forest type (conifer versus deciduous), presence/absence of seasonal snowpack, and forest age in 2002 are noted. (a) Conifer, seasonal snow, 500 and 150 years (Andrews 2, Andrews 8); (b) conifer, transient/no snow, 150 years (Andrews 9); (c) conifer, transient/no snow, 150 years (Coyote 4); (d) conifer, no snow, 100 yrs (Caspar I); (e) deciduous, seasonal snow, 64 years (Hubbard Brook 3); (f) deciduous, transient snow, 95 years (Fernow 4); (g) deciduous, no snow, 75 years (Coweeta 2); (h) deciduous, no snow, 75 years (Coweeta 36).

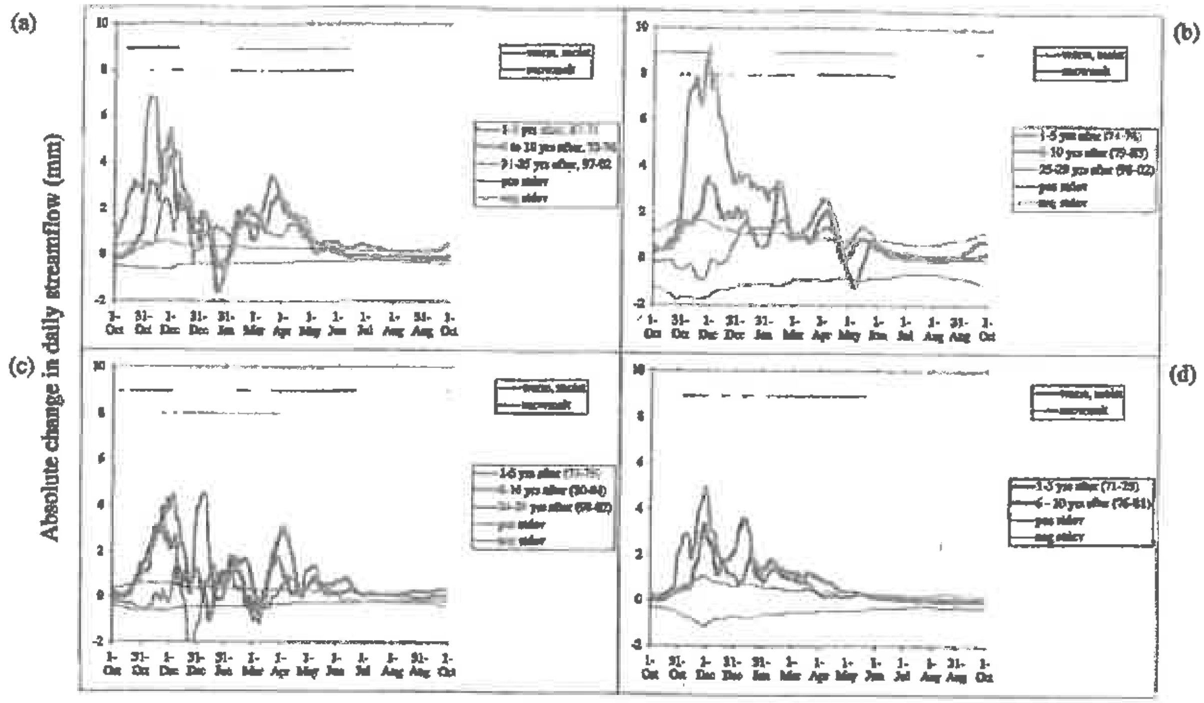

Figure 4. Absolute change in daily streamflow (mm) by day of water year (1 October - 30 September) for 5-year periods after forest removal at fourteen treated/control basin pairs. At the six conifer forest pairs, forest age (time since most recent forest disturbance) and snow conditions were (a) 462 year-old Douglas-fir/western hemlock forest, seasonal snow (Andrews 1/2); (b) 125-to 450-year old Douglas-fir/western hemlock forest, seasonal snow (Andrews 6/8); (c) 125 year old Douglas-fir/western hemlock forest, transient snow (Andrews 10/2); (d) 125-year old mixed-conifer forest, transient/no snow (Coyote 3/4); (e) 90-year old coast redwood/Douglas-fir forest, no snow (Caspar C/I); (f) 90-year old coast redwood/Douglas-fir forest, no snow (Caspar E/I). At the eight deciduous forest pairs, forest age (time since most recent forest disturbance) and snow conditions were (g) 27 year-old deciduous forest, seasonal snow (Hubbard Brook 2/3); (h) 32 year old deciduous forest, seasonal snow (Hubbard Brook 4/3); (i) 45 year old forest, seasonal snow (Hubbard Brook 5/3); (j) 50-year old red oak/sugar maple forest, transient/no snow (Fernow 1/4); (k) 56-year old red oak/sugar maple forest, transient/no snow (Fernow 7/4); (l) 50-year old deciduous forest, no snow (Coweeta 7/34); (m) 12-year old deciduous forest, no snow (Coweeta 13/14); (n) 36-year old deciduous forest, no snow (Coweeta 37/36).

four conifer basins, whereas absolute changes for the most part were independent of warm, moist seasons in the deciduous forest basins (Table 5). Days with absolute streamflow changes were three to many times more likely to occur during warm, moist periods than other periods in these six basin pairs, but they were no more, or slightly less likely to occur during warm moist periods in four deciduous forest basins. Net increases of 100 to 400 mm occurred in fall and spring in conifer forest basins, and net increases of 100 to 200 mm occurred in summer in deciduous forest basins (Table 5).

[26] Relative streamflow change was significantly associated with warm periods in all basins (Table 6). Relative streamflow changes in the 1 to 5-yr period after forest removal were significantly associated with periods of warm temperatures (summer), and amounted to net increases of 5 to 200% of summer flows (Table 6). However, in one case involving removal of 12-yr old forest (Coweeta 13/14), relative streamflow responses were not associated with season, and in another case (Coweeta 7/34), relative streamflow changes were significantly associated with cold periods. In conifer forest basins, summer streamflow changes disappeared by 5 to 10 years after forest removal. By 25 to 35 years after forest removal in conifer forest basins, a significantly higher than expected number of days had summer streamflow deficits exceeding −25%, but the net changes in summer streamflow ranged from +6 to −48% (Table 6). In contrast, streamflow changes were significantly more likely during the summer in all periods after forest removal in most of the deciduous forest basins, but the net changes in summer streamflow ranged from +33% (Fernow 1/4) to −42% (Hubbard Brook 2/3) (Table 6).

[27] In basins with snowpacks, absolute streamflow changes were significantly associated with periods of snowmelt in all 5-yr periods after forest removal (Table 7). In conifer forest basins with seasonal snowpacks (Andrews 1/2 and 6/8), these changes amounted to net increases of 100 to 200 mm during the snowmelt period (Table 7). In the conifer forest basin with a transient snowpack (Andrews 10), initial streamflow surpluses became streamflow deficits relative to the control, which has a seasonal snowpack (Andrews 2). In the deciduous forest basins, streamflow deficits occurred

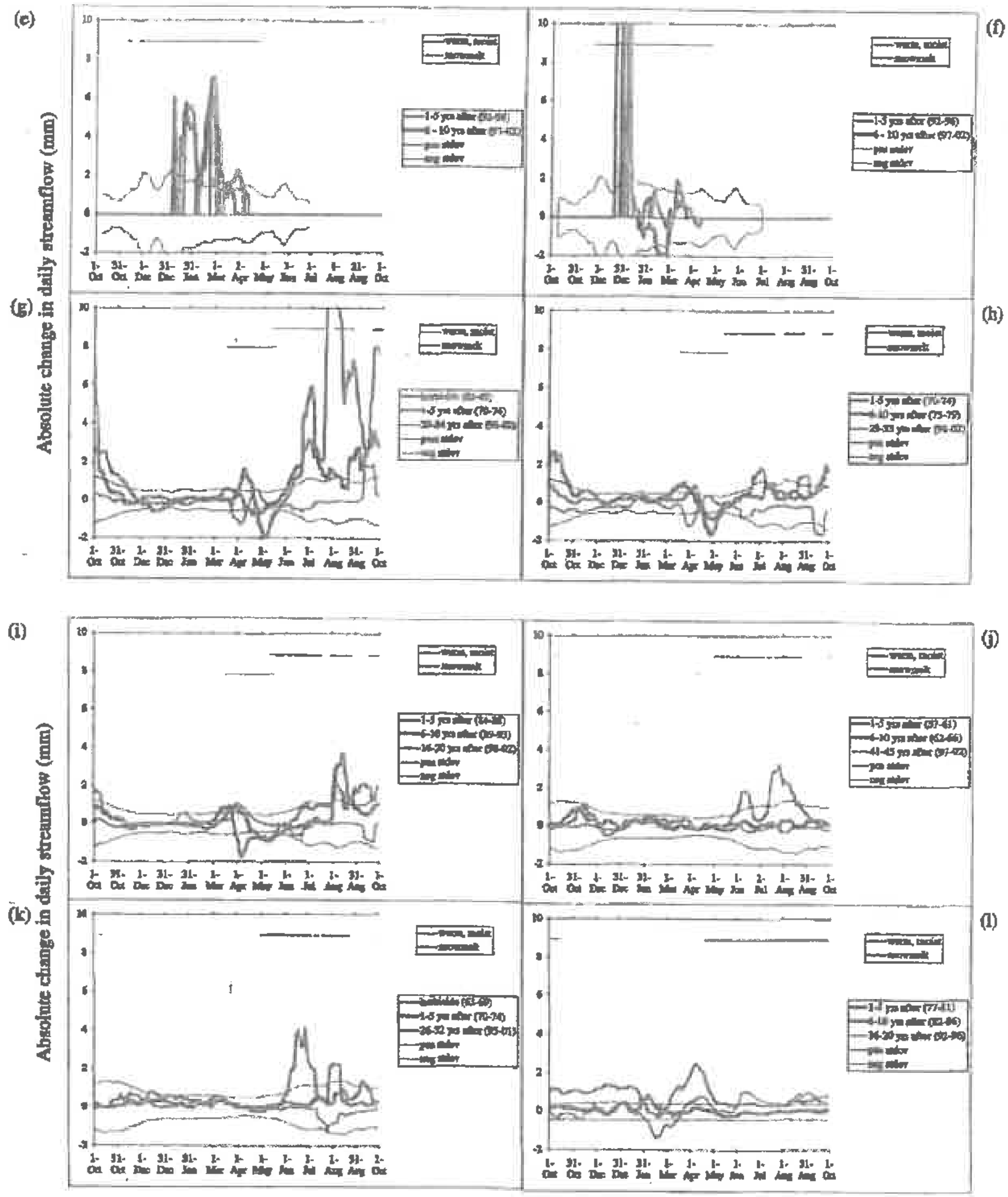

Figure 4. (continued)

during the snowmelt period; net changes ranged from +19 to −47 mm.

5.3. Successional Effects

[28] Streamflow responses to forest removal were related to two aspects of forest succession: (1) age of the regenerating forest (i.e., time since treatment, Figure 6), and (2) the difference in forest age between the treated and control basins (Figure 7). Streamflow responses to forest removal declined over several decades of forest regrowth, but the rate of decline varied by season and forest type and age, and there is considerable between-site variability in response for any given posttreatment period (Figure 6). For the entire water year, streamflow surpluses were highest and most persistent after removal of 90 to 450-yr old conifer forests, and lowest and most ephemeral after removal of

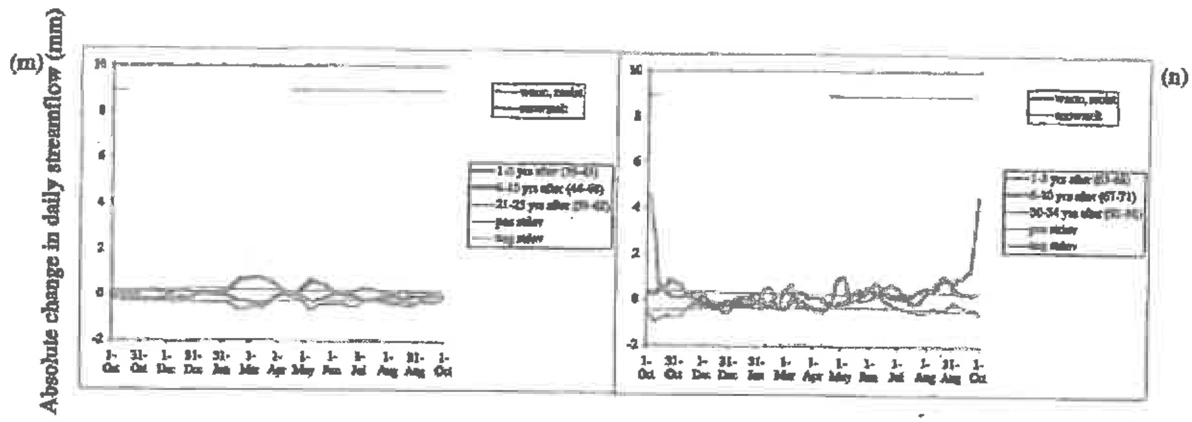

Figure 4. (continued)

12 to 56-yr old deciduous forests (Figure 6a). Conifer forests with transient snow or no snow had intermediate responses in annual streamflow. Surpluses during the snowmelt period persisted for up to four decades after removal of conifer forests from basins with a seasonal snowpack (Figure 6b). Streamflow surpluses in warm, moist seasons were higher and more persistent in conifer forest basins compared to deciduous forests (Figure 6c). By 20–25 years after forest removal (period 5), streamflow deficits had developed in August in all but one treated basin (Figure 6d). Although absolute changes were small, August streamflow 15 years after forest removal had declined by 60 to 80% relative to pretreatment August streamflow (Figure 6d).

[29] The age of forest at the time it was harvested (which is equivalent to the difference in age between the forest in the control and the treated basin) explains additional variability in streamflow response beyond that explained by season or time since treatment (Figure 7). Streamflow response in both absolute (Figure 7) and relative (data not shown) terms increased log-linearly, from treated basins with deciduous forests that were 12 to 56 years younger than their control basins, to treated basins with conifer forests 90 to 460 years younger than their control basins. Changes in annual streamflow, in streamflow during the warm, moist season, and in the snowmelt period were significantly positively related to forest age, in both the 1 to 5- and 15 to 25- yr periods after forest removal

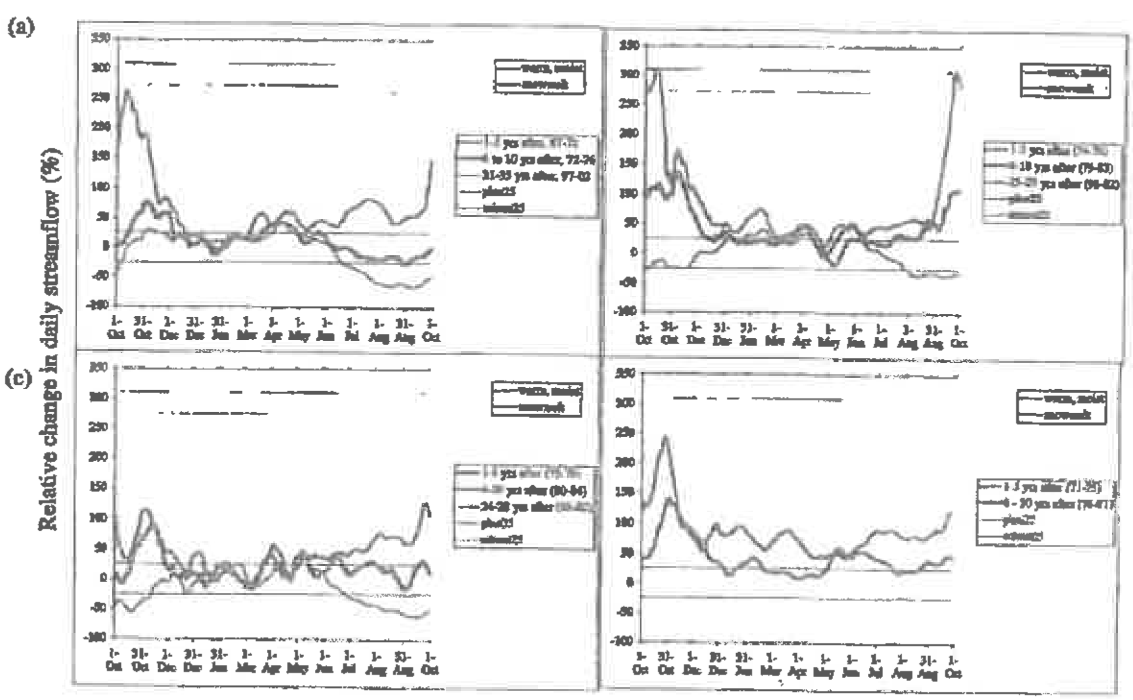

Figure 5. Relative (%) change in daily streamflow (mm) by day of water year (1 October–30 September) for 5-year periods after forest removal at fourteen treated/control basin pairs. See Figure 4 for basin names, forest types, and ages.

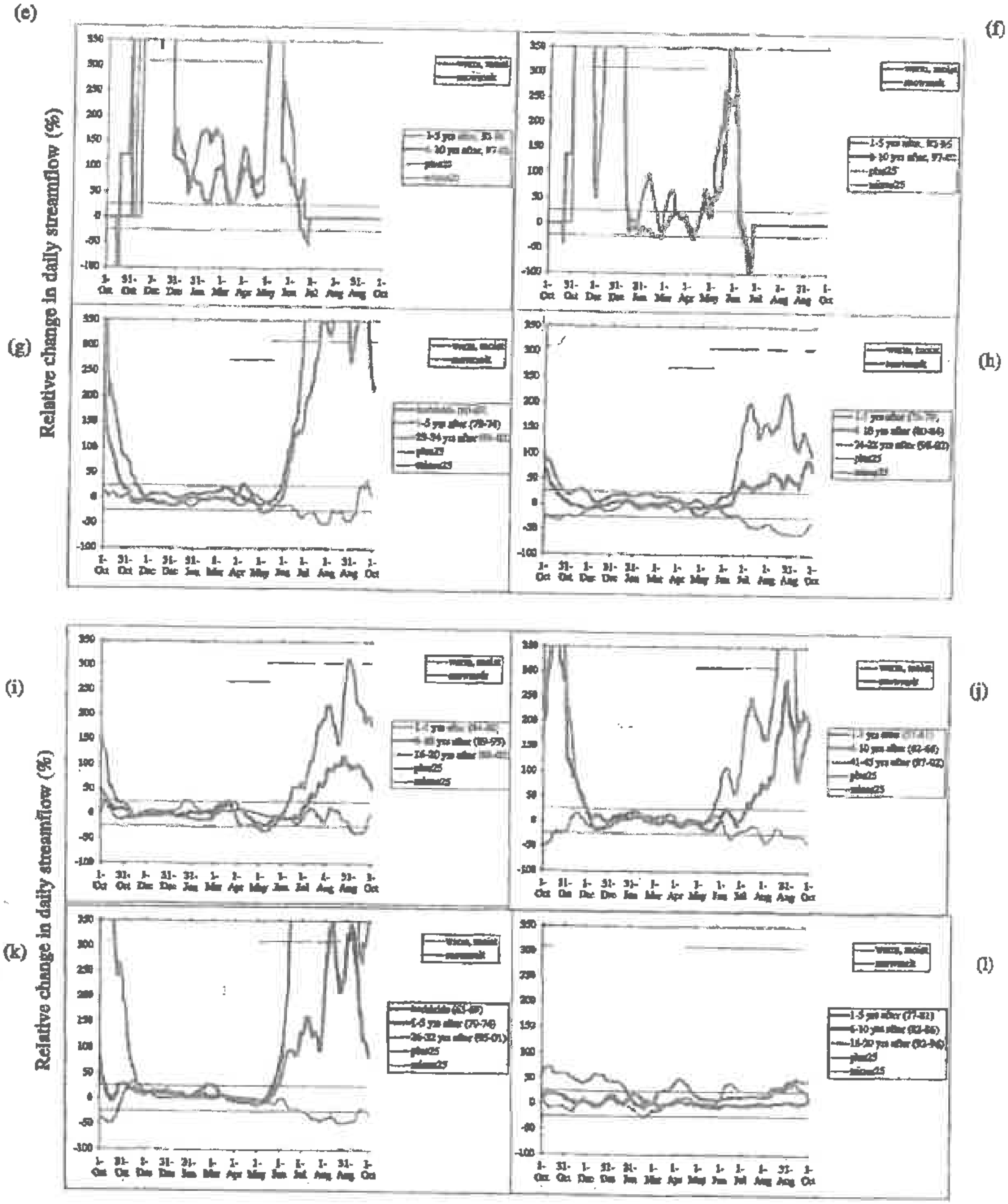

Figure 5. (continued)

(Figure 7). Fitted relationships explained from 45 to 92% of variation in absolute changes (Figure 7) and from 37 to 65% of variation in percent changes in streamflow (data not shown). Even when the "conifer-seasonal snow" points in Figure 7 were removed, six of eight regressions were still significant, with r^2 values ranging from 0.40 to 0.81. Change in streamflow during the cold season was not related to forest age in the 1 to 5-yr period, but was related to forest age in the 15 to 25-yr period after forest removal (Figures 7g and 7h).

6. Discussion

[30] Streamflow response to experimental forest removal and regrowth in fourteen treated/control basin pairs in the Pacific Northwest and eastern United States indicates that

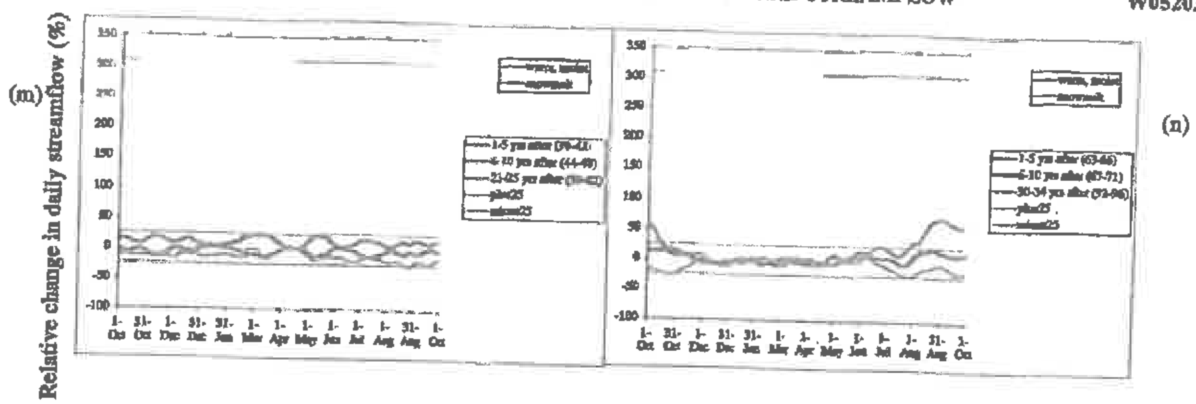

Figure 5. (continued)

Table 6. Relative Streamflow Changes in Warm Seasons After Forest Removal and During Forest Regrowth at Fourteen Pairs of Small Experimental Basins in Pacific Northwest Conifer and Eastern Deciduous Forests, USA[a]

		Years After Forest Removal									
Forest Type/Basin Pair	Treatment	1 to 5	6 to 10	11 to 15	16 to 20	21 to 25	26 to 30	31 to 35	36 to 40	41 to 45
Conifer Forests										
Andrews 1/2										
Change (%)	110	60	−7	−22	−7	−5	−12	−48		
Odds ratio	61[d]	53[d]	0.1[d]	1	2	0.3[b]	1	23[d]		
Andrews 6/8										
Change (%)		52	33	35	39	10	−13			
Odds ratio		22[b]	2	1	1	0.1[c]	2			
Andrews 10/2										
Change (%)		25	37	16	13	23	6			
Odds ratio		44[d]	0.5	1.0	2[b]	0.9	15[d]			
Coyote 3/4										
Change (%)		145	67							
Odds ratio		145[d]	0.02[b]							
Deciduous Forests										
Hubbard Brook 2/3										
Change (%)	469	186	36	−12	15	−18	−42	3		
Odds ratio	404[d]	18[d]	9[d]	3[b]	7[d]	20[d]	22[d]	18[d]		
Hubbard Brook 4/3										
Change (%)		70	55	26	−25	−43	−42	−35		
Odds ratio		744[d]	10[d]	17[d]	11[d]	22[d]	10[d]	13[d]		
Hubbard Brook 5/3										
Change (%)		91	61	0	−19					
Odds ratio		347[d]	14[d]	8[d]	6[d]					
Fernow 1/4										
Change (%)		100	10	11	17	22	33	22	1	−5
Odds ratio		334[d]	4[c]	4[c]	10[d]	5[b]	7[d]	7[d]	6[d]	6[d]
Fernow 7/4										
Change (%)	95	38	6	−10	−3	5	−24			
Odds ratio	351[d]	31[d]	0.7	1.4	4[c]	6[d]	8[d]			
Coweeta 7/34										
Change (%)		21	0	−11	17					
Odds ratio		0.2[d]	0.2	0.6	8[d]					
Coweeta 13/14										
Change (%)		4	4	−7	−10	−16				
Odds ratio		3	0.6	1	0.2	19[b]				
Coweeta 37/36										
Change (%)		28	10	9	–	−5	−8	−8		
Odds ratio		173[d]	3	16[b]	–	11	–	0.1		

[a]Percent change and odds ratios are shown for each basin pair and postharvest time period. Blanks, dashes, and odds ratios are defined in legend to Table 5.
[b]Chi-squared tests of independence between relative streamflow changes and the warm season were significant at $p < 0.05$.
[c]Chi-squared tests of independence between relative streamflow changes and the warm season were significant at $p < 0.001$.
[d]Chi-squared tests of independence between relative streamflow changes and the warm season were significant at $p < 0.0001$.

Table 7. Absolute Streamflow Changes in Snowmelt Periods After Forest Removal and During Forest Regrowth at Fourteen Pairs of Small Experimental Basins in Pacific Northwest Conifer and Eastern Deciduous Forests, USA[a]

Forest Type/Basin Pair	Treatment	Years After Forest Removal								
		1 to 5	6 to 10	11 to 15	16 to 20	21 to 25	26 to 30	31 to 35	36 to 40	41 to 45
Conifer Forests										
Andrews 1/2										
Change (mm)	167	170	154	153	159	139	141	103		
Odds ratio	7^{b}	11^{d}	5^{d}	8^{d}	6^{d}	4^{c}	8^{d}	7^{d}		
Andrews 6/8										
Change (mm)		139	139	180	237	171	126			
Odds ratio		4^{c}	4^{c}	8^{d}	9^{d}	6^{d}	12^{d}			
Andrews 10/2										
Change (mm)		6	14	21	−17	−24	−14			
Odds ratio		4^{c}	11^{d}	4^{c}	5^{d}	9^{d}	6^{d}			
Deciduous Forests										
Hubbard Brook 2/3										
Change (mm)		−10	−8	−27	−17	−47	−19	−17	−18	
Odds ratio		0.7	12^{d}	160^{d}	91^{d}	185^{d}	60^{d}	100^{d}	75^{d}	
Hubbard Brook 4/3										
Change (mm)		−1	−12	−5	−25	1	−4	−13		
Odds ratio		172^{d}	227^{d}	–	118^{d}	73^{d}	40^{d}	60^{d}		
Hubbard Brook 5/3										
Change (mm)		−41	0	10	19					
Odds ratio		372^{d}	384^{d}	75^{d}	40^{d}					

[a]Change and odds ratios are shown for each basin pair and postharvest time period. Blanks, dashes, and odds ratios are defined in legend to Table 5.
[b]Chi-squared tests of independence between absolute streamflow changes and the snowmelt season were significant at $p < 0.05$.
[c]Chi-squared tests of independence between absolute streamflow changes and the snowmelt season were significant at $p < 0.001$.
[d]Chi-squared tests of independence between absolute streamflow changes and the snowmelt season were significant at $p < 0.0001$.

forest effects on streamflow are strongly seasonal, and depend upon the age or successional stage of the forest. The analysis involved a complete re-analysis of primary data using a novel approach to paired-basin analysis, rather than relying upon reviews or meta-analyses of published studies as in *Bosch and Hewlett* [1982] or *Robinson et al.* [2003]. Our findings may differ slightly from published values for specific sites [*Rothacher*, 1970, 1975; *Douglass and Swank*, 1972; *Harr et al.*, 1979, 1982; *Swift and Swank*, 1981; *Hornbeck et al.*, 1993, 1997; *Martin et al.*, 2000; *Lewis et al.*, 2001; *Swank et al.*, 2001] because of differences in watershed pairing, use of daily average flows, and log-transformation of data. The results are relevant to ecophysiology, global change modeling, and stream ecology as well as hydrology, and they highlight the future potential for paired basin experiments.

[31] Atmospheric stresses (i.e., temperature, vapor pressure) and soil moisture stresses imposed on individual plants [e.g., *Eagleson*, 2002] scale up to influence streamflow at the small watershed scale, producing streamflow responses to forest removal and regrowth that were concentrated during seasons when moisture and temperature are conducive to evapotranspiration. Evapotranspiration depends upon (among other things) soil moisture, net interception, and evaporation from the canopy (Figure 1). Streamflow responses were larger in absolute terms after removal of conifer compared to deciduous forests, for basins with similar mean annual precipitation, confirming the site-specific work of *Swank and Douglass* [1974]. Conifers are adapted to use water throughout the year, as long as soil moisture and temperatures are not limiting, whereas transpiration in deciduous trees is limited to periods when leaves are present. Plant-level differences between conifer and deciduous forests were accentuated at the basin scale in this study, because coniferous forests were older than deciduous forests, and evapotranspiration from deciduous understory and early successional components of the regenerating conifer stands was limited by dry summers typical of these western sites.

[32] Changes in forest canopy interactions with the snowpack over the course of succession provide a possible alternative mechanism for documented long-term changes in snowmelt runoff [*Hodgekins et al.*, 2003]. Seasonal snowpack volume, and hence the snow water equivalent available to melt in the spring, depends upon the balance of additions and losses to sublimation and melt (Figure 1). Removal of deciduous forest canopies increases the exposure of cold snowpacks to winter sunlight in climates of eastern forests, and characteristically dense regenerating stands (e.g., of pin cherry [*Marks*, 1974] may intercept more snow, enhancing sublimation and reducing snowpack volume. Therefore in the first decade after removal of deciduous forest canopies, snowmelt occurred earlier and streamflow was reduced during the snowmelt period compared to 40 to 60 yr-old forests (Figures 4g–4i). This effect was reversed after two or three decades of forest regeneration, and snowmelt occurred later, but streamflow remained reduced during the snowmelt period compared to the control. In contrast, removal of conifer forest canopies decreases interception and increases the exposure of warm snowpacks to radiative heat losses, cooling mixed rain/snow to snow, in climates of Pacific Northwest forests [*Harr*, 1981]. Moreover, sparse regenerating stands [*Halpern*, 1989; *Acker et al.*, 2002] may intercept less snow. All these factors enhance snow accumulation and increase snowpack volume [*Marks et al.*, 1998; *Storck et al.*, 2002]. Therefore in the first decade after removal of conifer forest canopies, snowmelt occurred earlier and streamflow was

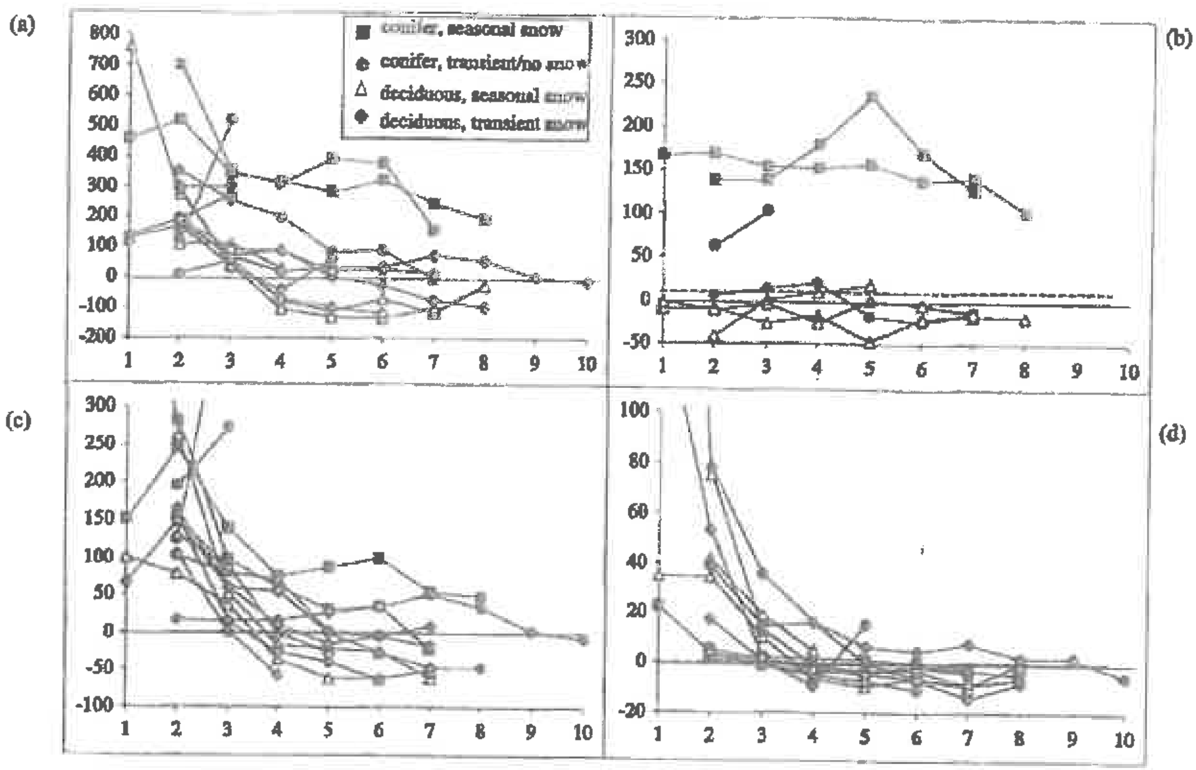

Figure 6. Effect of time since treatment (5-yr period after forest removal) on absolute changes in streamflow (mm) in fourteen treated/control basin pairs. (a) Entire water year, (b) snowmelt period, (c) warm, moist period without snow (summer for deciduous forest sites, fall for conifer forest sites), (d) August lowflow period. X axis values are 1 = treatment period, 2 = 1 to 5-years after forest removal, . . ., 10 = 41 to 45 after forest removal.

increased during the snowmelt period compared to 125 to 500 year-old forests (Figures 4a and 4b). After two or three decades of forest regeneration, snowmelt occurred later, and streamflow during the snowmelt period remained elevated, compared to the control.

[33] Streamflow variability in winter may be coupled to forest vegetation through lagged effects transmitted by soil moisture reservoirs. Lagged effects were limited to circumstances when moisture was held at high tensions, such as when soil moisture content was low or soils were very fine-textured. Soil moisture at high tensions has low hydraulic conductivity, so a "pulse" of increased or decreased soil moisture could take months to travel from the rooting zone through a small basin to the gage. Thus in deciduous sites, maximum streamflow responses in summer appeared near the middle or end of the warm period (Figures 4g–4k, 4n). In two cases (Figures 4l and 4m) the maximum streamflow response appeared several months after the end of the summer, an effect noted by earlier workers [*Swank et al.*, 1988].

[34] The strong relationships of streamflow change to two aspects of forest age (time since treatment and age of the forest at the time it was removed) support the notion that forest succession results in more efficient use of fixed moisture resources [*Eagleson*, 2002]. Forest age is a proxy for forest condition, which influences hydrologic processes. Specifically, time since treatment, and time since most recent severe disturbance are proxies for leaf area, sapwood densities, species composition, and canopy structure, which in turn are proxies for interception, evaporation, and transpiration. Thus as noted by *Hornbeck et al.* [1993, 1997] and *Swank et al.* [2001], young (10 to 30-year old) forests regenerating from disturbance were higher water users per unit leaf area than older forests (12 to 450 years older). However, based on 14 basin pairs in both conifer and deciduous forests, young forests (10 to 30 yrs old) were higher water users than old forests (70 to 450 yrs old) only in relative terms during late summer periods (August). In fact, the converse was true: removal of old (90 to 450-year old) conifer forests had a larger absolute effect on streamflow than removal of young (13 to 56-year old) deciduous forests. As forest succession proceeds over 50, 100, or 500 years, many factors (the increasing age of individual trees, changes in water use by new species succeeding in the overstory and understory, altered interception capacity, or development of a canopy epiphyte community) may increase the ability of a forest community to capture and store water. Disturbance history can help predict the ranges of streamflow responses to forest removal, but further work [e.g., *Link*, 2001] is needed to elucidate the many hydrologic mechanisms that operate in aging forests.

[35] Streamflow responses to forest removal observed in this study indicate that forest vegetation effects on streamflow variability may have consequences for stream ecology [e.g., *Poff et al.*, 1997]. In basins draining northwestern conifer forests, persistent absolute streamflow increases

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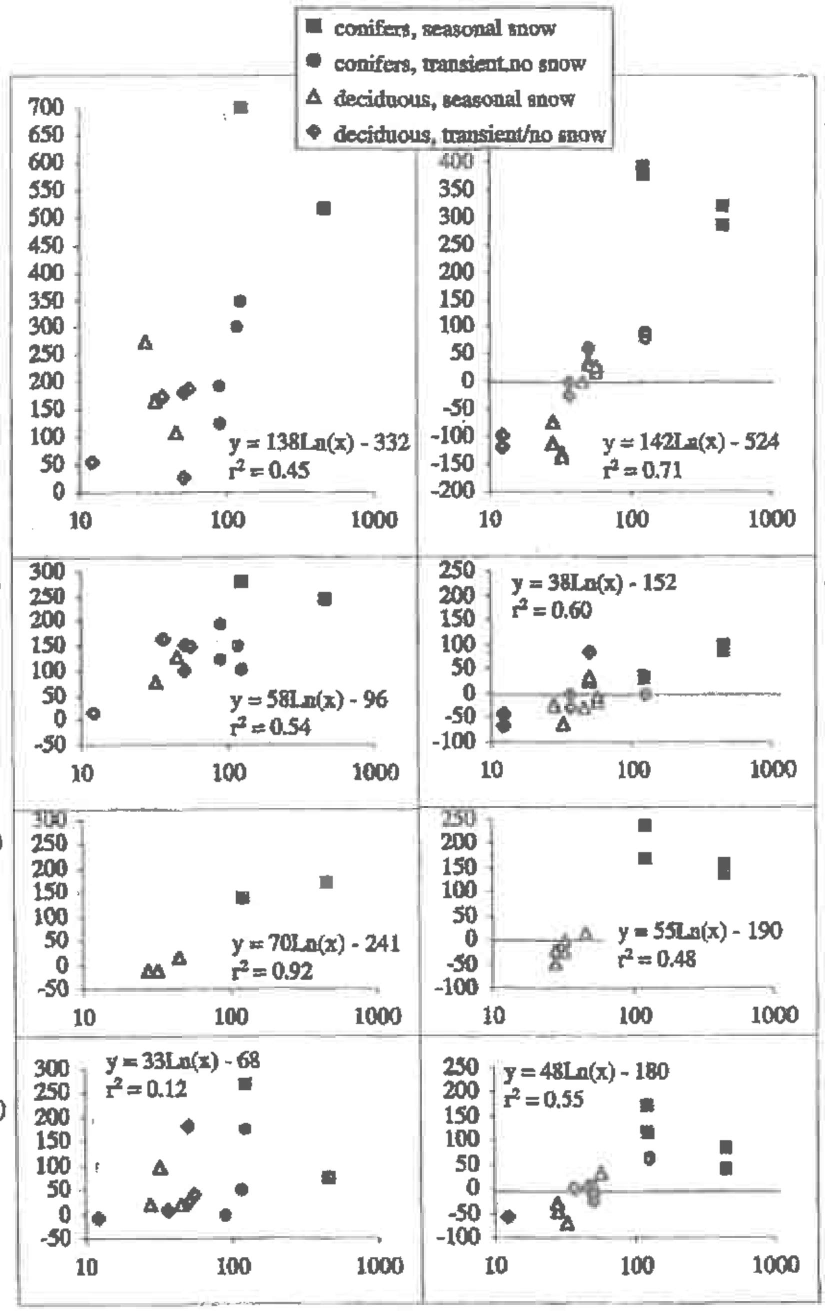

Figure 7. Effect of forest age at the time of harvest (time since most recent forest disturbance) on absolute change in water yield for various seasons and stages of succession. Entire water year: (a) 1 to 5 year and (b) 15 to 25 year periods after forest removal. Warm, moist season, fall for conifers, summer for deciduous forest: (c) 1 to 5 year and (d) 15 to 25 year periods after forest removal. Snowmelt season: (e) 1 to 5 year and (f) 15 to 25 year periods after forest removal. Cold season (winter): (g) 1 to 5 year and (h) 15 to 25 year periods after forest removal. Herbicided basin (Hubbard Brook 2) was excluded from regression for the warm, moist season, 1 to 5 year period after forest removal. Least-squares fitted log-linear models and r^2 values are shown.

during spring, combined with persistent relative summer deficits, imply that stream organisms are subjected to bigger ranges of streamflow variability in young compared to old-growth forest stands. Basins draining young eastern forests also may experience higher streamflow variability compared to older forests as a result of the combined effects of forest canopy on streamflow through changes in snow accumulation and melt, and summer water use.

[36] The methods used in this study represent a departure from prior work, and indicate the potential for continued analyses of paired-basin experiments.

[37] 1. The treated/control relationship in paired-basin experiments, rather than a black and white one, can be viewed as a function of continuous, and continuously changing, differences between basins in vegetation structure, composition, and climate. Thus multiple basins may be used as controls for a given treated basin, and the responses may be compared.

[38] 2. Paired-basin records provide the opportunity to quantify and compare streamflow responses at multiple temporal scales, including storm events, seasons, successional periods, and decadal climate change. Work is needed to examine how streamflow responses at seasonal and successional timescales, addressed in this study, interact with streamflow responses at the storm event scale [e.g., *Jones*, 2000; *Lewis et al.*, 2001], and at the scale of decadal climate change [e.g., *Greenland et al.*, 2003].

[39] 3. Small paired-basin experiments permit comparison of streamflow responses across vegetation types and treatments, climates, and basin scales. This analysis, which was restricted to <100-ha, mountainous, temperate deciduous and conifer forest basins, could be extended with additional replicates of these basin types, or records from other climates, other treatments (e.g., fire), or other vegetation types. The very high streamflow variability at basins of <20 ha may obscure some important streamflow changes, so records from larger basin scales should be included in analyses. Relevant data are available through Hydro-DB [*Baker et al.*, 2000].

[40] Prediction of streamflow from ungaged basins is a major ongiong challenge for hydrologists (see e.g., the PUB initiative, http://iahs.info). This study indicates that to some extent streamflow can be predicted from climate, forest type, and disturbance history effects on hydrologic processes. The approaches presented in this paper provide useful advances for understanding and prediction of hydrologic response.

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AN ABSTRACT OF THE THESIS OF

Timothy D. Perry for the degree of Master of Science in Geography presented on December 7, 2007.

Title: Do Vigorous Young Forests Reduce Streamflow? Results from up to 54 Years of Streamflow Records in Eight Paired-watershed Experiments in the H. J. Andrews and South Umpqua Experimental Forests.

Abstract approved:

Julia A. Jones

This study quantified the magnitude and timing of summer streamflow deficits in paired-watershed experiments in the Cascade Range of Oregon where mature and old-growth conifer forests were subjected to clearcutting, patch cutting, and overstory thinning treatments in the 1960s and 1970s. Hydrologic effects of clearcutting, small-patch cutting, and overstory thinning in the mixed conifer/brush zone were studied (1 watershed (WS) each) in the Coyote Creek WS of the South Umpqua Experimental Forest at 42° 1′ 15″N and 122° 43′ 30″W. Hydrologic effects of clear cutting (3 WS), shelterwood cutting (1 WS), patch cutting (1 WS), and young forest thinning

(1 WS) were examined in the Tsuga heterophylla zone at the H. J. Andrews experimental forest at 44° 14′ 0″N and 122° 11′ 0″ W. Climate of both sites is marine west coast with winter precipitation and dry summers, producing minimum streamflows in August and September. Changes in flow frequency distributions were detected by counting days below streamflow thresholds where the thresholds were established using percentiles from pre-cutting streamflow records. Changes in relative streamflow were established by the station pair method. Summer streamflow deficits were largest and most persistent in 35 to 50-year-old forest plantations created from clearcutting and shelterwood cutting in the 1960s and 1970s. Summer streamflow deficits were smallest and most ephemeral in a stand that experienced 50% overstory thinning in 1971. Summer streamflow deficits of intermediate size and persistence developed in watersheds in which 25 to 30% of the area had been patchcut in the 1960s or 1970s. A sparse (12%) precommercial thin of a 27-year-old stand exhibiting summer streamflow deficits had comparatively little effect on streamflow deficits. Streamflow deficits emerged as early as March or April and persisted into October and November in the warmer, drier site in southern Oregon (Coyote Creek), whereas summer streamflow deficits were restricted to July through September in the cooler, wetter Andrews Forest. These findings are

consistent with previous studies demonstrating (1) increases in water use in certain conifer species relative to others (e.g. Douglas-fir versus pine); (2) higher water use in young (i.e., 10 to 50-yr-old) compared to old (100 to 250-yr-old) stands of many tree species; and (3) decreased interception capacity of young relative to old forest stands associated with loss of canopy epiphytes. Results appear to be robust, despite gaps in data availability, uncertainties associated with changes in stream gauging, streamflow trends over time in control watersheds, and multi-decadal fluctuations in regional climate over the study period. These findings support the notion that variable-intensity logging prescriptions over small areas to approximate natural forest structure may have the least effect on summer streamflows. However, more research, preferably new paired watershed experiments, is needed to quantify the magnitude and duration of summer streamflow effects from various levels of overstory and understory thinning treatments.

(S)

Summer streamflow deficits from regenerating Douglas-fir forest in the Pacific Northwest, USA

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ABSTRACT

Despite controversy about effects of plantation forestry on streamflow, streamflow response to forest plantations over multiple decades is not well understood. Analysis of 60-yr records of daily streamflow from eight paired-basin experiments in the Pacific Northwest of the United States (Oregon) revealed that conversion of old-growth forest to Douglas-fir plantations had a major effect on summer streamflow. Average daily streamflow in summer (June through September) in basins with 34 to 43-yr-old plantations of Douglas-fir was 50% lower than streamflow from reference basins with 150 to 500-yr-old forests dominated by Douglas-fir, western hemlock, and other conifers. Study plantations are comparable in terms of age class, treatments, and growth rates to managed forests in the region. Young Douglas-fir trees, which have higher sapwood area, higher sapflow per unit of sapwood area, higher concentration of leaf area in the upper canopy, and less ability to limit transpiration, appear to have higher rates of evapotranspiration than old trees of conifer species, especially during dry summers. Reduced summer streamflow in headwater basins with forest plantations may limit aquatic habitat and exacerbate stream warming, and it may also alter water yield and timing in much larger basins. Legacies of past forest management or extensive natural disturbances may be confounded with effects of climate change on streamflow in large river basins. Continued research is needed using long-term paired-basin studies and process studies to determine the effects of forest management on streamflow deficits in a variety of forest types and forest management systems.

Keywords: stationarity, succession, climate change, native forests, plantations, water scarcity

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1. INTRODUCTION

Widespread evidence that streamflow is declining in major rivers in the US and globally raises concerns about water scarcity (Adam *et al.*, 2009; Dai *et al.*, 2009; Luce and Holden, 2009; Vorosmarty *et al.*, 2000). Climate change and variability are implicated as causes of many streamflow trends (Lins and Slack, 1999, 2005; McCabe and Wolock, 2002; Mote *et al.*, 2003; Hodgkins *et al.*, 2003, 2005; Stewart *et al.*, 2004, 2005; Nolin and Daly, 2006; Hamlet and Lettenmaier, 2007; Barnett *et al.*, 2008; Jefferson *et al.*, 2008; Lara *et al.*, 2008; Dai *et al.*, 2009; Kennedy *et al.*, 2009; Jones, 2011). However, large-scale plantation forestry, often using non-native tree species, is expanding in much of the temperate zone on Earth, despite widespread evidence that intensive forestry reduces water yield (Cornish and Vertessy, 2001; Andreassian, 2004; Brown *et al.*, 2005, Farley *et al.*, 2005; Sun *et al.*, 2006; Little *et al.*, 2009). Water yield reductions are greater in older plantations, during dry seasons and in arid regions (Andreassian, 2004; Brown *et al.*, 2005; Farley *et al.*, 2005; Sun *et al.*, 2006). Yet, downstream effects of forestry are debated (van dijk and Keenan, 2007).

Despite general studies of water partitioning in forested basins (e.g., Budyko, 1974, Zhang *et al.*, 2001, Jones *et al.*, 2012), it is unclear how streamflow varies during forest succession, relative to tree species, age, or growth rates in native forest and forest plantations (Creed *et al.*, 2014). In the Pacific Northwest of the US, forest plantations have reduced summer streamflow relative to mature and old-growth forest (Hicks *et al.*, 1991; Jones and Post, 2004). However, the magnitude, duration, causes, and consequences of summer water deficits associated with forest plantations are not well understood.

In the Pacific Northwest, large areas of old-growth forest have been converted to forest plantations. We examined how changes in forest structure and composition have affected streamflow using multiple paired-basin experiments in western and southwestern Oregon, where regenerating forests are currently aged 40 to 50 years, and reference forests are aged 150 to 500 years. Many studies have reported on these experiments, including vegetation ecology (e.g., Marshall and Waring, 1984; Halpern, 1989; Halpern and Franklin, 1990; Halpern and Spies, 1995; Lutz and Halpern, 2006; Halpern and Lutz, 2013) and hydrology (e.g., Rothacher, 1970; Harr *et al.*, 1979; Harr and McCorison 1979; Harr *et al.*, 1982; Hicks *et al.*, 1991; Jones and Grant, 1996, Jones, 2000; Jones and Post, 2004, Perkins and Jones, 2008; Jones and Perkins, 2010; Jennings and Jones, 2015). We asked:

1. How has daily streamflow changed over the past half century in reference basins with 150- to 500-yr-old forest?
2. What are the trends in daily streamflow over 40 to 50-year periods, from basins with regenerating forests compared to reference basins?
3. How are changes in summer streamflow related to forest structure and composition in mature and old-growth forests vs. forest plantations?

2. STUDY SITE

The study examined streamflow changes in eight pairs of treated/reference basins in five paired-basin studies. Five of the basin pairs (eight basins) were located in the H.J. Andrews Experimental Forest (122° 15' W, 44° 12' N) in the Willamette National Forest. Three basin pairs (4 basins) were located at Coyote Creek in the South Umpqua Experimental Forest (122° 42' W, 43° 13' N) in the Umpqua National Forest (Table 1, Figure 1). Basins are identified as Andrews 1, 2, etc. = AND 1, 2, etc.; Coyote 1, 2, etc. = COY 1, 2, etc. (Table 1).

The geology of the study basins is composed of highly weathered Oligocene tuffs and breccias that are prone to mass movements. The upper elevation portion of the Andrews Forest (above ~800 m, AND 6, AND 7, AND 8) is underlain by Miocene andesitic basalt lava flows (Dyrness, 1967; Swanson and James, 1975; Swanson and Swanston, 1977). Soils are loamy, well-drained, and moderately to highly permeable, with considerable variation in depth and rock content (Rothacher *et al.*, 1969; Dyrness, 1969; Dyrness and Hawk, 1972).

The Andrews Forest ranges from 430 to 1600 m elevation; study basins range from 430 to 1100 m elevation (Table 1). Area-averaged slope gradients are >60% at low elevation (AND 1, AND 2, AND 3, AND 9, AND 10) and 30% at high elevation (AND 6, AND 7, AND 8). Mean daily temperature ranges from 2°C (December) to 20°C (July) at 430 m and from 1°C (December) to 17°C (July) at 1300 m. Mean annual precipitation is 2300 mm, >75% of precipitation falls between November and April, and actual evapotranspiration (AET) averages 45% of precipitation. The South Umpqua Experimental Forest (Coyote Creek basins) ranges from 730 to 1065 m elevation. Most slope gradients are <40% (Arthur 2007). Mean daily temperature (at USHCN station OR356907, 756 m elevation, 30 km SE of Coyote Creek) ranges from 3 °C (December) to 20 °C (July). Mean annual precipitation (at OR356907) is 1027 mm, >80% of precipitation falls between November and April, and AET averages 45% of precipitation.

Study basins are located along a gradient of seasonal snow depth and duration (Harr, 1981, 1986). At high elevation (> 800 m, AND 6, AND 7, and AND 8), average snowpack water equivalent (SWE) on April 30 exceeds 700 mm (30% of annual precipitation), and snow may persist for six months, whereas at low elevation (<700 m, AND 9, AND 10), snow rarely persists more than 1–2 weeks and usually melts within 1–2 days; peak SWE is ~2% of precipitation (Harr *et al.*, 1979; Harr and McCorison, 1979; Harr *et al.*, 1982; Perkins and Jones, 2008). Snow at the South Umpqua Experimental Forest (Coyote Creek) usually melts within 1–2 weeks.

Vegetation at the Andrews Forest is Douglas-fir/western hemlock forest. Mature and old-growth forest regenerated after wildfires in the early 1500s and mid-1800s (Weisberg and Swanson 2003, Tepley 2010, Tepley *et al.*, 2013). Overstory canopy cover is 70 to 80% and leaf area index is >8 (Dyrness and Hawk, 1972; Marshall and Waring, 1986; Lutz and Halpern, 2006). Vegetation at the South Umpqua Experimental Forest is mixed conifer (Douglas-fir, white fir, incense cedar, sugar pine), and overstory canopy cover is 70 to 80% (Anderson *et al.*, 2013).

At the Andrews Forest the first paired-basin experiment began in 1952 (AND 1, 2, 3); a second paired basin experiment began in 1963 (AND 6, 7, 8) and a third paired-basin experiment began in 1968 (AND 9, 10), with continuous records except at AND 7 (Table 1). Pre-treatment periods exceeded seven years in all cases and were ten years for AND 1/2, AND 6/8, and AND 7/8. Streamflow instrumentation changed in some basins over the period of record (Table 1). Because of the timing of instrumentation changes at AND 9/10, AND 2 is used as the reference basin for AND 10 (see supplemental material). At the South Umpqua Experimental Forest, the Coyote Creek paired-basin experiment began in 1963 (Table 1). The pre-treatment period was seven years. Despite a break in the record from 1981 to 2000, streamflow instrumentation is unchanged (M. Jones, personal communication).

3. METHODS

This study examined changes in daily average streamflow and its relationship to climate and forest structure and species composition in paired basins. Climate, vegetation, and streamflow have been measured for multiple decades at the Andrews Forest and Coyote Creek (see supplemental materials). Tree-level vegetation data were used to calculate basal area for all species, proportions of basal area for major species, and size class distributions.

Daily streamflow data for the period of record were used to calculate the change in streamflow by day of water year utilizing the method developed by Jones and Post (2004). The ratio R of daily streamflow between the treated basin T and reference (control) basin C for year y and day d was calculated following Eberhardt and Thomas (1991) as:

$$R_{yd} = \ln(T_{yd} / C_{yd}) \qquad (1)$$

The mean value of this ratio M for all the years y in a given period p was:

$$M_{pd} = \text{Average } (R_{yd}) \text{ for all "y" in "p"} \qquad (2)$$

The percent difference P_{pd} between the treated:reference ratio of streamflow on day d in the pre- and post-treatment period p compared to M_{pd} in the pre-treatment period 0 (M_{0d}), was:

$$P_{pd} = 100*(e^{(M_{pd} - M_{0d})} - 1) \qquad (3)$$

The 15-day smoothed percent change in daily streamflow, S, was:

$$S_{pd} = \sum(P_{pD}*E_{pD}) / \sum(E_{pD}) \text{ over } D = d-7, d-6, \ldots, d, \ldots, d+6, , d+7 \qquad (4)$$

The smoothed daily percent difference S_{pd} was averaged for 5-year post-treatment periods and plotted as a function of day of the water year. S_{pd} also was summed by month and plotted as a function of time (year). Percent changes in daily streamflow were calculated for eight treated/reference basin pairs: COY 1/4, COY 2/4, COY 3/4, AND 1/2, AND 3/2, AND 6/8, AND 7/8, AND 10/2. The significance of percent changes was assessed based on comparison with the 15-day smoothed values of the pre-treatment standard error of P_{pd}.

A daily soil water balance was created for AND 2 based on mean daily values of precipitation and discharge, daily evapotranspiration estimated from S_{pd} (Jones and Post, 2004) and mean daily snow water equivalent modeled in Perkins and Jones (2008). In addition, long-term trends in streamflow were calculated for each day of the water year from the beginning of the record to 1996, for AND 2, 8, and 9, following Hatcher and Jones (2013) (see supplemental materials).

Flow percentiles were calculated for each gage record, and the numbers of days of flow below each percentile were tallied by water year. The difference in numbers of days below selected percentiles between the treated and reference basin for 1995 to 2005 was calculated and compared to summer discharge at the reference basin for 100% treated/reference pairs.

4. RESULTS

The structure and composition of native mature and old-growth forest in reference basins varied, reflecting wildfire history, but was stable over the study period. Basal area ranged from 66 to 89 m^2/ha depending on the basin and the year (Table 2). Douglas-fir (*Pseudotsuga menziesii*) was the dominant species, representing 55 to more than 90% of basal area, with varying amounts of western hemlock (*Tsuga heterophylla*) and western redcedar (*Thuja plicata*) in AND 2 and AND 8, and California incense cedar (*Calocedrus* *decurrens*) and white fir (*Abies concolor*) in COY 4 (Table 2). Trees in AND 2 (N-facing) and AND 8 (upper-elevation) were very large, with weighted mean stem diameter of roughly 0.66 m. In contrast, trees were smaller on the low-elevation, SW-facing, relatively hot, dry slopes of AND 9 and the mid-elevation COY 4 in southwest Oregon, with mean diameter of just over 0.3 m (Table 2). Stem density ranged from 87 stems/ha at the N-facing AND 2 to over 400 stems/ha at the SW-facing AND 9. Over a 25-year period, stem density and basal area were stable in AND 2, although there was a slight net loss of Douglas-fir and a gain of western hemlock (Table 2). The size-class distributions of Douglas-fir reveal moderate-severity historical fire in AND 2 and moderate to high-severity fire AND 8 in the mid 1800s, which produced cohorts of regenerating Douglas-fir (Figure 2).

Basal area and growth rates in the 34 to 43-yr-old plantations in the treated basins are at the lower end of those reported for managed plantations in the region (Figure 3). Basal area at the most recent measurement period (2007 to 2010) ranged from 27 to 35 m^2/ha, or between one-third and one-half of the basal area in the corresponding reference basin (Table 2). Douglas-fir, which was planted in the treated basins, was the dominant species, representing more than 80% of basal area. Stem density was five to ten times higher in plantations than matched reference basins, and ranged from 533 to more than 1700 stems/ha (Table 2). Mean diameters in plantations were one-third to one-fifth of those in corresponding reference basins, except for COY 1, where the large mean stem diameter (31 cm) reflects the retention of 50% of the overstory from the shelterwood harvest (Table 1, Table 2). Trees were smallest in AND 7 (shelterwood harvest, plantation aged 34 yrs) and largest in 100% clearcut and burned basins AND 1 (plantation, aged 40 yrs) and COY 4 (plantation, aged 35 yrs). AND 10, which was clearcut but not burned, had a very high number of small stems (plantation, aged 35 yrs) (Table 1, Table 2, Figure 2). Adjusting for age, rates of basal area growth were similar in all the 100% clearcut basins. The unburned basin (AND 10) and the shelterwood harvest basin (AND 7) had slightly lower rates of growth in the third decade after harvest (AND 10) and a pre-commercial thin (12% basal area removal) at year 28 in AND 7, but rates were similar by 35 years (Figure 3).

The daily soil water balance for the reference basin (AND 2, Figure 4) reveals extremely low rates of evapotranspiration and soil moisture in old-growth forests during the summer (July through September). Evapotranspiration is limited by low temperature in winter, and low soil moisture in summer.

Daily streamflow has not changed in reference basins (Figure 5). Runoff declined slightly during the periods of snowmelt, but these minor changes were significant only at AND 2 (Figure 5). Summer streamflow did not change over time.

Conversion of old-growth forest to Douglas-fir plantations, which reached 34 to 43 years of age by the end of the record analyzed here, had a major effect on summer streamflow. By the mid 1990s, average daily flow in summer (June through September) in basins with plantation forests had declined by roughly 50% relative to the reference basins with 150 to 500-yr-old forests (Figure 6 a). When plotted by time since harvest, summer streamflow deficits appeared when plantation forests reached fifteen years of age (Figure 6 b). The trend of declining summer streamflow was temporarily reversed in the late 1980s, especially at AND 1/2 and AND 6/8, after a severe freezing event in November of 1986. A pre-commercial thin (12% basal area) in AND 7 in 2001 did not slow the decline of summer streamflow.

When examined by day of year, forest harvest produced large streamflow increases from June through December in the first ten years after harvest (Figure 7). Initial summer streamflow surpluses were lowest, and disappeared most quickly, in 50% thinned ("shelterwood") basins (AND 7, COY 1), and they were highest at the 100% clearcut basins (AND 1, 6, 10, COY 3) (Figure 7). Conversion of mature and old forest to young plantations produced streamflow surpluses in winter and spring of 25 to 50%, which persisted virtually unchanged to the present in the Andrews Forest, but not at the drier, more southerly Coyote Creek (Figure 7).

By 20 to 25 years after 100% clearcutting, summer streamflow was lower in all plantation forests compared to reference basins (Figure 7 a to e) and also in one 25% patch cut basin (Figure 7 g). In 100% clearcut basins, summer streamflow deficits began by early July, and persisted until early October (AND 1, AND 7, Figure 7 a,c), to the end of November (AND 6, AND 10, Figure 7 b,d), or to the end of December (COY 3, Figure 7 e). Deficits were largest in August and September, when streamflow from forest plantations was 50% lower than from reference basins. Summer deficits did not emerge over time in treatments involving shelterwood (50% thinned, COY 1) and very small gaps (0.6 to 1.3-ha patch cuts, COY 2) (Figure 7 f,h). Relative to 50% thinning (shelterwood) and very small gaps, intermediate-sized gaps (8-ha patch cuts, AND 3) produced larger initial summer surpluses and persistent summer deficits. The largest gaps (20 to 100-ha clearcuts) produced the largest summer surpluses and the largest, persistent summer deficits, which extended into the fall season (Figure 7 a-d). Thinning of young forest (AND 7) did not counteract summer streamflow deficits.

Summer streamflow deficits occurred during the period of minimum flow, when soil moisture is most limiting (Figure 4, 7). The duration of summer streamflow deficits (defined as difference in the number of days below the 1st percentile in basins with plantations vs. reference basins) was greater during dry compared to wet summers, at low compared to high elevation, and at the more southerly Coyote Creek compared to the Andrews Forest (Figure 8). Forest plantations that were aged 25 to 35 years in 1995 to 2005 had as many as 100 more days with flow below the 1st percentile compared to the reference basin (Figure 8). Within a basin pair, the number of days of flow below the 1st percentile increased in dry relative to wet summers (Figure 8).

5. DISCUSSION

This study showed that, relative to mature and old-growth forest dominated by Douglas-fir and western hemlock or mixed conifers, forest plantations of native Douglas-fir produced summer streamflow deficits within fifteen years of plantation establishment, and these deficits have persisted and intensified in 50-yr-old forest stands. Forest stands in the study basins, which are on public forest land, are representative of managed (including thinned) forest stands on private land in the region, in terms of basal area over time (Figure 3), age (10 to 50 years), clearcut size (20 ha), and average rotation age (50 years) (Lutz and Halpern, 2006; Briggs 2007). There are no significant trends in annual or summer precipitation (Abatzoglou *et al.*, 2014) or streamflow at reference basins over the study period. This finding has profound implications for understanding of the effects of land cover change, climate change, and forest management on water yield and timing in forest landscapes.

The size of canopy opening explained the magnitude and duration of initial summer streamflow surpluses and subsequent streamflow deficits, consistent with work on soil moisture dynamics of canopy gaps. In 1990, Gray *et al.* (2002) created experimental gaps in mature and old-growth forests in Oregon and Washington, including neighboring sites to the study basins, with gap sizes of 40 to 2000 m^2 (tree height to gap size ratios of 0.2 to 1.0). The smallest gaps dried out faster during the summer than the largest gaps, with the highest moisture levels in the medium-sized gaps, which had less direct radiation and less vigorous vegetation than the largest gaps. In late summer (September) volumetric soil moisture declined to 15% in references, 18% in small gaps, and 22% in each of the first three years after gap creation (Gray *et al.*, 2002). Together, the paired-basin and experimental gap results indicate that even-aged plantations in 8-ha or larger clearcuts are likely to develop summer streamflow deficits, and these deficits are unlikely to be substantially mitigated by dispersed thinning or small gap creation.

Relatively high rates of summer evapotranspiration by young (25 to 45-yr-old) Douglas-fir plantations relative to mature and old-growth forests apparently caused reduced summer streamflow in treated basins. Young Douglas-fir trees (in AND 1) had higher sapflow per unit sapwood area and greater sapwood area compared to old Douglas-fir trees (in AND 2) (Moore *et al.* (2004). In summer, young Douglas-fir trees have higher rates of transpiration (sapflow) compared to old Douglas-fir trees, because their fast growth requires high sapwood area, and because their needles appear to exercise less stomatal control when vapor pressure deficits are high. Leaf area is concentrated in a relatively narrow height range in the forest canopy of a forest plantation, whereas leaf area is distributed over a wide range of heights in a mature or old-growth conifer forest. In summer, these factors appear to contribute to higher daily transpiration rates under young conifers relative to mature or older conifers, producing pronounced reductions in streamflow during the afternoons of hot dry days (Bond *et al.*, 2002). At sunset, transpiration ceases, and streamflow recovers. Hence, daily transpiration produces large diel variations in streamflow in AND 1 (plantation) relative to AND 2 (reference). Other factors, such as differences in tree species composition (Table 2), the presence of a hyporheic zone, or deciduous trees in the riparian zone of AND 1, may also contribute to differences in streamflow between these basins (Bond *et al.*, 2002; Moore *et al.*, 2004; Wondzell *et al.*, 2007).

Reduced summer streamflow has potentially significant effects on aquatic ecosystems. Summer streamflow deficits in headwater basins may be particularly detrimental to anadromous fish including steelhead and salmon, by limiting habitat, exacerbating stream temperature warming, and potentially causing large-scale dieoffs (Hicks *et al.*, 1991; Arismendi *et al.*, 2012, 2013, Isaak *et al.*, 2012). Summer streamflow deficits may also exacerbate tradeoffs in water use between in-stream flows, irrigation, and municipal water use.

Reductions in summer streamflow in headwater basins with forest plantations may affect water yield in much larger basins. Much of the Pacific Northwest forest has experienced conversion of mature and old-growth forests to Douglas-fir plantations over the past century. Climate warming and associated loss of snowpack is expected to reduce summer streamflow in the region (e.g., Littell *et al.*, 2010). Declining summer streamflows in the Columbia River basin may be attributed to climate change (Chang *et al.*, 2012, 2013; Hatcher and Jones, 2013), but these declines may also be the result of cumulative forest change due to plantation establishment, fire suppression (Perry *et al.*, 2003), and forest succession after wildfire and insect outbreaks, which kill old trees and promote growth of young forests (e.g., Biederman *et al.*, 2015).

Air temperature has warmed slightly in the Pacific Northwest (0.6 to 0.8°C from 1901 to 2012 [Abatzoglou *et al.*, 2014]), but water yields from mature and old-growth forests in reference basins have not changed over time. In the reference basins used in this study, we observed small changes in biomass and shifts in species dominance, consistent with changes expected as part of forest succession in mature and old-growth forests, but we did not observe large-scale mortality documented by van Mantgem *et al.* (2009).

This study demonstrates that plantations of native tree species produced summer streamflow deficits relative to mature and old-growth forest, consistent with prior studies in the US Pacific Northwest (Jones and Post, 2004) and in mixed-deciduous forests in the eastern US (Hornbeck *et al.*, 1997). Research is needed to compare these effects to declining water yield from plantations of fast-growing non-native species in the southern hemisphere (Little *et al.*, 2009, 2014; Scott 2005; Farley *et al.*, 2005). Despite summer streamflow deficits, young forest plantations in the Andrews Forest yield more water in winter, contributing to increased flooding (Harr and McCorison, 1979; Jones and Grant, 1996; Beschta *et al.*, 2000; Jones, 2000; Jones and Perkins, 2010).

6. CONCLUSIONS

Paired basin experiments are central to advancing long-term, integrated forest hydrology. Over the past half-century, many key paired-basin experiments (e.g., at US Forest Service Experimental Forests and LTER sites such as Coweeta, Hubbard Brook, and Andrews, as well as others) have evolved into headwater ecosystem studies, with detailed information about hydrology, climate, vegetation, biogeochemistry, and sediment export. These studies provide rigorous causal inferences about effects of changing vegetation on streamflow at successional time scales (multiple decades) of interest in basic ecology, applied forestry and conservation. They permit researchers to distinguish forest management from climate change effects on streamflow. Paired-basin experiments are place-based science, integrate multiple disciplines of science and policy, and can dispel assumptions and conjectures such as equilibrium, common in hydrological modeling studies.

Long-term paired-basin studies extending over six decades revealed that conversion of mature and old-growth conifer forests to plantations of native Douglas-fir produced persistent summer streamflow deficits of 50% relative to reference basins, in plantations aged 25 to 45 years. This result challenges the widespread assumption of rapid "hydrologic recovery" following forest disturbance. Widespread transformation of mature and old-growth forests may contribute to summer water yield declines over large basins and regions around the world, reducing stream habitats and sharpening conflict over uses of water.

Continued research is needed to examine how forest management influences streamflow deficits. Comparative studies, process studies, and modeling are needed to examine legacies of various past and present forestry treatments and effects of native versus non-native tree species on streamflow. In addition, long-term basin studies should be maintained, revived, and extended to a variety of forest types and forest ownerships, in order to discriminate effects of climate versus forest management on water yield and timing, which will be increasingly important in the future.

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Table 1: Name and abbreviation, area, elevation range, natural vegetation, streamflow gaging method and record length, harvest treatment, logging methods, and treatment dates for basins used in this study. Sources: Harr *et al.*, 1979; Rothacher, 1965; Harr *et al.*, 1982; Rothacher *et al.*, 1967; Jones and Post, 2004.

Basin name	Area (ha)	Elevation range (m)	Natural vegetation	Streamflow record length, instrumentation[b]	Treatment, date[a]	Logging Method
Coyote 1 COY 1	69.2	750-1065	Mixed conifer	1963-81 V; 2001-present V	Roads 1970; 50% over-story selective cut, 1971	Tractor yarded
Coyote 2 COY 2	68.4	760-1020	Mixed conifer	1963-81 V; 2001- present V	Permanent roads 1970; 30% 2 to 3-ha patch cuts, 1971	16% high-lead cable yarded; 14% tractor yarded.
Coyote 3 COY 3	49.8	730-960	Mixed conifer	1963-81 V; 2001- present V	Permanent roads 1970; 100%; clearcut 1971	77% high-lead cable yarded; 23% tractor yarded.
Coyote 4 COY 4	48.6	730-930	Mixed conifer	1963-81 V; 2001- present V	Reference	N/A
Andrews 1 AND 1	95.9	460-990	450-500-yr–old Douglas-fir forest	1952-present (1952-present T [rebuilt 1956]; 1999-present SV)	100% clearcut 1962-1966	100% skyline yarded
Andrews 2 AND 2	60.7	530-1070	450-500-yr–old Douglas-fir forest	1952-present (1952-present T; 1999 - present SV)	Reference	N/A
Andrews 3 AND 3	101.2	490-1070	450-500-yr–old Douglas-fir forest	1952-2005 T; 1999 -present SV	Roads 1959; 30% patch-cut 1962	30% high-lead cable yarded
Andrews 6 AND 6	13.0	863-1013	130- 450-year old Douglas-fir forest	1964-present; (1964 – 1997 H; 1997-present T; 1998 present SV)	Roads; 100% clearcut 1974; broadcast burn 1975	90% high-lead cable yarded; 10% tractor yarded
Andrews 7 AND 7	15.4	908-1097	130- 450-year old Douglas-	1964-1987; 1995-present (1964 – 1997 H;	Roads 1974; 60% shelterwood	40% skyline yarded;

			fir forest	1997- present T; 1998 - present SV)	cut 1974; remaining overstory cut 1984; broadcast burn lower half of WS 1975; 12% basal area thin 2001	60% tractor yarded.
Andrews 8 AND 8	21.4	955-1190	130- 450-year old Douglas-fir forest	1964-present (1964 –1987 H; 1987 present T; 1973 – 1979 SV, 1997 – present SV)	Reference	N/A
Andrews 9 AND 9	9	425-700	130- 450-year old Douglas-fir forest	1969-present (1969 -1973 H; 1973 present T; 1973 – 1979 SV, 1997 present SV)	Reference	N/A
Andrews 10 AND 10	10	425-700	130- 450-year old Douglas-fir forest	1969-present (1969 -1973 H; 1973 present T; 1973 – 1979 SV, 1997 - present SV)	100% clear-cut 1975; no burn	100% high-lead cable yarded

a Broadcast burns were controlled burns over the cut area intended to consume logging debris.
b H: H-flume; T: trapezoidal flume; V: v-notch weir or plate. Summer V-notch weirs have been used for improved discharge measurements over the following periods: since 1999 at Andrews 1, 2, and 3; since 1998 at Andrews 6, 7, and 8; and from 1969 to 1973 and since 1997 at Andrews 9 and 10.

Table 2. Vegetation characteristics of the study basins, sampled over the period 1981 to 2011. Basal area is mean ± standard deviation. PSME = *Pseudotsuga menziesii* (Douglas-fir), TSHE = *Tsuga heterophylla* (western hemlock), THPL = *Thuja plicata* (western red cedar), ABCO = *Abies concolor* (white fir), CADE = *Calocedrus decurrens* (California incense cedar), PILA = *Pinus lambertiana* (sugar pine).

					Basal area								Stem density (stems/ha)	
					(m^2/ha)	As %								
Watershed	N of plots	Plot size (m^2)	Year	Age	All	PSME	TSHE	THPL	ABCO	CADE	PILA	Other[a]	All	PSME
Treated patches														
AND 1	132	250	2007	40	33 ± 14	85	3	1	0	0	0	11	1454	919
AND 3	61	250	2007	43	35 ± 12	80	11	2	0	0	0	7	1857	621
AND 6	22	250	2008	34	35 ± 9	77	11	9	0	0	0	3	1107	699
AND 7	24	250	2008	24	23 ± 10	70	9	4	0	0	0	17	900	551
AND 10	36	150	2010	35	27 ± 12	81	4	2	0	0	0	13	893	437
COY 1[bc]	--[f]	--[f]	2011	35-200[g]	66	56	5	0	17	12	5	5	992	194
COY 2[c]	4	150	2006	35	31 ± 12	82	0	0	0	13	0	5	1733	1150
COY 3[c]	4	150	2006	35	45 ± 13	80	0	0	0	10	0	10	1533	1083
Reference														
AND 2	67	250	1981	150-475[d]	69 ± 29	70	24	2	0	0	0	4	262	67
	67	250	2006	175-500[d]	72 ± 29	65	29	2	0	0	0	4	438	87
AND 8	22	1000	2003	175-500[d]	86 ± 24	64	26	9	0	0	0	2	580	144
	22	1000	2009	175-500[d]	89 ± 24	64	26	9	0	0	0	2	565	139
AND 9	16	1000	2003	175-500[d]	84 ± 25	92	4	0	0	0	0	4	630	434
	16	1000	2009	175-500[d]	85 ± 25	92	5	0	0	0	0	3	602	417
COY 2[b]	--[f]	--[f]	2011	150-350[g]	89	61	0	0	10	17	11	1	1169	172
COY 4[b]	--[f]	--[f]	2011	150-350[g]	66	55	5	0	18	11	5	6	975	183

-- Not available.

a Other (at Coyote Creek) includes *Arbutus menziesii* (madrone), *Pinus ponderosa* (ponderosa pine), and *Taxus brevifolia* (Pacific yew). Other (at the Andrews Forest) includes *Acer macrophyllum* (bigleaf maple), *Castanopsis chrysophylla* (giant chinquapin), and *Prunus emarginata* (bitter cherry).

b 2011 stand exam data for matrix (not forest plantations) from Anderson *et al*., 2013.
c Source: Arthur, 2007.
d Multi-age stand with mixed-severity fire history.
e Coyote 1 was sampled in 2006 (Arthur, 2007) and 2011 (Anderson *et al*., 2013).
f Data from a forestry stand examination, not from plots, and no standard error is provided.
g Source: Rothacher, 1969.

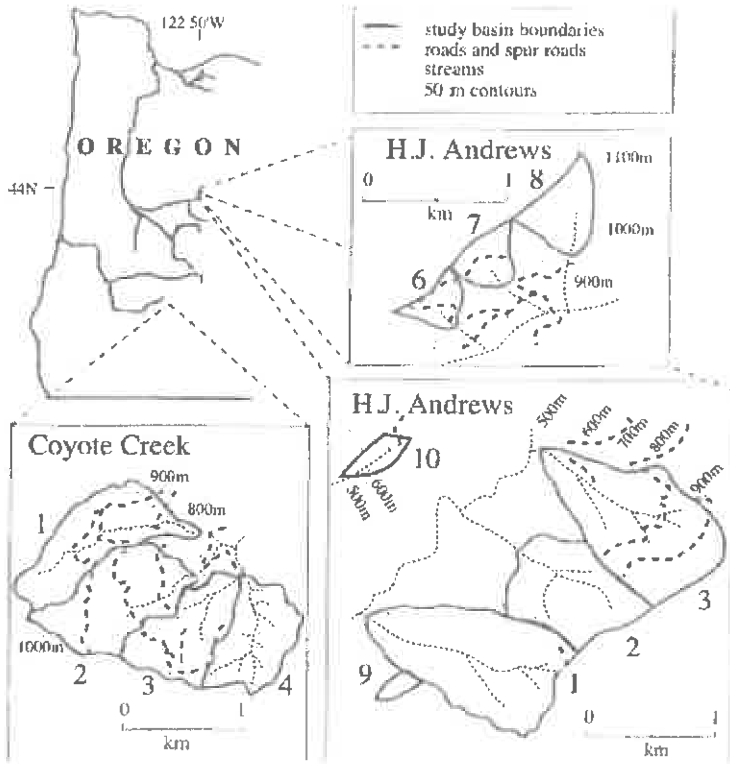


Figure 1. Location of study basins in western Oregon.

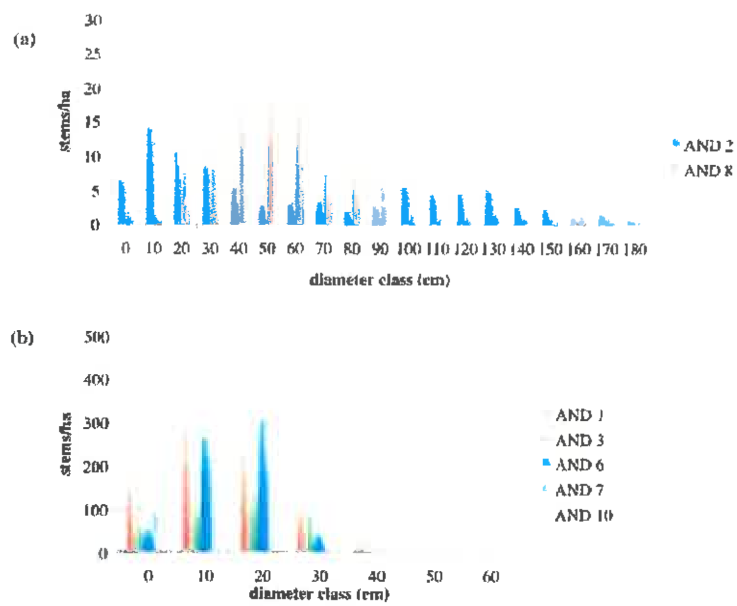


Figure 2. Size class distributions of Douglas-fir (Pseudotsuga menziesii, PSME) in plantations and reference basins in the Andrews Forest. (a) reference basins used in this study: AND 2 (2006), AND 8 (2009). (b) basins with young Douglas-fir plantations: AND 1 (aged 40 yrs, 2007), AND 3 (clearcut patches, aged 43 yrs, 2007), AND 6 (aged 34 yrs, 2008), AND 7 (aged 34 yrs, 2008), AND 10 (aged 35 yrs, 2010).

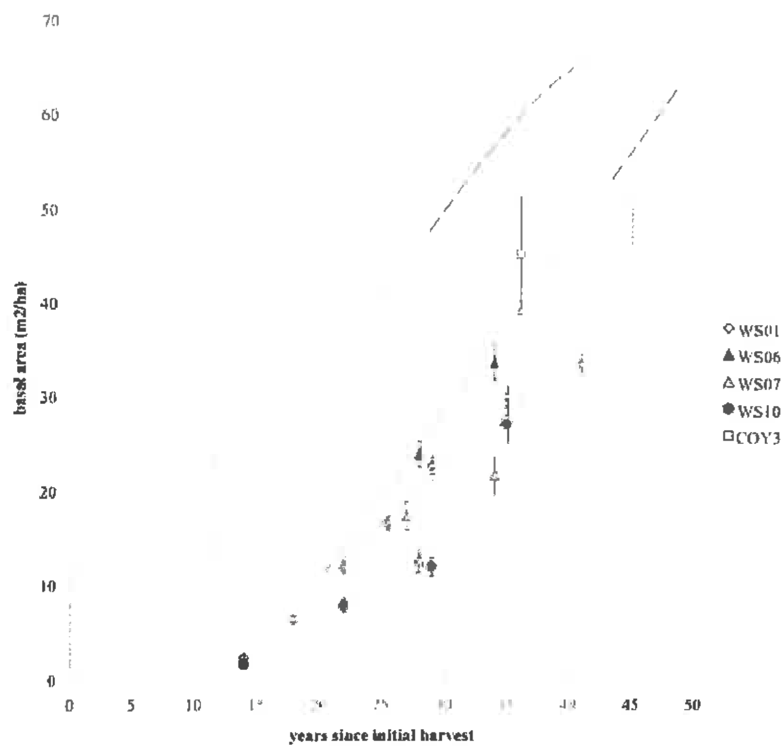


Figure 3. Basal area as a function of time since treatment forest plantations in this study, and comparable values from forest plantations in the region. Values are means ± standard error from numbers of plots shown in Table 2. The diagonal thick grey dashed lines are the basal area reported from control (unthinned) plots (upper line), heavily thinned plots (lower line) and lightly thinned plots (middle line) in the Hoskins levels-of-growing-stock (LOGS) installation (site II) in western Oregon (Marshall and Curtis 2002). The diagonal thin grey dashed line indicates average annual basal area for Douglas-fir plantations on relatively high site productivity locations affected by various levels of infection from Swiss needle cast in the Oregon Coast Range (Maguire et al., 2002). The diagonal thin grey dotted line indicates basal areas for experimental Douglas-fir plantations at low site productivity locations (site V) at Wind River (100 km N of the Andrews Forest, at a similar elevation to the experimental basins) (Harrington and Reukema 1983). The vertical grey dotted line is estimated Douglas-Fir basal area from growth and yield models for 45-yr-old stands (Marshall and Turnblom 2005). The vertical grey dashed line is range of basal areas in stands of Douglas-fir, western hemlock, and mixtures (Amoroso and Turnblom 2006).

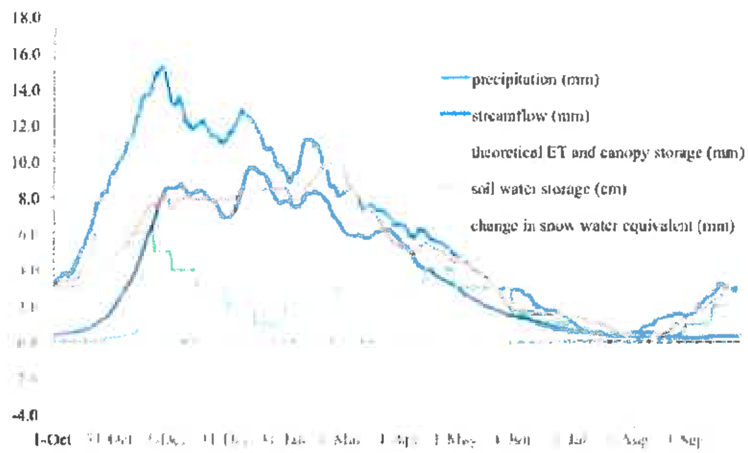


Figure 4. Water balance of mean daily values of precipitation (P), streamflow (Q), ET, snow water equivalent (N), and soil water storage (S) in AND 2, based on data from 1953 to 2003 water years, where S = P – Q – ET - ΔN. Daily ET was estimated from the response of AND 1/2 to clearcutting calculated by Jones and Post (2004) and from summer sapflow measured in AND 2 by Moore et al., (2004). Snow water equivalent was based on average modeled daily values from Perkins and Jones (2008).

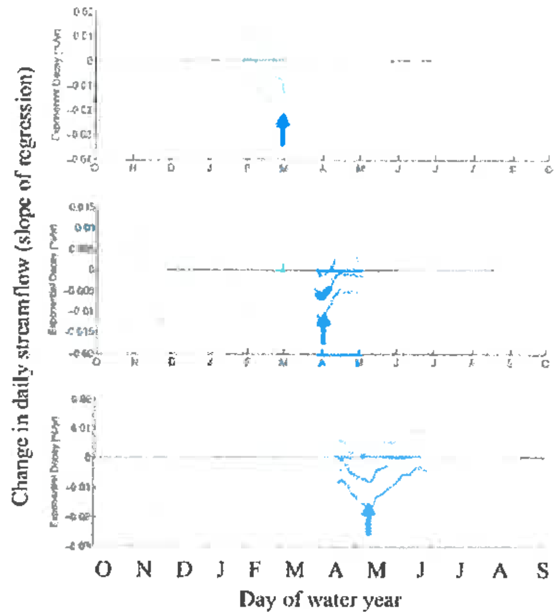


Figure 5. Streamflow change for period of record to 1996, by day of water year (October to September) for three reference basins: (a) AND 9 – 400-700 m; (b) AND 2 – 500-1000 m; and (c) AND 8 – 800-1100 m. The green line is the trend in streamflow (positive or negative) on that day of the year, relative to the long-term mean streamflow on that day (indicated as zero). Black lines are the 95% confidence interval around the trend. Blue arrows indicate days of declining streamflow, and dark blue lines are days of significant declines in streamflow; declines are significant only at AND 2. Shaded boxes show the period of snowmelt from Perkins and Jones (2008). K. Moore, unpublished data.

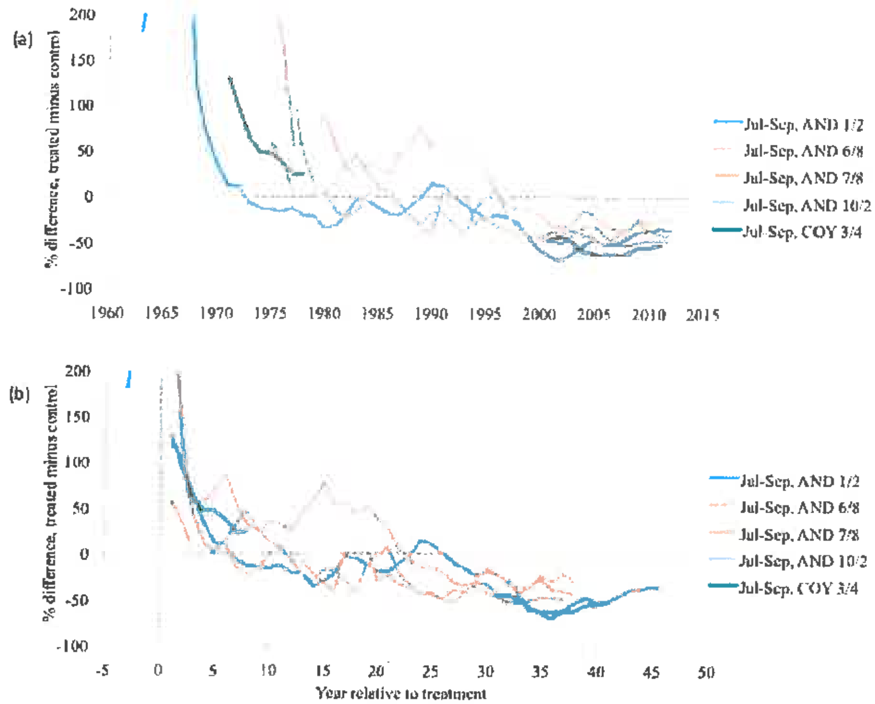


Figure 6. Trends in average daily streamflow (July through September) in basins with forest plantations as a percent of streamflow in the reference basin, for five basin pairs with 100% clearcut basins. (a) by year. (b) by time since treatment. Basin pair names include treated/reference. Percents are 3-year running means. Grey box is the mean ± the standard error of the treated-reference basin relationship from July to September during the pre-treatment period.

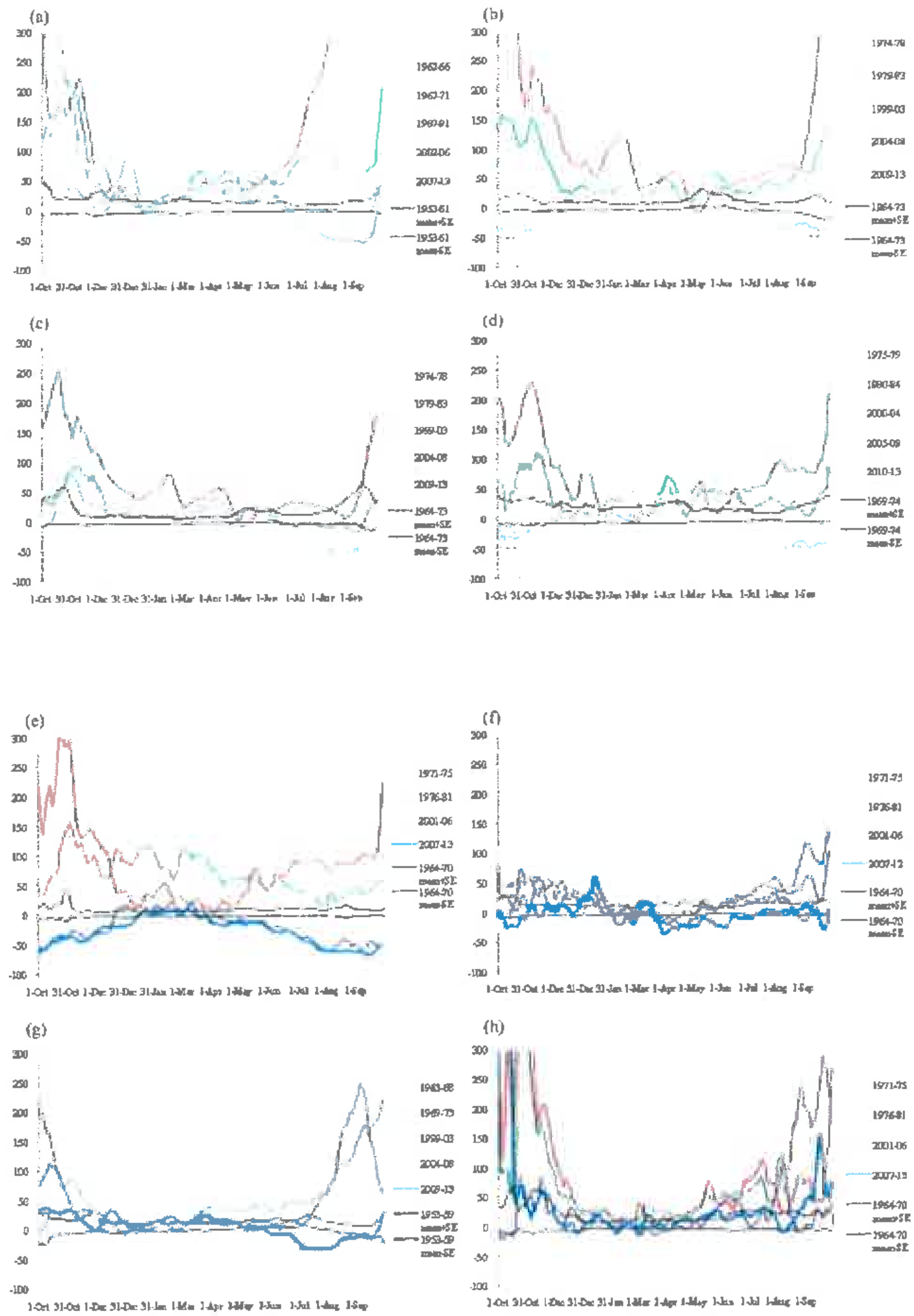


Figure 7. Percent change in streamflow by day of water year in five-year periods after forest harvest and plantation establishment for eight pairs of basins. (a) AND 1 (100% clearcut 1962-66) vs. AND 2 (reference), (b) AND 6 (100% clearcut 1974) vs. AND 8 (reference), (c) AND 7 (50% cut 1974, remainder cut 1984) vs. AND 8 (reference), (d) AND 10 (100% clearcut 1975) vs. AND 2 (reference), (e) COY 3 (100% clearcut 1970) vs. COY 4

(reference), (f) COY 1 (50% cut 1970) vs. COY 4 (reference), (g) AND 3 (25% patch cut 1963) vs. AND 2 (reference), (h) COY 2 (30% patch cut 1970) vs. COY 4 (reference). Black lines represent the mean and standard error of the percent difference between the treated and reference basins during the pre-treatment period. Dashed grey line is a 50% decline in streamflow at the treated basin relative to its relationship to the reference basin during the pre-treatment period.

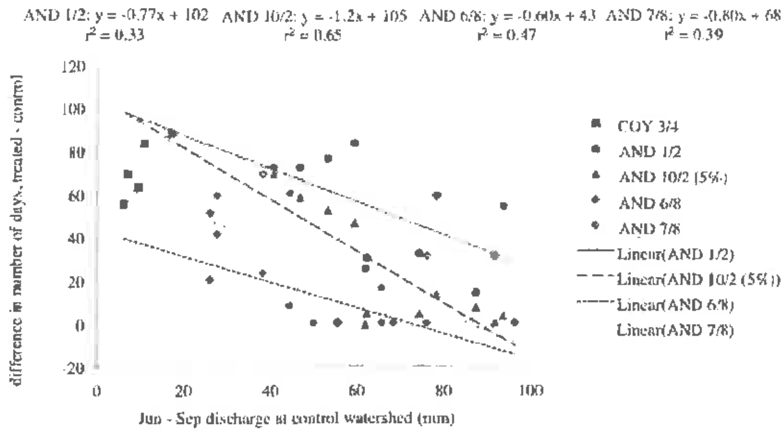


Figure 8. Difference in number of days in the 1st and 5th (AND 10/2) flow percentiles from 1995 to 2005, in basins with 25 to 40-yr-old plantations relative to reference (old-growth) basins. A value of zero on the Y-axis indicates that the basin with forest plantation had the same number of days in the low flow percentile as the reference basin; a value of 80 indicates that the basin with forest plantation had 80 more days in the low flow percentile than the reference basin. Negative slopes of regression lines indicate that the duration of low streamflow increased in drier summers in the forest plantation, relative to the reference basin. The 5th percentile was used for AND 10/2 because only a few years had >0 days in the 1% category.

Councillor Llewellyn (verbal report)

I was at the Health Network meeting this week in Campbell River and we had a really nice presentation from a fellow that started an initiative to get kids out playing. At this point we don't have that problem here as they kids don't have cell service or great internet access so they tend to be what they call more "free range" kids. There was a new buzz word called "physical literacy". This was the first time I heard this idea or was aware of it. He was talking about maybe communities like this and Gold River haven't gotten into the cell phones and computers but we need to get a head of it before that stuff comes here to get them thinking that yes that is a nice alternative but this is more fun.

I was also at the meeting here for the rural health sites visit and was very impressed with the number of people that turned out. They were really impressed with the number of people that came out. We are very active, involved community.

Fowler/Llewellyn: VOT 351/2019
THAT these Council reports be received. **CARRIED**

Bylaws
None.

L. Correspondence

1 **Ted Olynyk, Community Relations Manager, BC Hydro Re: 2019 UBCM Convention**

2 **Rosemary Bonanno, Executive Director, Vancouver Island Regional Library Board Re: Proposed Tahsis Branch**

3 **Hon. Claire Trevena, MLA, North Island Re: BC Hydro future rate designs**

4 **MP Rachel Blaney- Letter and report to Minister Wilkinson**

5 **Ministry of Citizens' Services, Information Access Operations Re: Request for Access to Records - Freedom of Information and Protection of Privacy Act (FOIPPA)**

Fowler/Llewellyn: VOT 352/2019
THAT these correspondence items received. **CARRIED**

Fowler/Elder: VOT 353/2019
THAT all item 2,3,4 and 5 be pulled for discussion. **CARRIED**

L1 Brief discussion

L2 **Fowler/Llewellyn: VOT 354/2019**

THAT Council consider Tahsis branch location options, prepared by staff, as part of the 2020-2024 financial plan work up. **CARRIED 1 "no" vote registered Councillor Elder**

L3 Council was encouraged to login and individually complete the survey at https://www/bcuc.com

L4 Brief discussion followed.

L5 The CAO spoke to this correspondence item.

M. New Business
None.

N. Public Input #2
A member of the public had questions regarding salmon fishing closures to which the Mayor, Council and Staff responded.

Recess

Fowler/Elder: VOT 355/2019

THAT the Regular Council meeting recess to go in to the Committee of the Whole meeting at 8:30 p.m.

Reconvene:

Fowler/Elder: VOT 356/2019

THAT the Regular Council meeting reconvene at 9:46 p.m.

Rise and Report

July 2nd Committee of the Whole Meeting Fowler: COW 61/2019

THAT the Tahsis Delegation apply to meet with Ministers: Donaldson, Trevena, Heyman, Popham, Dix (subject to clarifying nurse salary discrepancies), and Anne Kang, Parliamentary Secretary for Seniors and that the Delegation also seek meetings with Telus, BC Hydro and the BC Wildfire Service and EMBC (joint meeting) at the 2019 UBCM Convention.

Adjournment

Llewellyn/Fowler: VOT 357/2019

THAT the meeting be adjourned at 9:46p.m. **CARRIED**

Certified Correct this

6th Day of August 2019.

Chief Administrative Officer

E2

Minutes

Village of Tahsis

Meeting	**Committee of the Whole**
Date	**Tuesday July 2, 2019**
Time	**8:38 p.m.**
Place	**Municipal Hall - Council Chambers**

Present

Mayor Martin Davis
Councillor Bill Elder
Councillor Sarah Fowler
Councillor Lynda Llewellyn

Regrets

Councillor Josh Lambert

Staff

Mark Tatchell, Chief Administrative Officer

Public

no public in attendance

Call to Order

Mayor Davis called the meeting to order at 8:38 p.m.
Mayor Davis acknowledged and respected that Council is meeting upon Mowachaht/ Muchalaht territory

Introduction of Late Items

None.

Approval of the Agenda

Llewellyn : COW 59/19
THAT the Agenda for the July 2, 2019 Committee of the Whole meeting be adopted as presented. **CARRIED**

Business Arising

1 **UBCM Planning - Cabinet Minister and other meeting requests and respective topics**

Llewellyn : COW 60/19

THAT this information package be received. **CARRIED**

Council discussed which Cabinet Ministers to seek meetings with at the 2019 UBCM convention, the topics to be presented as well as other organizations to meet with.

Fowler : COW 61/19

THAT the Tahsis Delegation apply to meet with Ministers: Donaldson, Trevena, Heyman, Popham, Dix (subject to clarifying nurse salary discrepancies), and Anne Kang, Parliamentary Secretary for Seniors and that the Delegation also seek meetings wth Telus, BC Hydro and the BC Wildfire Service and EMBC (joint meeting) at the 2019 UBCM Convention. **CARRIED**

Llewellyn : COW 62/19

THAT Council Rise and Report on the UBCM meeting decisions.

CARRIED

Adjournment
Fowler : COW 63/19
THAT the meeting be adjourned at 9:45 p.m. **CARRIED**

Certified correct this
6th Day of August, 2019

Corporate Officer

F3

Minutes

Village of Tahsis

Meeting	**Committee of the Whole**
Date	**Thursday July 4, 2019**
Time	**1:09 p.m.**
Place	**Municipal Hall - Council Chambers**

Present

Mayor Martin Davis
Councillor Bill Elder
Councillor Sarah Fowler
Councillor Lynda Llewellyn

Regrets

Councillor Josh Lambert

Staff

Mark Tatchell, Chief Administrative Officer

Guests

Mike Davis, RPF, Tenures Forester, WFP
Paul Kutz, RPF, Senior Operations Planner, WFP
Kindry Mercer, RPF, Manager, Regional Initiatives, WFP
Dan McAllister, M.Sc., P. Ag., Director and Soil Scientist, EcoLogic Consultants

Public

1 member of the public, plus two Ministry of Forests, Lands, Natural Resource Operations and Rural Development staff and two other staff from Ecologic Consultants.

Call to Order

Mayor Davis called the meeting to order at 1:09 p.m.
Mayor Davis acknowledged and respected that Council is meeting upon Mowachaht/ Muchalaht territory

Introduction of Late Items

Letter of Support for Campbell River Supportive Housing Project under "New Business"

Approval of the Agenda

Fowler : COW 68/19
THAT the Agenda for the July 4, 2019 Committee of the Whole meeting be adopted as amended.

CARRIED

Business Arising	1	**TFL 19 Draft Timber Supply Analysis Information Package**	

Using the Powerpoint deck attached, Mike Davis briefed Council on the TFL 19 Management Plan, the Timber Supply Review process, key aspects of TFL 19 including McKelvie Community Watershed, and the next steps in the TSR process.

Council, staff, other guests and the public participated in a question and answer session with Mike Davis and other WFP staff.

Fowler : COW 69/19

THAT this information package be received. **CARRIED**

New Business	1	Letter of Support prepared by the Community Health Network (SRD) for Campbell River Supportive Housing Project	

Fowler : COW 70/19
THAT this draft letter of support be received **CARRIED**

Fowler : COW 71/19
THAT the Village write a letter in support of the Campbell River Supportive Housing Project and send it to the Community Health Network by Tuesday July 9th. **CARRIED**

Adjournment
Fowler : COW 72/19
THAT the meeting be adjourned at 3:33 p.m. **CARRIED**

Certified correct this
6th Day of August, 2019

Corporate Officer

TFL 19 TIMBER SUPPLY REVIEW

July 2019

Western Forest Products Inc.

Outline

- Management Plan (MP) Approval / AAC Determination Process
- MP Content Requirements
- TFL 19 Information Package (IP) Review
    - Factors influencing timber supply
    - McKelvie Community Watershed

July 4, 2019

1

TFL Management Plan Content Requirements

- Specified in "TFL Management Plan Regulation"
  1. General description of the land base, including a map.
  2. A history of licence holders
  3. List of boundary changes involving over 200 hectares
  4. Title and description of publicly available planning documents used to guide management of TFL
     a. Forest Stewardship Plan (FSP)
     b. Landscape level plans (e.g. Landscape Unit Plans, Higher Level Plans)
     c. Plans required by forestry certification schemes
  5. Timber Supply Analysis
  6. Supporting documentation for the timber supply analysis (e.g. IP)
  7. Summary of public review process

Legislated content

2

Timber Supply Review Process

1. WFP submits draft TSA Information Package (IP) to government
   i. IP summarizes data and assumptions for timber supply analysis
   ii. Agency / Public review
   iii. FN consultation / information-sharing
2. IP accepted
3. Timber Supply analysis (TSA)
   i. "Base Case"
   ii. Sensitivity Analyses
4. Draft MP & TSA review, consultation, information-sharing
5. TSA Accepted
6. Proposed MP submitted
7. AAC determined and MP approved

Generally 12-24 month process

3

What Influences Timber Supply?

1. How much forest land is available
2. The age class distribution of the available forest
3. What constraints there are on the available forest land
4. How fast trees grow

Will review these 4 factors

4

Land Base Category Definitions

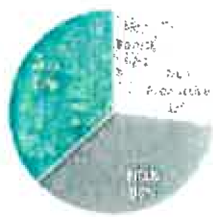
- **Total Area** = total area within TFL 19
- **Forested Area** = area within TFL 19 capable of growing trees
- **Productive Forest Area** = area within TFL 19 capable of growing trees large enough to harvest
- **Operable Area** = productive forest area within TFL 19 physically accessible
- **Timber Harvesting Land Base (THLB)** = estimate of operable area within TFL 19 available for harvest given objectives for all forest values
- **Non-contributing Land Base (NCLB)** = productive forest area within TFL 19 that does not contribute to timber supply

Terms used to describe land base segments

5

TFL 19 Area Summary

- 171,100 ha Total
- 151,200 ha Forested
- 125,000 ha Productive Forest
- 91,000 ha Operable Forest
- 63,200 ha THLB
- 61,000 ha NCLB

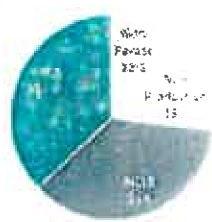


Less operable land base than other Van Isle TFLs

6

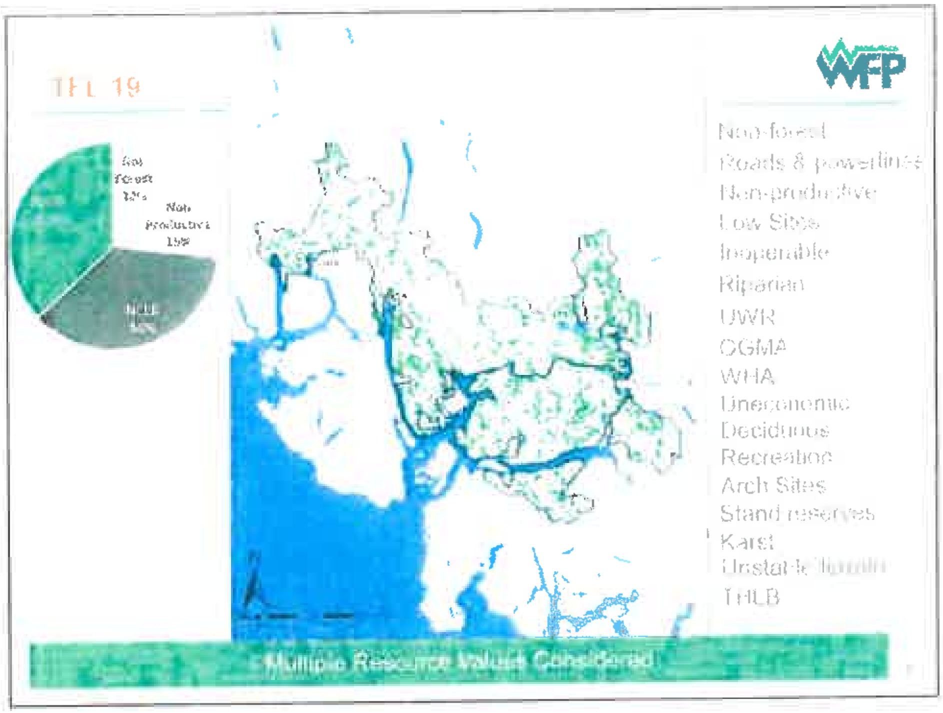
TFL 19 THLB

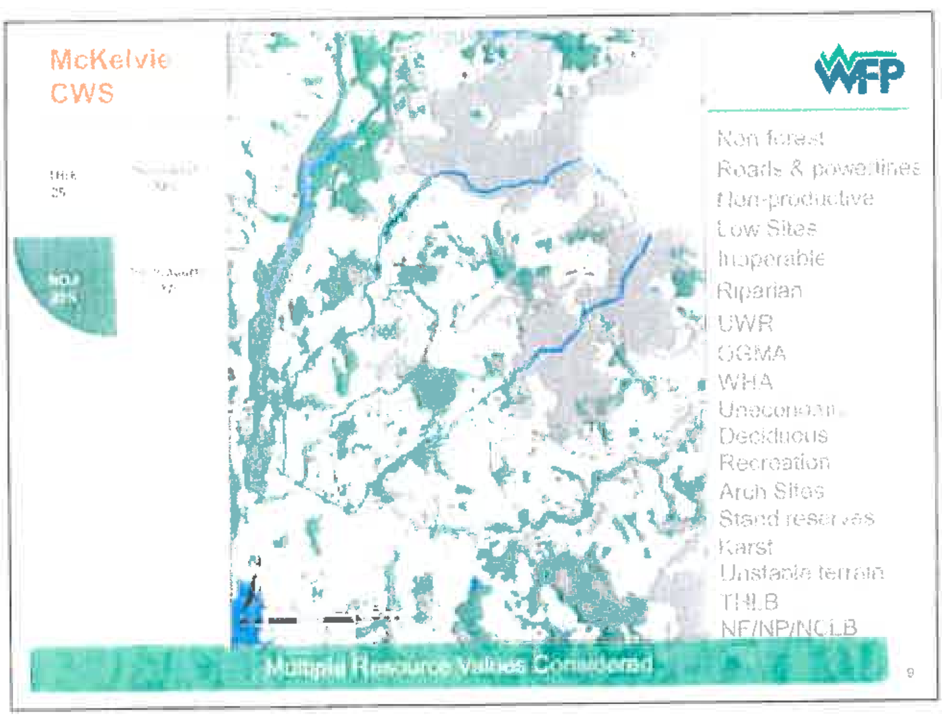
[illegible]	Total Area (Ha)	Net Area (Ha) Schedule A Timber Licence	Schedule B Crown	Grand Total	% Total	% Prod
Total Land Base	171,119	4,012	167,106	171,119	100.0%	
Less Non-forest	17,686	151	17,535	17,686	10.3%	
Less Existing Roads & Powerlines	2,164	66	2,098	2,164	1.3%	
Total Forested	151,269	3,796	147,473	151,269	88.4%	
Less Non-productive	26,264	300	25,964	26,264	15.4%	
Total Productive	124,985	3,496	121,489	124,985	73.0%	100.0%
Low Sites	44,393	410	16,237	16,647	9.7%	13.3%
Less Inoperable	68,965	549	16,826	17,375	10.2%	13.9%
Total Operable		2,537	88,426	90,963	53.2%	72.8%
Reductions:						
Riparian Management	7,164	82	2,536	2,618		
Ungulate Winter Ranges	6,916	129	3,222	3,351		
Old Growth Management Areas	22,238	203	7,366	7,569		
Wildlife Habitat Areas - legal	2,620	24	150	174		
Wildlife Habitat Areas - proposed	541	-	280	280		
Uneconomic	76,308	119	3,196	3,315		
Deciduous-leading	3,049	6	326	332		
Recreation	6,874	3	86	89		
Known Archaeological Sites	684	8	379	387		
Unidentified Cultural Resource Features		4	39	43		
Existing Stand-level Reserves	3,678	29	1,277	1,306		
Karst	931		269	269		
Terrain Stability	45,686	137	5,353	5,490		
Future Stand-level Reserves		72	2,512	2,584		
Total Unusable Reductions		816	26,971	27,787	16.2%	22.2%
Current THLB		1,721	61,455	63,177	36.9%	50.5%



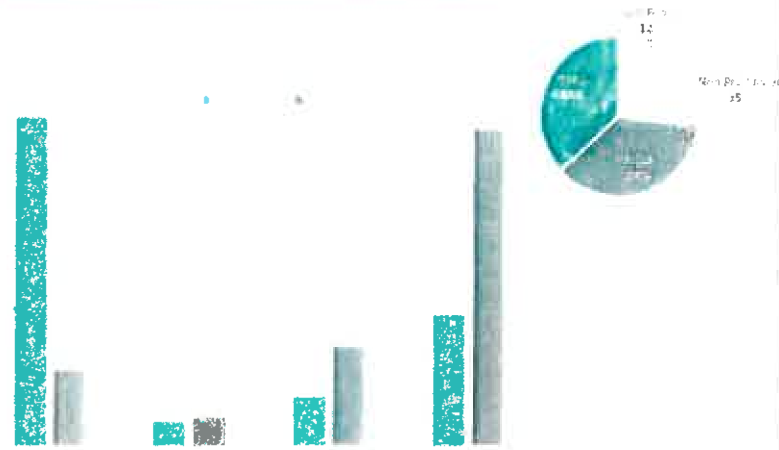
50% of Productive Forest not available for harvesting

7


TFL 19
Non-forest
Roads & powerlines
Non-productive
Low Sites
Inoperable
Riparian
UWR
OGMA
WHA
Uneconomic
Deciduous
Recreation
Arch Sites
Stand reserves
Karst
THLB
Multiple Resource Values Considered


McKelvie CWS
Non forest
Roads & powerlines
Non-productive
Low Sites
Inoperable
Riparian
UWR
OGMA
WHA
Deciduous
Recreation
Arch Sites
Stand reserves
Karst
Unstable terrain
THLB
NF/NP/NCLB
Multiple Resource Values Considered
9

TFL 19 Forest Age Class



Sustainable timber supply reliant on harvesting 121+ age classes

10

Resource values managed within THLB

1. Visual Quality Objectives (VQOs)
2. Adjacency / green-up
3. Landscape-level biodiversity
4. Limit rate-of-harvest in community and fisheries sensitive watersheds
5. Initial second growth harvest percentage
6. Heli contribution
7. Minimum harvest criteria (how small a tree will be harvested?)

Harvest System	Minimum Stand Diameter
Ground	30 cm
[illegible]	37 cm
[illegible]	42 [illegible]

Applied within the timber supply model

11

Growing the forest

- Aggregate stands into "Analysis Units"
  - a) Stands expected to grow at similar rates
  - b) Based on biogeoclimatic zone, site index, age class and leading species
- Yields generated using industry-standard models
  - Variable Density Yield Projection (VDYP)
  - Table Interpolation Program for Stand Yields (TIPSY)

Check yield model outputs with LIDAR

12

What's next?

- Complete review period for IP (August)
- Consider comments received and revise IP as necessary
- Conduct timber supply analysis based on revised IP
- Make draft Management Plan & timber supply analysis available for review and comment / information-sharing (October – December?)
- Consider comments received and revise MP as necessary
- Submit final MP

Targeting February 2020 for completion

13

H 1

VILLAGE OF TAHSIS			
Policy Title:	Code of Conduct	Policy No.	2015
Effective Date	August 6, 2019	Supersedes	Policy N/A
Approval	Council	Resolution Number	XXX/2019
Review Date	August 6, 2023		

Section 1 - PURPOSE

As local elected representatives we recognize that responsible conduct is essential to providing good governance for the Village of Tahsis.

We further recognize that responsible conduct is based on the foundational principles of integrity, accountability, respect, impartiality, inclusion, leadership and collaboration and transparency.

In order to fulfill our obligations and discharge our duties, we are required to conduct ourselves to the highest ethical standards by being an active participant in ensuring that these foundational principles and the standards of conduct set out below, are followed in all of our dealings with every person, including those with other members, staff and the public.

Respectful dialogue fosters effective communication. The Code aims to establish clear boundaries for communication without stifling debate. By implementing the Code, Council will build a safe space for honest, authentic, brave, passionate, and respectful dialogue.

Section 2 - DEFINITIONS

"Accountability"	means an obligation and willingness to accept responsibility or to account for one's actions. Conduct under this principle is demonstrated when Council, individually and collectively, accepts responsibility for actions and decisions.
"Impartiality"	means when making decisions relying on objective criteria rather than on the basis on bias, prejudice or preferring one person's views over another for improper reasons.
"Inclusion"	means that Council will have regard to those with disadvantages to ensure that they have seamless access to enjoy the same programs and services as all others.

"Integrity"	means being honest and demonstrating strong ethical principles. Conduct under this principle upholds public interest, is truthful and honourable.
"Leadership and Collaboration"	means an ability to lead, listen to, and positively influence others; it also means coming together to create or meet a common goal through collective efforts. Conduct under this principle is demonstrated when a Council member encourages individuals to work together in pursuit of collective objectives by leading, listening to, and positively influencing others.
"Respect"	means having due regard for others' perspectives, wishes and rights; it also means displaying deference to the offices of local government, and the role of local government in community decision making. Conduct under this principle is demonstrated when a member fosters an environment of trust by demonstrating due regard for the perspectives, wishes and rights of others and an understanding of the role of the local government
"Transparency"	means a commitment to conducting Council business in open meetings, unless prohibited by statute, sharing information with the public and having an "open door" policy.
"Village of Tahsis"	means the Corporation of the Village of Tahsis

Section 3 – Scope of Policy

3.1 The policy applies to all members of Council and the CAO. It is each member's individual responsibility to uphold the letter and the spirit of this Code of Conduct in their dealings with other members, staff and the public.

3.2 Elected officials must conduct themselves in accordance with the law. This Code of Conduct is intended to be developed, interpreted and applied by members in a manner that is consistent with all applicable Federal and Provincial Laws, as well as the bylaws and policies of the local government, the common law and any other legal obligations which apply to members individually or as a collective Council.

Section 4 – Standards of Conduct

Members of Council and the CAO will exhibit the values of:

- Accountability
- Impartiality
- Inclusion
- Integrity
- Leadership and Collaboration
- Respect
- Transparency

as defined above in fulfilling their duties and obligations as elected officials and staff.

Section 5 – General Conduct

5.1 Council members must adhere to the values, principles and provisions of the Code of Conduct.

5.2 Council members must act lawfully and within the authorities of the *Community Charter*, the *Local Government Act* and any other applicable statutes and regulations.

5.3 Council members have an obligation to consider issues and exercise powers, duties and functions in a manner that avoids arbitrary and unreasonable decisions.

5.4 Council members must avoid behavior that could contravene:
- this policy;
- the BC *Human Rights Code*; and
- Village bylaws and policies, including the Respectful Workplace and Prevention of Harassment, Bullying and Discrimination

5.5 Council members must treat one another, staff and the public with dignity and respect. They must also refrain from behavior that is an abuse of power or otherwise amounts to discrimination, harassment, personal threats, intimidating or demeaning behavior or verbal attacks upon the character, professionalism or motives of others.

5.6 Council members shall not:
- undermine other members of Council or Council as a whole by making critical, denigrating or derogatory comments about the views, decisions, positions, expressed or approved by Council;
- engage in physical altercations with any person;

- defame, libel or slander a member of Council, staff or the public;
- utter or otherwise make threats of violence aimed at a member of Council, staff or the public; and/or
- utter or otherwise make racist, sexist or homophobic remarks

5.7 Contraventions of the General Conduct rules, as set out this section, may result in sanctions being imposed by Council.

Section 6 – Conduct of Meetings

6.1 Council members shall prepare themselves for meetings by reading all materials, and during the meeting listen courteously to all discussions and focus on the business at hand. Council members should refrain from interrupting other speakers while not unnaturally constraining dialogue.

6.2 Council members are encouraged to be courageous in bringing forward ideas and in debate while being mindful of the impact of their language on others.

6.3 Council members shall further the public interest by keeping an open mind, acting on the best information and being transparent in decision making.

6.4 Council members shall not engage in:

- side conversations
- eye rolling
- disrespect of the Chair
- foul language
- verbal condemnation of other members of Council

H2

VILLAGE OF TAHSIS

Report to Council

To: Mayor and Council

From: **John Manson, PEng**

Date: **July 31, 2019**

Re: **Tahsis Municipal Wharf**

PURPOSE OF REPORT:

To advise Council with respect to the current condition of the Municipal Wharf, and to request Council input on the location of the proposed SAR/Coast Guard wharf, presently proposed to be located south of the Municipal Wharf within Village waterfront lease.

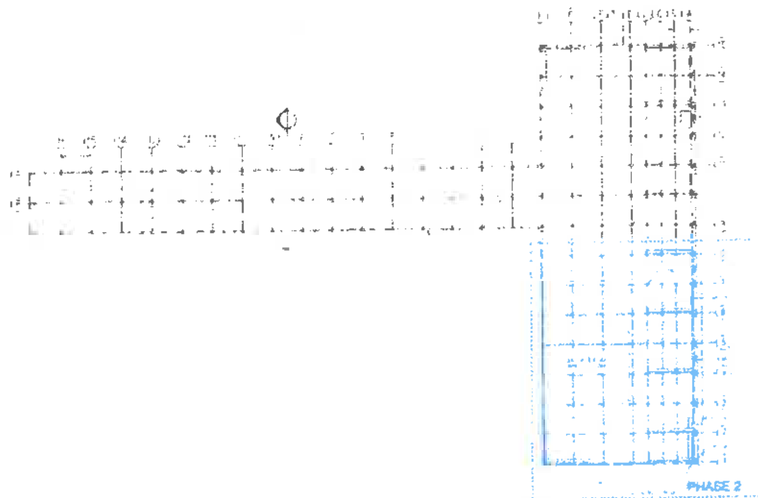
BACKGROUND:

The Village currently owns a wharf facility at the foot of Wharf Street, near the proposed search and rescue facility. This wharf, which consists of a gangway originally designed for vehicle traffic, along with a storage shed, an electrical service panel, HIAB crane, gangway and float, sufficient to accommodate approximately 60 meters of temporary moorage. The wharf was built by Fisheries and Oceans in 1965, five years prior to municipal incorporation. Since its early days wharf use has evolved from commercial and industrial to today's use which is primarily public sector with some minimal commercial. The wharf is now used mostly by federal agencies: including the Department of Fisheries and Oceans (Fisheries Officers), Canadian Coast Guard, Canadian Navy and the RCMP. In 2003 the federal government transferred ownership of the wharf, to the Village as part of a federal government cost saving measure. The transfer included a onetime lump sum payment for ongoing maintenance.

Since the transfer of ownership, the Village has undertaken routine maintenance of the facility, which consists of concrete decking overlain a creosote timber pile and stringer type structure. The shed is currently being used to store equipment for the Tahsis Salmon Enhancement Society and the Tahsis Lions Club.

While the facility has held up well over the years, it is structurally nearing the end of its lifetime. This is evidenced by the recent inspection report that the Village commissioned by McElhanney Engineering (See Appendix "A"). This report included inspection of the top sides, deck panels, stringers, pile caps, piles, cross bracing on both the Approach Trestle and the Wharf head itself.

While the topside and deck panels have some 'life' left in them (8-10 years), but many of the piles and pile caps are nearing the end of their lifetime (0-2 years). The report provides an estimate for the replacement of Piles, Pile Caps, Stringers, and replacement with a timber deck instead of the concrete deck. The estimate includes both Phase One and Phase Two repairs (red and blue areas on the sketch below).



The cost for the entire deck repair is approximately $920,000. Should the repair only cover phase one (area in pink), the cost would be reduced to approximately $700,000. These costs do not include any costs for the ramp and float.

The recent structural condition survey completed by McElhanney Engineering Services has confirmed that some critical components of the existing Municipal Wharf have reached the end of their expected lifetime, and as such, the approach ramp is no longer capable of handling the vehicle design loads for which it was originally designed. At the recommendation of the Engineer, signs will be placed on the structure limiting use to pedestrian use only, maximum 500 lbs. live loading.

The cost to repair the Municipal Wharf is estimated in the range of $700,000-$920,000, depending on the scope of the upgrade (Phase One only, or both Phase One and Phase Two upgrading). The cost to demolish the structure is approximately $80,000.

The Village has little, if any funds available to upgrade, or even maintain this structure. There is no funding or fee collection mechanism in place at this time to recover the ongoing cost of the wharf. The principal users of the wharf include RCMP, Coast Guard, Fisheries and Oceans, Navy, and a small amount of commercial traffic. In terms of commercial traffic, the value of the wharf is likely more to do with future economic development opportunities, rather than its current commercial usage.

FISHERIES AND OCEANS – COAST GUARD SEARCH AND RESCUE PROJECT:

Fisheries and Oceans Canada is in the process of building a new Coast Guard Search and Rescue facility in the Village. The facility consists of a new building to be located near the intersection of South Maquinna Drive and Tootouch Place (the former parking lot), as well as a new wharf built to accommodate either a Bay or Cape Class vessel and a rigid hull inflatable boat (RHIB) vessel.

Construction has commenced on the building, and design options are currently being developed for the wharf facility.

On April 3, 2019, Moffatt and Nichol provided Fisheries and Oceans/Coast Guard with a report on alternatives with respect to a new SAR Float Facility, which included an option to locate the new float by replacing the float at the existing wharf (See Appendix "B" and "C").

The report estimated the cost of a new float and gangway at approximately $930,000 for Option 1 (Existing Wharf Option). Due to the extra costs associated with the existing wharf, Fisheries and Oceans then focused their work on an alternative location south of the existing wharf using the existing timber trestle approach (the "Airline" Dock), and a further option using a new land access (Appendix "D" and "E" respectively). The cost for a new float on the existing trestle (Appendix "D") is $920,000, and a stand-alone facility with a new land access point (Appendix "E") is $850,000. The "stand alone facility" option shown in Appendix "E" has recently (July 30) been modified to the alignment shown in Appendix "F", which moves the landfall of the approach trestle to line up with Village Owned land. In the July 30 telephone conference call between Village staff and the Coast Guard design team, it appeared that the team was favouring the option shown in Appendix "F". The Village was requested to provide comments on the alternatives developed so far. This is relevant to the discussion of the Municipal Wharf, as one of the options they have developed uses this Wharf.

Without a basis of sustainable funding going forward, the only option available to the Village would be to demolish the wharf.

If the Village wished to continue to own and manage the wharf, a long term sustainable funding model needs to be developed. This could include options such as the creation of a Harbours Board, which has the statutory ability to levy fees and rents. Alternatively, direct agreements or leases could be sought from the principle users of the facility. This latter option would likely make more sense for the Village, as the administrative costs would be greatly simplified based on the few users of the facility.

COAST GUARD PROJECT – INPUT FROM THE VILLAGE:

As discussed, the Coast Guard team is seeking input from the Village with respect to the potential siting of a new wharf to service the SAR facility. The most favoured option presented to Village staff by the Coast Guard team at the July 30 meeting appeared to be the layout shown in Appendix "F", which is a new stand-alone trestle and wharf, with a new trestle land access point.

Staff provided our initial comments on the plan, as follows:

- The team should review the legal implications of the location of the landing point of the proposed trestle to ensure that there are no upland owner consent issues;

- The trestle landing location may be conflicting with an existing road boulevard which is used for parking on a regular basis.

- Staff are recommending that a better location for the new wharf would be the location originally investigated – the Municipal Wharf. The landing location is better, electrical service is available, and there is less conflict with other activities within the Village lease tenure.

- In earlier discussions with Coast Guard about using the existing Municipal wharf facility, there were concerns about federal expenditures on "private" facilities. We requested that the team further review the possibility of assisting with the upgrading cost, as the Village does not have funding mechanism for this work, and no grants are available for wharf upgrades. We suggested this could alternatively solved by selling the wharf back to the Federal Government for $1, as they are principle users of the facility.

Staff believe that the best solution to meet the needs of the new SAR Coast Guard facility, and other federal users, would be to pursue the upgrading of the Municipal Wharf using funds available from the SAR project, and either arranging suitable lease agreements with the federal users of the facility to enable long term maintenance funding, or alternatively, to give the facility back to the federal government so that future maintenance costs would not be borne by the Village.

FINANCIAL IMPLICATIONS:

Facilities such as the Municipal Wharf should be sustainably funded through either a user pay system, or equivalent funding stream. If this is not possible, and the Village is unable to fund the upkeep of the facility through the general tax base, the Village should consider demolition due to safety and liability issues and lack of facility maintenance funding.

RECOMMENDATION:

Canada Coast Guard is seeking input from the Village with respect to the siting of the new SAR wharf facility. It is recommended that Council consider the following resolutions:

1. That the Village support the new SAR/Coast Guard wharf facility being placed at the location of the current Municipal Wharf, generally in accordance with Drawing SK-02, either by the use of lease agreements, or alternatively by transferring the ownership of the wharf back to the Federal Government or suitable respective agency;

2. That the SAR/Coast Guard project, or alternatively the various federal agencies that use the Municipal Wharf be requested to fund the upgrading costs identified in the 2019 McElhanney Condition Assessment Report, Revision 0.

3. That the Village not support the alternate wharf location's being proposed further south at this time.

Respectfully submitted:

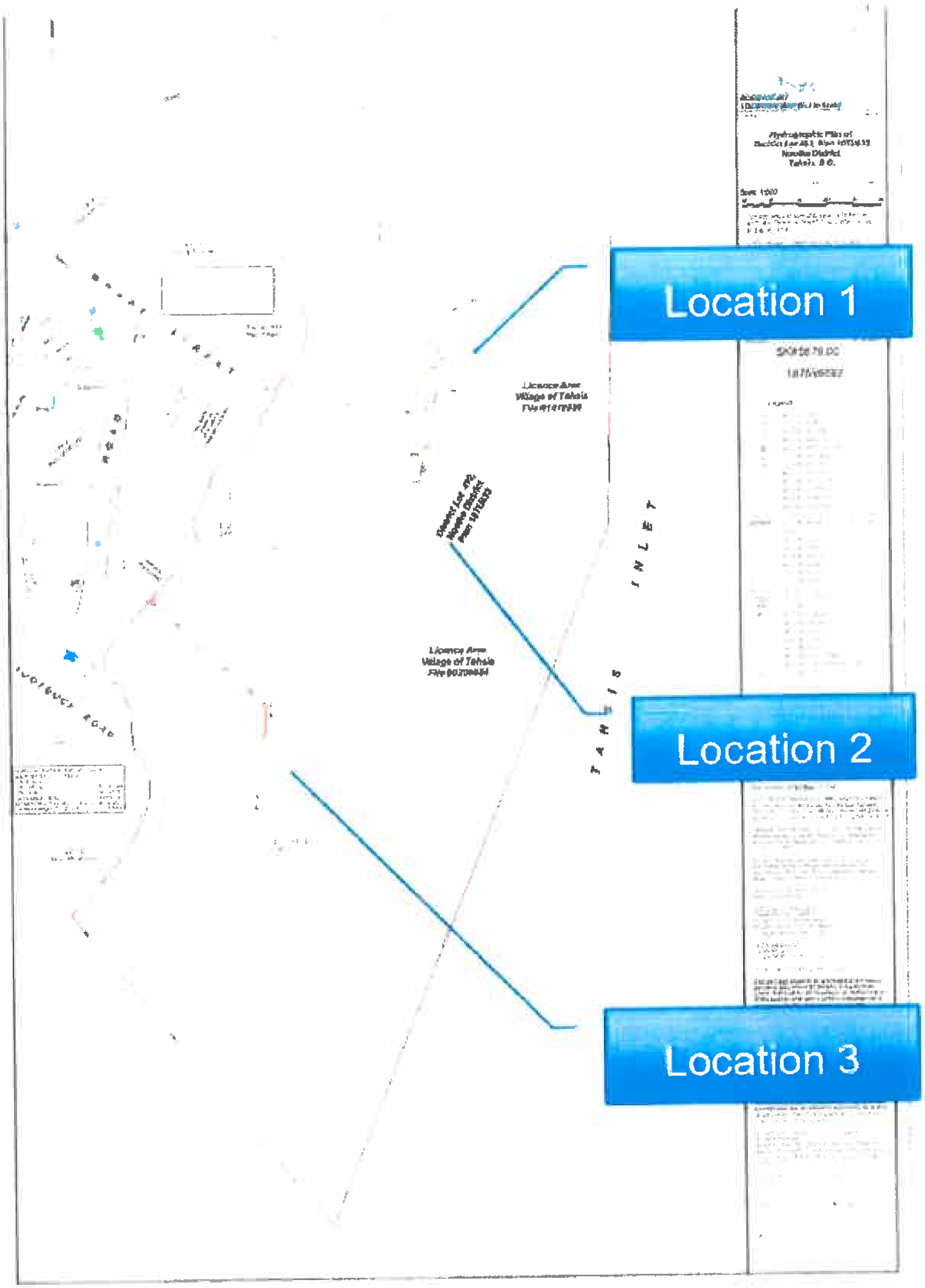
John Manson, PEng
Project Manager

Appendix "A"

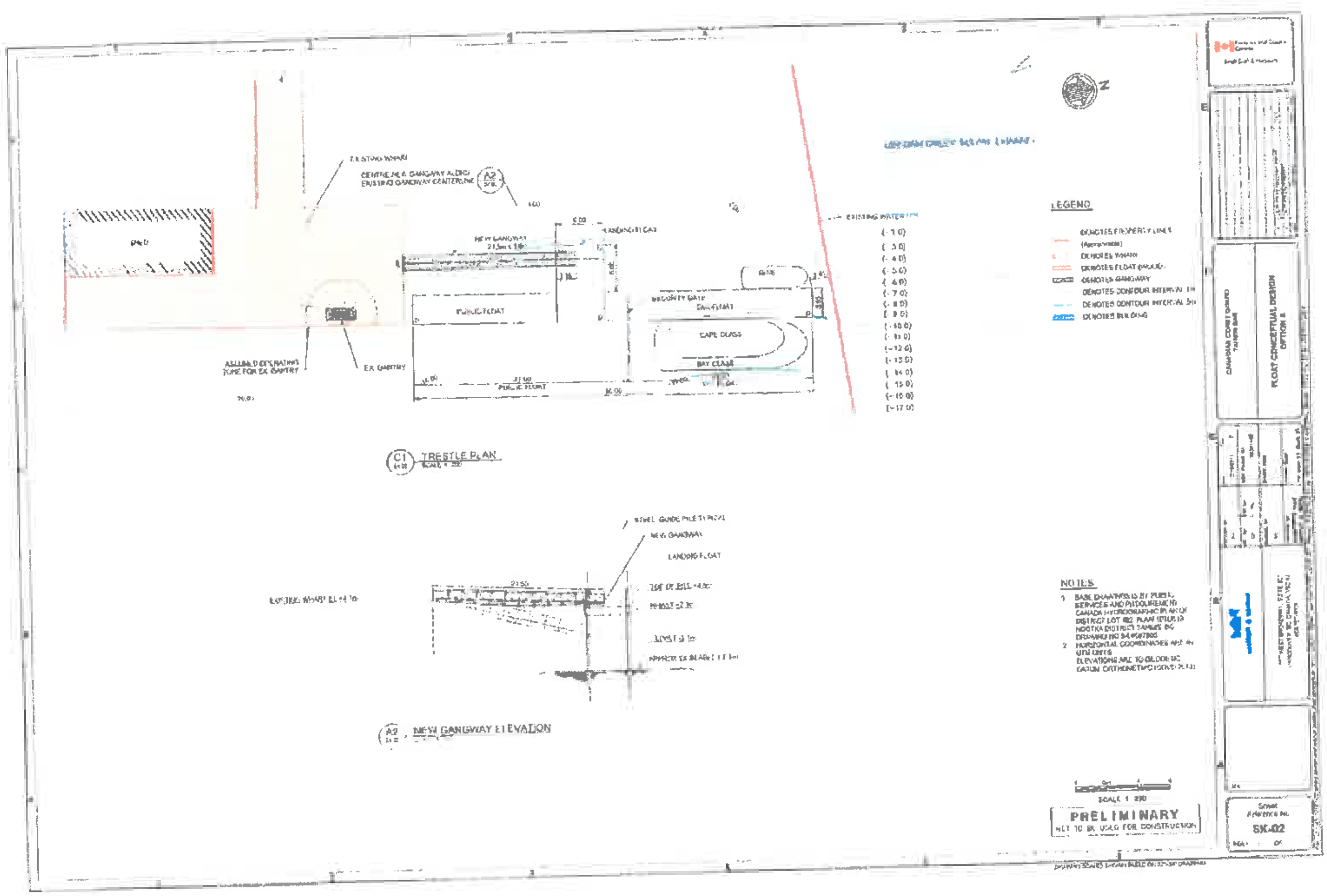
49140_Village of
Tahsis_Municipal Wha

http://villageoftahsis.com/wp-content/uploads/2019/07/49140_Village-of-Tahsis_Municipal-Wharf-Inspection_Rev0.pdf

Appendix "B"



Appendix "C"



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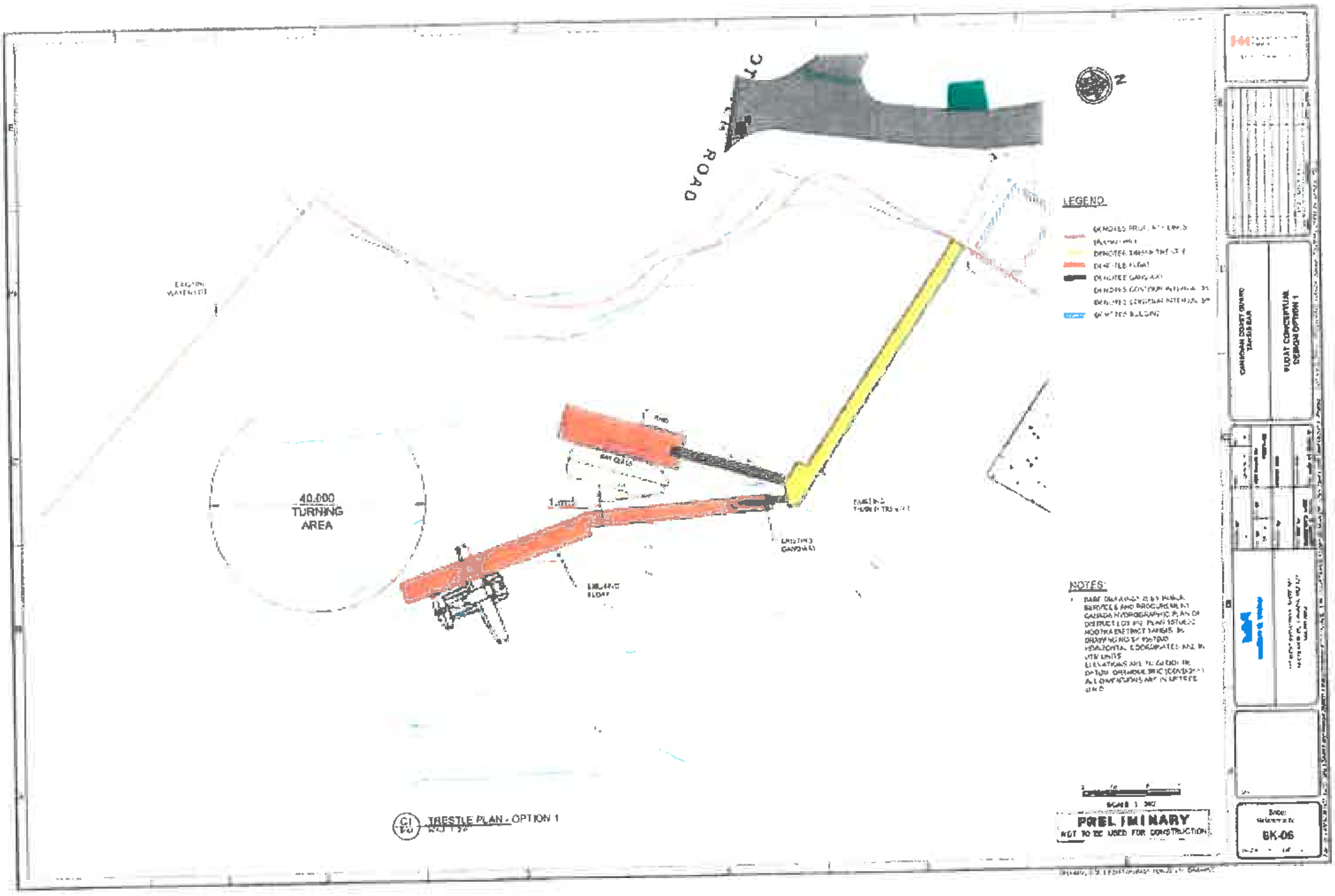
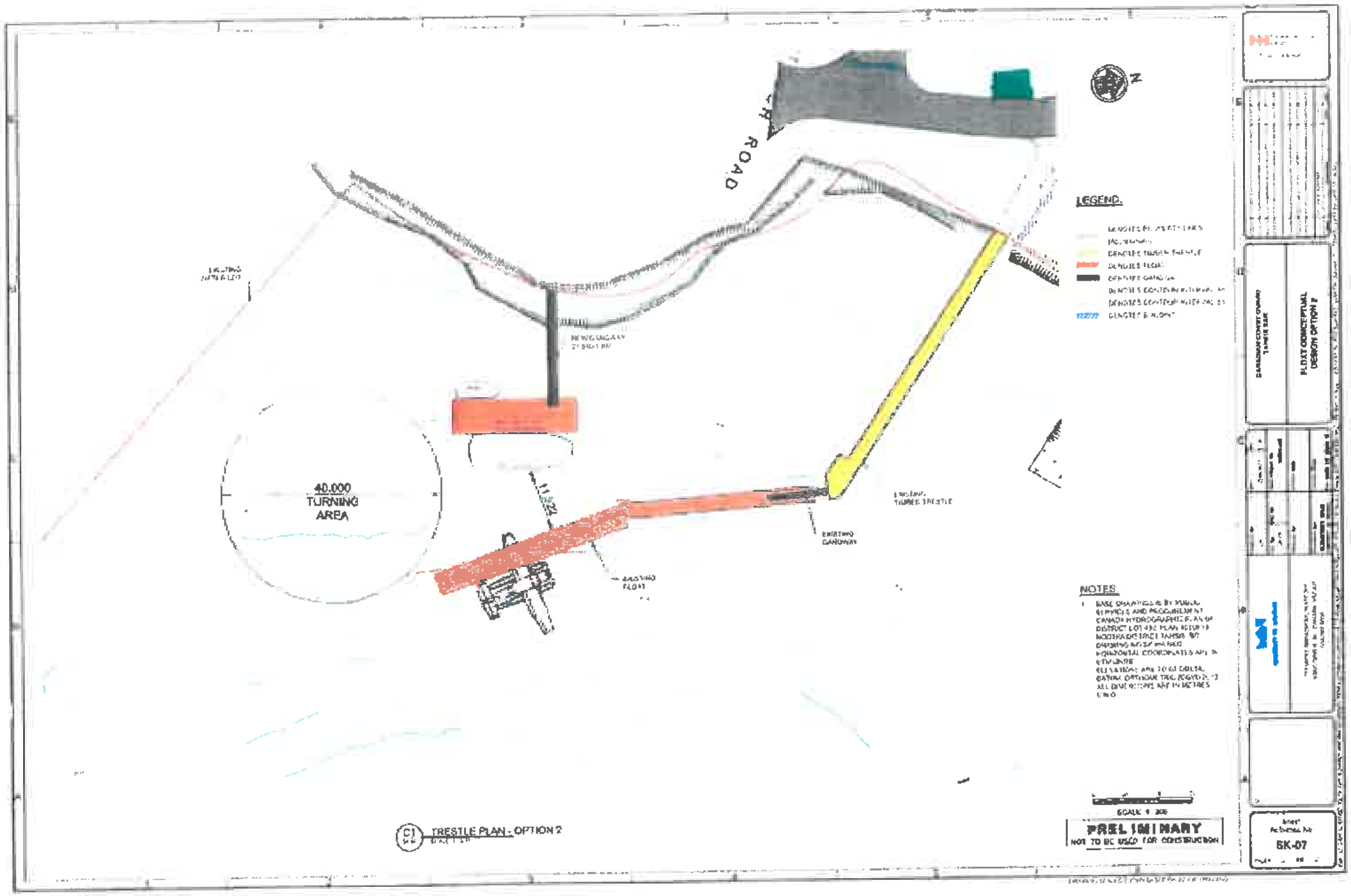
Appendix "D"

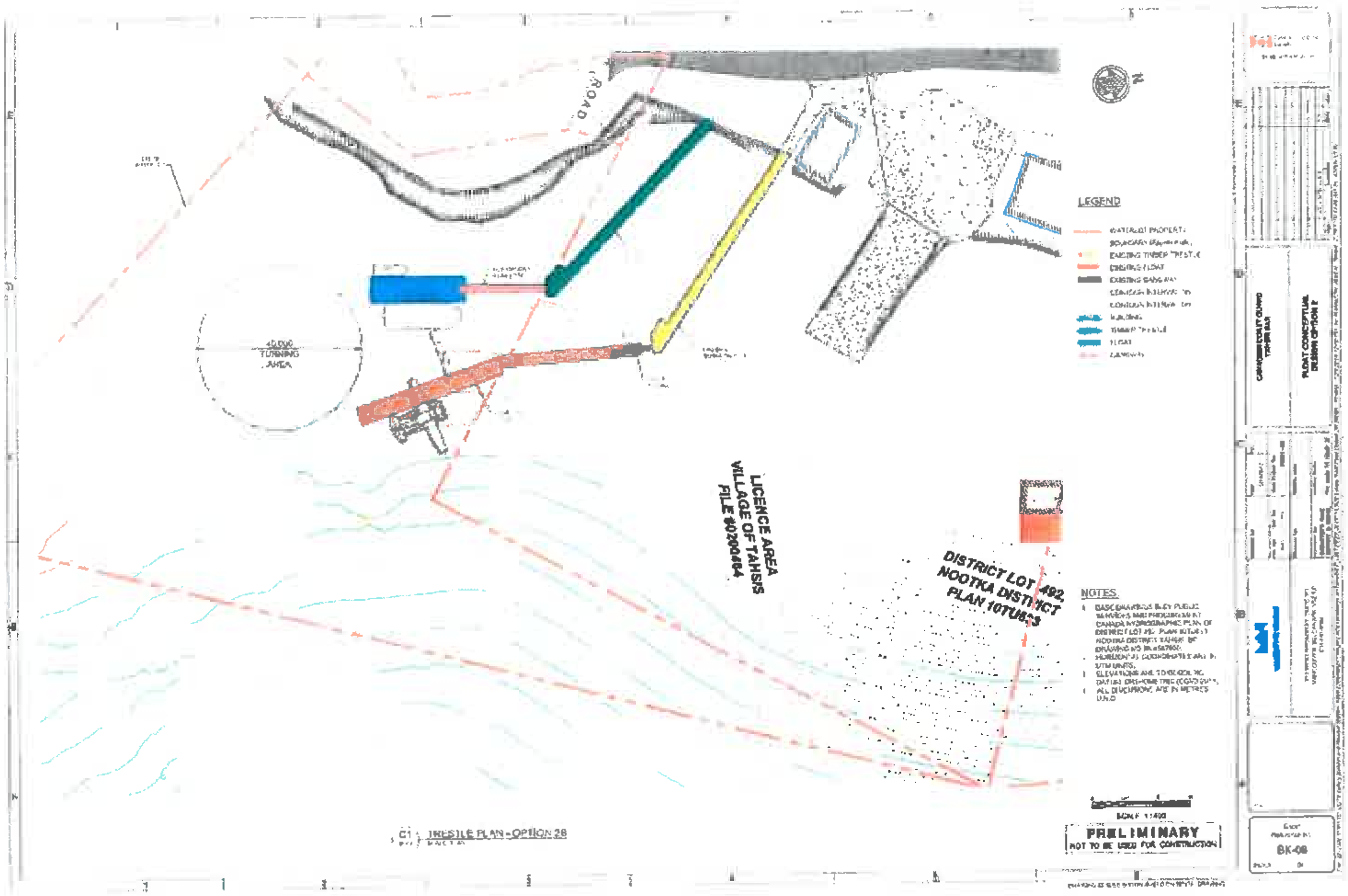


ROAD
LEGEND
40,000
TURNING
AREA
NOTES:
TRESTLE PLAN - OPTION 1
PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION
SK-06

Appendix "E"


ROAD
LEGEND
40.000
TURNING
AREA
NOTES
TRESTLE PLAN - OPTION 2
PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION
SK-07

Appendix "F"



LEGEND
NOTES
LICENCE AREA
VILLAGE OF TAHSIS
FILE #0200484
DISTRICT LOT 492,
NOOTKA DISTRICT
PLAN 10TU8
ROAD
TURNING AREA
PRELIMINARY
NOT TO BE USED FOR CONSTRUCTION
TRESTLE PLAN - OPTION 2B
BK-08

H4

VILLAGE OF TAHSIS

Report to Council

To: Mayor and Council

From: Director of Recreation

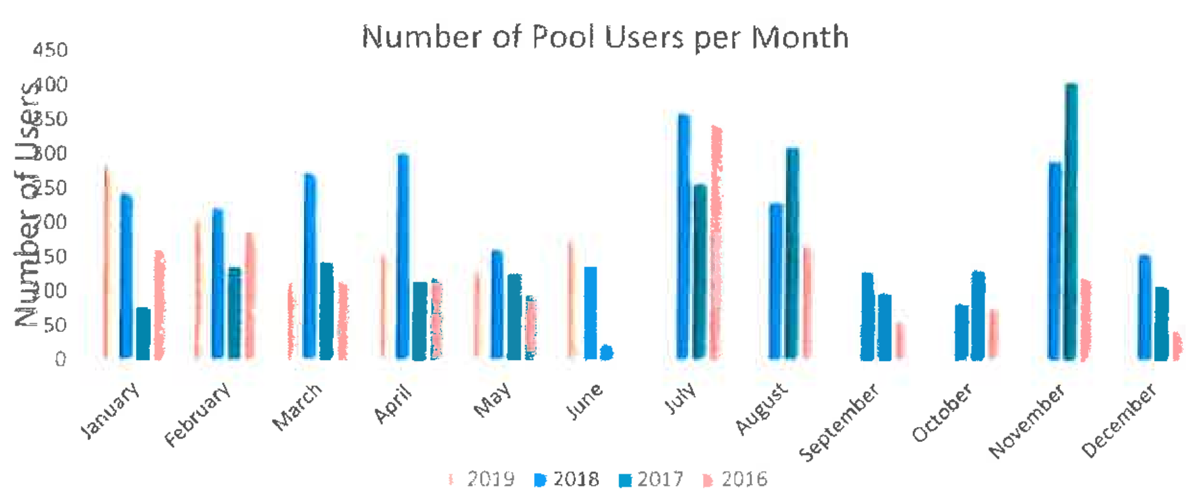
Date: July 11, 2019

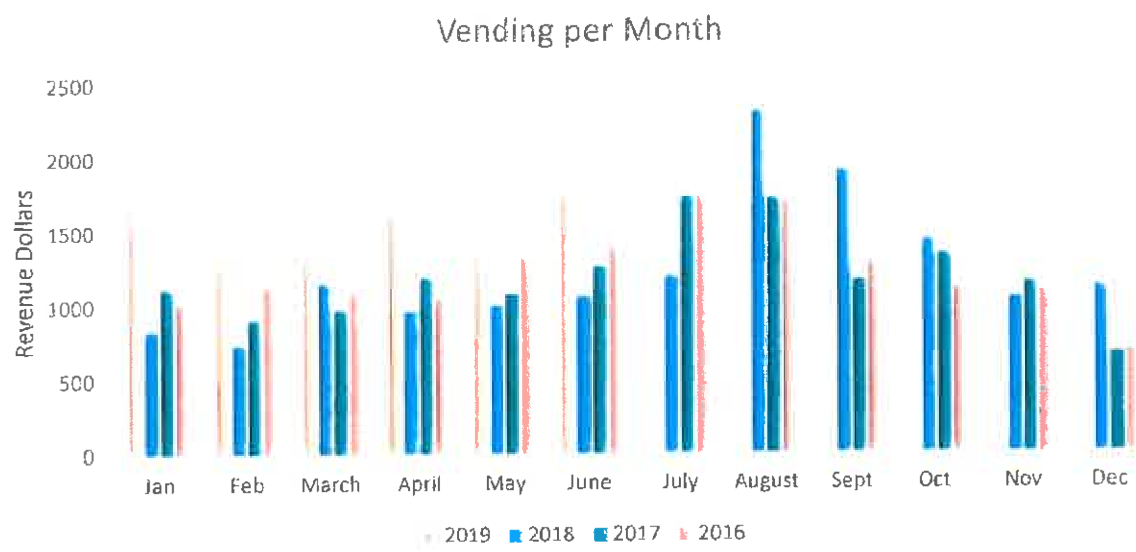
Re: Recreation Centre 2019 Q2 attendance and revenue report

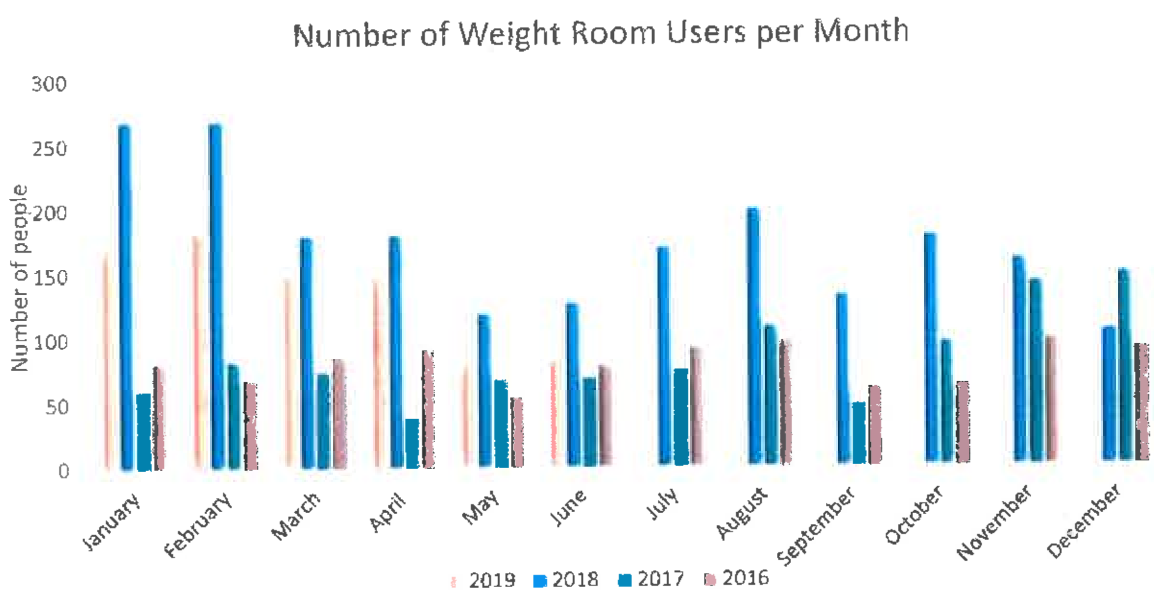
PURPOSE OF REPORT:
To provide Council with Rec Centre attendance and revenue information for fiscal year 2018.

BACKGROUND:
On October 17, 2017 Council adopted Fees and Charges Bylaw No 594 which eliminated fees for persons using the Rec Centre's swimming pool, gym, weight room and sauna. The Bylaw adjusted and established other Rec Centre fees.

Council's decision was made to encourage greater use of the facility in order to improve the overall health and wellness of Tahsis residents. Council concluded that the social and health benefits outweighed the relatively small amount of revenue (about $7,000 in 2016) generated annually in user fees







Programs offered in 2018

Yogalates, Restorative yoga, Aqua fit, swimming lessons, adult and public swim

Program that will be offered in 2019

Restorative yoga, Aqua fit, swimming lessons, adult and public swim, rock climbing, Zumba

POLICY/LEGISLATIVE REQUIREMENTS:
Fees and Charges Bylaw No. 594, 2017

FINANCIAL IMPLICATIONS:

Year	Revenue	Direct Costs	Net	%Cost/Revenues
2018	15597.73	11454.80	4142.93	73.4%
2017	13839.34	9437.22	4402.12	68.2%
2016	13942.56	7591.12	6351.44	54.4%

Prepared by

Sarah Jepson

Sarah Jepson

Approved by

Mark Tatchell

H5

Tahsis Age-Friendly Community Action Plan

Presentation to Council

July 8, 2019

O'HARA & ASSOCIATES
CONSULTING

Agenda

- Introductions
- Project Objectives
- Approach & Methodology
- Question & Answer

Inclusive
Age-Friendly
Accessible

O'HARA & ASSOCIATES
CONSULTING

O'Hara & Associates Consulting

- After spending 12 years working alongside consultants as employees within the public sector, a clear need was identified to do things differently.
- Our approach is to lead a company that deeply connects with the communities we are aiming to support in order to provide tailored consulting that supports and fosters age-friendly, complete communities.
- O'Hara & Associates Consulting Inc. is located in Toronto, Ontario and was founded in 2018 to provide advice and consultation on how to appropriately serve seniors through public sector services.

Our **vision**: *to make Canada one of the best places in the world to age.*

Our **mission**: *to provide services that contribute to age-friendly, inclusive and complete communities.*

O'HARA & ASSOCIATES
CONSULTING

O'Hara & Associates Consulting

Aislin O'Hara

Certified Professional Consultant on Aging

- Over 12 years experience in designing & leading public programs and services for seniors and persons with disabilities
- Former Customer Experience Lead for Toronto Transit Commission paratransit services, Wheel-Trans. Developed & implemented various initiatives for older adults with disabilities.
- Researched, authored & implemented over 21 age-friendly policies
- Co-authored City of Toronto Seniors Strategy including drafting recommendations that are actionable and realistic to improve the quality of life for seniors and contribute to an age-friendly community.
- Project Advisor for Toronto HomeShare which is an intergenerational program that matches older adults who have spare bedrooms with students in need of affordable housing.

O'HARA & ASSOCIATES
CONSULTING

O'Hara & Associates Consulting

Mitchell Underhay

Technical Lead

- Bachelor of Community Design, Honours in Environmental Planning
- Developed Project Manager and experience leading projects for seniors and older adults
- Experience in consulting, designing and implementing strategies that are age-friendly, accesible and inclusive
- Senior Community Liaison Officer for Toronto Transit Commission delivering extensive public consultation & stakeholder engagement
- Development Manager for Wind Energy Projects in Nova Scotia & Maine, leading community oriented wind projects
- Extensive background in GIS asset mapping using multiple criteria for geographic analysis

O'HARA & ASSOCIATES
CONSULTING

Project Objectives

"Ensure the Village is positioned through its plans, policies and programs to support and sustain active, social and independent lifestyles for its mature adults and seniors."

- Evaluate the current state of age-friendliness
- Actively engage the Tahsis community
- Articulate the needs of mature adults and seniors living in the Village
- Identify gaps in programs and services to inform future strategies
- Develop realistic, achievable community action plan that improves quality of life for seniors in Tahsis now and in the future.

O'HARA & ASSOCIATES CONSULTING

Project Approach

Phase 1 "Discovery"

1. Develop a rich understanding of the current state
2. Engage the community & give voice to their needs & priorities

- **Task 1 Inventory List**

Categorizes and ranks the availability of all community assets for older adults

- **Task 2 Community Surveys**

Identifies the needs & priorities for seniors in Tahsis as well as risk/social isolation assessment

- **Task 3 World Café**

Facilitated public meeting to solicit feedback from all community members

O'HARA & ASSOCIATES CONSULTING

World Café(s)

- Roundtable focus groups with 5-7 people per table
- 3 key discovery questions (1 per table)
  - What is working well for seniors in Tahsis?
  - What is not working well for seniors?
  - How can Tahsis improve life for seniors?
- 20 minute discussion
  - co-facilitator writes responses on sticky notes and posts on chart paper
- 15 minute presentation of key ideas (5 minutes per table)
- 10 minute individual questions
  - What short-term improvements could we make now?
  - What long-term improvements do we need to plan for?

-- Refreshment Break --

- 30 minutes to identify priorities and collect additional ideas
  - Using DOT stickers, participants will prioritize the sticky notes
  - Participants can add ideas to chart paper
- 5 minute wrap up

O'HARA & ASSOCIATES CONSULTING

Project Approach

Phase 2 "Analysis"

1. Synthesize all data from phase 1
2. Analyze for key themes and opportunities

- **Task 4 Analysis of Phase 1 data**

Inventory list, surveys, world café data

- **Task 5 Asset Map**

Visual representation of all services/resources as well as the type/availability

- **Task 6 Policy Review**

Apply an age-friendly lens to all policy/planning & strategy documents

O'HARA & ASSOCIATES CONSULTING

Project Approach

Phase 3 "Recommendations & Delivery"

1. Summary of all key findings
2. Community action plan with recommendations & implementation strategies

- **Task 7 Community Action Plan Report**

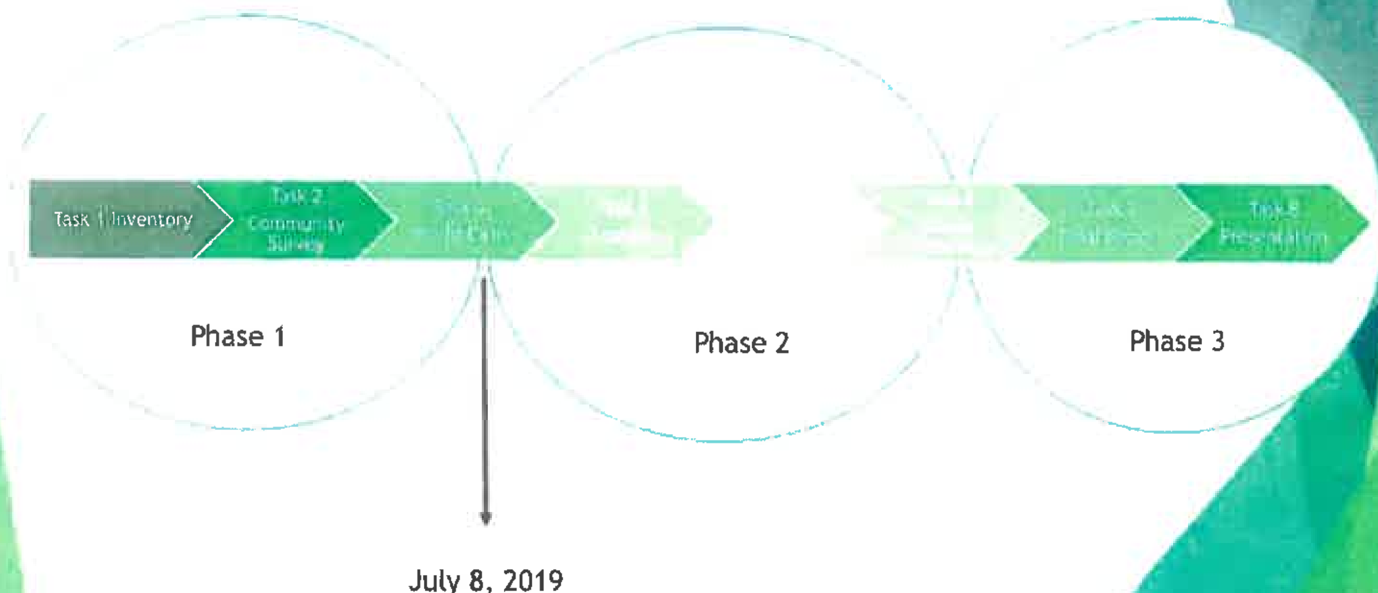
Tasks 1-6 will culminate in a final community action plan report including the identified needs for seniors and recommendations on how to best meet those needs over the longer-term

- **Task 8 Presentation to Village of Tahsis**

Specific recommendations & implementation strategies will be presented to Tahsis Council for consideration & incorporation into Village plans, policies and programs

O'HARA & ASSOCIATES
CONSULTING

Where are we now?



Thank you!

Aislin O'Hara
Project Manager
416-721-1972
aislin@oharaconsult.com

Mitch Underhay
Technical Lead
647-472-2020
mitch@oharaconsult.com

O'HARA & ASSOCIATES
CONSULTING

H6

VILLAGE OF TAHSIS

Report to Council

To: **Mayor and Council**

From: **John Manson, Project Engineer**

Date: **August 6, 2019**

Re: **Roads Project Update**

PURPOSE OF REPORT:

For Information.

BACKGROUND:

In February of 2018, the Village received a grant of $3,510,980 through UBCM to cover 100% of the cost of upgrading roads and associated utilities on South Maquinna Drive, Rugged Mountain Road, and Alpine View Road. McElhanney Engineering Services was retained in 2018/2019 to undertake project design, and construction management services. The project was tendered in early 2019, and awarded to Hazelwood Construction for construction in the summer of 2019, and potentially also the spring of 2020, depending on weather conditions.

DISCUSSION:

The project budget allows for approximately $2.9 Million in construction costs pursuant to the unit price contract with Hazelwood Construction. The contract provides for a number of provisional items, such as rock excavation, which are only paid out if the items are required. The unit price contract is also set up to allow for extending the scope of the works though the negotiation of extra work orders, many of which are based on unit prices already in the contract. The rational for this approach is to allow some flexibility in extending or modifying scope where it is in the interest of the Village to do so.

The construction schedule submitted by the Contractor allows for construction during the summer of 2019, with substantial completion in October of 2019. The Contractor's schedule included construction initially on South Maquinna, then Alpine View, and finally Rugged Mountain. While the terms of the tender allow for work to be done the following spring, the contractor at this point is planning on completing the work by the fall of 2019. This will likely be dependent on weather conditions in the fall for the paving of Rugged Mountain, which is currently scheduled in October. Should weather conditions not be conducive to paving, the final paving work on Rugged Mountain may be rescheduled to the spring. Alpine View will be paved late August or early September.

At present, the contractor is 1-2 weeks ahead of schedule. Work is now complete on South Maquinna, and most of the underground works are now complete on Alpine View. At the request of the Village, additional paving work was undertaken on South Maquinna, south of the driveway entrance to the Marina, south to the Village Hall driveway. This extra work was done by a combination of unit prices, as well as time and materials, at an additional cost of approximately $60,000. Rock excavation quantities have also been somewhat higher than originally estimated at tender, for a current additional cost of approximately $40,000. This extra work is being funded through the project contingency.

The project team is also considering additional potential paving work outside the scope of the project on Head Bay Road and Tootouch Crescent, but we are not recommending this work be undertaken until the underground works on Rugged Mountain are completed, and project budget projections can be more accurately determined.

FINANCIAL IMPLICATIONS:

This project is fully funded through a UBCM grant of $3,510,980. Construction is proceeding within the scope of the grant funding, and no additional funds are anticipated to be required by the Village to complete the project.

RECOMMENDATION:

For Information.

Respectfully submitted:

John Manson, PEng
Project Manager

Tahsis - Roads Project Budget 31-Jul-19

	2018	2019	totals to Aug 1	Remaining Estimated Expenditires	Final Estimated Costs
Mcelhanney Invoices	$77,040.36	$135,903.65			
	$5,661.60	$24,021.11			
	$3,118.22	$8,253.94			
		$7,512.11			
Mcelhanney Total	$85,820.18	$175,690.81	$261,510.99	$151,989.01	$413,500.00
other	$3,962.64	$21,000.09	$24,962.73	$30,000.00	$54,962.73
Construction	$0.00	$544,694.40	$544,694.40	$1,778,551.00	$2,323,245.40
July Estimate (Construction)		$582,506.00	$582,506.00		$582,506.00
Total	$89,782.82	$1,323,891.30	$1,413,674.12	$1,960,540.01	$3,374,214.13

Grant Budget maximum	$3,510,980.00	
Contingency remaining	**$136,765.87**	3.9%

Final Construction Cost Estimate **$2,905,751.40**

L1

Village of Tahsis

July 3, 2019

Hon. Claire Trevena
MLA, North Island
Room 306 Parliament Buildings
Victoria, BC
V8V 1X

Dear Minister Trevena,

I am writing to thank you for meeting with Tahsis Council on May 21st in Tahsis. We know that you have a heavy schedule with competing priorities so we are especially grateful that you made time to meet with Council as well as spend time in the community.

This letter summarizes Council's main points from the meeting.

Council continues to advocate for more improvements to the Head Bay Forest Service Road. Ultimately, our goal is to see the entire road surface seal coated but, in the interim, there are significant advantages to seal coat the short interspersed gravel sections located between the Conuma Hatchery (kilometer 28) and Tahsis. We also encourage better signage to improve safety, especially at blind corners. As you would likely agree, future economic growth in Tahsis depends on a safe and reliable transportation corridor and modern communication. We are counting on your Ministry to make this a priority in the 2020-2021 provincial budget.

Our municipal wharf has exceeded its functional life so it will be de-commissioned unless major repairs are carried out. As a community that relies on maritime access for goods and services, the wharf is a pivotal asset that needs to be rehabilitated for economic development. We welcome your suggestions for possible provincial funding for this project.

The Rural Coordination Centre for BC, a project of the Joint Committee for Rural Health, recently held a meeting in Tahsis which attracted one of the Centre's larger turnouts demonstrating the importance that we, as a community, place on health care. The importance of the Tahsis Health Centre cannot be overstated so we look forward to government's continued funding and support for this vital service.

Village of Tahsis
977 South Maquinna Drive
P.O. Box 219 Tahsis BC V0P 1X0
TEL: (250) 934-6344 FAX: (250) 934-6622
www.villageoftahsis.com

With an aging population we are keen to develop and implement services such as assisted housing and transportation to support seniors aging in place. As you suggested, we will follow up with the District of Port Hardy to learn about their assisted living programs and services but also seek provincial government program support.

A regional transportation service is needed so seniors and persons who are financially compromised can access food, health care and other basic needs. Those unable to drive are reliant on the goodwill of others which can place them in a precarious and vulnerable situation. As Minister of Transportation and Infrastructure and our MLA we ask that you consider improvements to transportation services in this region.

Finally, Council needs to continue to impress upon you and your government the importance of protecting and preserving the McKelvie Creek watershed and the ridge which rises up east of the Village. The Village is close to completing a watershed assessment which will be used to develop a watershed protection plan similar to plans in Campbell River and the Comox Valley. Only the provincial government has the authority to set aside this valley bottom old growth forest from timber harvesting and thereby protect the source of the community's drinking water and preserve an ecological treasure. The Village also seeks to reach a community forest agreement, in conjunction with the Mowachaht/Muchalaht First Nation, with the provincial government and the to establish a community forest within the Tahsis area to create jobs and maintain viewscapes.

Again, we sincerely thank you for meeting with Tahsis Council and for your on-going interest and support for the community. We look forward to continuing our conversation at the UBCM Convention.

Respectfully,

Mayor Martin Davis on behalf of Tahsis Council

L2

City of Richmond

6911 No. 3 Road,
Richmond, BC V6Y 2C1
www.richmond.ca

June 28, 2019
File:

Finance and Corporate Services Division
City Clerk's Office
Telephone: 604-276-4007
Fax: 604-278-5139

All BC Municipalities
Via email

Re: Lobbyist Registration

This is to advise that Richmond City Council at its Regular Council meeting held on Monday, June 24, 2019 considered the above matter and adopted the following resolution:

> ***To forward the following resolution for consideration at UBCM and to send copies to the local governments of B.C. for their favourable consideration prior to the 2019 UBCM meeting:***
>
> > ***Whereas the BC Lobbyists Registration Act (LRA) requires individuals and organizations who lobby public office holders and meet specific criteria to register their lobbying activities in an online public registry; and***
> >
> > ***Whereas the goal of the BC Lobbyists Registration Act (LRA) is to promote transparency in lobbying and government decision-making;***
> >
> > ***Therefore be it resolved that UBCM request that a lobbying regulation system for municipal government, similar to the provincial mechanism under the BC Lobbyists Registration Act, be established.***

Accordingly, the above has been submitted to UBCM and the City of Richmond Council requests your favourable consideration of the resolution at the 2019 UBCM convention.

Yours truly,

David Weber
Director, City Clerk's Office

6223283

Richmond

L3

City of Richmond

6911 No. 3 Road,
Richmond, BC V6Y 2C1
www.richmond.ca

June 28, 2019

All BC Municipalities
Via email

Re: Proposed UBCM Resolution – Conflict of Interest Complaint Mechanism

This is to advise that Richmond City Council at its Regular Council meeting held on Monday, June 24, 2019 considered the above matter and adopted the following resolution:

To forward the following resolution for consideration at UBCM and to send copies to the Local Governments of BC for their favourable considerations prior to the 2019 UBCM meeting. Additional copy to be sent to the Minister of Municipal Affairs.

Conflict of Interest Complaint Mechanism

> ***Whereas professional regulatory bodies, such as CPABC, BC Law Society, APEGBC, and others, have conflict of interest and ethics rules for their members and enforce them through a complaints process;***
>
> ***Whereas the public expects elected representatives to be held to a professional standard of conduct;***
>
> ***And whereas the only remedy for a citizen complaint of a municipal elected person's conflict of interest is through a judgement of the Supreme Court of British Columbia;***
>
> ***So be it resolved that the Province of British Columbia consider a mechanism including to resolve and remedy conflict of interest complaints through a non-partisan Municipal Conflict of Interest Commissioner or expansion of the scope of powers of the BC Conflict of Interest Commissioner.***

Accordingly, the above has been submitted to UBCM and the City of Richmond Council requests your favourable consideration of the resolution at the 2019 UBCM convention.

Yours truly,

David Weber
Director, City Clerk's Office

pc: The Honourable Selina Robinson, Minister of Municipal Affairs and Housing

6223169

Richmond

L4

City of Richmond

6911 No. 3 Road,
Richmond, BC V6Y 2C1
www.richmond.ca

June 28, 2019

All BC Municipalities
Via email

Re: Proposed UBCM Resolution – Statement of Disclosure Updates

This is to advise that Richmond City Council at its Regular Council meeting held on Monday, June 24, 2019 considered the above matter and adopted the following resolution:

To forward the following resolution for consideration at UBCM and to send copies to the Local Governments of BC for their favourable considerations prior to the 2019 UBCM meeting. Additional copy to be sent to the Minister of Municipal Affairs.

> ***Statement of Disclosure Updates***
>
> ***Whereas professional regulatory bodies, such as CPABC, BC Law Society, APEGBC, and others, have conflict of interest and ethics rules for their members, under which appearance of conflict of interest is disallowed;***
>
> ***Whereas the public expects elected representatives to act to a professional standard of conduct;***
>
> ***And whereas the scope of decisions and responsibilities of an elected representative can be broad and encompass a variety of issues;***
>
> ***So be it resolved that the Statement of Disclosure for municipal nominees and elected representatives be updated to additionally include a spouse's assets; a spouse's liabilities; and real property, other than their primary residence, held singly or jointly by a spouse, child, brother, sister, mother or father, to the best knowledge of the candidate. Further, within 60 days of being sworn in, to file a confidential financial disclosure statement to a non-partisan Municipal Conflict of Interest Commissioner.***

Accordingly, the above has been submitted to UBCM and the City of Richmond Council requests your favourable consideration of the resolution at the 2019 UBCM convention.

Yours truly,

David Weber
Director, City Clerk's Office

pc: The Honourable Selina Robinson, Minister of Municipal Affairs and Housing

6223161

Richmond

L5

CITY OF PORT MOODY

OFFICE OF THE MAYOR

June 27, 2019

Selina Robinson, Minister of Municipal Affairs and Housing
PO Box 9056 Stn Prov Govt
Victoria, BC V8W 9E2

Dear Honourable Selina Robinson,

At the Regular Council Meeting of June 25, 2019, the City of Port Moody passed the following resolution:

> *THAT a letter to the Ministry of Municipal Affairs and Housing be sent by the Office of the Mayor expressing Support for Property Assessed Clean Energy Enabling Legislation for BC indicating our concerns and requesting that a study of PACE best practices be undertaken with expert stakeholders, including UBCM and FCM staff, in order to guide changes to legislation to allow for PACE programs in BC as recommended in the report dated June 4, 2019 from Councillor Amy Lubik regarding Support for Property Assessed Clean Energy Enabling Legislation for BC;*
>
> *AND THAT the following resolution regarding Support for Property Assessed Clean Energy Enabling Legislation for BC be endorsed by the City of Port Moody and forwarded for consideration at the 2019 UBCM convention and forwarded to other UBCM members for support:*
>
> > *WHEREAS climate change is the greatest threat to our municipalities;*
> > *AND WHEREAS the pillars of the Clean BC program include better buildings, incentivizing retrofits and upgrading BC's stock of public housing so residents, many of whom are low-income families or seniors, can live in a more energy-efficient, healthier, and comfortable home;*
> >
> > *AND WHEREAS the cost of clean energy infrastructure is a major barrier for low and middle income earners, as well as small businesses and municipalities;*
> >
> > *AND WHEREAS Property Assessed Clean Energy (PACE) legislation has proven to be effective in financing retrofits in other jurisdictions;*

100 Newport Drive, Port Moody, B.C. V3H 3E1 Telephone: 604.469.4515 Fax: 604.469.4664

THEREFORE BE IT RESOLVED THAT the Province of British Columbia work with expert stakeholders with knowledge of Property Assessed Clean Energy (PACE) best practices, including UBCM and FCM, to study the application of PACE in BC and develop PACE enabling legislation for BC Municipalities.

Property Assessed Clean Energy (PACE) is a proven, common-sense financing tool that will allow the British Columbia Government to address the need to create transition jobs and address climate change, all without adding to the provincial debt. PACE is a powerful tool which, with the right legislative framework, could create a new clean energy ecosystem, bring new capital into the province, and significantly bolster the existing sustainability marketplace. The world is grappling with the tension between the carbon-based energy industry and a consensus that emissions are directly contributing to climate change. Currently, buildings account for 40% of GHG's. Through the development of a robust and thriving PACE ecosystem, BC can dramatically reduce its emissions by radically improving the energy efficiency of both its existing building stock and new builds.

The Federation of Canadian Municipalities is currently developing programs/grants for PACE; however these are not available in BC. It has been suggested that using limited municipal or foundation type funding instead of accessing private capital limits resources available for Property Assessed Clean Energy (PACE) projects. PACE delivers market certainty and turns sustainability measures into solid business case initiatives.

The City of Port Moody is asking that British Columbia develop enabling legislation for a strong and vibrant PACE program. An optimum solution could involve maximizing both government and private investments. A strong PACE program will deliver reductions in BC's municipal and provincial GHG emissions and make a significant contribution towards governments' ability to deliver on its GHG reduction commitments, to support reducing energy poverty, and to create Green Jobs. Such an initiative, if ultimately implemented in BC, would become one of the most significant steps municipalities could take to tackle climate change.

Sincerely

Meghan Lahti

Meghan Lahti
Acting Mayor, City of Port Moody

CC: All UBCM Members

L6

RECEIVED

CITY OF
PRINCE GEORGE

OFFICE OF THE MAYOR

1100 Patricia Blvd. | Prince George, BC, Canada V2L 3V9
p: 250.561.7600 | www.princegeorge.ca

July 2, 2019

Mayor and Council
Village of Tahsis
Box 219
Tahsis, BC V0P 1X0

Dear Mayor Davis and Members of Council,

At the City of Prince George regular Council meeting held June 24, 2019, Council gave consideration to proposed Union of British Columbia Municipalities (UBCM) resolutions regarding: Proceeds of Crime; and Clean-Up of Needles and Other Harm Reduction Paraphernalia. The following resolutions were approved for submission to the UBCM for consideration at the 2019 Convention.

1. <u>Proceeds of Crime</u>

   WHEREAS the provision of police services places a significant financial burden on local government;

   AND WHEREAS the Civil Forfeiture Crime Prevention and Crime Remediation Grant Program funds community crime reduction and crime prevention activities, but does not address local government policing costs, including expenditures related to investigations and police work that result in seizures of proceeds of crime;

   THEREFORE BE IT RESOLVED that the Province share seizures of proceeds of crime with local governments to help address protective services costs.

2. <u>Clean-Up of Needles and Other Harm Reduction Paraphernalia</u>

   WHEREAS the low barrier distribution of harm reduction supplies, including syringes and other safe injection supplies, in communities across BC poses a significant safety and cleanliness concern;

   AND WHEREAS local governments, businesses and residents are bearing the escalating cost of cleaning up needles and drug paraphernalia in public spaces;

THEREFORE BE IT RESOLVED that UBCM request ongoing provincial funding to local governments to cover the cost of cleaning up needles and drug paraphernalia in their communities.

On behalf of Prince George City Council, your support of these resolutions at the 2019 UBCM Convention is appreciated.

If you have any questions or would like more information please feel free to contact my office at MayorAdmin@princegeorge.ca or 250-561-7691.

Sincerely,

Mayor Lyn Hall
City of Prince George

L7

MUNICIPALITY OF NORTH Cowichan

7030 Trans-Canada Highway
Duncan, BC V9L 6A1 Canada
www.northcowichan.ca
T 250.746.3115
F 250.746.3133

JULY 15, 2019

File: 0250-20-UBCM

VIA EMAIL: UBCM Members – All Elected Officials

Dear UBCM Members,

Re: UBCM Resolution – Regional Management of Forestry

This letter is to advise that North Cowichan Municipal Council passed the following resolution on June 19, 2019. Accordingly it has been submitted to the UBCM, and accepted for the 2019 Convention:

WHEREAS the forest industry in British Columbia has been on a steady decline in recent decades, with dozens mill closures, thousands of lost jobs and once-thriving rural communities experiencing severe economic decline – due in large part to corporate mismanagement, misguided government policies, and lack of public oversight;

AND WHEREAS many communities across British Columbia and globally have demonstrated that when local people are empowered to manage public forests and other common resources through community forest licenses, regional trusts and other community-based governance models, there are significant social, economic and environmental benefits;

THEREFORE BE IT RESOLVED that the Province of British Columbia explore the feasibility of:

- **Adopting a new model of regionally-based forestry management that will empower local communities to engage in long term planning of the regional economies and ecosystems;**
- **Creating a Forest Charter passed by the Legislature that includes an overall vision, sustainability principles, and standards for our forests; and**
- **Appointing a Forester General to serve as a new independent officer who will report annually to the Legislature and work with the diverse regions of our province on local land planning processes.**

Enclosed for your information is the paper *Restoring Forestry in BC*, which provides a strong basis for the resolution. Council requests your favourable consideration of this important issue at the upcoming Convention.

Yours Truly,

Matt O'Halloran
Deputy Corporate Officer

Enclosure

L8

BRITISH COLUMBIA

VIA E-MAIL
Ref: 244242

July 15, 2019

Dear Mayor:

Since Childcare BC launched in 2018, we have taken great strides towards our vision of universal child care: a system that will provide parents with access to affordable, high-quality child care whenever and wherever they need it.

One of the key pillars of Childcare BC is accessibility. Under this pillar, the Childcare BC New Spaces Fund offers funding to create new licensed child care spaces for British Columbian families.

Today, we have good news to share. Public sector organizations, Indigenous Governments, and non-profit societies can now access more money through the Childcare BC New Spaces Fund to create spaces. Based on feedback from communities throughout British Columbia, we have tripled the funding maximums up to:

- **$3 million per facility** (previously $1 million) **for up to 100% of project costs** for public sector organizations and Indigenous Governments,
- **$1.5 million per facility** (previously $500,000) **for up to 100% of project costs** for Indigenous non-profit societies, and
- **$1.5 million per facility** (previously $500,000) **for up to 90% of project costs** for non-profit societies and Child Development Centres.

We are making this change to recognize that in many communities, high capital costs can be a barrier to creating child care spaces. Increasing funding maximums means that more communities can access the Childcare BC New Spaces Fund, and more families will benefit from access to licensed child care.

For a breakdown of applicant type, new funding maximums and provincial contribution levels, see attached table.

Looking ahead, the ministry is also creating a multi-project funding stream so that public sector organizations and established non-profit societies can submit a single proposal for multiple projects, or for large-scale projects that require more than the funding maximums. More information on this stream will be available in coming weeks.

…/2

Ministry of Children and Family Development

Office of the Minister

Mailing Address:
Parliament Buildings
Victoria BC V8V 1X4

Location:
Parliament Buildings
Victoria

We hope you share this information with your colleagues, partners and clients, and apply for funding if you are an eligible organization. By working together, we can make life better for British Columbia's families by improving access to child care.

Childcare BC New Spaces Fund guidelines, application forms and FAQs are available at www.gov.bc.ca/childcare/newspacesfund. If you have any questions, you can contact the Childcare BC New Spaces Fund Program at MCF.CCCF@gov.bc.ca or 1 888 338-6622 (option 5).

Thank you.

Sincerely,

Katrine Conroy
Minister of Children and Family Development

Katrina Chen
Minister of State for Child Care

Appendix: Contribution Percentages and Funding Award Commitment by Applicant Type

Applicant Type	Required Organization Contribution	Provincial Contribution	Maximum Provincial Funding Amount*	Funding Award Commitment
Public sector organizations and Indigenous Governments	0%	100%	Up to $3,000,000	Up to 15 years
Indigenous Non-Profit Societies	0%	100%	Up to $1,500,000	Up to 15 years
Non-Profit Child Care Providers and Child Development Centres	10%	90%	Up to $1,500,000	Up to 15 years
For-profit child care organizations (Businesses and Incorporated Companies).	25%	75%	Up to $250,000	Up to 10 years
The maximum provincial funding amount applies to a single physical location. Projects occurring within the same physical location are considered as a single project.				

Minister of Rural Economic Development

Ministre du Développement économique rural

Ottawa, Canada K1P 0B6

RECEIVED

His Worship Martin Davis
Mayor
Village of Tahsis
977 South Maquinna Drive
Tahsis, British Columbia V0P 1X0

JUL 0 8 2019

Dear Mr. Mayor:

Thank you for your letter of March 6, 2019, regarding cellular service on Northern Vancouver Island. Please accept my apologies for the delay in responding.

As Minister of Rural Economic Development, I am committed to fulfilling the responsibilities entrusted to me in this portfolio, to work with Canadians and champion economic opportunity and quality of life in rural Canada. I am also pleased to lead the rollout of infrastructure and broadband investments in rural Canada, and to work with other federal ministers to advance important priorities benefitting rural Canada.

Recently, I announced two strategies: *Rural Opportunities, National Prosperity: An Economic Development Strategy for Rural Canada* (www.infrastructure.gc.ca/rural/strat-eng.html) and *High-Speed Access for All: Canada's Connectivity Strategy* (www.canada.ca/get-connected). Together, these strategies demonstrate our government's commitment to a prosperous, competitive and thriving rural Canada, and to ensuring that, over time, all Canadians have access to affordable high-speed Internet.

These strategies set out our government's roadmap for the future of rural Canada, and to achieve our connectivity goals. They build on insights from rural Canadians, and provide a roadmap for addressing challenges and capitalizing on the opportunities in rural Canada.

Connectivity, whether Internet or cellular, is the top rural issue that I have heard to date from Canadians. Our government recognizes that wireless mobile connectivity on major highways and roads is an important need, including for safety. To support the expansion of mobile wireless services to rural and remote areas, Innovation, Science and Economic Development Canada continues to auction spectrum to increase its availability to wireless providers.

...2

Canada

In addition to direct investments to advance connectivity, the Government of Canada is focused on increasing competition to improve affordability while increasing coverage and service quality. We are encouraging businesses of all sizes to invest in next-generation technology through the Accelerated Investment Incentive. Since the Incentive was announced in the fall of 2018, several telecommunications carriers have made plans to expand wireless coverage to rural areas, including along roads. The Government is also working on ensuring that telecommunications policy focuses on consumers in order to strengthen the ability of Canadians to access quality services at more affordable prices.

Efforts to strengthen and capitalize on rural Canada's enormous potential will require governments, businesses and communities to collaborate. This is an important theme of the Rural Economic Development Strategy, and these partnerships will enable progress and produce results for rural Canada.

Thank you for your interest in my portfolio.

Sincerely,

The Honourable Bernadette Jordan, P.C., M.P.
Minister of Rural Economic Development

2.10

UBCM Union of BC Municipalities

July 22, 2019

RECEIVED
JUL 26 2019

Mayor Martin Davis
Village of Tahsis
Box 219
Tahsis, BC V0P 1X0

Dear Mayor Martin Davis:

RE: **GAS TAX AGREEMENT COMMUNITY WORKS FUND PAYMENT**

I am pleased to advise that UBCM is in the process of distributing the first Community Works Fund (CWF) payment for fiscal 2019/2020. An electronic transfer of $101,869.77 is expected to occur within the next 30 days. These payments are made in accordance with the payment schedule set out in your CWF Agreement with UBCM (see section 4 of your Agreement). UBCM is also making an additional one-time payment towards CWF funding approved for disbursement by the Federal government under Budget 2019 to supplement the fiscal 2018/2019 allocation.

CWF is made available to eligible local governments by the Government of Canada pursuant to the Administrative Agreement on the Federal Gas Tax Fund in British Columbia. Funding under the program may be directed to local priorities that fall within one of the eligible project categories.

First CWF Payment: $32,782.04
CWF One-Time Payment: $69,088
Total EFT Transfer: $101,869.77

Further details regarding use of CWF and project eligibility are outlined in your CWF Agreement and details on the Gas Tax Agreement can be found on our website at www.ubcm.ca.

For further information, please contact Gas Tax Program Services by e-mail at gastax@ubcm.ca or by phone at 250-356-5134.

Very best,

Arjun Singh
UBCM President

CC: Deborah Bodnar, Director of Finance

L11

Local Government Program Services

...programs to address provincial-local government shared priorities

UBCM

FIRST NATIONS' Emergency Services BRITISH COLUMBIA

BRITISH COLUMBIA
www.gov.bc.ca

The Strategic Wildfire Prevention Initiative is managed by the Strategic Wildfire Prevention Working Group. For program information, visit the Funding Program section at:

www.ubcm.ca

LGPS Secretariat

Local Government House
525 Government Street
Victoria, BC V8V 0A8

E-mail: swpi@ubcm.ca
Phone: (250) 356-2947
Fax: (250) 356-5119

July 18, 2019

RECEIVED
JUL 26 2019

Mayor Davis and Council
Village of Tahsis
Box 219
Tahsis, BC V0P 1X0

Re: Completion of FireSmart Project (SWPI-887: Tahsis Wildfire Prevention, 2018)

Dear Mayor Davis and Council,

Thank you for submitting final report documentation for the completion of the above noted FireSmart project. The Strategic Wildfire Prevention Working Group has reviewed your submission and the reporting requirements have been met.

The final report notes total project costs of $5,709.34. Based on this, payment in that amount will follow shortly by electronic funds transfer. This payment represents full payment for the project and is based on total eligible costs.

I congratulate you on the successful completion of this project and offer best wishes for future community safety work in your community.

Sincerely,

Peter Ronald
Programs Officer

cc: *Mark Tatchell, Chief Administrative Officer, Village of Tahsis*

L12

Janet St. Denis

Subject: FW: Sierra Club BC Support letter draft

From: **Mark Worthing** <mark@sierraclub.bc.ca>
Date: Mon, Jul 29, 2019 at 2:27 PM
Subject: Sierra Club BC Support letter draft

Hi Martin,

We chatted briefly online the other day about a support letter for one of Sierra Club BC's grant applications. Here's a draft for you to work off of, refine or write up as you see fit. I think you said you had to run it by council early August. Might be out that was with Troy doing a trip to Nootka Island so maybe see you around then in town.

Thank so much for doing this - much appreciated.

Here's a google doc link you can work from, and I cut & pasted the text below as well for you:
https://docs.google.com/document/d/1xXxAbNeaNqBhccInbLAsTOGYTtFoZvqIsuL6-ew6Qps/edit?usp=sharing

Mark

Date

Attention: Real Estate Foundation Advisory Committee Members,

I am writing to request your support for Sierra Club BC's grant application to the Real Estate Foundation for their forest conservation work with municipalities and Indigenous nations in the Nootka Sound/Tahsis region.

The Tahsis town council has voiced our support for the conservation initiatives being led by Nuu-chah-nulth nations & municipal leadership. The rapid rate of logging jeopardizes the health of forest ecosystems and salmon habitat, and conservation and restoration are urgently needed in at-risk watersheds like McKelvie Creek adjacent to our community. Sierra Club BC has demonstrated a strong commitment to working respectfully with First Nations, and would provide welcome support for this initiative.

I have been impressed with the respectful way in which Sierra Club BC has approached the Tahsis local government, and the credibility of the information and resources that they have provided.

With their educational skills, mapping expertise, commitment to doing field assessments to shine a light on what is happening in the forests, and respectful approach to working with local and Indigenous governments, Sierra Club BC provides a crucial role in shifting the narrative about forests on Vancouver Island. Their work is important and much needed, as the rate of logging and climate change rapidly change the ecosystems in which we live and work.

I support their work, and I recommend granting approval of their application.

Sincerely,

Mayor Martin Davis & Tahsis Council

Date

Attention: Real Estate Foundation Advisory Committee Members,

I am writing to request your support for Sierra Club BC's grant application to the Real Estate Foundation for their forest conservation work with municipalities and Indigenous nations in the Nootka Sound/Tahsis region.

The Tahsis town council has voiced our support for the conservation initiatives being led by Nuu-chah-nulth nations & municipal leadership. The rapid rate of logging jeopardizes the health of forest ecosystems and salmon habitat, and conservation and restoration are urgently needed in at-risk watersheds like McKelvie Creek adjacent to our community. Sierra Club BC has demonstrated a strong commitment to working respectfully with First Nations, and would provide welcome support for this initiative.

I have been impressed with the respectful way in which Sierra Club BC has approached the Tahsis local government, and the credibility of the information and resources that they have provided.

With their educational skills, mapping expertise, commitment to doing field assessments to shine a light on what is happening in the forests, and respectful approach to working with local and Indigenous governments, Sierra Club BC provides a crucial role in shifting the narrative about forests on Vancouver Island. Their work is important and much needed, as the rate of logging and climate change rapidly change the ecosystems in which we live and work.

I support their work, and I recommend granting approval of their application.

Sincerely,

Mayor Martin Davis & Tahsis Council

L13

Rita Aedan,
907 Princess Victoria View,
P. O. Box 303,
Tahsis, B. C. V0P 1X0

July 31st, 2019,

Mayor and Council, Village of Tahsis,
977 South Maquinna Drive,
Tahsis, B. C. V0P 1X0

Dear Mayor and Council,

On behalf of our community group, McKelvie Matters, I am hereby submitting copies of duly signed petition forms concerning Logging of the McKelvie Creek Watershed, Tahsis, B. C. which, as of this date, the original duly signed petition forms, have been sent to our elected representative, Claire Trevena, MLA for presentation to the Legislative Assembly of the Province of British Columbia.

The Legislature's first sitting this coming Fall is scheduled for October 7th, 2019.

It has been an honour and privilege to serve our community in our fight to save the irreplaceable and I will continue on until we succeed...because, succeed we will!

Best Regards to All of You,

Rita Aedan

Rita Aedan

Encl: 15 pages petition forms
Petition addressed to Legislative Assembly
Letter to Claire Trevena, MLA

Rita Aedan,
907 Princess Victoria View,
P. O. Box 303,
Tahsis, B. C. V0P 1X0

July 31, 2019.

Hon. Claire Trevena, MLA
908 Island Highway,
Campbell River, B. C. V9W 2C3

Dear Claire Trevena,

RE: Petition to the Legislative Assembly Province of B.C.

Enclosed please find our signed petition forms for presentation to the Legislative Assembly hopefully on the first day of this Fall's session, October 7th, 2019 concerning logging of the McKelvie Creek Watershed, Tahsis, B.C.

Also please find the brochure "McKelvie Matters", originally produced for our community group of the same name, of which I currently represent in forwarding along the petition to you for representation within the Legislature.

Yours truly,

Rita Aedan

Rita Aedan,
McKelvie Matters

Email: ceritanne@conumacable.com
Phone: 250-934-7751

Encl: 15 page petition
McKelvie Matters brochure

To the Honourable the Legislative Assembly of the Province of British Columbia, in Legislature Assembled.

The petition of the undersigned, citizens of the Village of Tahsis, B. C. and environs, states that: We respectfully request that the Legislative Assembly of the Province of British Columbia immediately protect and preserve the McKelvie Creek in Tahsis for drinking watershed, wildlife and recreational values.

Your petitioners respectfully request that the Honourable House take action as deemed appropriate to protect and preserve the McKelvie Creek, our community watershed, which lays within the McKelvie Old Growth forest.

Dated this 31st day of July, 2019.

Rita Aedan, on Behalf of the Tahsis community group McKelvie Matters
Rita Aedan
P. O. Box 303, Tahsis, B. C. V0P 1X0

Petition to the Legislative Assembly of the Province of British Columbia

Logging of The McKelvie Creek Watershed ~ Tahsis, B. C.

Action petitioned for:	*We respectfully request that the Legislative Assembly of the Province of British Columbia immediately protect and preserve the McKelvie Creek in Tahsis for drinking watershed, wildlife, and recreational values.*

Printed Full Name	Signature	Address	Comment (optional)
Janet Kirsey	[illegible]	131 Beaton Rd Tahsis	Water is important
Sarah Fowler	[illegible]	1162 Discovery Crest	our heritage, our watch
Graham Bosecker	[illegible]	1162 Discovery Crest	The last unprotected old growth watershed on Vanc
[illegible]	[illegible]	1 Freda Rd	[illegible]
Teresa F[illegible]	[illegible]	202 - 901 Jewitt	All of the above
[illegible]	Karma Bosecker	1162 Discovery Cres	[illegible]
Gaia Bosecker	Gaia Bosecker	" " "	
Marlene Kennon	Marlene Kennon	3796 [illegible], Nanaimo	Can't live without water
Ian Llewellyn	[illegible]	Edith Rd Tahsis	
Amanda Glenn	[illegible]	1024 [illegible] Rd	We need the McKelvie more than [illegible]
Jane Gilmour	[illegible]	1150 Discovery	please don't let this happen
Stephanie Olson	Stephanie Olson	1165 N. Maquinna	—
BLAKE BIRCH	Blake Birch	1032 Resolution Dr	NO LOGGING IN OLD GROWTH!

Petition to the Legislative Assembly of the Province of British Columbia

Logging of The McKelvie Creek Watershed ~ Tahsis, B. C.

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Printed Full Name	Signature	Address	Comment (optional)
RITA DAWSON-WILLOTT	R. Dawson Willott	907 PRINCESS VICTORIA VIEW TAHSIS BC V0P 1X0	Water is Life!
Kimberley Anderson	Kimberley Anderson	1072 Resolution Dr. Tahsis BC V0P 1X0	Stay out of the Water Shed!
MAUREEN ROTH	Maureen Roth	253 N. MAQUINNA DR TAHSIS B.C V0P 1X0	STAY OUT !!!
TERRY FASSBENDER	[illegible]	323 MAQUINNA N TAHSIS BC V0P 1X0	THERE ARE MANY ALTERNATIVE TO USE
Brooke Jones	B Jones	651 N Maquinna Drive Tahsis BC, V0P 1X0	Please protect the old growth forest.
Pat Rhonck	Pat Rhono	635 ALPINE VIEW RD.	WE DON'T WANT IT LOGGED
James LaLonde	James Lalonde	635 ALPine view	We Don't want it
MERVIN ROTH	Mervin Roth	253 N. MAQUINNA TAHSIS B.C. V0P 1X0	[illegible]
Ray Dulong	Ray Dulong	1 Freda Rd. Tahsis, BC. V0P 1X0	Best to leave it as is!
Joe Greenwer	[illegible]	14 FREDA V0P 1X0	"
Cleo Fort	[illegible]	14 FREDA RD V0P 1X0	Somewhere else please.
GEORGE WHITE	[illegible]	13 FREDA RD	
Gavin Tinkle	[illegible]	304A Wakesiah Ave Nanaimo BC Canada	Protect the Steelhead!
Diane Wild	[illegible]	#8 EDITH RD	

Petition to the Legislative Assembly of the Province of British Columbia

Logging of The McKelvie Creek Watershed ~ Tahsis, B. C.

Action petitioned for:	*We respectfully request that the Legislative Assembly of the Province of British Columbia immediately protect and preserve the McKelvie Creek in Tahsis for drinking watershed, wildlife, and recreational values.*

Printed Full Name	Signature	Address	Comment (optional)
Anne Cameron	[illegible]	#5 Edith Rd	leave the murrelets and goshawks alone
J. HARVEY REYNOLDS	[illegible]	1024 Resolution Rd.	NO LOGGING
D. Piantyka	[illegible]	922 Resolution Rd	no logging
L. Tomashi	[illegible]	922 Resolution Rd	Community Forest/Watershed + logging for Revenue
Sean Robin	[illegible]	198 Fireclance Ln	NOT a good idea!
[illegible]	[illegible]	1375 McKilop Dr. Parksville	Dito!
Nadia Dale	[illegible]	10571 Hollybank Drive	old growth.
Gayle Goodwin	[illegible]	651 North Maquinna	
Russell MacKinnon	[illegible]	801 Jewitt Dr	no logging
Nicola Cyronta	[illegible]	Jewitt Drive	no logging
LENORA McINTYRE	[illegible]	1045 TUNNER ROAD COMOX VALLEY	no LOGGING
Wendy Hamm	[illegible]	1450 Tunner Dr Comox valley	NO Logging.
Wanda Whitsdale	[illegible]	564 North Maquinna	save our water.
SHEILA ORR	[illegible]	576 [illegible] Climb	SAVE our water

Action petitioned for:	We respectfully request that the Legislative Assembly of the Province of British Columbia immediately protect and preserve the McKelvie Creek in Tahsis for drinking watershed, wildlife, and recreational values.

Printed Full Name	Signature	Address	Comment (optional)
ELIZABETH CULLEN	[illegible]	15 Edith Rd	In solidarity!
Josh Lambert	[illegible]	625 West Bay rd	It's worth more standing!
DAN DEVAULT	Dan Devault	P.O. BOX 13 TOFINO	
Gordon Bennett	[illegible]	368 S. MAQUINNA	WATER SHED
Aubrey Stewart	aubrey Stewart	22 Freda rd	"
Katie Callaghan	Katherine Callaghan	215 N Maquinna Dr	
Tim Seaton	Tim Seaton	463 N. Maquinna	Watershed
MAXINE M. McCRAE	[illegible]	121 Boston RD.	Save our H2O (YOU)
Amanda Kabbs	Amanda [illegible]	28 Brabant Cres.	
Jason Kydd	[illegible]	1144 Discovery cres	
MARIO GGILBERT	[illegible]	615 CARDIAC CLIMB	H2O is BASIC TO LIFE
[illegible]	[illegible]	404 McKinlay View	No LOGGING IN VALLEY 3 WATERSHED
[illegible]	Darrell R Hunter	28-C Rugged Rdg	"
Barb Consalvi	B. Consalvi	56 Brabant Cres	

Petition to the Legislative Assembly of the Province of British Columbia

Logging of The McKelvie Creek Watershed ~ Tahsis, B. C.

Action petitioned for:	*We respectfully request that the Legislative Assembly of the Province of British Columbia immediately protect and preserve the McKelvie Creek in Tahsis for drinking watershed, wildlife, and recreational values.*

Printed Full Name	Signature	Address	Comment (optional)
Jim Godolphin	[signature]	58 Brabant Cres.	
Melina Holtslag	[signature]	1048 Resolution Rd	
Tony Holtslag	[signature]	1048 Resolution Rd.	
Deborah Donohue	[signature]	1167 Discovery cres.	
SILVIE KEEN	[signature]	523 ALPINE VIEW RD	
[illegible]	[signature]	65 Brabant Cres.	
Aaron Caswant	[signature]	615 cardiae	
Sierra Jannise	[signature]	4 Edith Rd.	Don't log valley or watershed we need what we have!
RICHARD BELLANGER	[signature]	127 ALPINE VIEW	"
CHERYL L NORTHCOTT	[signature]	1012 Resolution RD	This is among the last pristine OLDGROWTH stands plus its vital for water & WILDLIFE
BRENT ABBOTT	[signature]	121 McKELVIE ROAD	
KELLY ABBOTT	[signature]	121 McKELVIE ROAD	
Russ Nickerson	[signature]	41 main [illegible] Rd.	
[illegible]	[signature]	1164 DISCOVERY	

Petition to the Legislative Assembly of the Province of British Columbia

Logging of The McKelvie Creek Watershed ~ Tahsis, B. C.

Action petitioned for:	*We respectfully request that the Legislative Assembly of the Province of British Columbia immediately protect and preserve the McKelvie Creek in Tahsis for drinking watershed, wildlife, and recreational values.*

Printed Full Name	Signature	Address	Comment (optional)
Jim Pickets	[illegible]	319 North [illegible]	SAve water Shed.
Greg Fraser	[illegible]	Box 334, Tahsis BC	No logging in the watershed
GREG McINROY	[illegible]	BOX 45 TAHSIS	NO LOGGING. - HYDRO
Brenda Overton	[illegible]	#94 Tahsis Fallers WIFE	unnessary gReed
Keith Malcolm	[illegible]	Black Creek BC	
Alison Smeltz	[illegible]	Box 307 Tahsis BC	No logging the Valley or Water Shed! Worth more Standing.
BRIAN McLACHLAN	[illegible]	Box 113 Tahsis BC	
[illegible] Moore	[illegible]	7 Brabant Cres	
Doug Emmons	[illegible]	PO BOX 25	Water source should never be treated
[illegible] Kozak	[illegible]	Pt. Saskatchewan	
Devlin Alcock	Devlin alcock	Box 307 Tahsis BC	
Paul Dunn-Morris	[illegible]	Box 75 Tahsis B.C.	
Scott Schooner	[illegible]	Box 64, Tahsis B.C.	Please leave it alone.
Randall McFarland	Randall McFarland	Box 28 Tahsis BC	

Petition to the Legislative Assembly of the Province of British Columbia

Logging of the McKelvie Creek Watershed ~ Tahsis, B.C.

Action petitioned for:	*We respectfully request that the Legislative Assembly of the Province of British Columbia immediately protect and preserve the McKelvie Creek in Tahsis for drinking watershed, wildlife, and recreational values.*

Printed Full Name	Signature	Address	Comment (optional)
Julie Siemens	[illegible]	Box 239, Tahsis, B.C	
D. CLANCY	D Clancy	Box 295. Tahsis BC	
Joyce L. Davies	Joyce L Davies	Box 355 Tahsis	[illegible]
Josephine Milutinovic	Josephine Milad	Box 152 Tahsis, BC. VOP 1XO	
Carla Haywood	[illegible]	Box 338 tahsis BC VOP 1XO	
Murray Gagne	[illegible]	Box 8 Tashsis BC VOP 1XO	
MICHELLE HARROD	Michelle Harrod	BOX 128 23 EDITH RD VOP 1XO	
Jess Eslinger	[illegible]	Box 125 Tahsis B.C. VOP 1XO	
Pierre Jeanneau	[illegible]	Box 125, Tahsis BC. VOP 1XO	
[illegible]	[illegible]	123 [illegible]	
Shelley Parsey	Shelley Parsey	4 Rugged MTN RD	
[illegible] Nicholson	WAYNE NICHOLSON	13 A - RUGGED MD.	
Perry Bostmayer	[illegible]	81 Boston RD.	
[illegible] Eldridge	[illegible]	[illegible] Tahsis	

Petition to the Legislative Assembly of the Province of British Columbia

Logging of the McKelvie Creek Watershed ~ Tahsis, B.C.

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Printed Full Name	Signature	Address	Comment (optional)
Jesse Hitman	[signature]	85 Harbour View	
Joseph Meggam	[signature]	41 McKelvie	
Seth Eldridge	Seth Eldridge	82 Brabant Cres	
Diane Lewis	[signature]	BOX 398 TAHSIS BC ESPERANZA	
Lori Bennett	[signature]	547 Cardiac Climb TAHSIS BC	
Sally Atkinson	[signature]	1164 Discovery Cres.	
Lynda Llewelly	[signature]	22 Edith Rd	
Dawn Noye	[signature]	361 N Maquinna Dr	
MARTIN DAVIS	[signature]	1157 DISCOVERY CRES.	
Troy Moth	[signature]	625 West Bay	
Adam Batchelor	[signature]	625 West Bay	
Doug Edward	Doug Edward	537 N. Maquinna	
Lawrence Kling Jr	[signature]	647 Cardiac Climb	
Neil Sherwood	[signature]	3698 Ocean Grove Rd	Campbell River, BC

Petition to the Legislative Assembly of the Province of British Columbia

Logging of the McKelvie Creek Watershed ~ Tahsis, B.C.

Action petitioned for:	We respectfully request that the Legislative Assembly of the Province of British Columbia immediately protect and preserve the McKelvie Creek in Tahsis for drinking watershed, wildlife, and recreational values.

Printed Full Name	Signature	Address	Comment (optional)
[illegible]	[illegible]	4-F [illegible] Tahsis	
Kerry Bellanger	[illegible]	#44 Brabant Cresent	
[illegible]	[illegible]	44 Brabant Cres.	
Laura MacKenzie	[illegible]	860 Jewitt Dr	
[illegible]	[illegible]	860 JEWITT DR.	
John Archer	John Archer	[illegible] North Maquinna	
DAN SKOGMAN	[illegible]	76 RUGGED MT. RD	
Matthew Kilcup	Matthew Kilcup	253 N. Maquinna	
MASON BAKER	[illegible]	363 North Maquinna	
RANDY TAYLOR	[illegible]	288 ALPINE VIEW	
Tony Rodriguez	[illegible]	363 North Maquinna	
Seth Goossens	[illegible]	1162 Oscar's Cr	
Curtis Rutherford	[illegible]	41 McKelvie	
Jacqueline Baker	C Baker	1176 TIPPERARY PK	

Petition to the Legislative Assembly of the Province of British Columbia

Logging of The McKelvie Creek Watershed ~ Tahsis, B. C.

Action petitioned for:	We respectfully request that the Legislative Assembly of the Province of British Columbia immediately protect and preserve the McKelvie Creek in Tahsis for drinking watershed, wildlife, and recreational values.

Printed Full Name	Signature	Address	Comment (optional)
[illegible] ELLIOTT	[illegible]	BOX 325 TAHSIS BC	LOG THE VALLEY TO WOSS, STAY AWAY FROM McKELVIE
[illegible] Mohr	[illegible]	Box 208 Tahsis BC	
Christine Lewis	[illegible]	Box 208 Tahsis BC	
[illegible]	[illegible]	Box 362 Tahsis BC	
J. Masson	[illegible]	Box 371 Tahsis	
J. Taylor	[illegible]	Box 212 Tahsis	
C. Gordon	[illegible]	150 McKelvie Rd	No!
[illegible]. Natasha	[illegible]	801 [illegible] Drive	[illegible]
Ken Faltz	[illegible]	202 -801 Jewitt	We want to keep clean water [illegible]
Shannon Fastbender	[illegible]	323 N. Maquinna Dr.	
[illegible]	[illegible]	870-S Maquinna	
Louis BRISSARD	[illegible]	870 S. MAQUINNA	
LYNN MOHR	[illegible]	Box 208 TAHSIS	
Kim [illegible]	[illegible]	175-[illegible]	Back off

Petition to the Legislative Assembly of the Province of British Columbia

Logging of The McKelvie Creek Watershed ~ Tahsis, B. C.

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Printed Full Name	Signature	Address	Comment (optional)
Danielle Hozempa	Danielle Hozempa	1144 Discovery Cres	
Nancy Neufeld	N Neufeld	130 McKelvie Str	
William Davidson	[illegible]	150 McKelvie Rd	
Barbara Hylton	B Hylton	[illegible] N Maquinna	
Sierra McGarrigle	[illegible]	803 Jewitt Rd	
LIZ BELLANGER	L Bellanger	127 Alpine View	
DIANE BOAC	D Boac	191 N. Maquinna	
Tim Bowden	[illegible]	Esperanza, BC	
Laura Granger	L Granger	635 West Bay rd	

Petition to the Legislative Assembly of the Province of British Columbia

Logging of The McKelvie Creek Watershed ~ Tahsis, B. C.

Action petitioned for:	We respectfully request that the Legislative Assembly of the Province of British Columbia immediately protect and preserve the McKelvie Creek in Tahsis for drinking watershed, wildlife, and recreational values.

Printed Full Name	Signature	Address	Comment (optional)
[illegible] FITZGERALD	[illegible]	19 [illegible] Rd. Tahsis BC	[illegible]
André Lyons	[illegible]	587 Cardiac Club Tahsis BC	" " "
CHRISTINE BORG	[illegible]	191 McQuinna	
Pat O'Connell	[illegible]	929 Princess Victoria View Tahsis	
[illegible] H. TOWLE	[illegible]	19 - Edith Road Tahsis BC	
[illegible] BEAMIN	[illegible]	631 Cardiac Cl. Tahsis BC	
Corrine Olson	[illegible]	165 N. Maquinna	
~~Roy Dubory~~	~~Roy Dubory~~	~~1 Fraser Rd.~~	[illegible]
Steve Hughes	[illegible]	567 N. MAQUINNA	
LOUISE GUILBERT	[illegible]	48 - Brabant Cres. TAHSIS, BC.	

Petition to the Legislative Assembly of the Province of British Columbia

Logging of The McKelvie Creek Watershed ~ Tahsis, B. C.

Action petitioned for:	*We respectfully request that the Legislative Assembly of the Province of British Columbia immediately protect and preserve the McKelvie Creek in Tahsis for drinking watershed, wildlife, and recreational values.*

Printed Full Name	Signature	Address	Comment (optional)
RAY. Williams	[illegible]	Box-364 Gold River	MOWACHAHT Territory
Terry Williams	T. Williams	Box 364 Gold River	Mowachaht Terr.
[illegible] Samson	[illegible]	Box 43 Gold River	" "
Darrell Williams		Yuquot	" "
Simon John	[illegible]	PO Box 31 Zeballos BC V0P 2A0	Ehattesaht
[illegible] Wason	[illegible]	Esperanza	

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-118

Petition to the Legislative Assembly of the Province of British Columbia

Logging of the McKelvie Creek Watershed ~ Tahsis, B.C.

Action petitioned for:	*We respectfully request that the Legislative Assembly of the Province of British Columbia immediately protect and preserve the McKelvie Creek in Tahsis for drinking watershed, wildlife, and recreational values.*

Printed Full Name	Signature	Address	Comment (optional)
Duncan Shaw	[signature]	450 Chamiss Gold River Cres.	
mark Gotell	[signature]	1160 Discovery	
Sandy McDonald	Sandy McDonald	1160 Discovery	
Kathleen Rose Brand	K R Brand	1156 Discovery Cres	
Vicky Mattice	Mattice	Box 24 TAHSIS	
Elizabeth Young	E Young	407 N. Maquinna Dr.	
Judy Burgess	J.S.H. Burgess	751 N. Maquinna Dr	
~~Scott Schooner~~	~~[signature]~~	~~161 McKelvie Rd.~~	

Petition to the Legislative Assembly of the Province of British Columbia

Logging of The McKelvie Creek Watershed ~ Tahsis, B. C.

Action petitioned for:	*We respectfully request that the Legislative Assembly of the Province of British Columbia immediately protect and preserve the McKelvie Creek in Tahsis for drinking watershed, wildlife, and recreational values.*

Printed Full Name	Signature	Address	Comment (optional)
J HARVEY REYNOLDS	J Harvey Reynolds	1024 RESOLUTION RD	
Ramsay Duley	Cwatkins for Ramsay Duley	1042 Resolution Rd	
ANNA M'CRAE	[illegible]	21 Boston	owe $5.00 eggs
MARLENE Kennon	Marlene Kennon	123 Resolution DR	water matters

Late item L.14

Gmail

Glenda Hadley <lilaglendahadley@gmail.com>

Re: Public Boat Landing & Washdown Station

Tue, Aug 6, 2019 at 2:21 PM

Glenda Hadley <lilaglendahadley@gmail.com>
Draft

Village of Tashis: For Consideration

Due to the construction of the SAR building, fishermen have lost the use of the washdown station for their boats and trailers and easy access to the public boat landing. We used to be able to drive through the municipal parking lot in order to complete an easy turn into the public boat landing. Once our boat was launched we could then pull back into the municipal lot to rinse off our trailers.

Losing access to this road now requires making almost a 180 degree hard turn into the boat landing which makes it very hard on the boat trailer bearings.

In addition, the loss of access to the wash down station compounds the problem for bearings and brakes due to damage from submersion in the salt water.

I am asking you to consider creating access to the boat launch area from the north end of the landing which would enable vehicles to drive straight into the landing. I would also ask that you consider moving the wash down station to the top end of the landing. Both these actions would be beneficial to all the boat owners that need to access the only boat launch area in town.

Thank you for your consideration.

Sincerely,

Allen Carter
Tahsis Resident

Grant in Aid Application
Policy #2007

Name of Group or Organization: Culture Days Date: July 10, 2019

I hereby request a Grant in Aid from the Village of Tahsis. The details of this request are below.

1. State the exact amount of monies or in-kind assistance (eg. free use of facilities) requested.

   I am requesting free use of the gym for Sunday, September 29 from 2:00 to 9:00.

2. Briefly outline the purpose of this assistance.

   For the first time, Tahsis is going to take part in a national program called Culture Days. The purpose of this event is to get the public involved in arts activities. The event must be hands-on, free and open to the public.

3. Who will benefit from this activity? How many people will benefit?

   The three activities we are presenting will appeal to a wide age range of people. It is estimated as many as 100 people will attend the three sessions.

4. What steps have you taken to raise funds?

   Tahsis Literacy Society is funding the costs of the three workshops.

5. What other local groups have been approached for assistance? Please indicate what was requested from these groups and whether they have agreed to assist.

   Tahsis Literacy has committed $1300 and is providing the insurance needed at the rec centre under their coverage. Two private citizens are donating funds needed. Accommodation is being provided by homes in town.

Grant in Aid Application
Policy #2007

6. Have you approached the Federal or Provincial governments for assistance? Please indicate what was requested from these Senior Governments and whether they have agreed to assist.

   No.

7 Will this project proceed if funds or in-kind assistance are not provided by the Village?

   Yes, but in a venue that's not as well suited for the project.

Signature of Authorized representative

Please attach a budget for your project. Please be as complete as you can. You may be asked for further financial information.

If a Grant in Aid for funding is approved, the cheque should be made payable to:
No cheque. Just permission to use rec centre gym.
and be mailed to: P.O. Box 150, Tahsis, B.C. V0P 1X0

Contact person: Stephanie Olson
Phone number: 250-934-6236

COSTING OF CULTURE DAYS

Nicole Crouch, Art Therapy workshop

(complete description and Nicole's bio attached)

Budget	
Workshop fee	$325
Travel expenses	$100
Per diems x 2 days	$80
Materials (flexible)	$275 (maximum cost for tempera palettes brushes sharpies/markers
pencils	paper)
TOTAL	$780

Calligraphy Class

Pens $5 x 24 = $120

TOTAL $120

Square Dancing

The Tree Planter Band will come to play and do the calls. They are a group of four musicians who play square dance music at tree planter camps.

Transportation and pay $400

GRAND TOTAL FOR DAY's EVENT = $1300.00

Workshop Proposal for Culture Days in Tahsis, September 2019

Title: Room to Consider

Description: 20-minute slowtime showtime think tank visioning art project followed by 100 minute hanging out and informally continuing the work

Facilitator: Nicole Crouch, Art therapist, M.A., CCC

Synopsis

20-minute intensive: Participants are asked to please stay for the duration of the 20 minutes

Participants gather in a classroom.

The room will have a roll of paper (4 feet wide-esque) around the perimeter on the wall. If only 3 walls, or sections of walls are available, it still works.

First look at the colours in the room

The facilitator will ask participants to imagine a place or places in town where you feel good, places you are drawn to. Start with the places of light

Now imagine bringing colour and shape into these places- What does it look like? Cover everything in art

Prompt:

Go ahead and try to translate these images on the mural wall... Improvise

You can also describe to participating scribes (Celine, Troy or other group members) what they can imagine or go ahead and draw it themselves. Slow patient vibes; pause and room to consider. Encouragement, appreciation, joy.

Consider how these images might be portals- where might they take us? Who might enter through them?

100-minute hangout

Participants are free to come and go as they choose. The facilitators will draw a mountain silhouette line all around the top of the mural and ask participants to fill in the scene by incorporating elements of the town into the art visions.

M2

UBCM ORV Working Group for Rural Communities

Participate with UBCM and local governments via conference call prior to the 2019 UBCM Convention to discuss best practice to improve the ORV Management Framework with minor changes to the existing operation permit process, in support of the resolutions being brought forward at the 2019 UBCM Convention (*see Backgrounder, Resolutions and Aligning with Provincial Legislation References attached*)

Tahsis, Sayward and Tumbler Ridge have put forth an ORV Management Framework Resolution that has been endorsed by their local government area associations (AVICC & NCLGA) to be brought forward for endorsement at the 2019 UBCM Convention for minor changes to improve the existing Operation Permit process to better facilitate ORV tourism and community connectivity.

ORV Working Group participants will discuss the legal and policy considerations for local governments seeking to permit ATVs and SxS to access specific designated routes on municipal roads.

Learn what is currently being done in communities across BC, what bylaws have been passed to permit ORV use, what the challenges are, possible solutions, and opportunities to support and advocate for improved, safe and convenient, incidental access to public roads to allow rural communities to utilize existing infrastructure and sustainable trail networks to maximize the economic development benefits for the whole community.

If you are interested in participating in the UBCM ORV Working Group, please contact Marie Crawford at mcrawford@ubcm.ca at your earliest convenience to ensure you are included in the upcoming conference call.

If you have any questions or would like further information, please contact kim@atvbc.ca

BACKGROUNDER

ORV Tourism – Changing Social & Economic Trends for Rural Communities

Properly managed ATV destination tourism utilizes existing infrastructure and sustainable trail networks to maximize the economic development benefits for the whole community while respecting environmental and cultural values.

Many rural communities are interested in making it legally permissible to ride ATVs/SxS on a designated route in town to access fuel/food/lodging to facilitate tourism. The implementation of the Provincial ORV Management Framework, licensing, regulations and operation permits have made this possible.

The Off-Road Vehicle (ORV) Act was intended to create safe and more convenient incidental access to pubic roads and highways to better connect BC's rural communities and support a first-rate ORV trail network, and to allow local governments to expand their trail networks to take advantage of economic development opportunities by way of tourism.

The ORV Management Framework developed by the Province of BC is a cross-government initiative, consisting primarily of the Off Road Vehicle Act, which includes changes to the Motor Vehicle Act to provide safe, convenient, incidental access to highways including free police-issued operation permits.

As intended the ORV Act is creating significant economic opportunities for rural communities to establish inter-community ORV tourism. In BC we have vast crown land and trail networks connecting our rural communities that easily allow communities to establish a designated ORV trail network that has the potential to connect thousands of kilometers of trails and communities.

For an ORV trail network to be a viable tourism product, it must provide riders the ability to access food, fuel, and lodging for extended trips, which means riders must have ride-in access to services in communities along the route. Many rural communities are now issuing the operation permits required to access these services along a designated route, however currently a separate operation permit from each jurisdiction or community is required, which isn't conducive for tourism, as a rider first must travel to each of the communities to obtain their operation permit.

Currently Operation Permits are issued only by the local RCMP. ORV riders wishing to make a journey involving multiple communities must go to a community prior to making their trip hoping an officer will be there and available, then track down that local RCMP member and when they find the officer, they must hope he/she is able to take the time to issue an Operation Permit for that community. Then the riders must repeat this process in each community they plan to ride into - they might need 6 different permits or more and could take an ORV tourist days of travel to the various RCMP detachments by car, prior to their ride, just to get their Operation Permits, before they can even begin their actual ORV trip.

For many ORV routes, such as the North Island Inter-Community ORV Trail Network which is over 1,000 km's and connects 8 communities approximately only 1% of the route requires incidental public road access for which operation permits must be issued, however currently tourists must travel the whole 1,000 km route to obtain the required operation permits, before their ORV trip can begin.

It would make the Operation Permit process much more conducive to tourism if, once the connecting designated route has been approved by each jurisdiction, only one operation permit needs to be issued to cover the entire route; and that one permit could be issued by any of the jurisdictions along the route, so that a tourist could start their adventure at any location along the route. The permit would list the communities and the specific unique designated routes by which it will allow ride-in access.

Currently Operation Permits are issued only by local RCMP, however that is a drain on local RCMP resources as many rural towns do not have the staffing for these types of administrative tasks, therefore once a safe designated route has been approved by local RCMP or local government, then the local townhall or community office could issue the Operation Permits.

This will allow ORV tourism to flourish between communities, reduce the amount of time and resources for local RCMP and communities to issue operation permits, while creating a viable tourism product.

The ATV rider demographic includes family folks and mature adults, with above average income that enjoys outdoor recreation, cultural activities, dining out, with preference to camping near lakes and rivers, plans trips around specific destinations and are willing to travel. In short, they are they perfect tourist, as many are retired with lots of time to travel, utilizing all four seasons in many areas.

ATV tourism contributes hundreds of millions to the BC economy through product and service purchase from fuel, gear, accessories, to food, accommodation and more. There are roughly 125,000 ATV riders in BC with an additional 495,000 estimated to be within a one day drive of the province. A 2015 economic impact study indicates the combined investment and operating expenditure of ATV/SxS activities in BC has an annual impact of $502 million.

Vera Vukelich, the Manager Responsible for ORVs, Ministry of Forests, Lands, Natural Resource Operations and Rural Development, issued a letter dated July 2016 advising:

"I would also encourage your members to continue to work collaboratively with local staff from the Ministry of Transportation and Infrastructure, the Ministry of Forests, Lands and Natural Resource Operations, and local governments on proposals for ORV trails/routes that provide safe incidental access to highways (i.e. ORV travels along portions of the highway right-of-way to access a trail, ability to access gas stations and signage is in place for ORVs that may need to travel on the road for a short distance – of course, local circumstances will vary)"

The UBCM 2018 Annual Report (pg 41) advises that UBCM continues to monitor the implementation of the new ORV Act and its accompanying regulations, and that engagement continues with local governments interested in expanding their trail networks to take advantage of economic development opportunities by way of tourism, therefore the mechanisms are in place for local governments to work collaboratively with UBCM to advocate for improvements to the ORV Management Framework to better facilitate tourism and economic potential for rural communities.

OPPORTUNITIES TO SUPPORT ORV TOURISM

2019 UBCM ORV Working Group participate with UBCM and local governments via conference call prior to 2019 UBCM Convention to discuss best practice to improve the operation permit process in support of the ORV resolutions coming forward, identify goals and challenges. To participate, please contact mcrawford@ubcm.ca

2019 UBCM Session Proposal *jointly submitted by Sayward, Tahsis, Tumbler Ridge and ATVBC (UBCM approval pending)* – Attend and encourage others to attend the proposed clinic at UBCM Convention for a better understanding of the provincial regulatory framework which governs ORV use, the benefits of ORV tourism, and economic potential for rural communities.

2019 UBCM Convention Resolutions – show your support by voting in favour of the ORV Management Framework Resolutions coming forward for endorsement at the 2019 UBCM Convention from Sayward, Tahsis, and Tumbler Ridge as endorsed by AVICC and NCGLA.

ATVBC Booth at 2019 UBCM Tradeshow – visit ATVBC Booth #1020 for info and support for ORV tourism and rural economic development. For further info please contact kim@atvbc.ca

ORV Tourism - Aligning with Provincial Strategies & Legislation

The Province of BC recognizes that ORVs are increasingly popular across British Columbia prompting development of the Off-Road Vehicle Management Framework for safe and responsible use of ORVs on Crown land.

"Safe and more convenient incidental access to public roads and highways is key to the ORV Management Framework"

ORV tourism is supported by the Province of BC's ORV Management Framework with improved incidental public road access to better connect BC's rural communities in support of a first-rate ORV trail network. The BC government continues to implement improved road and highway crossings, in stages, under the Motor Vehicle Act.[1]

ORV tourism aligns with the Province of BC Trails Strategy vision of a world-renowned, sustainable network of trails, with opportunities for all, which provides benefits for trail users, communities and the province.[2]

ORV tourism allows rural communities to embrace the 2019-2021 Strategic Framework for Tourism in BC "*Welcoming Visitors – Benefiting Locals – Working Together*"[3] by allowing communities to utilize existing infrastructure and trail networks to support sustainable tourism growth.

ORV tourism supports people and improves the quality of life in rural communities by increasing the economic benefits for the whole community (direct and indirect spending) and enhances communities by establishing trails systems and community connectivity on designated routes to ensure users stay on trails to protect nature and respect the environment.

Based on an independent economic impact study completed by Smith Gunther Associates Ltd in 2015, **Canadians spent $6.9 billion on activities directly involving ATVs and SxS**, and the ATV/SxS recreation economy in **BC generated $502 million in consumer spending, 6,000 jobs, $260 million in labour force income, and $149 million in tax revenue annually**[4] (*note: 2015 study based on 100,000 machines; ICBC 2019 registration data indicates 20% plus increase, with over 120,000 ATV/SxS's registered in BC*)

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[1]Province of BC, Off Road Vehicles, ORV Management Framework, Improved Road Access for ORVs
https://www2.gov.bc.ca/gov/content/industry/crown-land-water/crown-land/crown-land-uses/off-road-vehicles/improved-road-access

[2]Province of BC, Trails Strategy for British Columbia
http://www.sitesandtrailsbc.ca/documents/Trail-Strategy-for-BC_V6_Nov2012.pdf

[3]Province of BC, Strategic Framework for Tourism in BC
https://www2.gov.bc.ca/gov/content/tourism-immigration/tourism-resources/bcs-tourism-framework

[4]Canadian Off-Highway Vehicle Manufacturers Council, Economic Impact Study of ATVs and SxS
https://www.cohv.ca/press-releases/canadians-spent-6-9-billion-on-direct-activities-involving-atvs-and-rovs-in-2015/
https://www.cohv.ca/wp-content/uploads/2016/11/Reduced-Two-Total-Economic-Impacts-of-ATVs-and-Side-Final-Report.pdf

Association of
Vancouver Island and
Coastal Communities

2019 Resolution

R6) Off-Road Vehicle (ORV) Management Framework **Village of Sayward, Village of Tahsis**

WHEREAS the Off-Road Vehicle (ORV) Act was intended to create safe and more convenient incidental access to public roads and highways to better connect BC's rural communities and support a first-rate ORV trail network, and to allow local governments to expand their trail networks to take advantage of economic development opportunities by way of tourism;

AND WHEREAS the current administrative process to obtain Operation Permits as permitted under the ORV Act is onerous and not conducive to convenient incidental access to trail networks connecting multiple communities as a separate operation permit must be obtained from each jurisdiction:

THEREFORE BE IT RESOLVED that the following changes to legislation are made:

- Only one (1) Operation Permit required for approved access to multiple jurisdictions and/or communities along a connecting designated ORV route and trail network issued in any of the jurisdictions or communities along the route.
- Operation Permits can be issued by any local RCMP or local government along a designated route.
- Operation Permit term extended from 2 years to 5 years to align with the driver's licence term.

Resolutions Committee recommendation: No Recommendation

Resolutions Committee comments:

The Resolutions Committee notes that the UBCM membership has not specifically addressed the issue of ORV operating permits. However, members have more broadened endorsed resolutions related to ORVs, such as 2013-B97, which requested provincial legislative amendments to authorize a local government to regulate the operation of off-road vehicles on municipal roads within that local government's boundaries.

Prior to 2013, the UBCM membership consistently endorsed resolutions calling on the Province to enact legislation and regulations for licensing and registration of off-road vehicles (2009-A6, 2007- B20, 2005-B10, 2002-B9).

https://avicc.ca/wp-content/uploads/2019/04/Program-and-Resolutions-2019.pdf
Page 36

ORV Management Framework Improvements to Facilitate Tourism

Sponsors: District of Tumbler Ridge

Year	Category	NCLGA Ref#
2019	Community and Resources	R18

STATUS

NCLGA Executive Recommendation: No Recommendation | Endorsed by the NCLGA Membership

DETAILS

Whereas the Off Road Vehicle Act (ORV) was intended to create safe and more convenient incidental access to public roads and highways to better connect BC's rural communities and support a first-rate ORV trail network and to allow local governments to expand their trail networks to take advantage of economic development opportunities by way of tourism;

And whereas the current administrative process to obtain Operation Permits as permitted under the ORV Act is onerous and not conducive to convenient incidental access to trail networks connecting multiple communities as a separate operation permit must be obtained from each jurisdiction;

Therefore be it resolved that the following changes to legislation are made:

- Only one (1) Operation Permit required for approved access to multiple jurisdictions and/or communities, along a connecting designated ORV route and trail network, which can be issued in any of the jurisdictions or communities along the route.

Operation Permits can be issued by local RCMP or local government.

Operation Permit term extended from 2 years to 5 years to align with driver's licence term.

RESPONSES

The Resolutions Committee advises that the UBCM membership has not specifically addressed the issue of ORV operating permits.

However, the Committee notes that the membership has more broadly endorsed resolutions looking to license and regulate ORVs (2016-B67, 2013-B97, 2011-B20, 2009-A6, 2007-B20, 2005-B10, 2002-B9).

View All Resolutions (/documents/resolutions)

M3

VILLAGE OF TAHSIS

Report to Council

To: Mayor and Council

From: Mark Tatchell, CAO

Date: July 22, 2019

Re: Municipal Insurance Association of BC ("MIABC") Voting Delegate and Alternate

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PURPOSE OF REPORT:

To seek Council's consideration of voting delegate and alternate for the MIABC Annual General Meeting to be held on September 24, 2019 in Vancouver in conjunction with the UBCM Convention.

OPTIONS / ALTERNATIVES

1. By resolution select a Voting Delegate and Alternate to vote at the MIABC Annual General; or
2. Any other alternative that Council deems appropriate

BACKGROUND:

The Municipal Insurance Association of BC (MIABC) Voting Delegate Orientation is scheduled to take place on September 24th at 4:00 p.m., immediately followed by the 32nd Annual General Meeting (AGM) at 4:30 p.m. These events will be held in Waterfront Ballroom A/B of the Fairmont Waterfront Hotel in Downtown Vancouver, located directly across from the Vancouver Convention Centre where the UBCM Convention is taking place.

The Village of Tahsis MIABC registered Voting Delegate is the late mayor, Jude Schooner. There are no alternates registered with MIABC to vote.

Under Article 6.13 of the Reciprocal Insurance Exchange Agreement, a Council resolution is required to change the voting delegate and/or two alternates. The resolution must be forwarded to MIABC by September 9th, 2019.

The AGM Booklet with further voting information will be distributed on August 23, 2019.

POLICY / LEGISLATIVE REQUIREMENTS:

N/A

FINANCIAL IMPLICATIONS:

N/A

STRATEGIC PRIORITY:

N/A

RECOMMENDED RESOLUTIONS:

Moved, seconded by Councillor ______________ THAT ______________ be selected as the Village of Tahsis Voting Delegate for the MIABC 2019 Annual General Meeting and future annual general meetings.

Moved, seconded by Councillor ______________ THAT ______________ be selected as the Village of Tahsis Alternate #1 for the MIABC 2019 Annual General Meeting and future annual general meetings.

Respectfully submitted:

Mark Tatchell, CAO

M4

VILLAGE OF TAHSIS

Report to Council

To: Mayor and Council

From: Mark Tatchell, CAO

Date: July 24, 2019

Re: Local Government Diking Authority

PURPOSE OF REPORT:
To seek Council's consideration to authorize the Village of Tahsis as the diking authority for existing dikes, improvements to these dikes as well as any new dikes that may be constructed.

OPTIONS / ALTERNATIVES

1. Approve the following proposed resolutions:

   "Moved, seconded by Councillors __________________ THAT to protect the public interest and safety of life and property that the Village of Tahsis become the diking authority and be fully responsible for the operation and maintenance of existing dikes, improvements to those dikes and new dikes and that the Village secure legal access to the lands on which all dikes are constructed."

   "Moved, seconded by Councillors ____________ THAT Council approve submitting a grant application to the Structural Flood Mitigation 2019 program."

2. Do not approve the proposed resolution;
3. Seek additional information from the Ministry of Forests, Lands, Natural Resource Operations and Rural Development; or
4. Any other alternative that Council deems appropriate

BACKGROUND:
Under the *Dike Maintenance Act*:

"dike" means an embankment, wall, fill, piling, pump, gate, floodbox, pipe, sluice, culvert, canal, ditch, drain or any other thing that is constructed, assembled or installed to prevent the flooding of land;

"diking authority" means

(a) the commissioners of a district to which Part 2 of the *Drainage, Ditch and Dike Act* applies,

(b) a person owning or controlling a dike other than a private dike, (b.1) if the final agreement of a treaty first nation so provides, the treaty first nation in relation to dikes on its treaty lands,

(c) a public authority designated by the minister as having any responsibility for maintenance of a dike other than a private dike, or

(d) a regional district, a municipality or an improvement district;

For historical reasons, the approximately 100 diking authorities in BC are comprised of several types of legal entities including municipalities, regional districts, improvement districts, diking districts under the Drainage Ditch and Dike Act, strata corporations, rate payers associations, government agencies, non-government organizations, private corporations and private individuals.

Operational experience over the past few decades has shown that many of these "diking authorities" have had significant difficulties in maintaining an "ongoing, adequately funded dike management program..." and "acquiring and maintaining legal access..."
This has been particularly true for those diking authorities that do not have the powers that are provided to local governments with respect to taxation, emergency response, land use approvals, expropriation, and other regulatory authority.

For more than ten years it has been provincial government practice to require that the diking authority for the new dike must be a local government.

The Village has two dikes, the North Maquinna floodwall and the dike that runs parallel to Cook Street. Although the Village was involved in the construction of both dikes, there is no record indicating that Council approved becoming a diking authority under the *Dike Maintenance Act*.

Having completed the Tahsis Flood Risk Assessment study, the Village is positioned to apply for funding under the provincial government's Structural Flood Mitigation 2019 grant program. The application deadline is October 25, 2019. To be eligible for the program, the local government applicant must be the diking authority for the dikes that would be improved with the grant monies.

POLICY/LEGISLATIVE REQUIREMENTS:

The policy and legislative requirements are described above.

FINANCIAL IMPLICATIONS:

The Village currently functions as the diking authority by conducting inspections, submitting reports and carrying out maintenance and repairs as needed on both dikes, so the Village has already absorbed those costs in the operating budget. To access provincial government grants it is a requirement for a local government to be a diking authority.

STRATEGIC PRIORITY:

N/A

RECOMMENDATION:

Approve the resolutions in Option 1.

Respectfully submitted:

Mark Tatchell, CAO

Late item
m.5

Demonstration Project Grants Application Form

About Toward Parity in Municipal Politics

Toward Parity in Municipal Politics is a 30-month project from the Federation of Canadian Municipalities, funded by the Department for Women and Gender Equality. Implemented in partnership with provincial and territorial municipal associations, Equal Voice and the Canadian Women Foundation, the project is building on past projects and current momentum towards greater equality in the municipal sector. Toward Parity will develop a National Action Plan to help overcome the barriers and increase opportunities for women to participate fully in Municipal politics.

About Demonstration projects

- Projects are eligible for up to **$5000 in funding.** The grants are intended to be either seed funding to incubate a new idea and gain support for gender equality in the community or to scale up an idea or initiative that has shown promise.
- **Submission deadline:** Please submit your application to women@fcm.ca by **August 15, 2019**
- The project must be implemented between **mid-September 2019 and June 1, 2020.**
- Applications must be led by an FCM member (municipal or local government) or affiliate member such as a provincial or territorial association.
- Successful applicants must have a partnership between a municipal or local government and a women's organisation, youth or community group working on women's issues or inclusion.
- Must focus on increasing opportunities or reducing barriers for women in municipal politics.
- Projects which promote diversity, inclusion and integration of youth will be prioritised.
- **Must be non-partisan** (funds cannot be used to support candidates, contribute to a political campaign or to a political party).

More information about eligibility requirements and submission process are available on our website.

Part A: Applicant information

Lead Applicant: Contact information

Please select your applicant type from the list below.

X Municipal/Local government (e.g. town, city, region, district, and local boards thereof)

- ❑ Group of municipalities
- ❑ Provincial or Territorial Association
- ❑ Municipality or group of municipalities - this includes partner Indigenous community with a shared service agreement

Mailing address

- Organization name (Please indicate the legal name of your organization) **-Village of Tahsis**
- Department - **municipal government**
- Mailing address **977 south Maquinna drive p o box 219**
- City – **Tahsis,**
- Province/territory – **British Columbia**
- Postal code – **V0P 1X0**
- Telephone number - **250-934-6344**

Primary contact information

- Salutation (optional)
- First name **-Sarah**
- Last name- **Fowler**
- Middle initial (optional)
- Title **municipal councillor**
- Email **sfowler@villageoftahsis.com**
- Telephone (business) **250-934-6344**
- Mobile phone (optional) home 250-394-7713

Partnerships: Contact information

Working in partnership is an essential element for this proposal as a means to increase reach, sustainability and impact of the initiative. Applications not working in partnership will not be considered. Partner organizations should be a women's organization, a community group or other incorporated body working on the promotion of gender equality, diversity and/or inclusion.

If working with multiple partners, repeat questions in this section for each partner involved in the project.

Primary contact information for eligible partner, municipal or Indigenous community partners

- Name of partner organization **JCR junior canadian rangers, (ladies auxiliary)**
- Province **British Columbia**
- Contact name and title **Dan Dahling; patrol leader Tahsis division (Debbie Vansolkema)**
- Email address **headbay@cablerocket.com**

Describe the partner organization

Up to 600 words.

Please provide a description of the partner organisation, mission and objective. Include examples of other projects, initiatives or activities that will be helpful to the successful delivery of the demonstration project.

The JCR's is a community based youth group supported by the cadet organization and national defence. The mandate is to promote three circles of learning and practice ranger skills like survival camping, as well as traditional indigenous and life skills. Their mission is to be an inclusive body that trains and celebrates service. In past partnerships they have been involved with the Tahsis Valley Fire Department to delivery pamphlets, canvassing door to door, during emergencies like boil-water advisories. They have also participated in stream keeping initiatives by planting trees in the Mckelvie watershed to address erosion and brought chainsaws to Yuquot (Friendly Cove) to help provide firewood. For Tahsis Days they partner with the ladies auxiliary to put on the duck race fundraiser, a canoe in the Inlet to retrieve the release rubber ducks. Annually they are involved in our municipal Remembrance Day ceremony at the cenotaph. The JCR's are a great opportunity for youth to develop leadership and team skill in addition to being involved in shoreline and clean up's. To be successful in a demonstration project for the towards parity initiative they would be integral in providing invaluable logistics and boots on the ground.

Describe the nature of the partnership

Up to 600 words.

Please describe the nature of the partnership between the lead applicant and women's group or community partner, including an overview of the collaboration, any previous joint initiatives and how roles and responsibilities will be shared among the participants (e.g. terms of reference or Memorandum of Understanding, evidence of municipal council support, financial contributions, etc.). Bullet points are acceptable.

- The nature of the partnership between the JCR's and the lead applicant (Councillor Fowler) is to establish a base camp for tapping Big Leaf Maple trees at the Village of Tahsis, owned property called Pete's farm during the march break week off school.
- This based camp is designed to explore potential opportunities in local food production but also provide a gathering space to have fireside chats about barriers and resiliency development strategies.
- By integrating the youth centred JCR group and the senior centred ladies auxiliary we share the common ground of diversity and valuing experiences that are different from our own.
- More collaborative opportunities of inclusion could focus on women issues in political campaigns by inviting the PAC of Captain Meres Elementary secondary school (Parents Advisory Council) once school starts in September.
- Previous joint initiatives in our small tight knit communities provide a highly collaborative chance to celebrate the caregivers and bucket fillers.
- The roles and responsibilities of setting up camp as school is over will be shared by the JCRs and the lead applicant. Leading up to the event we will need to secure in kind donations of firewood, camp equipment, cooking pots and buckets to collect the tree sap.

Provide evidence of commitments between partners

Please attach supporting documents that demonstrate a commitment between the partners who are applying to share a staff person under this grant.

- **For groups of municipalities**: You must provide proof of commitment by all partners involved. Supporting documents may include a Memorandum of Understanding, partnership document, letters of support from partner organisation signed by the Director, chief administrative officer or chief financial officer, council resolution, etc.

Note: if working with multiple partners please include the requested information for each partner implicated in the project. time sensitive deadline(AUG 15) motion presented as a late item at the aug 6 regular council meeting

evidence of municipal council support,

to apply for the grant application it is required that the village council to pass a motion below

whereas inclusion is part of the new code of conduct

therefore it be resolved to support councillor fowler`s

draft application to the FCM towards parity demonstration project https://fcm.ca/en/news-media/announcement/wilg/toward-parity-demonstration-projects?_cldee=bXRhdGNoZWxsQHZpbGxhZ2VvZnRhaHNpcy5jb20%3d&recipientid=contact-f98c5392ded9e61181c0005056bc2daa-3309d8f0ba06454e8f7ba8534c002bfc&utm_source=ClickDimensions&utm_medium=email&utm_campaign=FCM%20Voice&esid=63b0c195-8fa1-e911-80cc-005056bc7996

further support could include...

Approve grant in aid to allow for the use of Pete's farm,

Confirm opening of gate to allow vehicle parking and ease of access to the Leiner river waterfront.

Part B: Description of proposed initiatives

What is the focus and objective of your proposal?

500-1000 words. 35% of score.

Please describe the context and how this initiative will be able to open opportunities for women to engage in municipal/local leadership.

Feel free to include an overview of the realities, opportunities and potential in the community. Who are you targeting? What are you hoping to achieve? Why is it important to your community? How will this impact women in your community?

Note: Higher scores will be attributed to initiatives that also address one or more of the following:

- Initiatives that are targeting marginalised women or women who experience impacts from multiple barriers (including but not limited to indigenous women, racialized women, LGBTQ2S+, young women, etc.)
- Leveraging of resources to expand the reach, impact or scale of the grant (either from the community or from other funding sources)
- proposals that are the right size and scale for the community, that build on the community's unique strengths or character and those with high probability of success or replicability

The bucket filler March break campaign school is non partisan and open to all interested in participatory governance and place making. From spiel to syrup, integrates all ages and orientations including radicalized and LGBTQ2S+ for a shared goal, to make a local food product. A working group activity, welcome to anybody, where we will drill some large maples and observe how the sap is running given the weather.

To engage in an overview of realities for our community I will quote the Primary teacher (another great local role model and women leader) told me when I was lifeguarding, that "housekeeping sucks the soul." I believe my own experience of being a stay at home mom needed to hear someone else articulate what i was feeling. The constant nurturing and monotonous tasks oscillating between clean and dirty, care giving was draining my energy and reserves. Motherhood mimics this theme as I easily became stir crazy if stayed in the house all day trying to get ahead on my daily list of chores. Despite seemingly continuous effort I didn't seem to been making a dent in the mess or reaching my goal for the day.

By changing my objective to be more present in the moment (even in the hard ones) and make things like going to the park or social gathering more of a priority did I see more value in the efforts I made? This is evident by my own pursuit of working as a lifeguard for the village so I could take advantage of the chance to have a change of scenery, to embrace a ambition and aspiration that was outside of my motherhood identity. I imagine that caregivers of elderly or infirm people have the same test to incorporate self care into their routines. My desire to get out of the house in the evenings and talk to other people, illustrated how isolated I felt as a mother of young children.

Demands of the caregiver are vast and require a hyper vigilant attitude, whereby repetitive tasks are never complete. To maintain the activities of living is a form of leadership that is rhythmic and cyclical. I believe the talent and potential for local women to engage in municipal governance is ripe. In gathering in a culturally significant outdoor space we can embrace our pioneer spirit and be brave to express and validate each unique truth, together.

Improved access to information sharing, tools, training and a set of best practices, regardless of gender can allow empowerment. Informed decision making requires sometimes comparing apples to oranges and juggling a wide range of priorities. To dispel negative stereotypes or false perceptions discourse is required and collection of disaggregated data leads to a more fulsome intersection of what would otherwise seem unrelated.

Increased support mechanisms to address structural issues that can impede women from participating in public office. The work life balance includes a delicate web of daycare, or other family supports or responsibly, with a network of mentors, practical transportation sharing and normalizing nursing rooms in public/private spaces. To allow for a democratic system that is welcoming to all we must evolve to make government policies inclusive. Parental leave, economic inequity, elder care and stronger ties between minority communities can lead to more consultation and nuanced decision making.

This program's title was in part inspired by my child's junior kindergarten class. They had a bucket they filled up with pompoms every time the teacher witnessed an act of kindness, co-operation or inclusion. When the bucket was full they had a party celebrating the success of their students creating a welcoming atmosphere in their class room. It speaks to the way that every effort (or voice for that matter), albeit small or seemingly insignificant can have ripple effects and be an important part of the cumulative goal.

I hope to achieve a safe listening space that allows us to offer respite to caregivers of children, the infirm or elderly. By targeting the personal support workers, we can empathize with the impacts of multiple barriers. From social well being to self care we need to gather during the rainy season to counteract the unconnected feelings that can occur when people segregate and nest in their individual homes. To sustain a living collective action, whereby many hands work in unison to make maple syrup we can foster a do-it ourselves, can do attitude. Further our children can understand the work involved to make something from scratch, to teach them where things come from before they get to the store.

Choose your pillar

One of Toward Parity's main goals is to create an action plan that will **increase women's participation in municipal politics by increasing opportunities and reducing barriers**. At the core of this action plan are four pillars of action.

Please select **one pillar** that best describes the proposed activities for the demonstration grant.

- ☐ **Pillar 1: Improved Access to information:** Initiatives that enhance the sharing of information, tools, best practices, and training; includes the collection of disaggregated data for informed decision making and dispelling of negative stereotypes or false perceptions.
- X **Pillar 2: Enhanced Inclusion:** Incudes initiatives that facilitate the participation of all people, especially those efforts that strive to reduce systemic barriers (sexism, racism, ableism, etc.), economic inequality, intimidation and harassment.
- ☐ **Pillar 3: Increased support**: Mechanisms that provide support for some of the structural issues that could impede women from participating in public office. This can include, but is not limited to, access to mentorship, tools for work-life balance, support for family responsibilities, and practical supports like child care, transportation, nursing rooms etc.
- ☐ **Pillar 4: Improved governance and structure**: Include initiatives that are targeting systems and policies that are inclusive for all, such as parental leave or elder care. This also includes activities that improve participation and strengthen consultation with women and minority communities, and build stronger ties and nuanced decision making.

Describe where you see the initiative having the greatest impact: run/win/lead

Up to 400 words. 25% of score.

Barriers and opportunities can present themselves differently depending on the context of the candidate or elected official. Please state how your initiative will be moving the needle toward parity by either increasing the number of women running for local government, winning their campaigns or aimed at supporting women on council be successful and remain on council.

- **Run** – Increasing the number of women who consider or submit their candidacy. Can includes initiatives that provide education opportunities about being engaged in municipal leadership, such as committees, school board, etc.
- **Win** – efforts designed to help more women run more successful campaigns and win their candidacy. This can include campaign schools, training programs, skills building etc.
- **Lead** – address the context or realities faced by women, once they are on council or in local government, to be successful, have impact and want to remain in local government. Mentorship, enhancement of work life balance supports, anti-harassment initiatives can also be included here.

Tahsis has a strong legacy of women in leadership, so celebrating the successful candidates and female mayors would be a good start. I myself have identified Anne Cameron as a personal mentor whose truth telling steps I try follow in. I admired the way that the late Jude Schooner was calm in her demeanor. The challenge of moving the leadership needle towards parity must be implicitly seen as sharing stories of our challenges and accomplishments, the sum of its parts. Holistic approach of building bridges between identifies and our differences highlight the strength of interwoven diversity.

When I first ran for municipal council I was pregnant with my second child and I doubted my ability to juggle all the needs required of me. I lacked the confidence and support structure to believe I could rise to the challenge. I didn't even vote for myself the first I put my name on the ballot. Now I understand better how my faults and struggles can be a journey, that to slowly walk this road, humbly has helped me to build skills to persevere to become, all the more resilient. My recent win helps me comprehend the way to incorporate and encourage varied points of view. To connect the gaps and participate in a growth mindset I hope to become the best leader I can be, a role model for my own daughters and to find young people who want to take on an apprenticeship. The idea of service as passion and amalgamation of work and life to be a worthy artistic pursuit has lead me down a path of constantly making calculated, deliberate steps towards a shared goal.

To encourage more minority or female candidates to run, walk, crawl, take chances, make mistakes from which to learn and to stick there neck out requires us to rejoice and honour the sacrifices and contributions made by those who came before us. I know more now, than I did before, new information comes in so I evolve in my process. Opening my mind further than I previously thought possible, bit by bit slowly filling like a bucket, spilling over my modest expectations. I admire the vision and tact of those locally I have witnessed doing what they can do to be involved in governance.

Describe the anticipated impacts of your proposed initiatives

500-800 words. 25% of score.

Describe your vision of the impacts, sustainability and replicability of the initiative. Please include the probability of a ripple effect or any other anticipated impact of the project.

Objectives for a successful delivery are more about determining various spectrums of priorities, a variety course of action, oriented to process rather than results based. Ideally I think it likely to be a creative journey that will have surprising aptitudes surface from unlikely talent. Supplementary effects could be the engagement of indigenous elders and youth and the shared care giving of children at a time when school it out. The learning continues when the student become the teacher.

The anticipated impact is to have a wide-ranging roll call of candidates for the next municipal election. Beyond that I foresee increased assortment of points of view to more represent the full gamut of situations. To address the economic inequality we need to adopt a more anti discriminatory attitude, since homeless people cannot vote without proof of address. In addition to the potential outcome of delicious maple sap, we can have team building role play which builds empathy for those we would otherwise generally feel in contrast too.

As a non partisan, all party participatory candidate communication prospect we can offer a range of skill building sessions. Inclusion campaign school is a chance for using traditional techniques and liaison between different distinct groups. I hope to attract people with special needs as well as my peers, the other parents of young children in the village. The Junior Canadian rangers, a youth group of mainly teenager, together with the ladies auxiliary, which is predominately composed of seniors, expects to create a dynamic assortment of attitudes. Further we develop better proficiency at appreciating and indulging outlooks we would otherwise feel distanced from.

The ripple effect of hosting a March break campaign school is something that requires as much or as little financial contribution as one has. It can include professional fees and travel honorariums or can be an intimate gathering of a few hardy folk who didn't have a vacation planned. Scalability is flexible and resources can be leveraged to expand reach. It can be done with in-kind donations and sweat equity as it will reflect the unique character and flavours of any Canadian region. Finding the right size of informal networking assembly is an organic progression that will flex dependent on the circumstances.

In my estimation this bucket filling/ spring melt initiative is highly replicable and sustainable. Supplies can be brought from home like buckets to collect the sap in. Many people in Tahsis have wood heat so we can easily source the fuel to evaporate it into a thicker sap. I have jars at home if we end up having enough of a finished product to distribute and have taped as little as one mature tree. Learning about aptitude is a gradual process, the wisdom of watching and waiting for the right time or conditions. To make an inclusive process and reduce systemic barriers like sexism, racism and ableism we need everyone to participate. Without intimidation and harassment we can best strive for all people to be involved in the development and expansion of the commons.

Provide a summary budget and work plan

15% of score.

Attach a summary budget and work plan to this application. Note: the work plan can be a list of activities and timeline, a simple Gantt chart or a list of key dates with objectives that will result in successful delivery of the initiative.

Tentative key dates 2019-2020

July 29 secure JCR and ladies auxiliary partnerships

July 31 draft demonstration project application form for FCM towards parity initiative

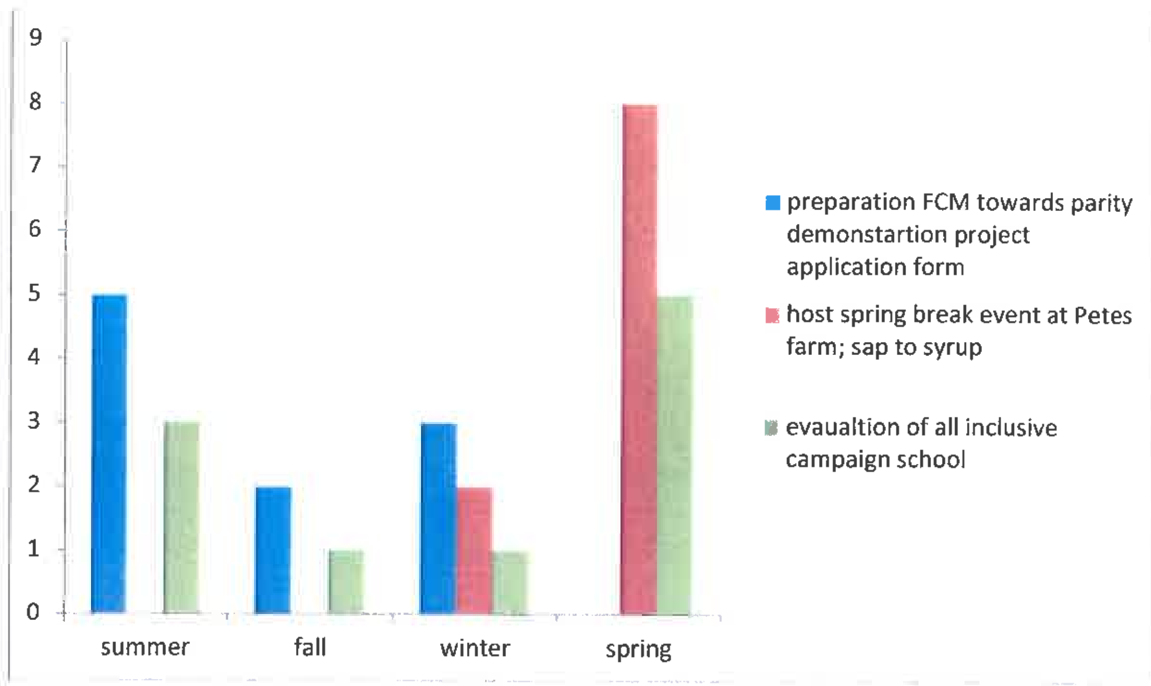
August 1-5 Circulate to Village of Tahsis council to secure Pete's farm location of March break gathering

August 6 Village of Tahsis, regular council meeting ; obtain evidence of municipal council support;

August 14 submit application form to FCM women@fcm.ca for Aug 15 deadline

Sept 3 submit grant in aid to open gates of Pete's farm during spring break

March break sap to syrup, inclusive campaign school with VOT and JCR



Sept- March

Facilitating donations of firewood , buckets, cooking pots, and jars for finished maple syrup

Invite indigenous elders and youth from the MMFN as well as promote to other groups like PAC, (parents advisory council) TCGS (Tahsis Community Garden society) Lions Club and Heritage society

Determine which Big leaf maples on the site are the most mature and best to drill a spiel into.

Spring break -Host base camp for the non partisan all parties campaign school fireside gatherings

Spring to summer 2020- distribute evaluation forms,

Follow up on expenses incurred

Thank all involved participants

Part C: Declaration and signature

Please review this declaration and have it executed by an authorized signatory of the Applicant. This declaration confirms that: a) the Applicant understands and will abide by the Federation of Canadian Municipalities' ("FCM") requirements, including those related to funding; and b) the information provided in and appended to the application is accurate and complete.

I, ____________Sarah Fowler_______________ **[name]**, _______________municipal _councillor _________ **[title]** of the _____village of Tahsis___________________________ **[organization]** (herein called the "**Applicant**"), hereby declare, without personal liability and in my capacity as __municipally elected council member________________ **[title]** of the Applicant, as follows:

1. That the Applicant will not be able to receive funding from FCM prior to entering into a legally binding agreement with FCM (the "**Agreement**") in respect of the project being applied for (the "**Initiative**") and that the said Agreement will contain pre-conditions to funding, all of which the Applicant must comply with, including without limitation:
    a. the Applicant having obtained all authorizations required to enter into the Agreement and carry out the Initiative;
    b. the Applicant having obtained assignments of copyright and waivers of moral rights from any consultants or third-parties who have contributed or will contribute to reports prepared on the Applicant's behalf, such that the Applicant will hold the copyright in all reports related to the Initiative;
    c. the Applicant providing reports and consenting to FCM sharing the lessons learned and experience gained from the Initiative with other communities across Canada by allowing FCM to publish reports, such as project completion and final reports, on the FCM website; and
    d. the Applicant having incurred costs in connection with the Initiative, and paid for by the Lead Applicant.
2. That the Applicant will carry out the Initiative in compliance with all applicable laws and regulations.
3. That the Applicant will confirm to FCM all sources of funding prior to executing the Agreement.
4. That all of the information contained in this application and in the accompanying documents is true, accurate and complete as of the date of submission.
5. That if any of the information contained in this application and in the accompanying documents becomes inaccurate, incomplete or incorrect, the Applicant will provide updated information and/or accompanying documents.

6. That the Applicant acknowledges and agrees that changes in scope to the initiative after this date of application may not be accepted by FCM.

By providing my signature I acknowledge and agree to all statements above.

__________Sarah Fowler____

Full Name (Print)

smfowler

Signature

July 31, 2019

Date

Note: The information provided in this application, including all attachments, will be kept confidential. Access to this information will be limited to:

- FCM employees and professional representatives who are involved with your Initiative
- FCM affiliated reviewers
- persons to whom the applicant has granted access and persons authorized by law

The information provided in applications, including attachments, is subject to FCM's Privacy Policy.

Appendix A. Eligible expenditures

Eligible expenditures are costs considered necessary to support the project. For this CFP, eligible expenditures include, but are not limited to:

Direct delivery expenditures (considered necessary to support the project)

- Travel: Travel expenses shall not exceed the rates for civil servants set out in the National Joint Council Travel Directive.
- Honoraria and professional fees
- Materials and supplies
- Facilities that are project specific such as room rental for activities
- Translation
- Engagement of Indigenous Elders
- Publicity and promotion
- Other:
    - Integration expenses relating solely to caring for dependants/children, elderly or persons with special needs
    - Expenses not included in other budget items, such as costs for refreshments/meals served during key project activities.

Note: All eligible costs are subject to assessment and negotiation.

Ineligible expenditures

Ineligible expenditures include, but are not limited to:

- Capital expenditures or equipment, such as a computers, land, buildings, vehicles and other major capital costs;
- Salaries, allowances, and benefits for members of a board of directors or other decision-making body;
- Campaign financing
- Provide direct service delivery (e.g. hiring additional staff to implement the activity);
- Capital renovations and construction;
- Activities that take place outside of Canada.
- Canada Revenue Agency or payroll penalties;
- Budget deficits, debt reduction, organizational reserves or endowment funds; and
- Costs incurred before a funding decision is made.

Appendix B: Applicant Evaluation

Note that the lead applicant is the entity (municipality, local government) that is applying for a grant as part of the Toward Parity demonstration projects and who will receive the funds from FCM if the application is successful. Successful applicants will be required to sign a Letter of Agreement with FCM outlining the objectives of their initiative and how the funds will be used.

	Criteria	Yes	No	Comments
1	The applicant is a local government (or consortium of local governments) and member of FCM	X		
2	Is working in partnership women's organisation, youth group, community group or Not-for profit	X		**JCR**
3	The applicant has demonstrated support of its senior decision makers and that of its partner as evidenced by a letter, motion or other directive from its Council, Board of Directors, Chief Executive Officer, President or other relevant official		X	**Expected August 6**
4	The initiative increase opportunities for women to engage in municipal/local leadership or reduce a barrier that is women in the community are experiencing limiting their participation.	x		
5	Links with one of the 4 Pillars of Action: ❑ **Pillar 1:** Improved Access to information: ❑ **Pillar 2:** Enhanced Inclusion : ❑ **Pillar 3:** Increased support: ❑ **Pillar 4:** Improved governance and structure:			**Pillar 2 focused**
6	Rational and impact on Run/Win/Lead with concrete examples of impact.	x		**Mistakes as learning**
7	Outlines the impact, sustainability and replicability of the initiative	x		

	Criteria	Yes	No	Comments
8	Includes a realistic budget and work plan	x		**Can commence without financial support**
	Optional Criteria: for additional considerations • Initiatives that are targeting marginalised women or women who experience impacts from multiple barriers (including but not limited to indigenous women, racialized women, LGBTQ2S+, young women, etc.) • Leveraging of resources to expand the reach, impact or scale of the grant (either from the community or from other funding sources) • Proposals that are the right size and scale for the community, that build on the community's unique strengths or character and those with high probability of success or replicability • Link with prioritized areas of intervention – mentorship, increase information, breaking down informal networking and decision making	x		**Creative fusion** **Local food work party**