

# Adaptation & Rehabilitation







## **Evidence of increased Variability**

**Increased Climatic  
Variability**

**Increased Demand &  
Limited Supplies**

**Increased Land Use  
Changes & Intensity**

**Land Use Change and Climate Change Interaction**

**Climate Change**  
**Increased Climatic Variability**

**Land Use Change**  
**Increased Land Use Intensity**

**Impact on the  
Hydrological Cycle**

**Floods**

**Increases in  
Rainfall Intensity**

**Imperviousness  
Soil Compaction  
Change in  
Vegetation Cover**

**Droughts**

**High Temperatures  
Little Precipitation**

**Lower Soil WHC  
Mono-Culture  
Soil Desication  
Veg. Resistance**

**Wildfires**

**High Temperatures  
Little Precipitation**

**High Fuel-Load  
Stressed Vegetation  
Age of Trees & Poor  
of Management**

**Disease**

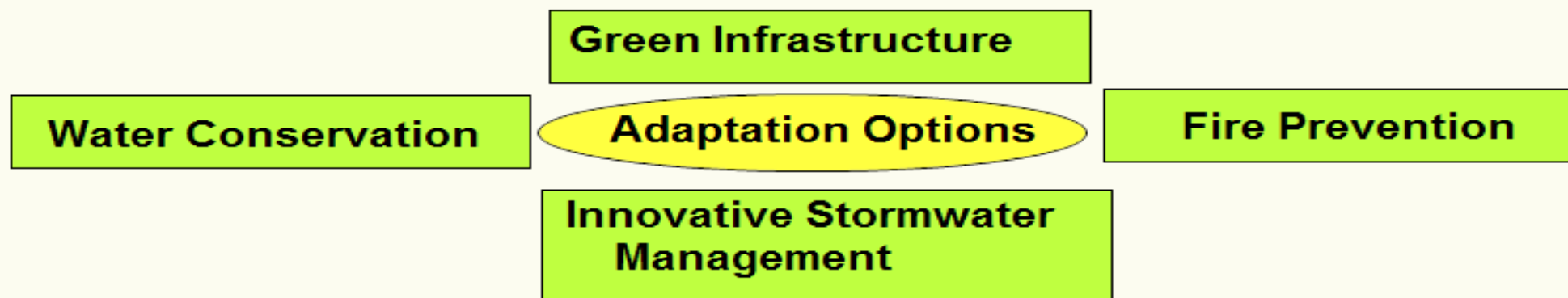
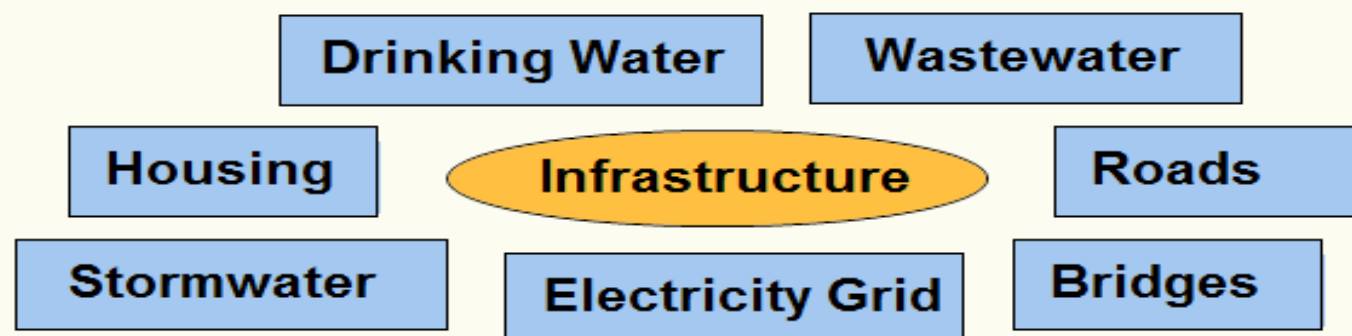
**High Temperatures  
Moisture Conditions**

**Sensitive Vegetation  
Mono-Culture  
Even Aged  
Management Issues**

**Windstorms**

**Excessive Wind  
Velocity**

**Rooting Depth of  
Trees, Edge Effect  
Soil Depth &  
Health of Trees,**





## Community Consultations Started in 2007

## 20 Communities in the Canadian Side of the Basin

### 2008-2010

- Elkford
- Kimberley

### 2010-2011

- Rossland
- Castlegar
- Kaslo

### 2012-2013

- Revelstoke
- Sparwood
- Dist. East Kootenay

28-29  
NOVEMBER 2007  
CRANBROOK, BC

Warmer winters. Warmer, drier summers.  
Lower summer river flows. Rising snowlines.  
Loss of glacial mass. Earlier spring runoffs.



PHOTO: KIMMY GOSAL

## Changing Climate, Changing Basin

A planning and action initiative with Local Governments and First Nations

### Join other community leaders in Cranbrook

You are invited to participate in a regional workshop for municipal, regional and First nations governments in the Columbia Basin. This workshop will introduce and seek feedback on a climate change adaptation initiative for local communities.

#### Why Attend:

- Our communities are vulnerable to climate change. We need to:
- Understand the potential impacts
  - Improve our resilience
  - Learn to adapt to the change
  - Find out what resources are available to help you.

#### When:

**28-29th November 2007**

Note: the workshop begins at 6pm on Wednesday 28 and finishes 3.30pm Thursday 29



#### Where:

The Rail Museum, Cranbrook, BC

#### RSVP by 31 October 2007

Initiative Coordinator: Michelle Laurie

Phone: 1-250-231-0635

Email: michelle.k.laurie@gmail.com





## Community Process

1. Learn about Climate Change
2. Identify Priorities in the Community
3. Assess Vulnerability and Risk
4. Develop Adaptive Strategies and Actions
5. Implement Strategy & Monitoring Program

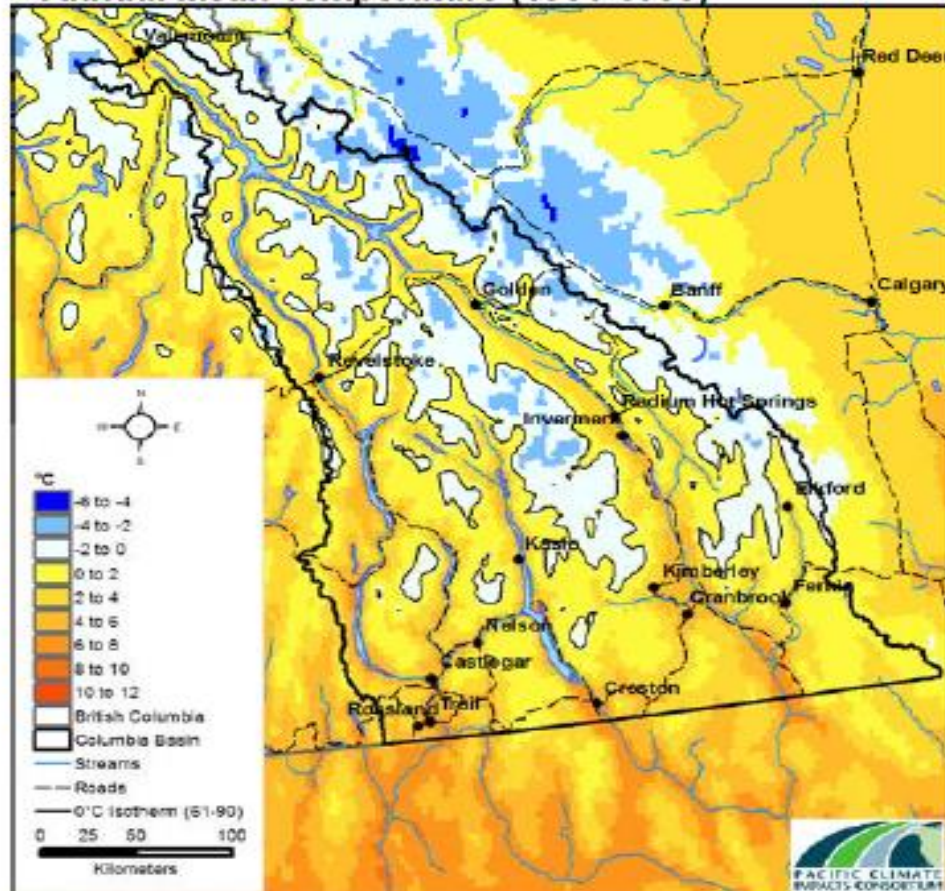




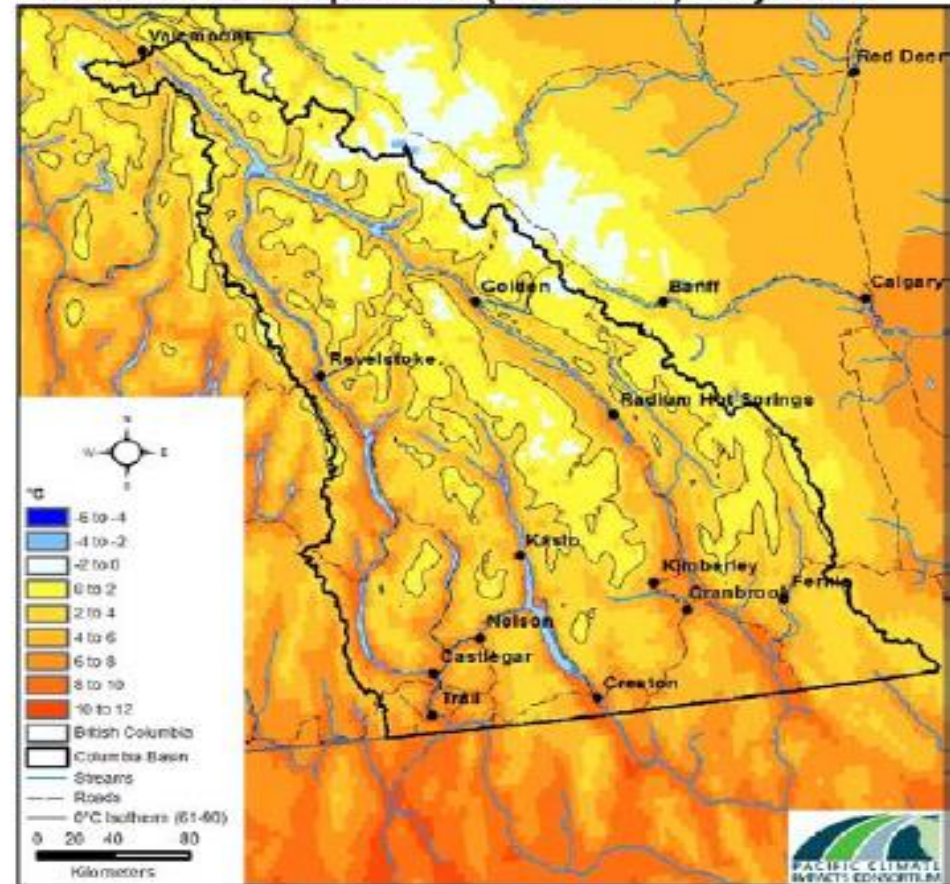
# Climate Projections (1961-1990 vs. 2041-2070)

## Annual Mean Temperature

Annual Mean Temperature (1961-1990)



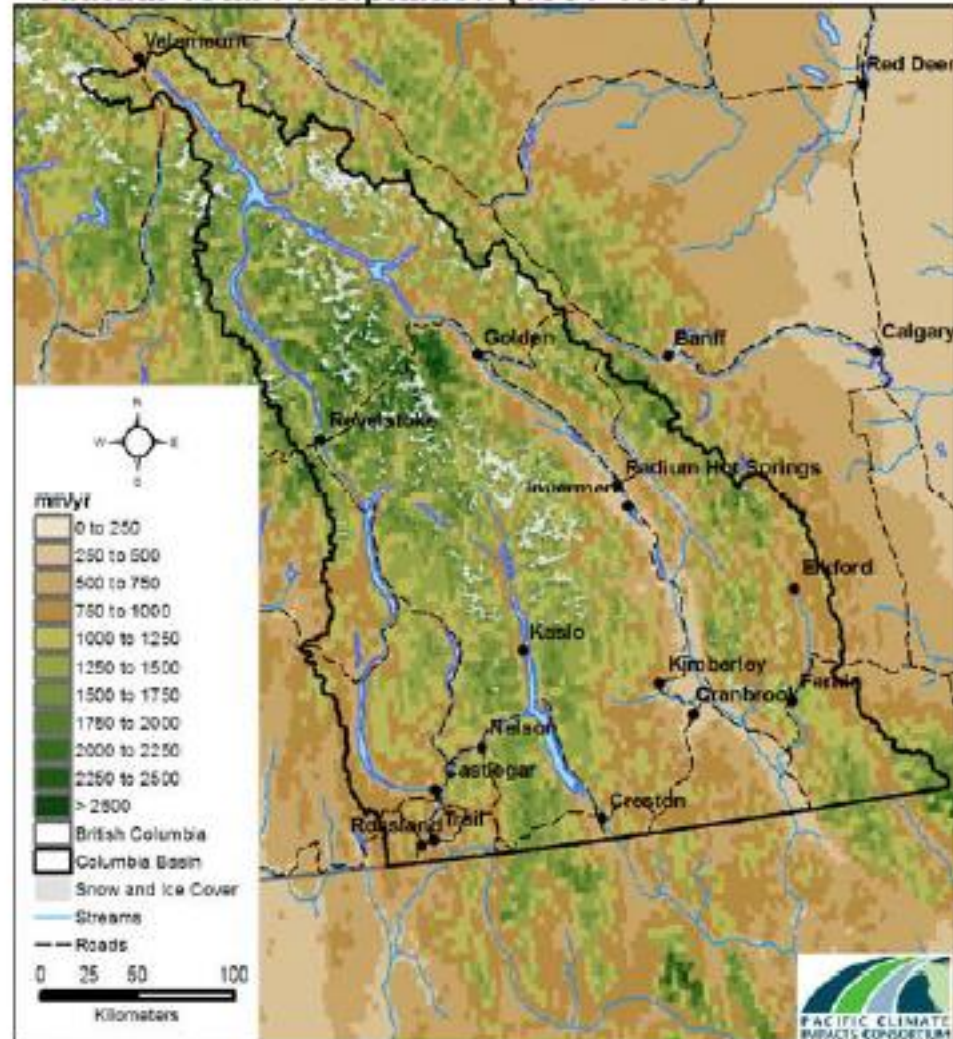
Annual Mean Temperature (2041-2070) Projection



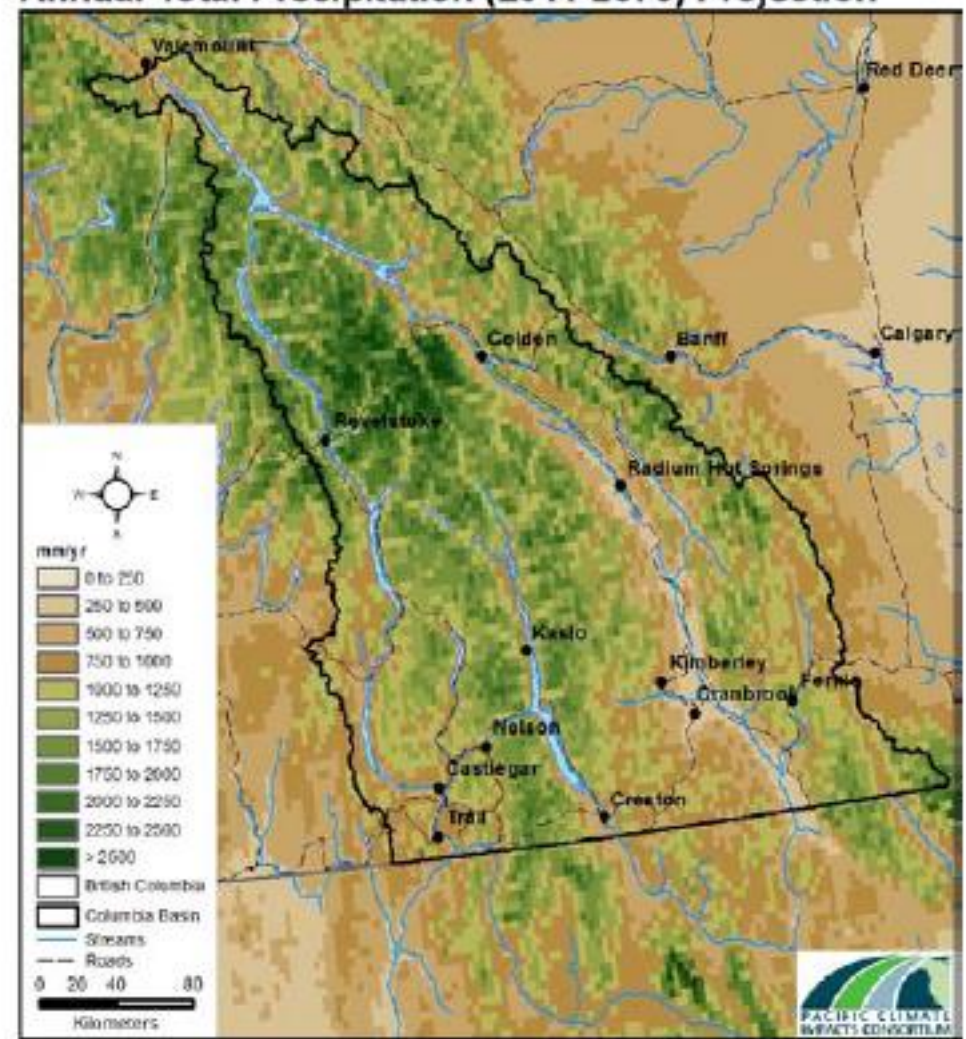


# Annual Total Precipitation

Annual Total Precipitation (1961-1990)



Annual Total Precipitation (2041-2070) Projection

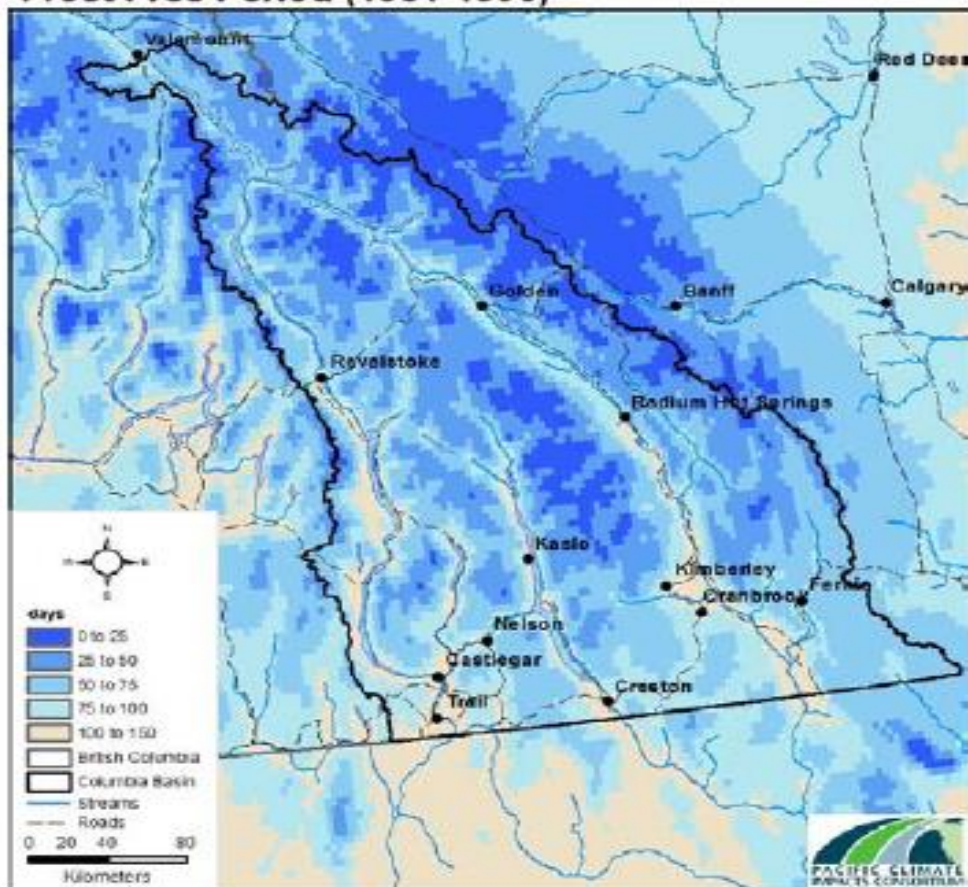




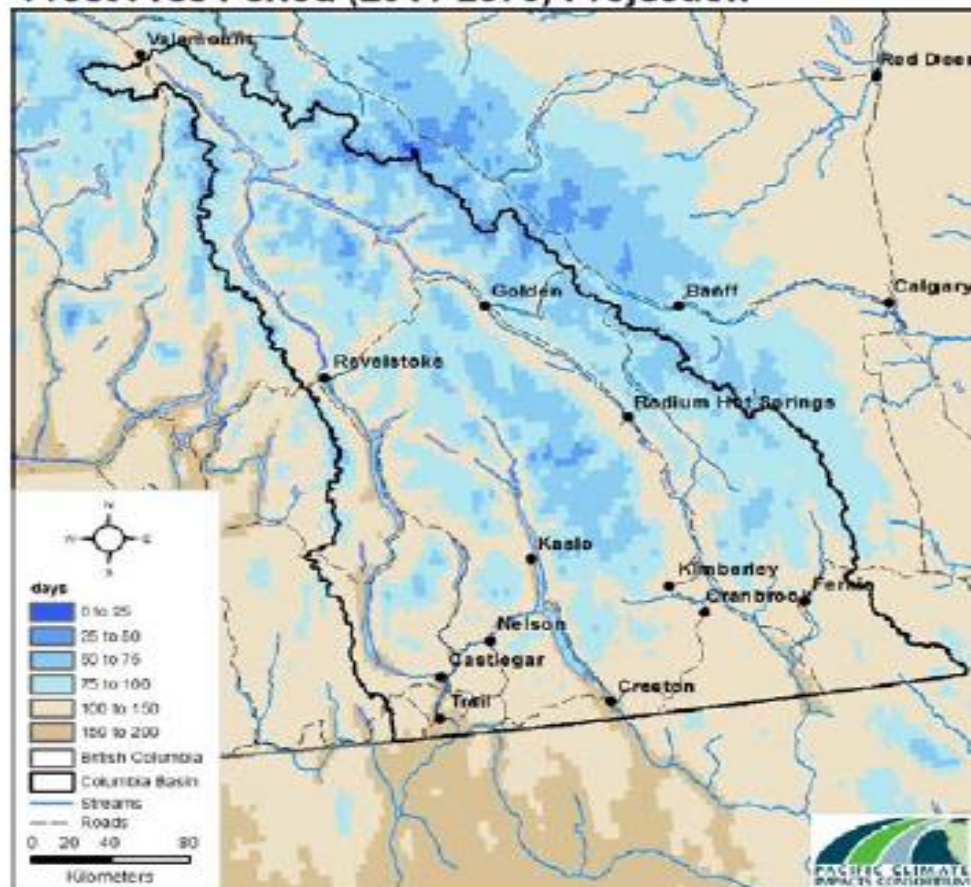
# Climate Projections (1961-1990 vs. 2041-2070)

## Number of Frost Free Days

Frost Free Period (1961-1990)



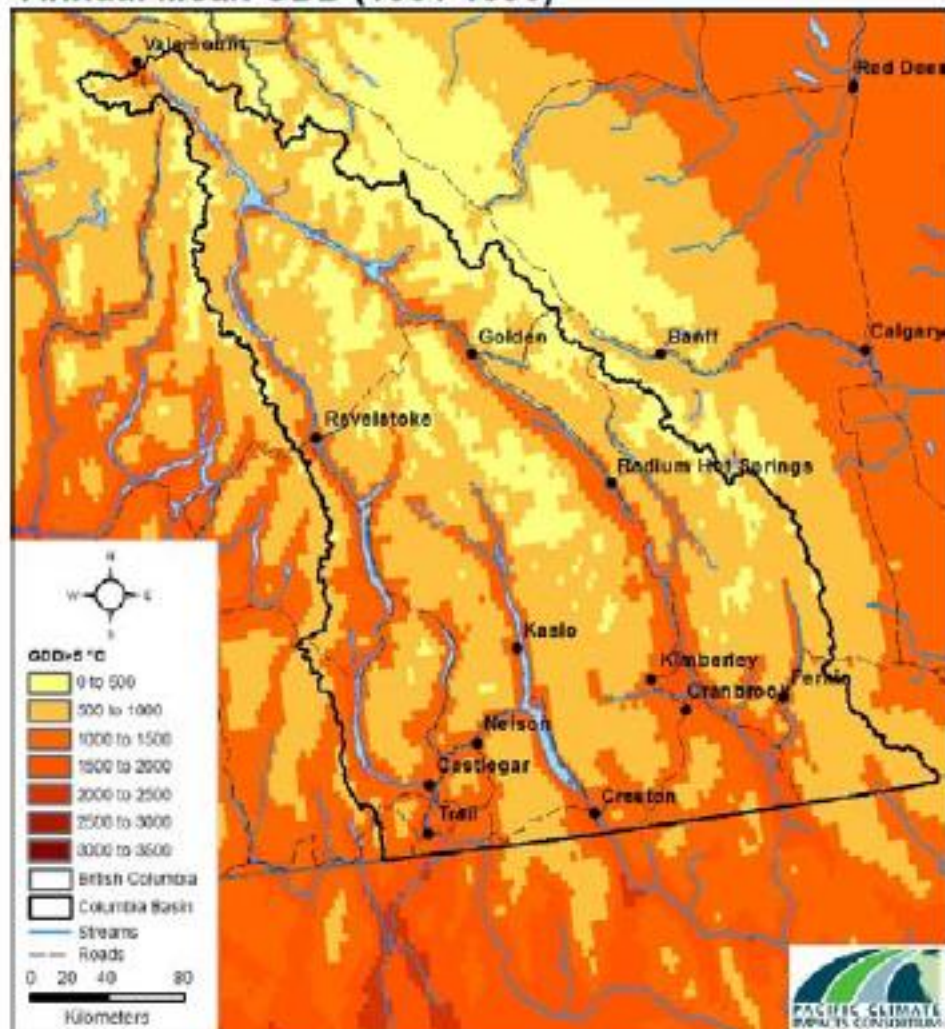
Frost Free Period (2041-2070) Projection



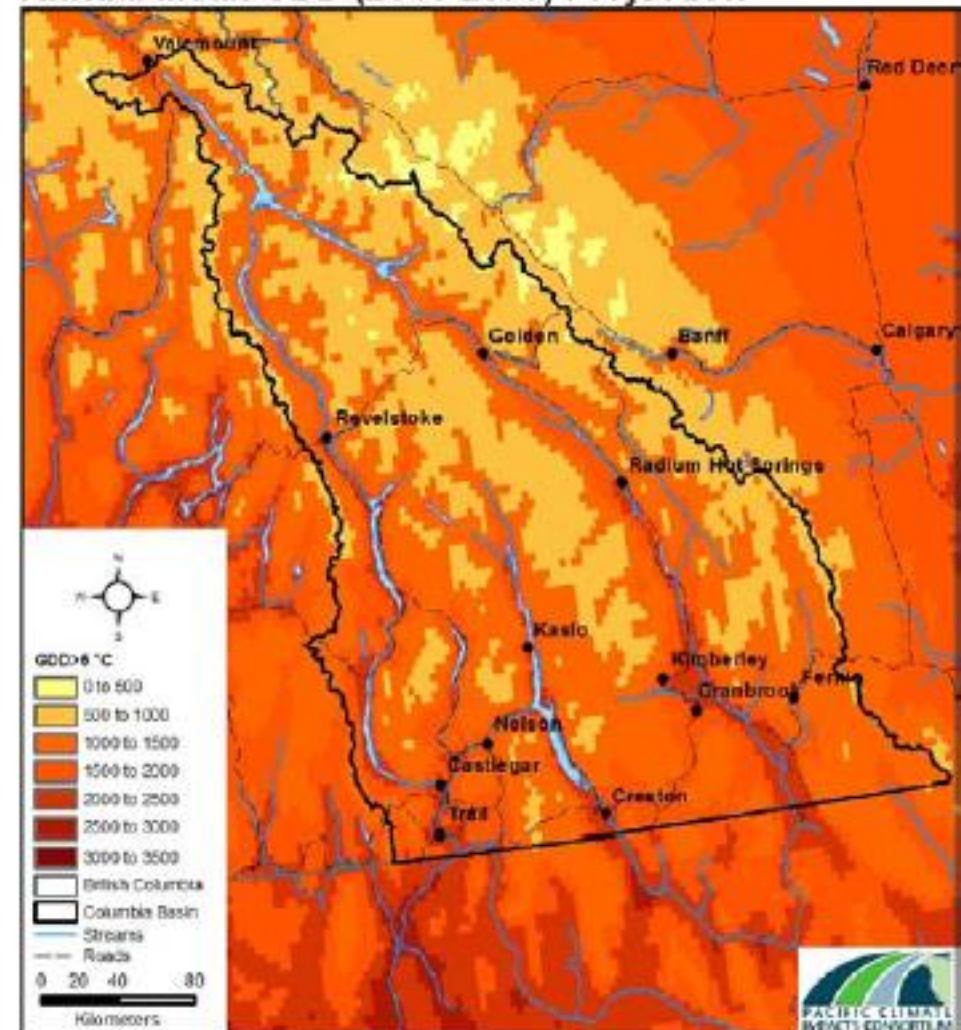


# Growing Degree Days

Annual Mean GDD (1961-1990)

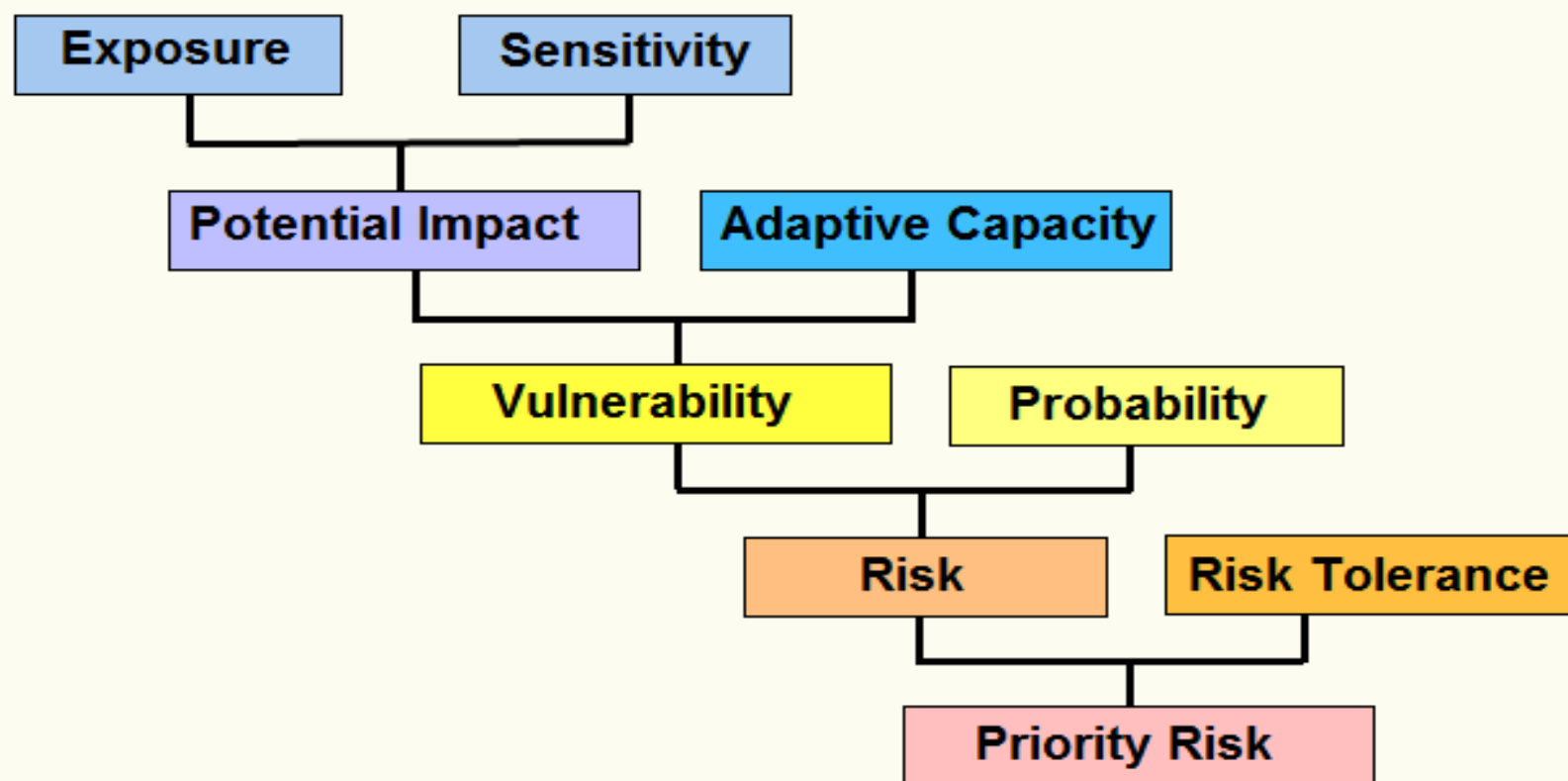


Annual Mean GDD (2041-2070) Projection





## Approach



**Vulnerability = Exposure x Sensitivity x Adaptive Capacity**

**Risk = Vulnerability x Probability**

# Priority Issues Identified by the Different Communities

Communities	Water Availability	Wildfire	Flooding Stormwater	Food Security	Infra-Structure	Tourism (Snow)	Energy
Elkford	3	1	2				
Kimberley	1	2			3	4	
Kaslo	1			2			
Rossland	1		3	4			2
Castlegar	1		3	2			

1	Highest Priority
2	2nd Priority
3	3rd Priority
4	4th Priority
	Minor Concern



# Priority Issues Identified by the Different Communities

Issues	Priorities	Extent of Problem	Initiatives
Water Availability	Highest Priority	Shortages in Winter & Summer	Water Conservation Winter & Summer
Wildfire	2nd Priority	Increased Disease & Drought	Reduce Fuel Load near Communities
Flooding Stormwater	3rd Priority	Increased Frequency	Improve Protection Risk Mapping
Food Security	4th Priority	Winter Access Issues	Extended Growing Season & Greenhouses

## Flooding: Sensitivity, Adaptive Capacity, Vulnerability

Flooding Risks	Sensitivity (L, M, H)	Adaptive Capacity (L, M, H)	Vulnerability (VL,L,M,H,VH)
Flooding of buildings or lands	High	Low	Very High
Damage to bridge integrity	High	Low	Very High
Storm water management stress	Moderate	High	Low
Death/ injury to river recreation users	Low	Moderate	Low
Pumphouse floods and compromises water supply	High	Moderate	High





## Wildfire: Sensitivity, Adaptive Capacity, Vulnerability

Wildfire Risks	Sensitivity (L, M, H)	Adaptive Capacity (L, M, H)	Vulnerability (VL,L,M,H,VH)
Wildfire enters District boundary	High	Low	Very High
Smoke alert from nearby wildfires	Moderate	Low	High
Evacuation of whole or part of community	Moderate-high	Moderate	Moderate- High
Road and highway closure (Hwy 43)	Moderate-high	Moderate	Moderate-High
Backcountry/ forest closures due to high fire risk	Moderate	Low	High
Damage to Infrastructure and Homes	High	Moderate	High
Loss of life from wildfires	High	High	Moderate
Closure of Mine due to fire risk (for at least one day)	Moderate	Low	High
Lawsuit against District for fire damage	Moderate	Moderate	Moderate



## Wildfire Risk Assessment Summary

Vulnerability	<b>Very high</b> <i>(High sensitivity, low adaptive capacity AC)</i>	<ul style="list-style-type: none"> <li>Wildfire enters district</li> </ul>			Wildfire Enters		
	<b>High</b> <i>(High sensitivity, moderate AC or Moderate sensitivity low AC)</i>	<ul style="list-style-type: none"> <li>Smoke alert</li> <li>Evacuation Road and highway closures</li> <li>Damage to infrastructure and homes</li> <li>Mine closure</li> </ul>		Evacuation Mine closure	Damage to Infrastructure Road highway closure	Smoke alert	
	<b>Moderate</b> <i>(Moderate sensitivity and adaptive capacity)</i>	<ul style="list-style-type: none"> <li>Lawsuit</li> <li>Loss of life</li> </ul>		Lawsuit Loss of life			
	<b>Low</b> <i>(low sensitivity moderate AC) or ( moderate sensitivity high AC)</i>	<ul style="list-style-type: none"> <li>Backcountry/ forest closure</li> </ul>				Backcountry forest closure	
	<b>Very Low</b> <i>(Low sensitivity, high adaptive capacity)</i>						
			Unlikely to occur	May occur once	Likely to occur at least once	Likely to occur several times	Occurs frequently
	Probability in 20 year planning period						

## Water Quality: Sensitivity, Adaptive Capacity, Vulnerability

Water Quality & Availability	Sensitivity (L, M, H)	Adaptive Capacity (L, M, H)	Vulnerability (VL,L,M,H,VH)
Decreased water quality	Low	Low	Moderate
Decreased water Availability	Moderate	Low	Moderate-High
Decreased aquifer recharge rate	Moderate	Low	Moderate-High
Decreased watershed health and integrity	Moderate	Moderate	Moderate
Increased turbidity of river water	High	Low	Very High
Increased cost of water treatment due to health regulation	Moderate	Moderate	Moderate



## Water Quality Risk Assessment Summary

Vulnerability	<b>Very high</b> <i>(High sensitivity, low adaptive capacity AC)</i>	•Turbidity				Turbidity in river (impacting fish)	
	<b>High</b> <i>(High sensitivity, moderate AC or Moderate sensitivity low AC)</i>	• Water Availability (Unknown probability) •Aquifer recharge – (Unknown probability)					
	<b>Moderate</b> <i>(Moderate sensitivity and adaptive capacity)</i>	• Water quality • Watershed health and integrity • Increased cost of water treatment due to health regulation		Water quality	• Watershed health and integrity • Increased cost of H <sub>2</sub> O treatment		
	<b>Low</b> <i>(low sensitivity moderate AC) or ( moderate sensitivity high AC)</i>						
	<b>Very Low</b> <i>(Low sensitivity, high adaptive capacity)</i>						
				Unlikely to occur	May occur once	Likely to occur at least once	Likely to occur several times
Probability in 20 year planning period							

# Specific Adaptation Methods



**Reservoir**

## Domestic Water Sources



**Groundwater**



**Rainwater Harvesting**



**Lake Water**



**Spring Water**



**Streamwater**



# Drinking Water Protection

## Different Water Sources Need Different Protection

### Stream

**Land Use Regulations**  
**Minimize Inputs**  
**Large Buffer Zones**  
**Revegetate Degraded Areas**  
**Stabilize Stream Banks**  
**Restrict Animal Access**

### Springs/Groundwater

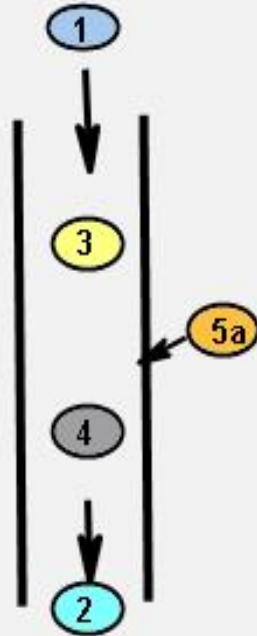
**Buffer Zone Around Well**  
**Protect Recharge Area**  
**Minimize Inputs (nutrients)**  
**Extraction = or < Recharge**

### Roofwater

**Clean Roof after Dry Season**  
**Type of Rood Material**  
**First Flush Removal**  
**Clean Storage Tank**  
**Minor Treatment**  
**Avoid Insect Access**



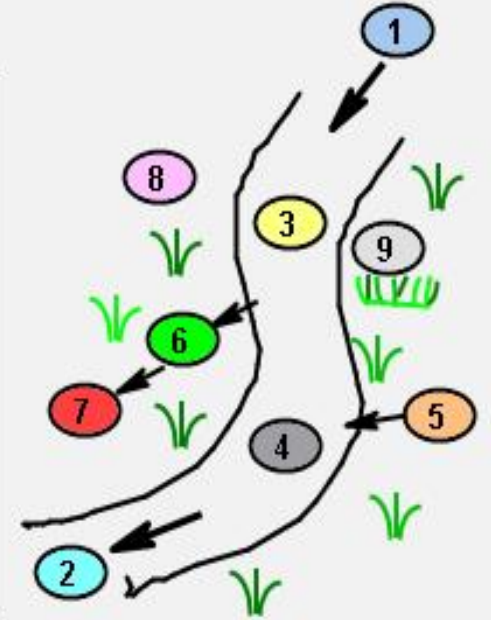
## Channelized River



## Differences Between:

- 1 Inflow from Upstream
- 2 Outflow Downstream
- 3 Evaporation
- 4 Rainfall into River
- 5 Natural Inflow Drainage
- 5a Inflow from Piping System
- 6 Channel Outflow Seepage
- 7 Groundwater Recharge
- 8 Evapotranspiration
- 9 Wetlands

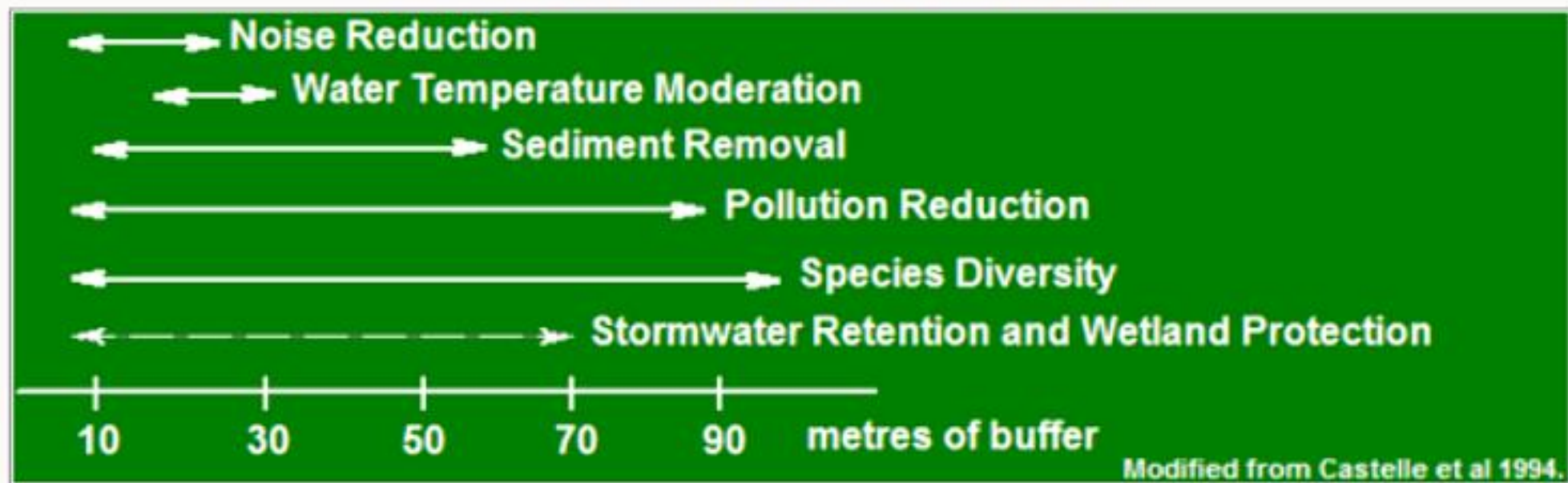
## Natural Channel





## Functions and Size of Riparian Buffer

### Functions and Size of Riparian Buffer Zones



**The Decision is Usually a Compromise Between Political and Public Acceptability**

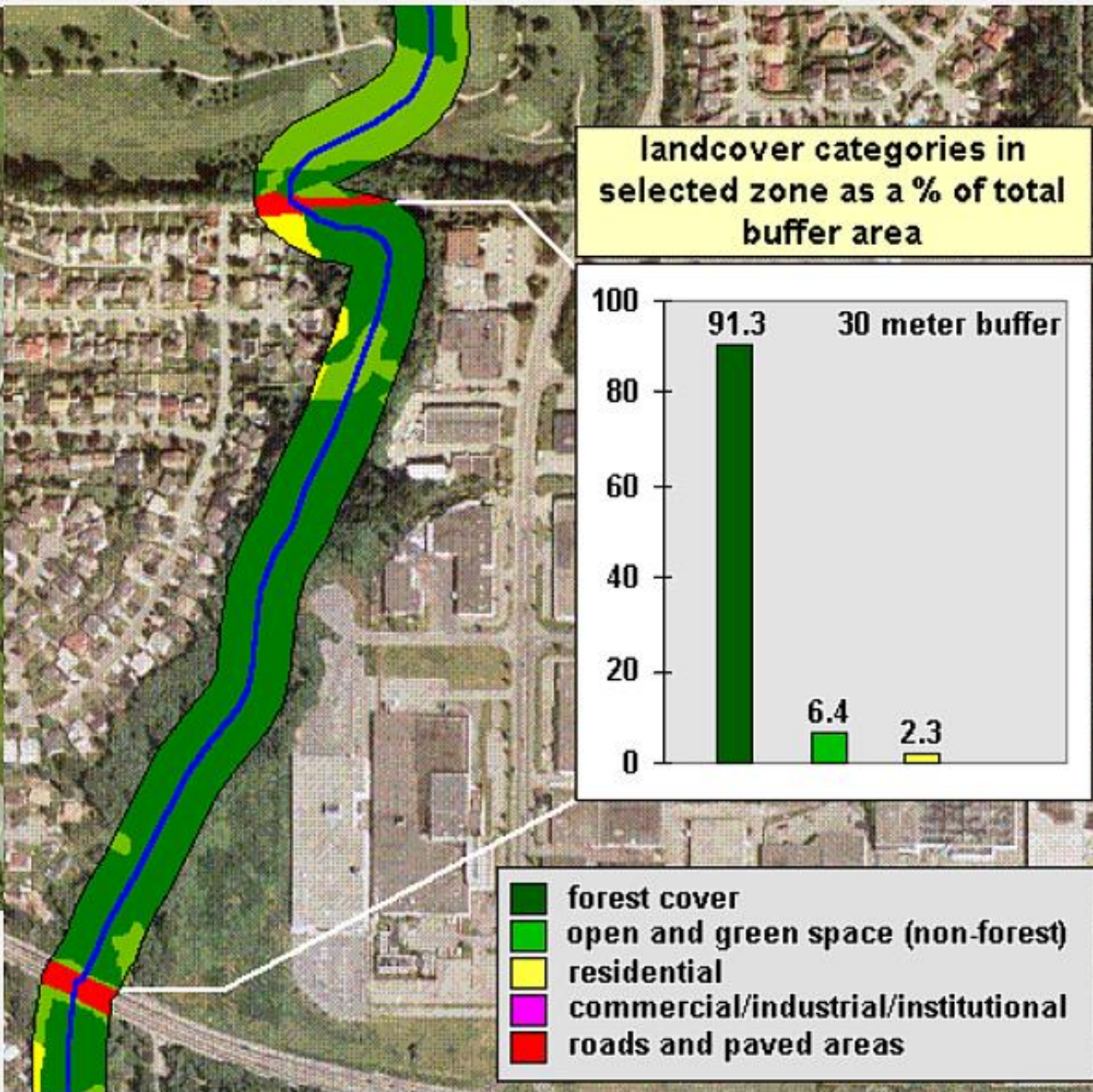
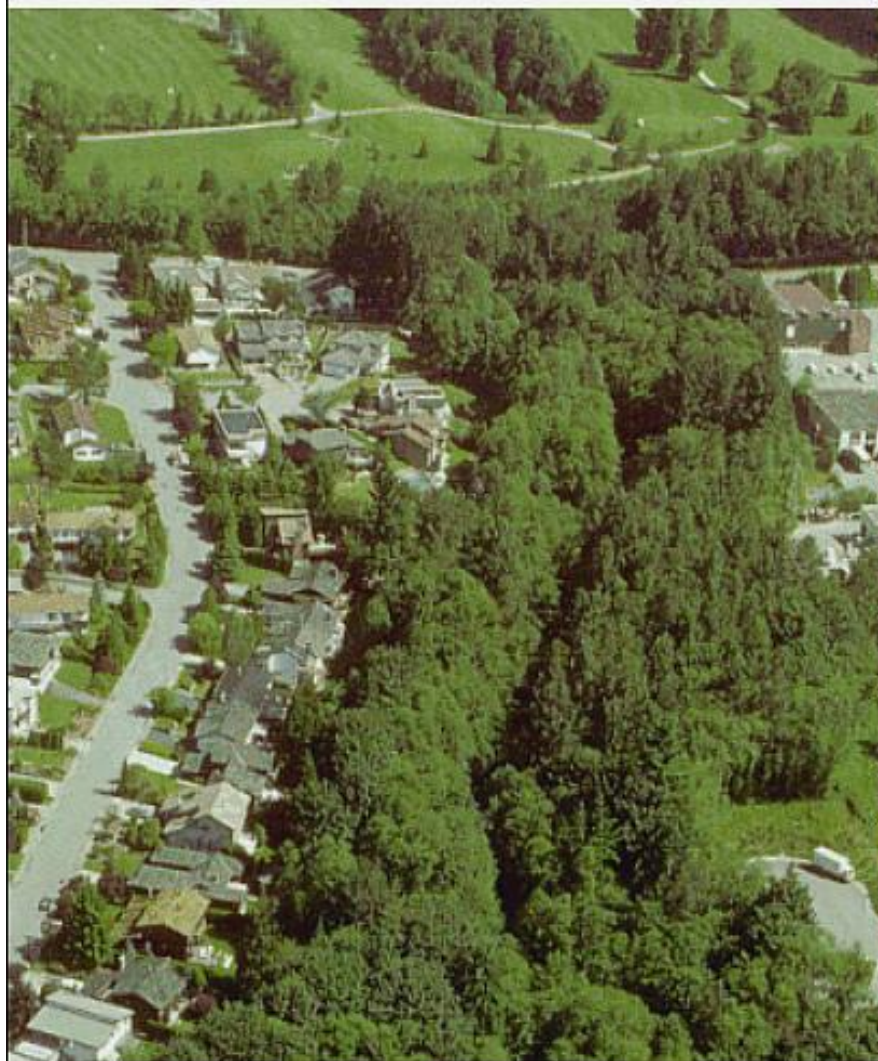
#### Dependent on:

- Functional Value of Resource
- Intensity of Adjacent Use
- Buffer Zone Characteristics
- Specific Buffer Requirements
- Size of Stream

#### General Guidelines:

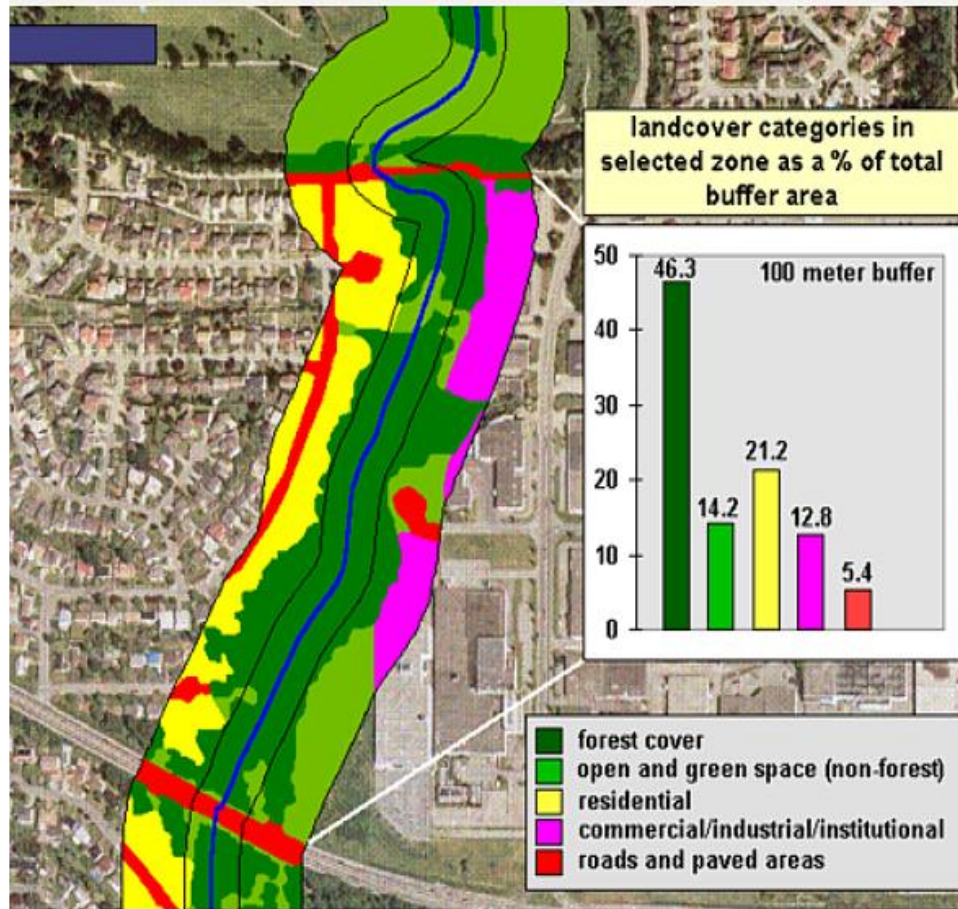
- 5 - 10 m Buffer is too Small
- 15 - 30 m Buffer is a Minimum
- 30 - 100 m is a Realistic Compromise
- Variable Size is Best but Difficult to Enforce from a Legal Perspective







### 100 m Buffer Zone



ONCE CHANNELIZED IT IS DIFFICULT AND EXPENSIVE TO RECREATE NATURAL CHANNELS







## **DETENTION SYSTEMS & CONSTRUCTED WETLANDS**

- 1. Detains & Stores Stormwater**
- 2. Collects Sediments**
- 3. Retains & Filters Pollutants**
- 4. Takes up Excess Nutrients**
- 5. Phytoremediation**
- 6. Recreational Opportunities**



### **To Minimize Mosquito Problems**

- 1. Minimize Amount of Stagnant Water (aerate, or maintain flow)**
- 2. Minimize Eutrophication**
- 3. Plant Appropriate Wetland Plants (Biodiversity)**
- 4. Introduce Fish (Stickleback)**
- 5. Treatment at Larvae Stage**





## Windstorm in Vancouver (Stanley Park) in 2008

**Decapitated  
2500 trees  
Some were  
250 Years Old**







**Windstorm in the Italian Alps 2018 Mainly Spruce with shallow Rooting Depth**

**Remediation Options:**

**Biodiversity, Minimize Even Age, Select Trees with Deep Rooting Systems**

## Forest Fires

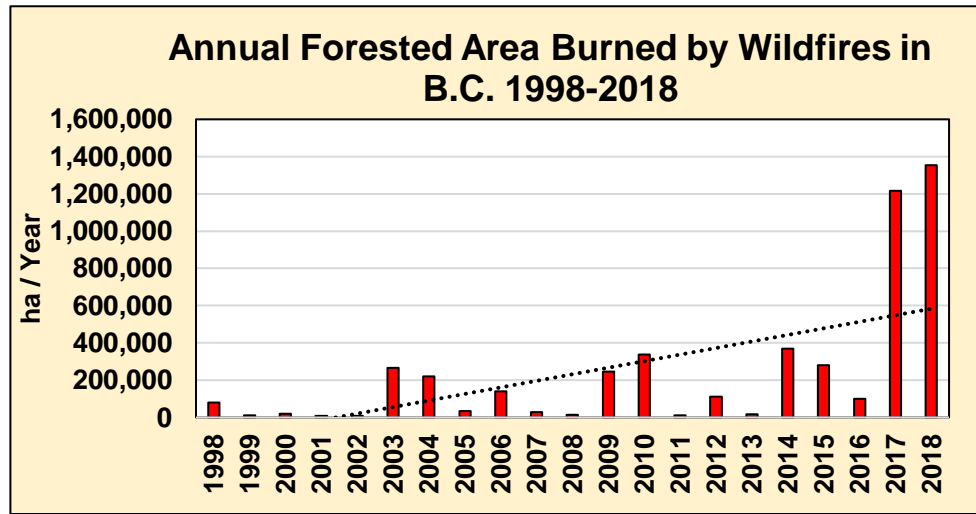
### Forest fire impacts on watershed



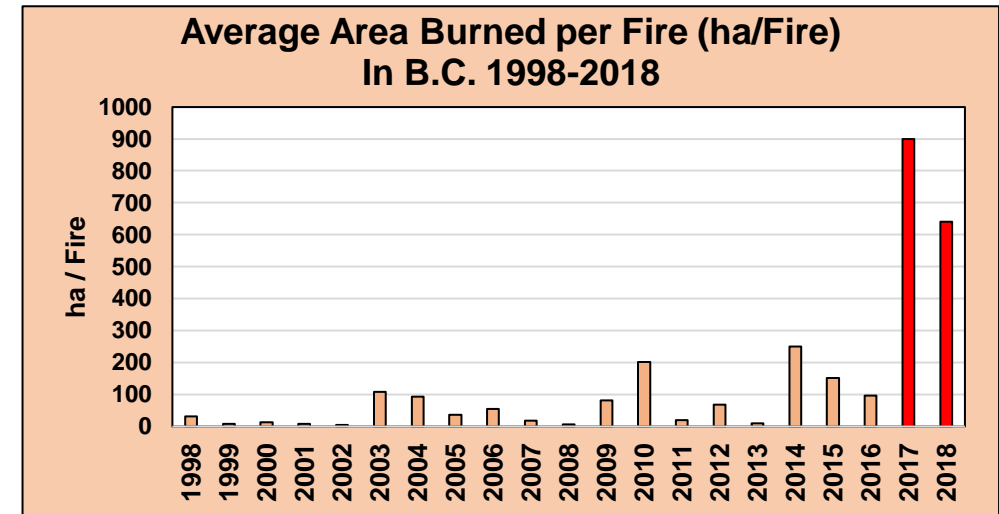
- Creates Hydrophobisity
- Reduces soil infiltration rates
- Lead to increased Erosion & sediment transport
- Increased streamflow
- Nutrient flush (short term increase in Nitrate)
- Increase in Total Organic Carbon (TOC) in water



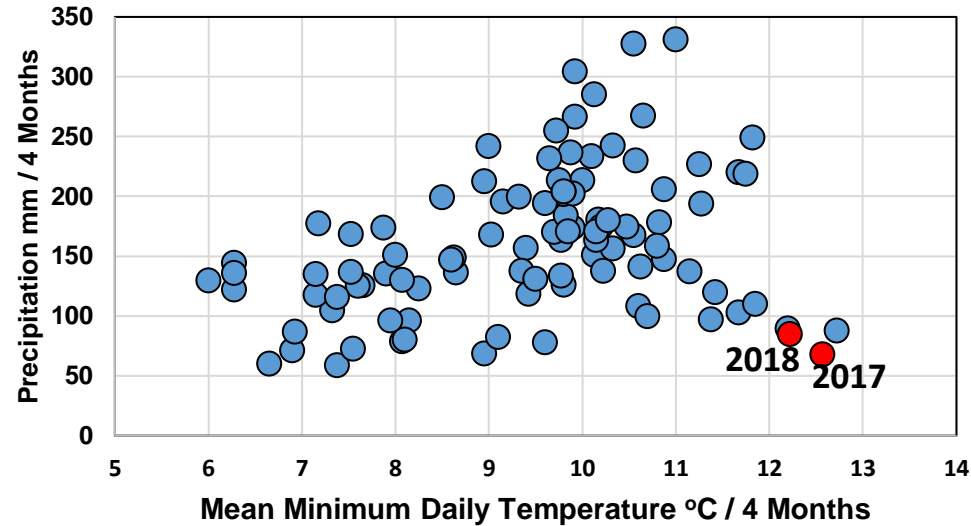
## HISTORIC WILDFIRE RECORD IN B.C.



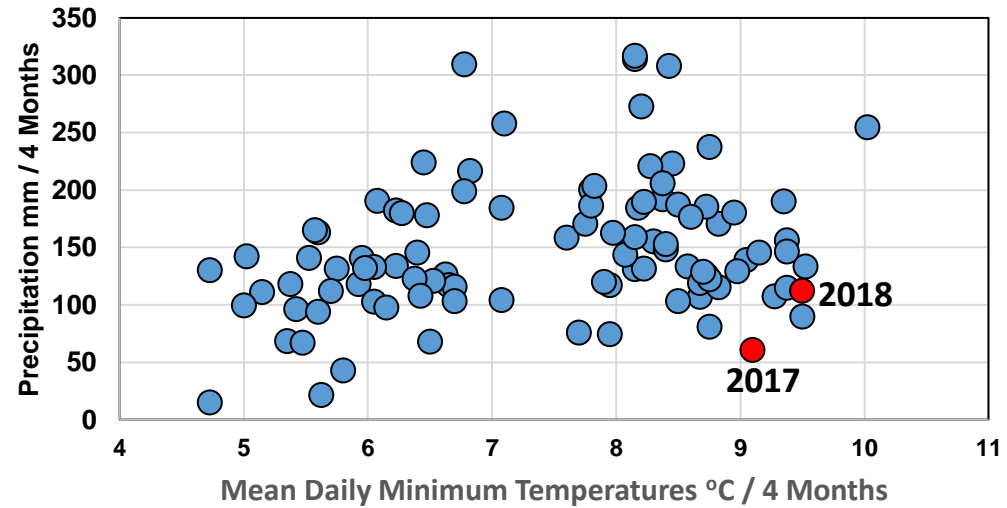
## AVERAGE SIZE OF WILDFIRE / YEAR



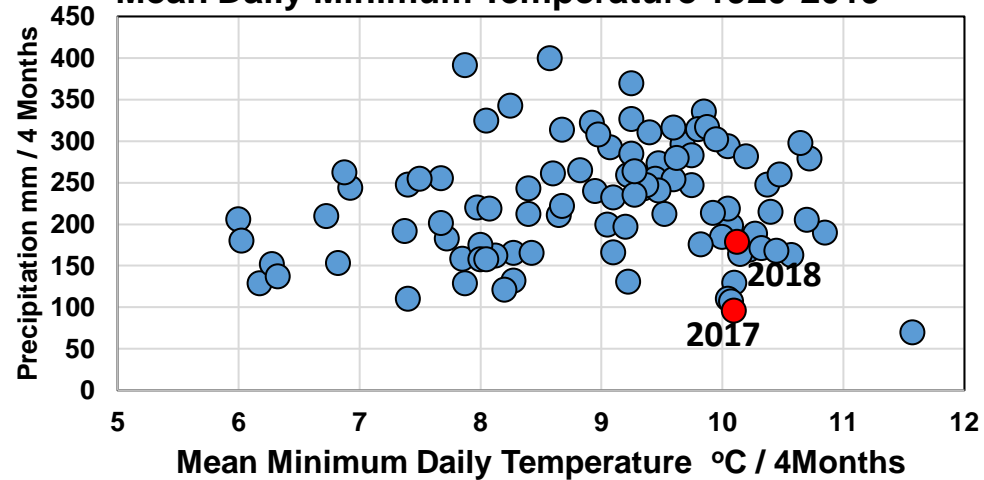
**Creston May-Aug Precipitation versus Mean Daily Minimum Temperatures 1920-2019**



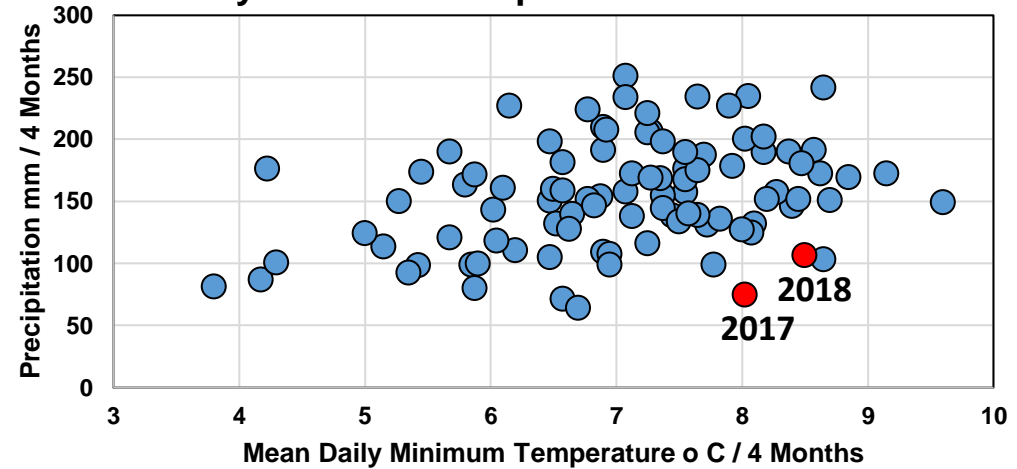
**Cranbrook May-Aug Precipitation versus Mean Daily Minimum Temperatures 1920-2019**



**Revelstoke May-Aug Precipitation versus Mean Daily Minimum Temperature 1920-2019**



**Golden May-Aug Precipitation versus Mean Daily Minimum Temperature 1920-2019**







# Pine Beetles and Fire

Estimated Area Affected in between  
1999 and 2014: 18 Million ha  
(2 times the size of Austria)

Impact since 1999: 800 Mio m<sup>3</sup> of timber



## Dilemma:

If harvested within 2-3 years the wood can still be used

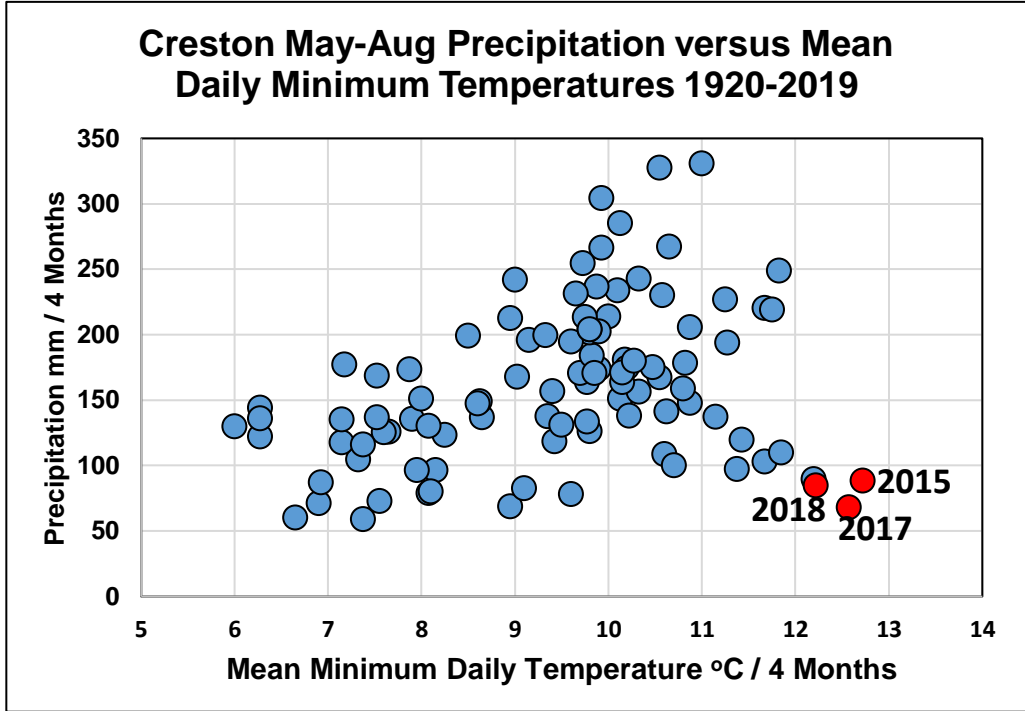
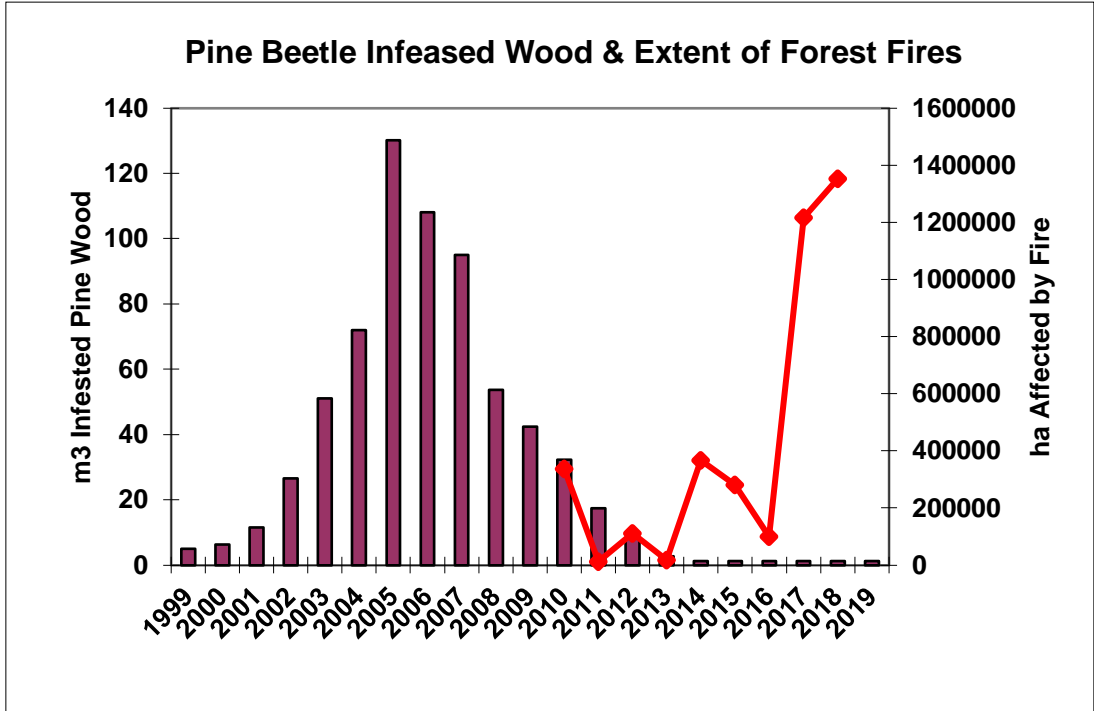
If left standing it creates a forest fire hazard

In both cases it is a problem for Carbon Balance

The impact on the hydrological cycle is uncertain

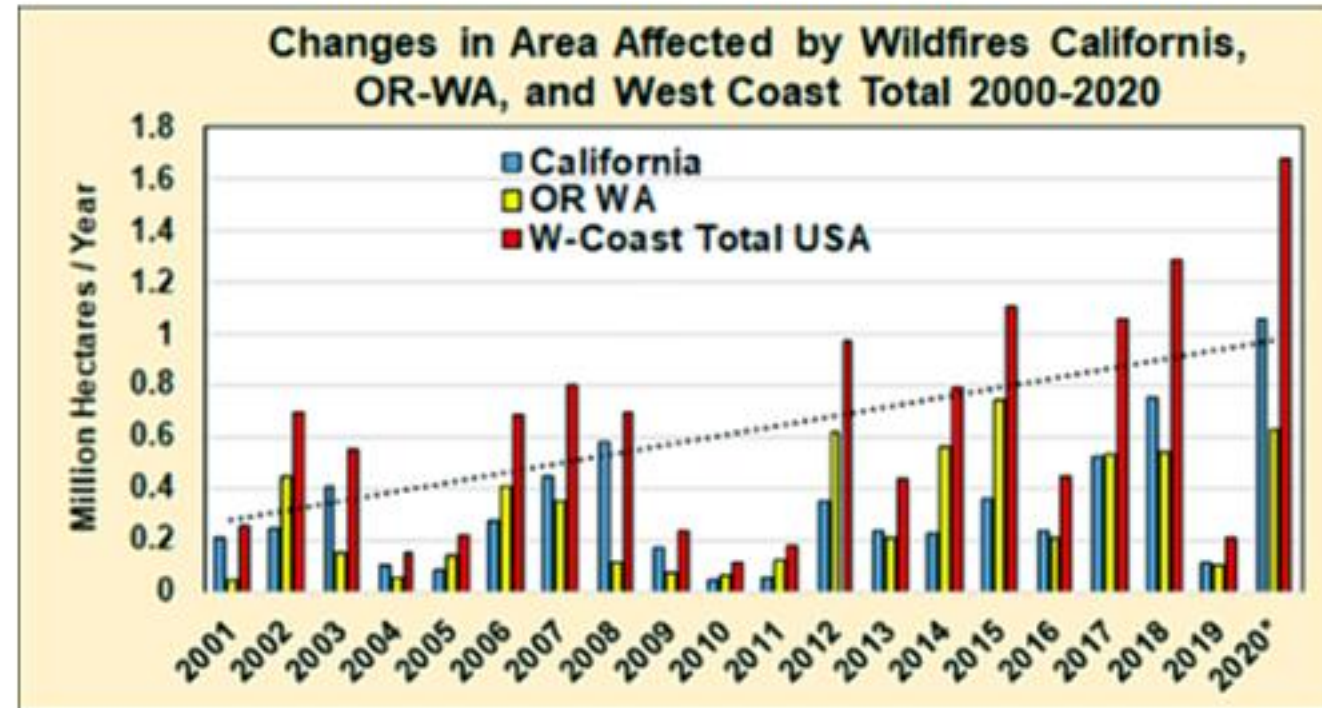






CO <sub>2</sub> Emissions from Wildfires in B.C.			
Wildfire Season	Area Affected	Fire CO <sub>2</sub> Emissions	Human CO <sub>2</sub> Emissions
2017	1.2 M ha	176 M t	64 M t
2018	1.38 M ha	193 M t	63 M t

## 2020 Was the Worst Fire Season on the West Coast of the USA



Data Sources: National Interagency Fire Centre 2020 (Note: Partial Data for 2020\*)

# Wildfire Issues and Mitigation Options

## Factors Promoting Wildfires

- Flammable Type of Trees
- Fuel Load Build-Up
- Insect Damaged Trees
- Tree Stress by High Temperature
- Extended Drought Conditions
- Trees Stressed by Air-Pollution
- Increased Temperature
- Decreases in Precipitation
- Less Snow Cover
- Soil Moisture Stress

## Mitigating Wildfires

- Plant Fire Resistant Trees
- Control Fuel Load Build-Up
- Remove Insect Damaged Trees
- Strategic Biomass Extraction
- Promote Grazing
- Provide Fire Breaks
- Prescribed Burns
- Remove Dead Branches
- Modify Tree Structures
- Fire Protection Plans

## Causes of Wildfire: People vs. Lightning Strikes

Canada	55 % = 45 %
Russia	70 % = 30%
Australia	90 % = 10 %
Amazone	100% = 0 %



## Traditional Versus New Approach to Floodwater Management

### Traditional Approach

#### Engineering, Structural

Get water off the land as quickly as possible by conveyance using pipes, structural channels & build protective structures in lowlands

### New Ecological Approach

#### Natural, Ecological

Spread & retain water on site by infiltration & detention to slow down & accommodate runoff. Mimic nature. Use soils, wetlands, buffers

Control Peak Flow

Resist Disturbance

Improve Prediction Capacity

Rigid Structural Boundaries

Seek Stability



Accept Peak Flow

Absorb Disturbance

Unpredictable

Flexible Boundaries

No Equilibrium, Unstable

# Stream Rehabilitation

## Watershed Restoration Techniques

Techniques are designed purposely to be low tech and labour intensive, and to be conducted largely by volunteers and community groups. They provide high visibility and generally high effectiveness for habitat restoration.





## Stream Bank Rehabilitations



### Purpose

- protects banks from erosion
- provides cover for fish
- introduces complexity
- nutrient cycling
- tree root stabilization
- site with more than 10 m section with problems

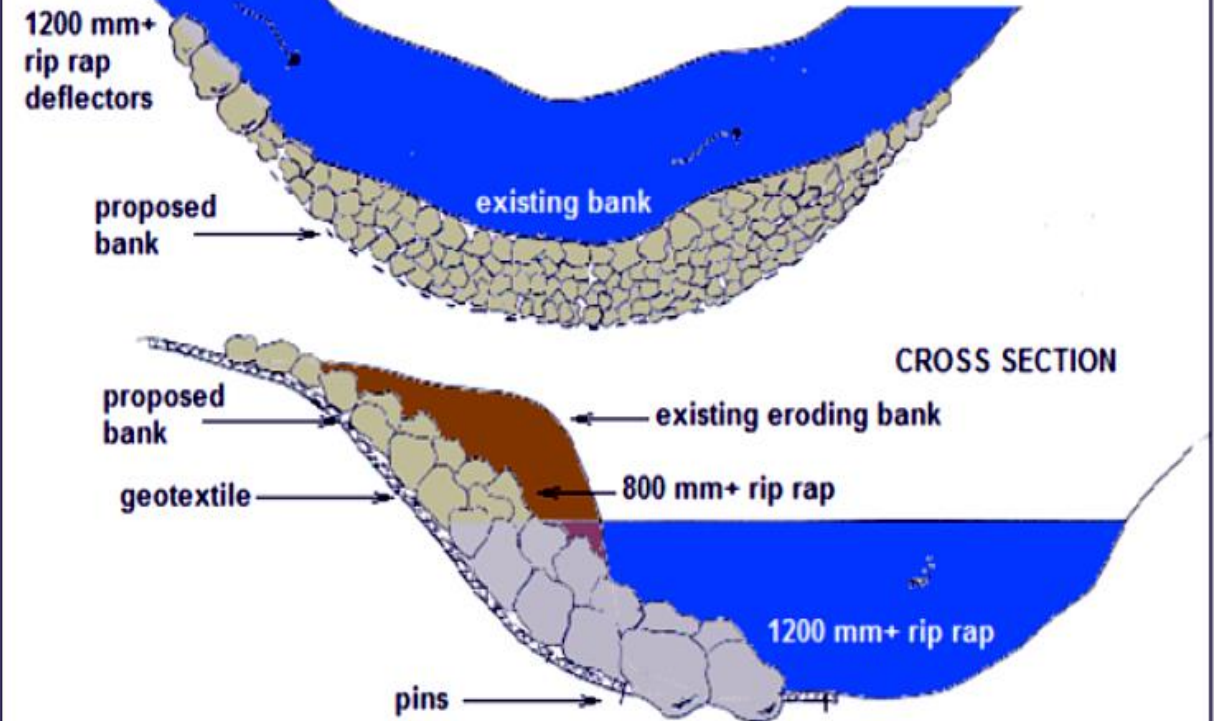
### Construction

- outside of meander
- select suitable trees (conifers)
- clear stream debris
- place geotextile down bank with 1 m fringe into stream
- 400 to 600 + rip rap are placed between stream revetment
- each tree can be wrapped to the bank

## Bank Stabilization (Rip-Rap)

### RIP RAP PLACEMENT FOR BANK EROSION

- 1200 mm+ rip rap placed on upstream end and along bank edge
- 800 mm+ rip rap placed on top of 1200 mm+ along bank, up to top of bank
- geotextile pinned to excavated bank below rip rap





## In Stream Complexing



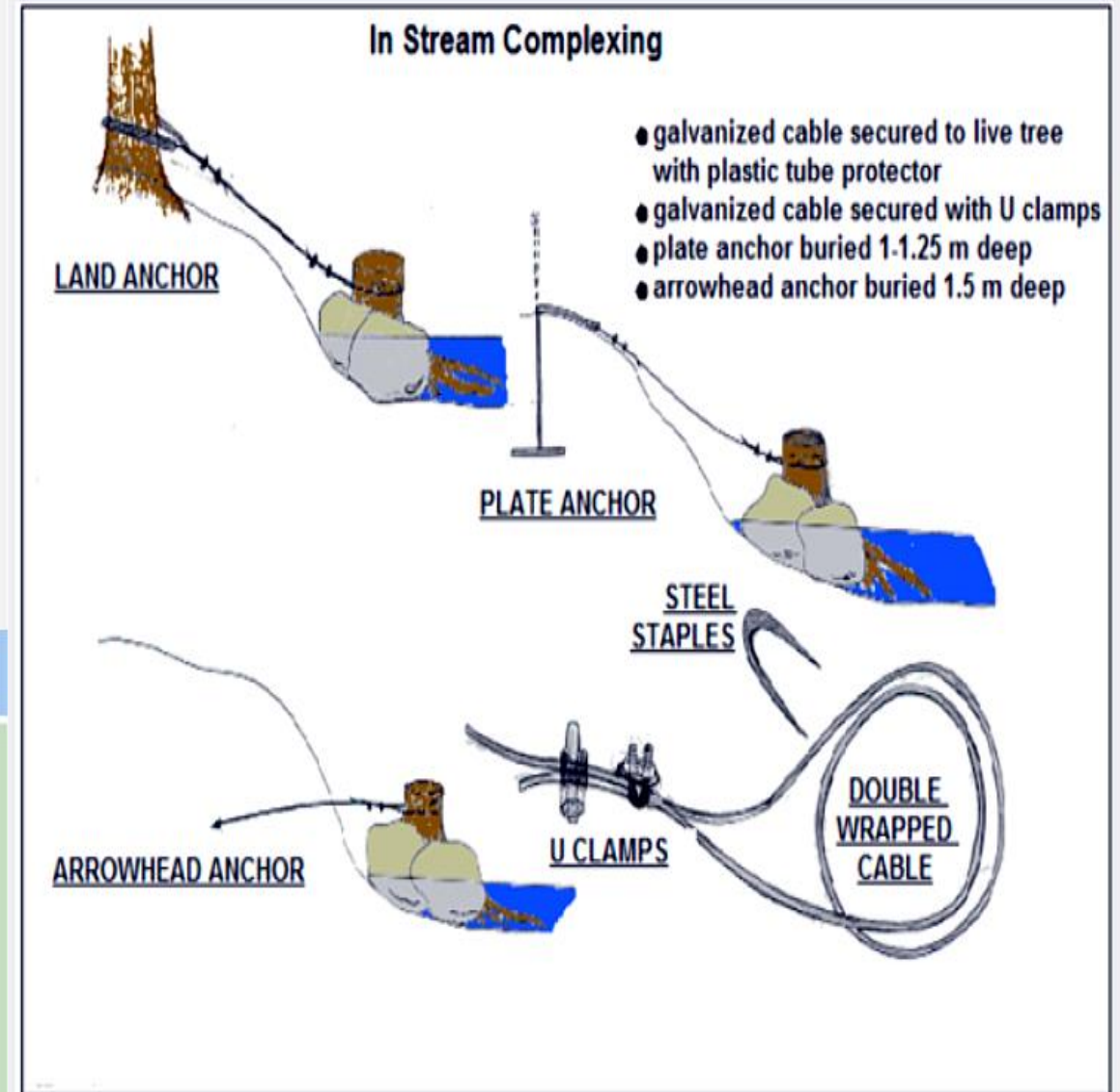
### Purpose

- cover and protection for fish
- nutrient input
- reduces stream velocity
- created pools
- increases rearing and spawning habitat
- cooler temperatures

### Construction

- where cover protection is limited
- large logs are needed
- placed instream and along banks
- anchored using steel cables and land anchor
- root wads can also be used

## Adding Large Woody Debris to Create Pools and Riffles





# Why Fence Streambanks

## Purpose

- keeps livestock away
- controls erosion and sedimentation
- input of manure and micro-organisms reduced
- reduces widening of stream due to trampling
- decreased excess nutrient input (eutrophication)
- increased oxygen

## Construction

- consider severity of area affected by flooding
- construct fence beyond zone of flooding
- minimum 8 m from banks
- crossings may be required
- use gravel crossings to reduce sediments

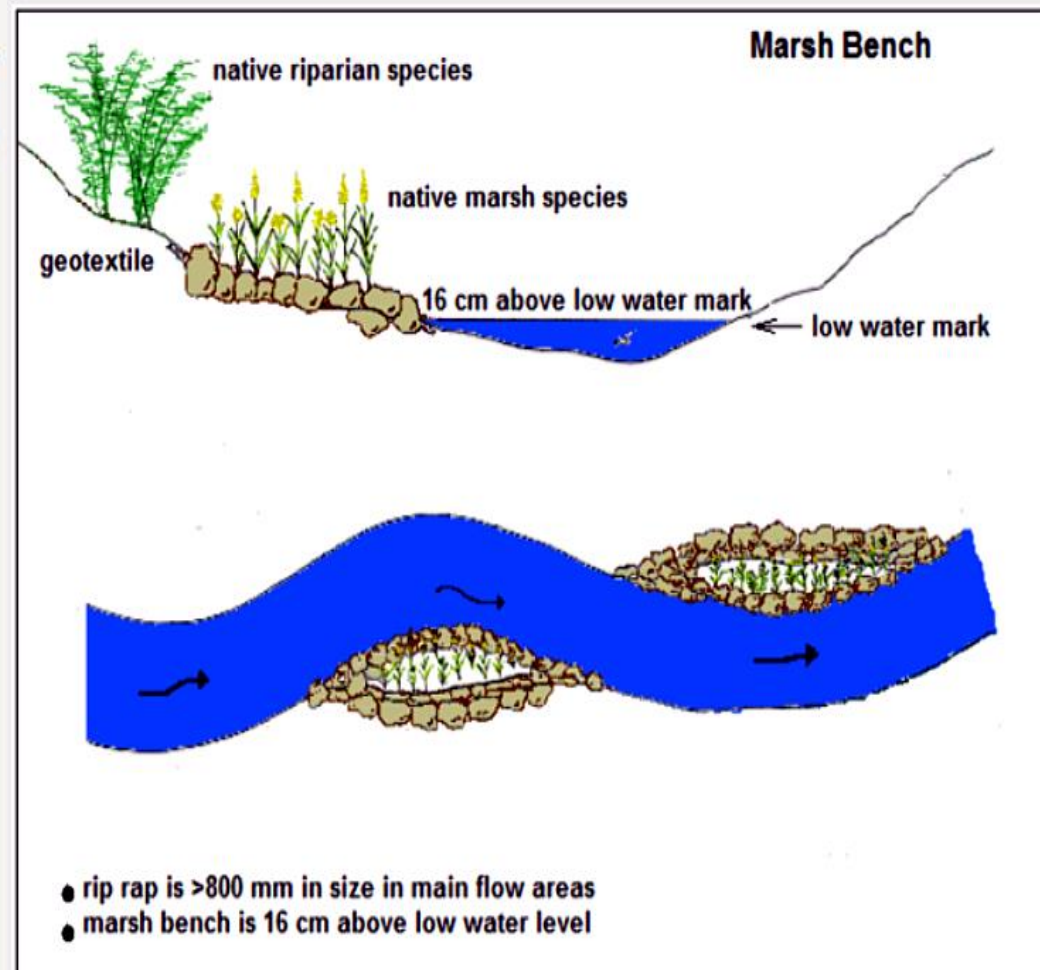




## Mash Benches and Wetlands

Purpose	Construction
<ul style="list-style-type: none"> <li>• produces rearing habitat</li> <li>• improves water quality</li> <li>• shelter and nutrients</li> <li>• stabilizes sediments</li> <li>• filters pollutants</li> <li>• regulates stream flow</li> </ul>	<ul style="list-style-type: none"> <li>• site must be compatible for wetland conditions (slope, elevation, soil type)</li> <li>• near stream for through flow</li> <li>• inside stream meander</li> <li>• excavation 50 cm below low stream flow level</li> <li>• use geotextile over inside edge</li> <li>• place rip rap on top</li> <li>• area on top planted with riparian species</li> <li>• outside stream edge is armored with rip rap</li> </ul>

## Mash Benches and Wetlands





# Vegetating Riparian Buffer Zones

Purpose	Construction
<ul style="list-style-type: none"><li>• improves vegetation adjacent to creek</li><li>• regulates temperature</li><li>• controls erosion</li><li>• improves cover and nutrient cycling</li><li>• filter pollutants</li><li>• increased biodiversity</li></ul>	<ul style="list-style-type: none"><li>• section that needs revegetation</li><li>• selected species that are native to the region</li><li>• use mixture of marsh plants, grasses, shrub and trees</li><li>• marsh for stream / land interface (fish protection)</li><li>• shrub for cover (insects)</li><li>• early spring or fall planting</li><li>• trees from nursery seedlings or salvage (some planting from whips of mature trees)</li></ul>

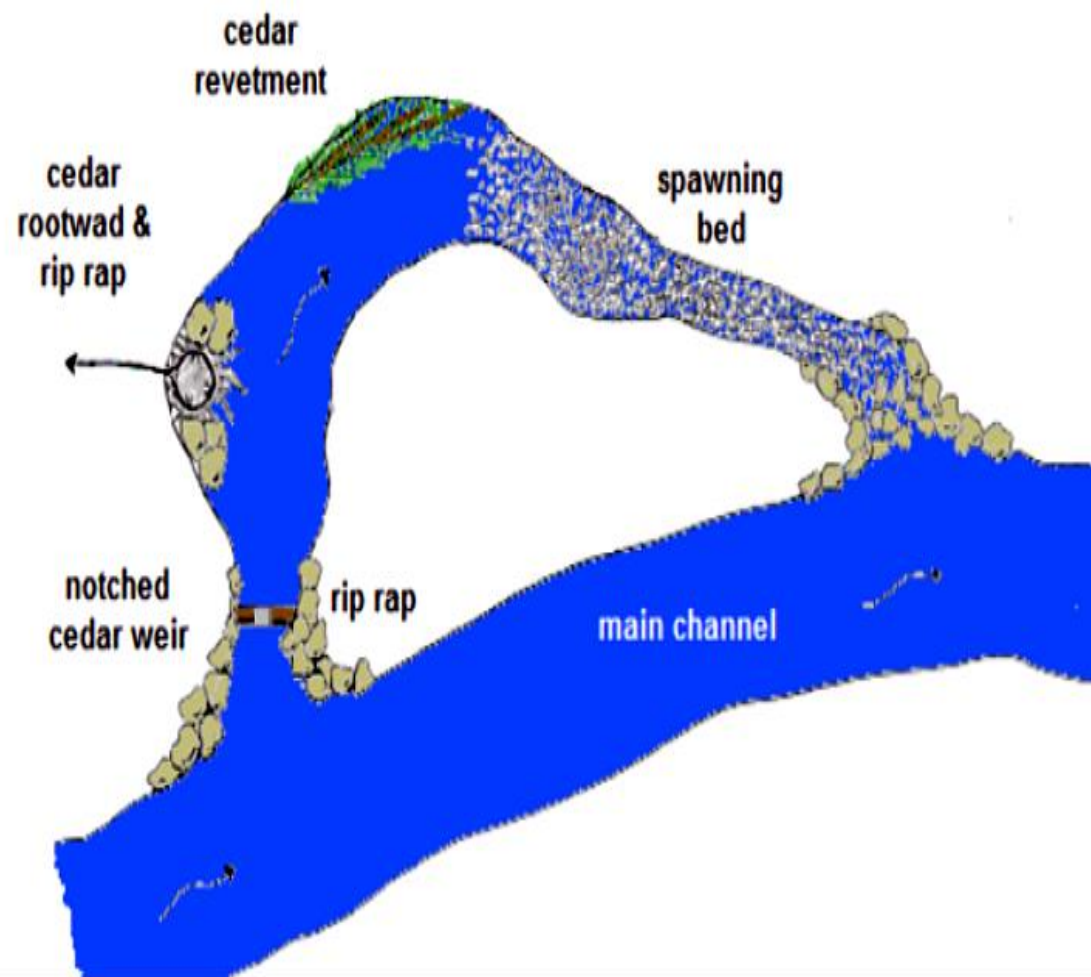


# Why Build New Side Channels

Purpose	Construction
<ul style="list-style-type: none"><li>• duplicates most favourable aspects of spawning and rearing habitat</li><li>• creates additional habitat</li><li>• combines all aspects of stream rehabilitation</li></ul>	<ul style="list-style-type: none"><li>• large undertaking with potentially maximum benefits</li><li>• site should be stable and have cool water supply</li><li>• excavate trench connected with adjacent stream</li><li>• upstream end needs to be reinforced with rock berm (steady flow)</li><li>• creates pools and riffles</li><li>• add gravel</li><li>• large woody debris</li><li>• overhangs</li></ul>

## Building Side Channels

### Side channel with instream complexing





## Building New Side Channels







**Riparian Buffer Zone:  
Transition Between Aquatic & Terrestrial Environment**

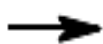
**Influences micro-climate, facilitated nutrient flow and plant diversity.  
Acts as a protection for sediment & contaminant inputs, provided  
corridor for wildlife movement, and works as a filter systems**





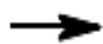
## Adaptation Strategies

**Demand Management**



**Urban, Agricultural, Recreational Use**

**Stormwater Management**



**Site, Neighborhood, Watershed, Design Flood**

**Drought Management**



**Allocation Strategy, Conservation**

**Hazard Protection**



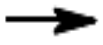
**Beneficial Management Practices**

**Rainwater Harvesting**



**Green Water Management, Soil Infiltration**

**Fire Risk Reduction**



**Reducing Fuel Loads & Fire Breaks**



**Sources for more detailed Information on the Adaptation Program:**

**Columbia Basin Trust:**

<http://adaptationresourcekit.squarespace.com/community-action-plans/>

**Elkford Climate Adaptation Program**

[http://adaptationresourcekit.squarespace.com/storage/Elkford\\_CCA\\_Report-\\_FINAL-31.pdf](http://adaptationresourcekit.squarespace.com/storage/Elkford_CCA_Report-_FINAL-31.pdf)

**Food Security, Virtual Water and Increased Climatic Variability**

<http://wmc.landfood.ubc.ca/webapp/VWM>