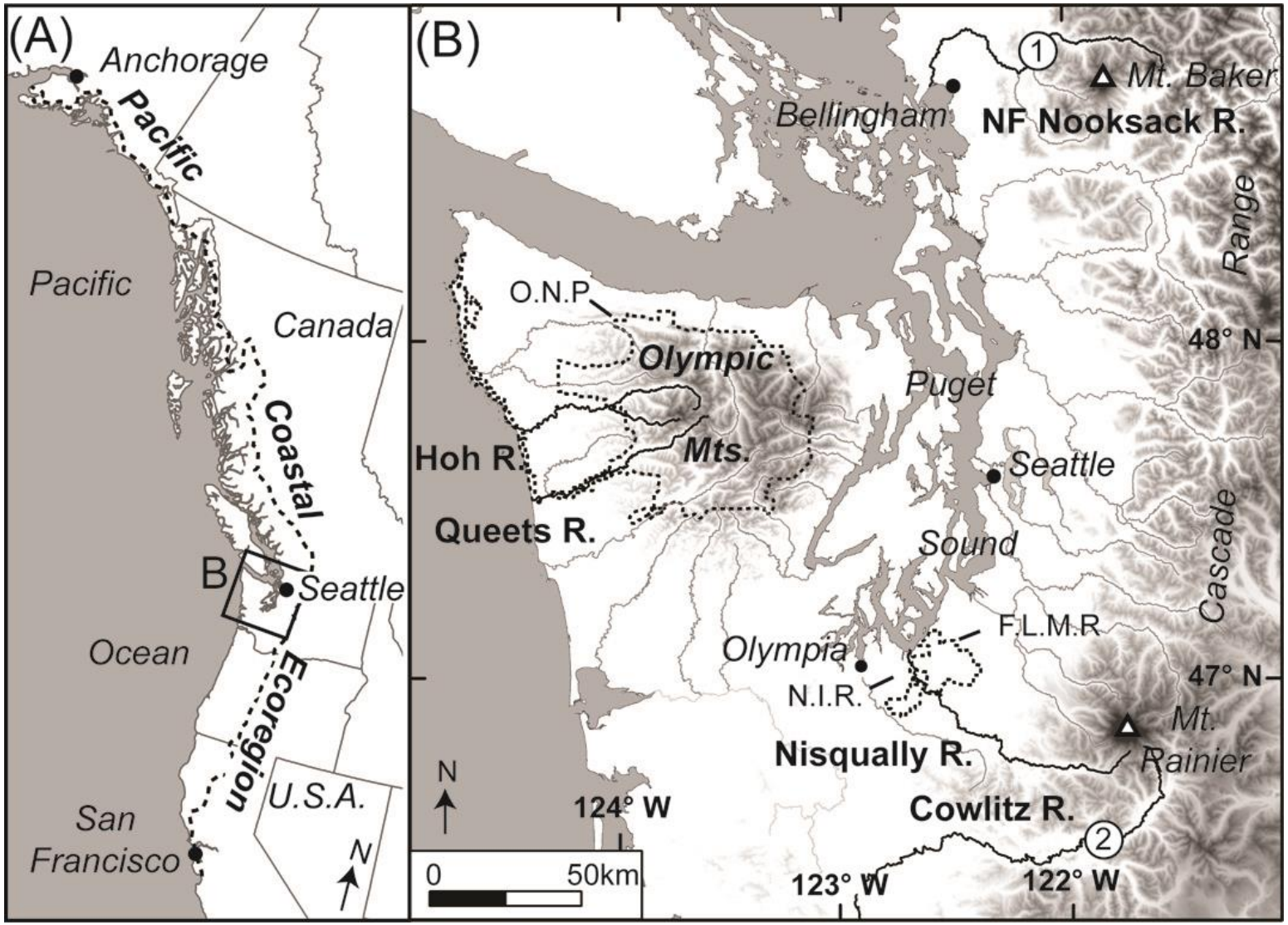
Restoration of Floodplain Forests in Coastal River Valleys of the Pacific Northwest

Kevin Lloyd Fetherston

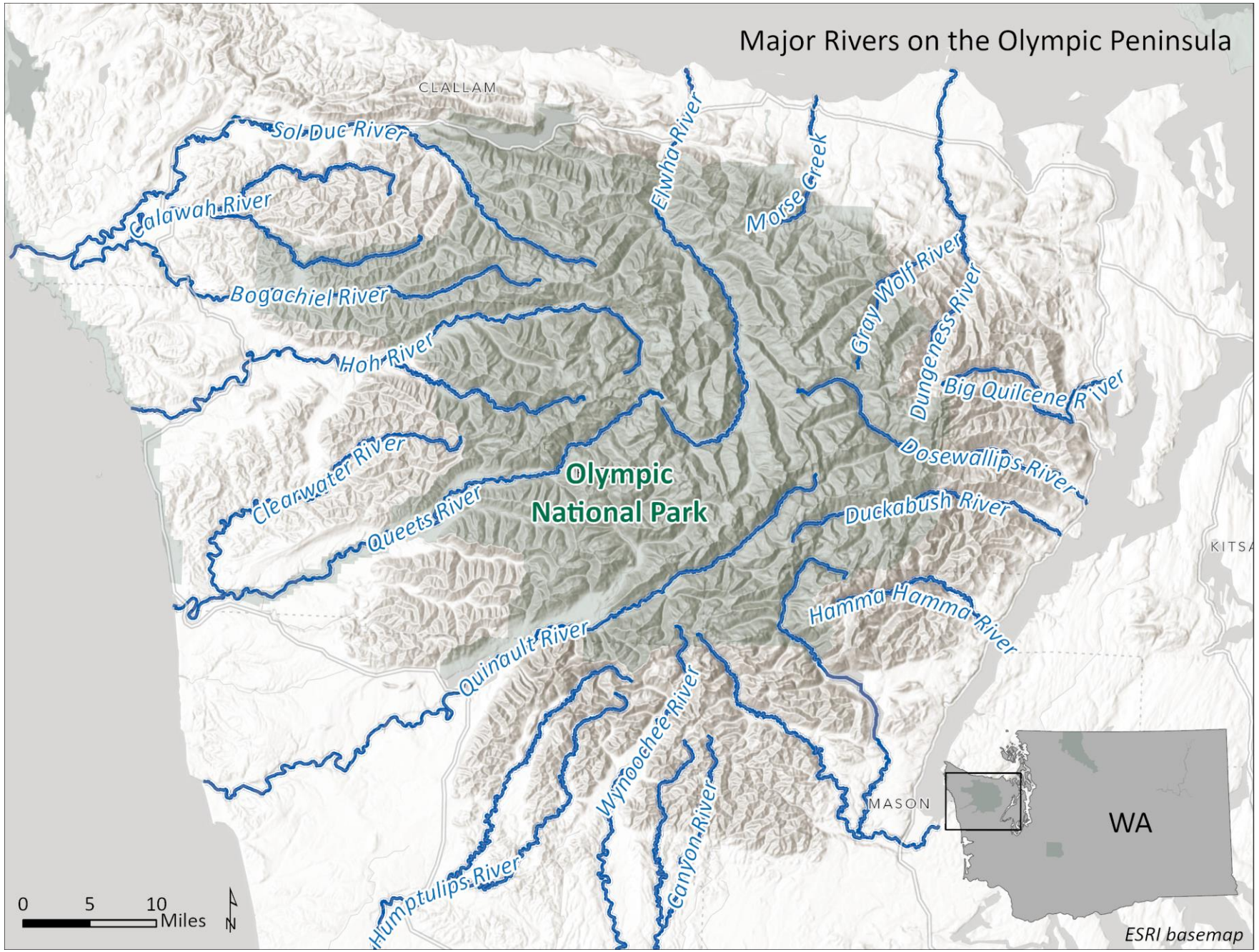
December 18, 2024

Natural Systems Design Speaker Series

Pacific Coastal Ecoregion & Olympic Peninsula



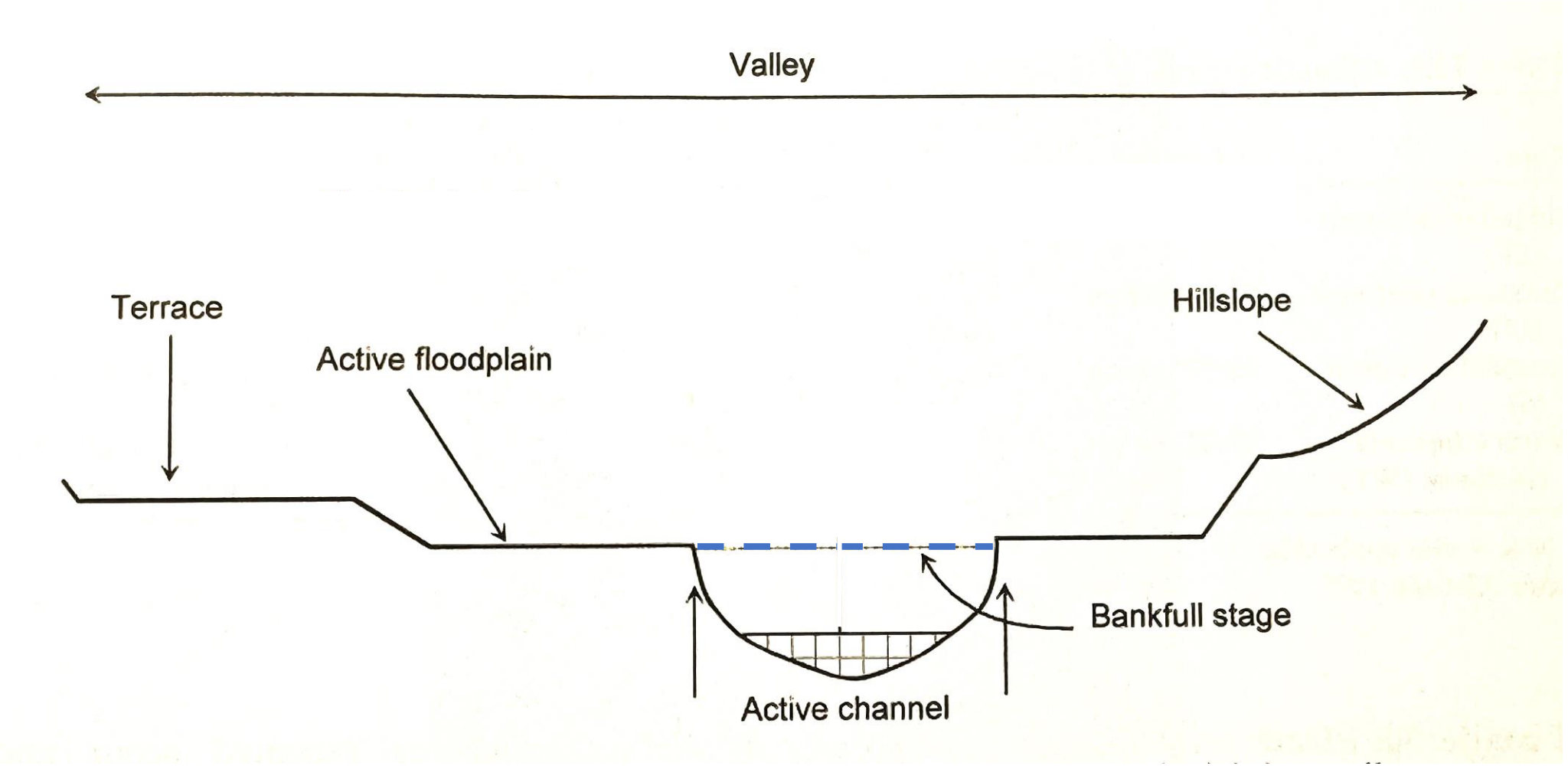
(Collins, Montgomery, Fetherston, Abbe 2012)



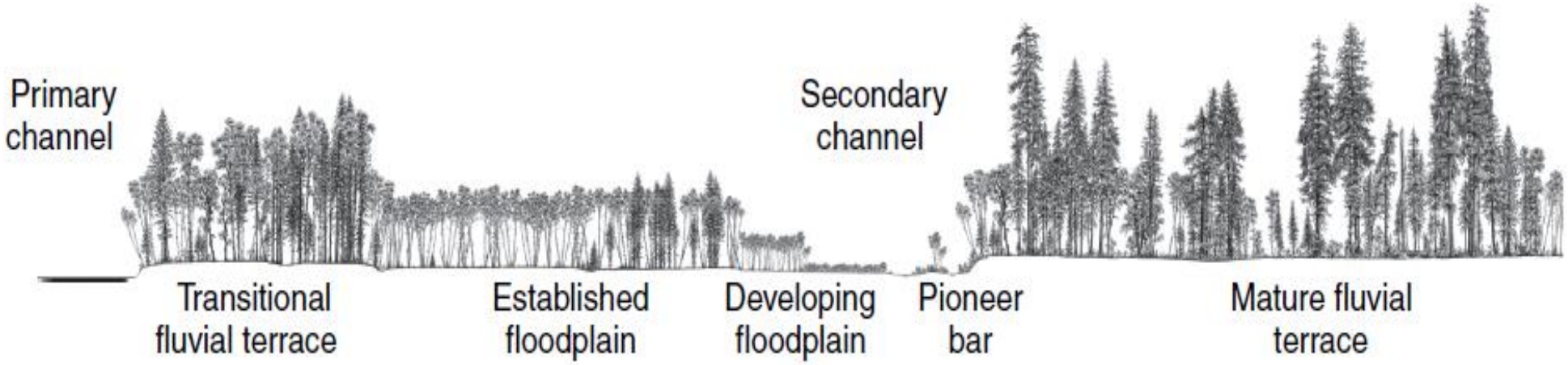
(Ginevra Moore)

(Fetherston 2005)

Typical Alluvial Valley Landforms

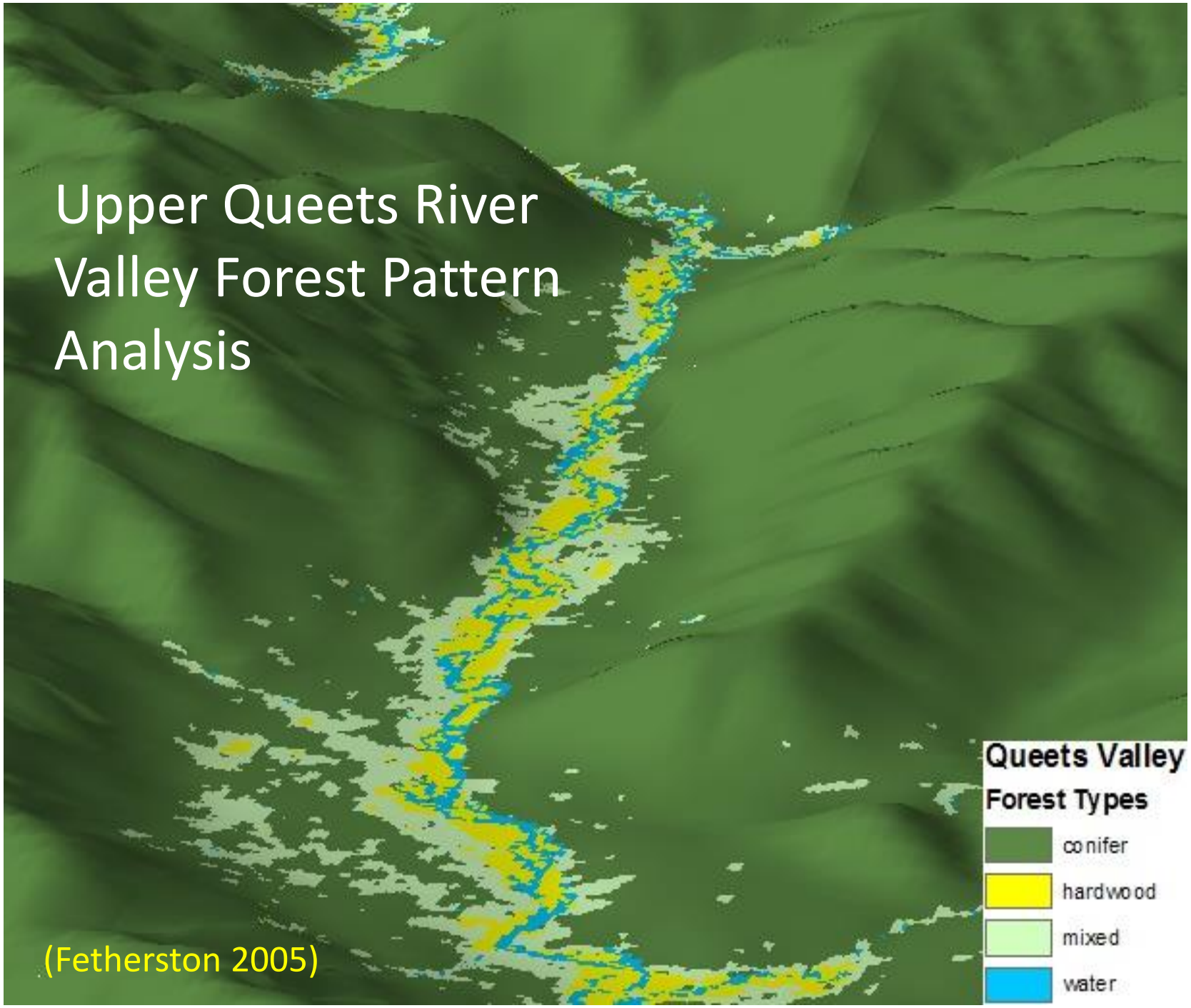


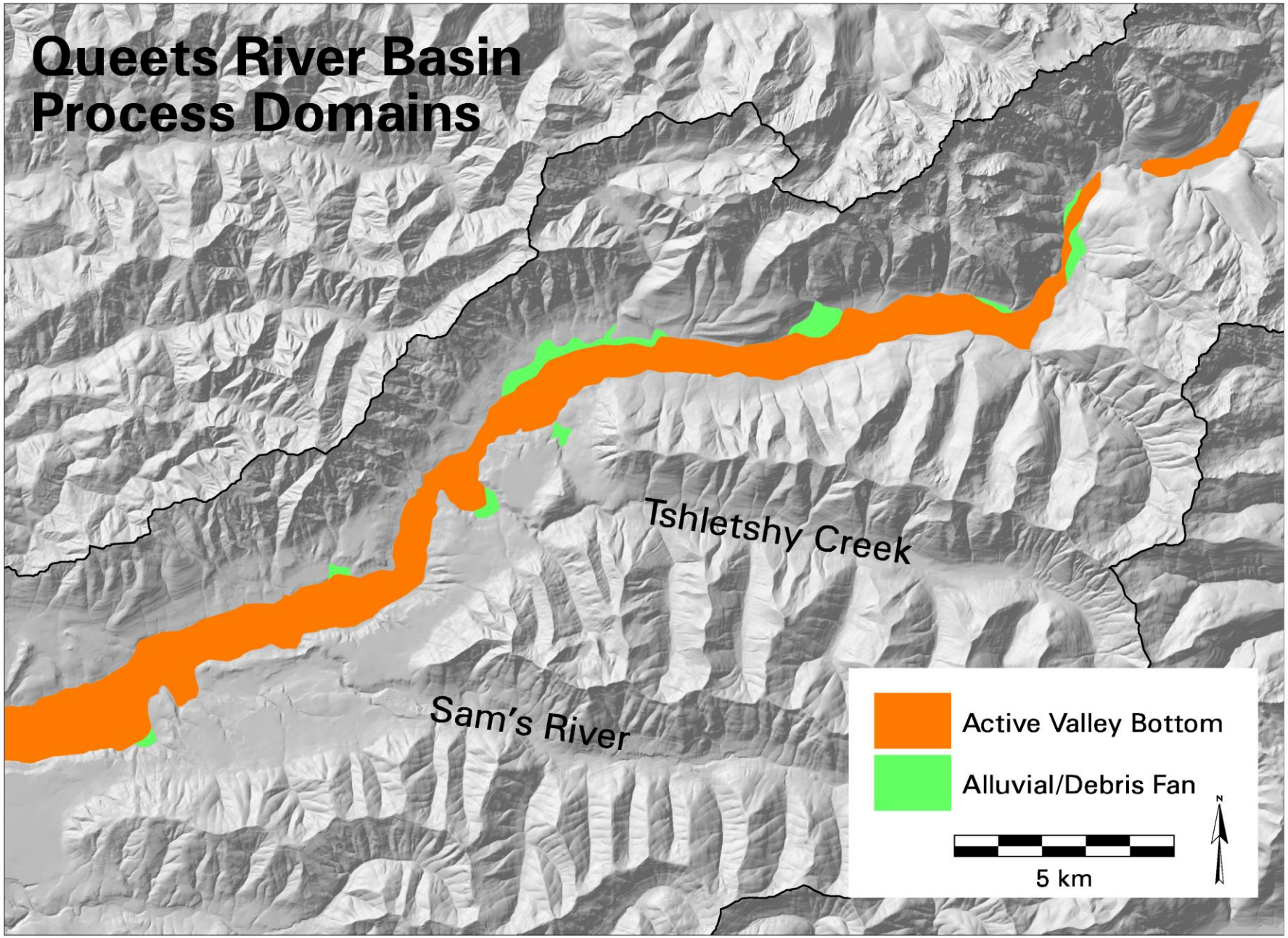
River Valley Landform & Forest Patch Types Queets River



Forest pattern, refers to spatial arrangement of forest patches with different structures
Forest structure, refers to arrangement and size of trees
Foundational trees, those tree species with strong roles in structuring their ecosystems (Kramer et al. 2020)

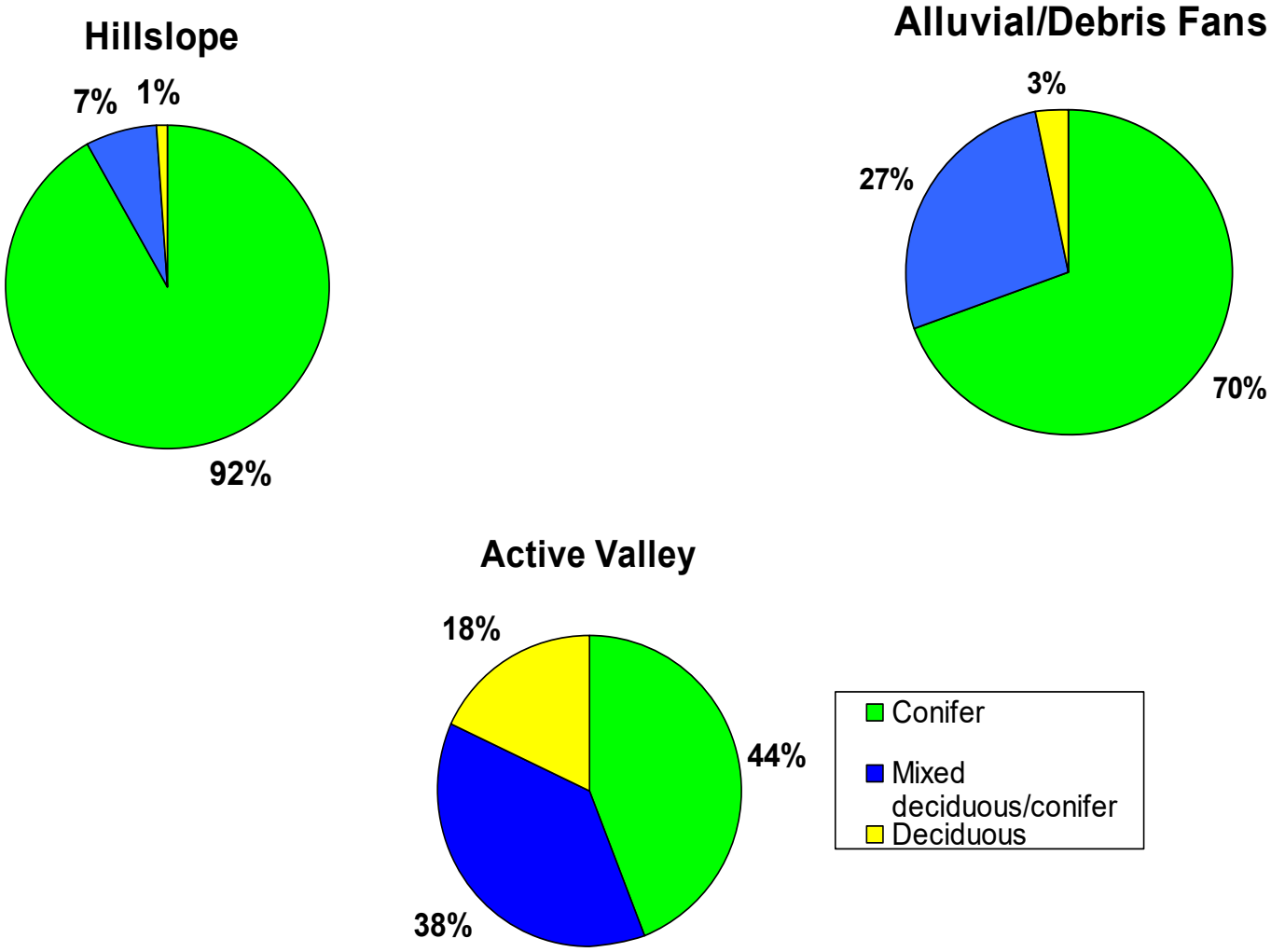
(Latterell et al. 2006; original art by Robert Van Pelt)


Upper Queets River Valley Forest Pattern Analysis
(Fetherston 2005)
Queets Valley
Forest Types
conifer
hardwood
mixed
water



(Montgomery 1999; Fetherston 2005)

Process Domain
Forest Type Pattern Analysis, Upper Queets Basin



(Fetherston 2005)

Identifying River Vally Forest Pattern-Process Linkages

What are the disturbance and ecological processes generating and maintaining forest pattern, composition and structure?

- For developing restorative silvicultural and river engineering strategies and designs understanding these linkages is critical

What are tree species biologic characteristics

- Sitka spruce, Douglas-fir, western hemlock, red alder, black cottonwood
- Life-history strategies: reproductive characteristics, growth rates, shade tolerance, structure, life spans
- Tree species successional / developmental sequence

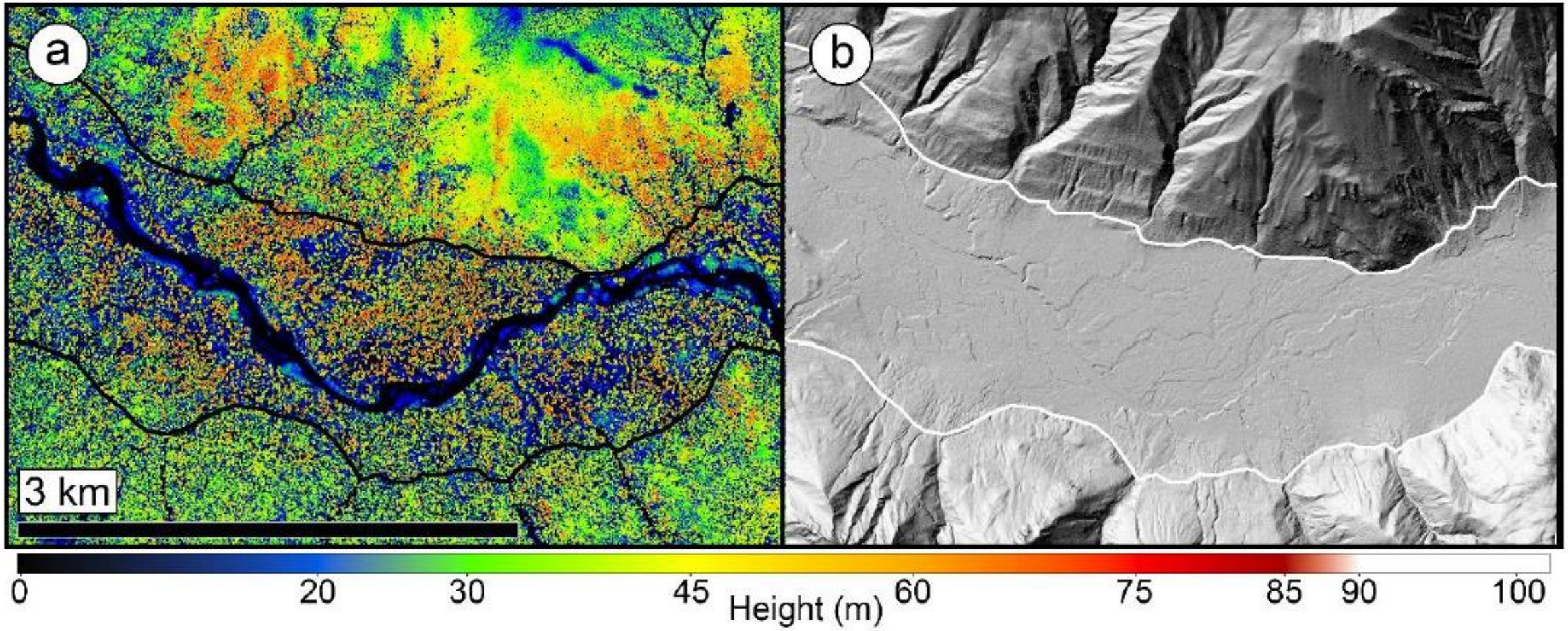
Large Trees—Forest compositional and structural patterns

(Kramer et al. 2019; Kramer et al. 2020)

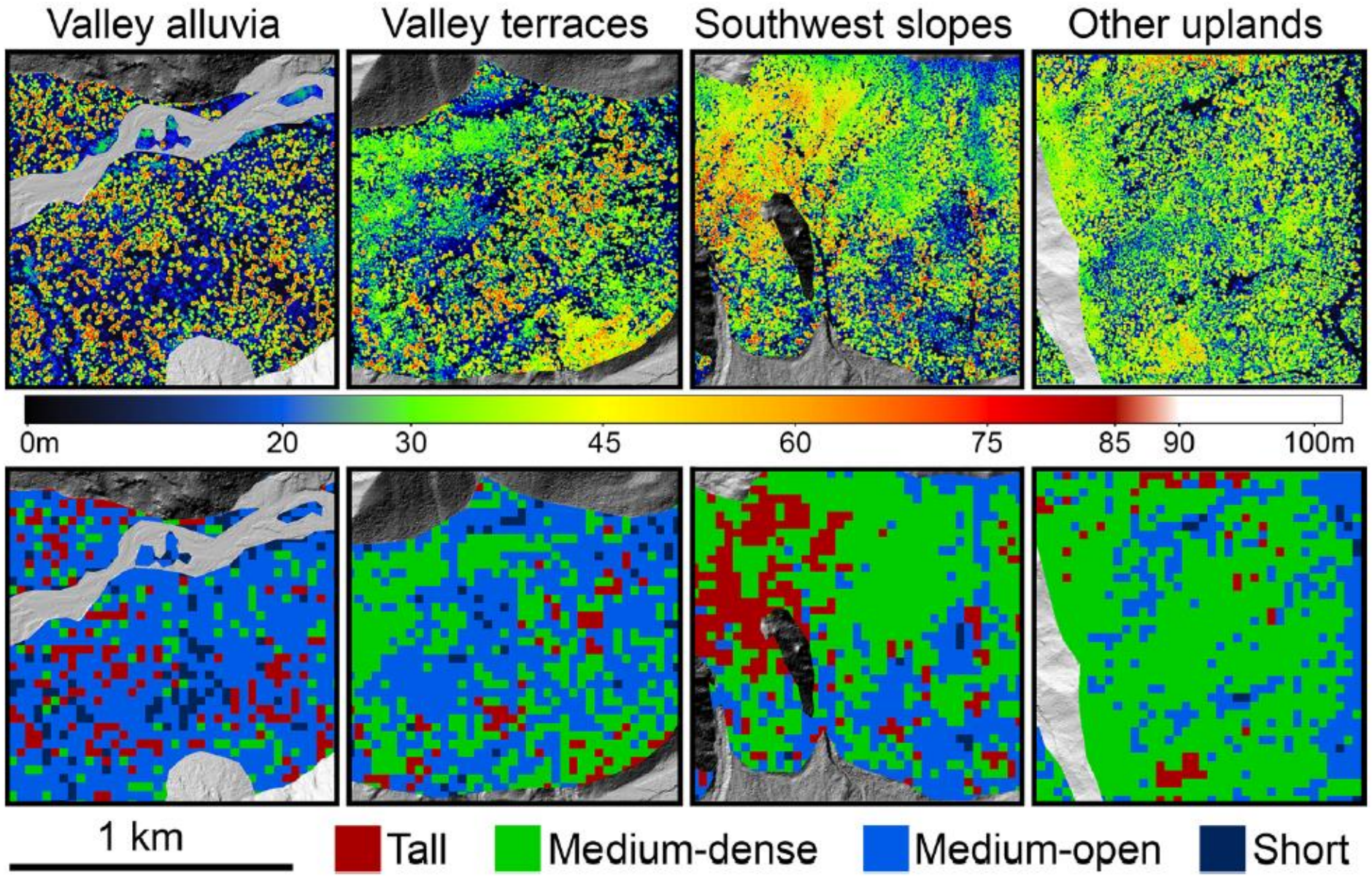
- “Elite Trees” are, large, old, and trees with complex canopy structures
- >55-60 m (180-197 ft) height
- Sitka spruce and Douglas-fir
- Key habitat of endangered Marbled Murrelet and Northern Spotted Owl in coastal PNW river valley forests
- Silvicultural techniques to accelerate development

(Kramer et al. 2020)

River Valley Forest Structural and Spatial Patterns
LiDAR Height Canopy Model Analyses
(Kramer et al. 2020)



(2013 LiDAR)



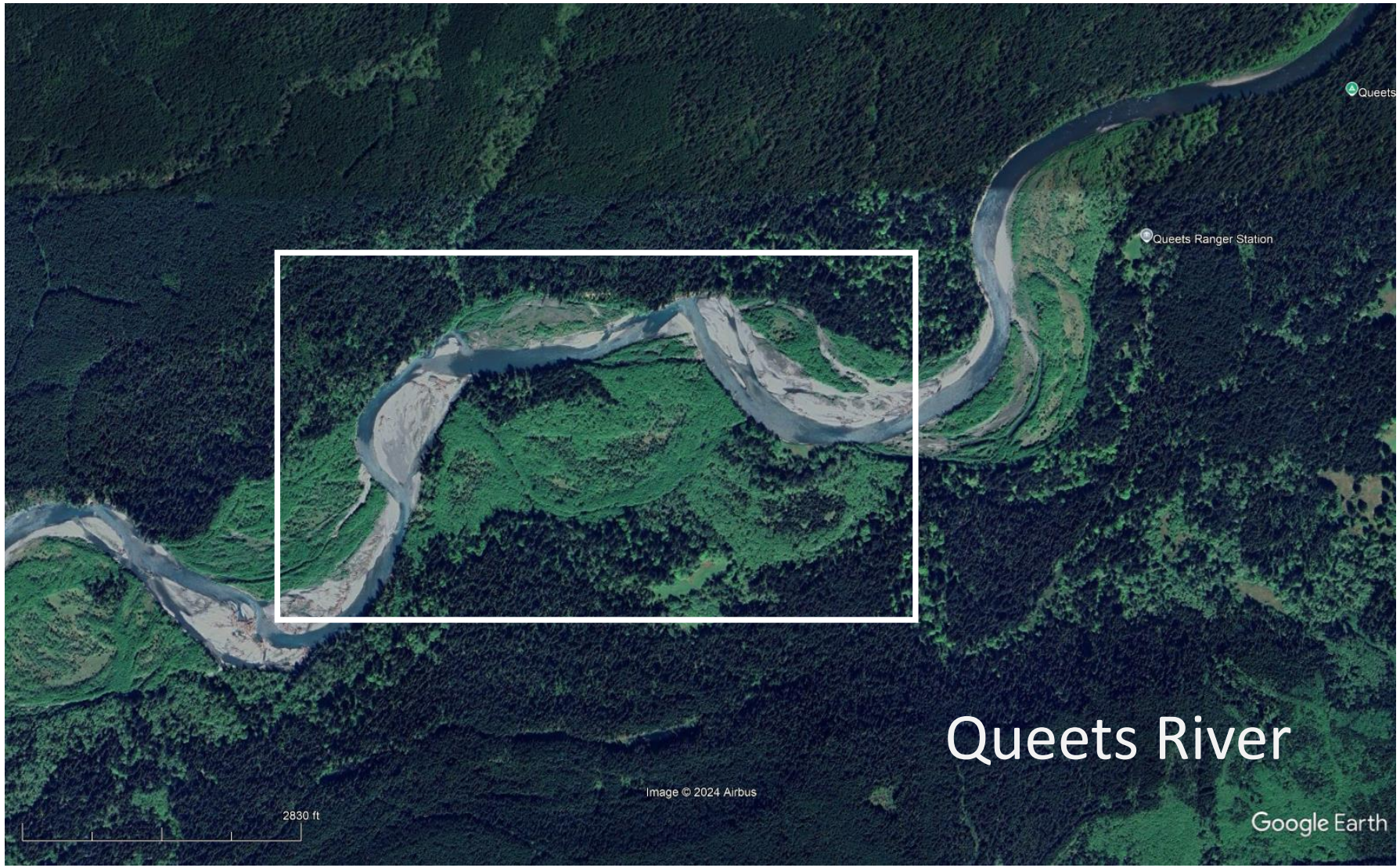
0.75 m and 30-m resolution classified canopy structure (Kramer et al. 2020)

Fire Disturbance- Paradise Fire Queets River (2015) ~2,700 acres

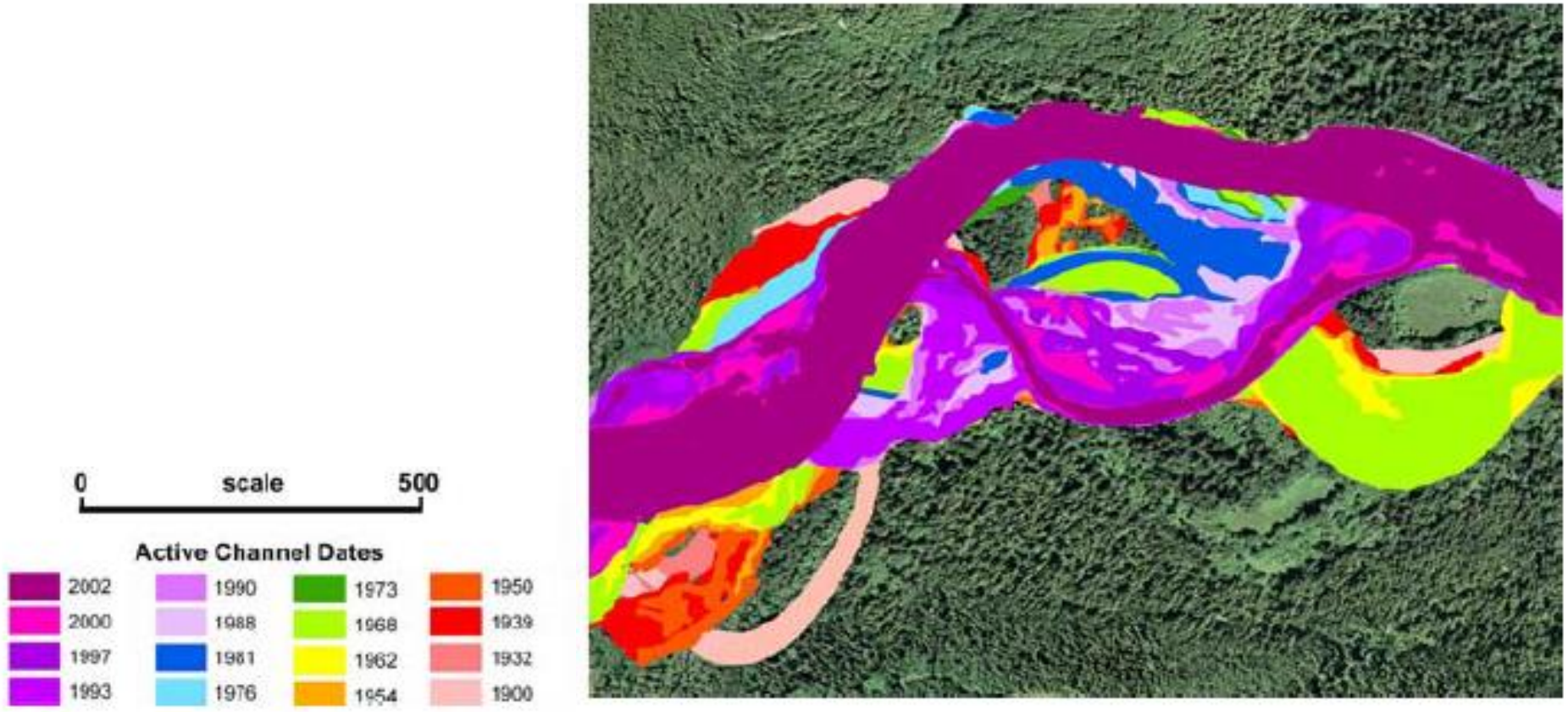
Wind–Coastal Pacific Northwest Forests

Herbivory – Elk Herds Olympic Peninsula

Queets River Valley Forest Mosaic
Valley Forest Patch Type Pattern-Process Linkages



Channel Movement & Erosional Floodplain Disturbance, Queets River 1900-2002



(VanPelt et al. 2006; Naiman et al. 2010)

Exponential Erosion Rates for Patch Types Queets River, WA (Latterell et al. 2006)

River landform	Patch Half-life (years): time channel erodes half of existing patches	95% Loss of existing patches(years)
Channel system (rate of colonization)	18	78
Pioneer bar	30	131
Developing floodplain	21	90
Established floodplain	68	291
Transitional fluvial terrace	62	265
Mature fluvial terrace	401	1730

Log-jam Mediated Channel Avulsion, Bank Failure and Terrace Large Wood Recruitment

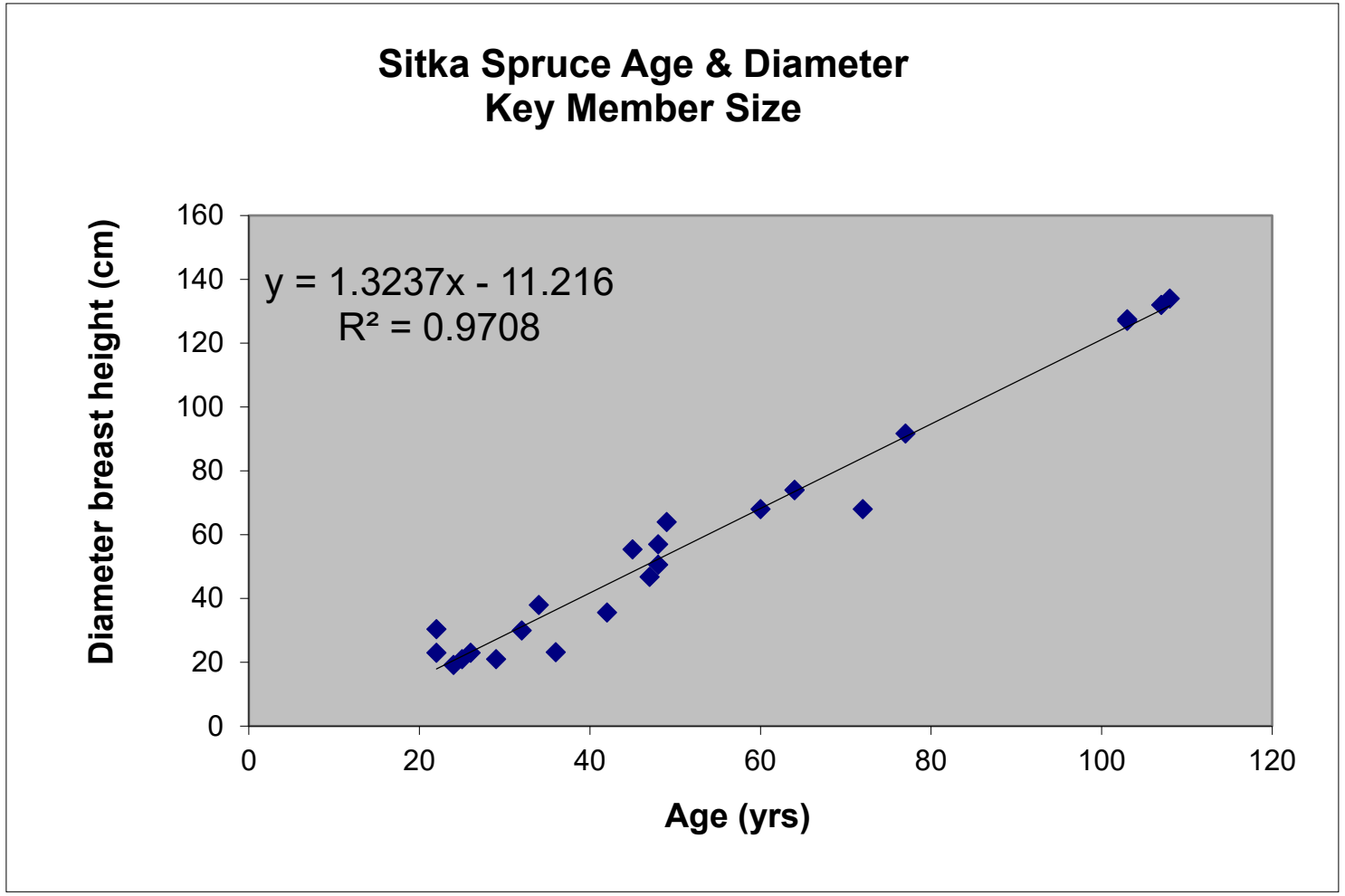

Terrace Forest
Large Trees
Queets River
Sitka spruce

Terraces are the Large Tree Source Pools

(Latterell et al. 2006; Latterell and Naiman 2007)

- Large tree “key members” are > 1-m diameter in mainstem Queets River
- Channel meandering delivers most live large trees to the channel
- Episodic cutoffs and avulsions are locally important
- Patches of mature forest 100’s of meters from the channel become important sources of large wood.
- Queets River recruits 95% of large trees from ≥265 m (870 ft) laterally from the channel within only 63 years
- Large tree input rates are patchy
- Mature terrace forests
  - large trees > 1-m diameter
  - 35±4 (20-47) / hectare
  - (14±2 (8-19) / acre)
- Conifers almost exclusively
- Large black cottonwood may also function as key member

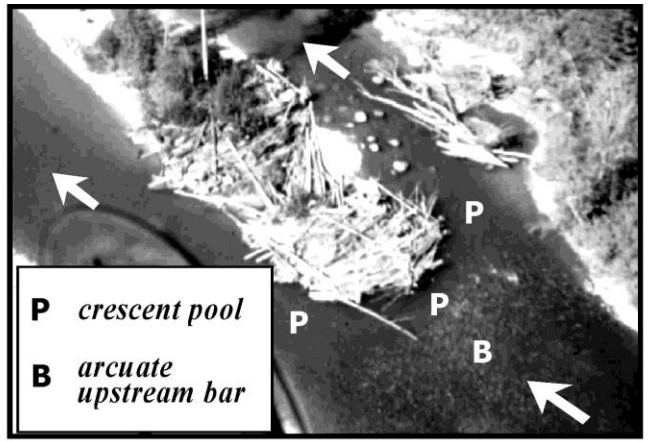
Sitka spruce Years to Key Member Size (>100 cm diameter) ~84 years, Queets River

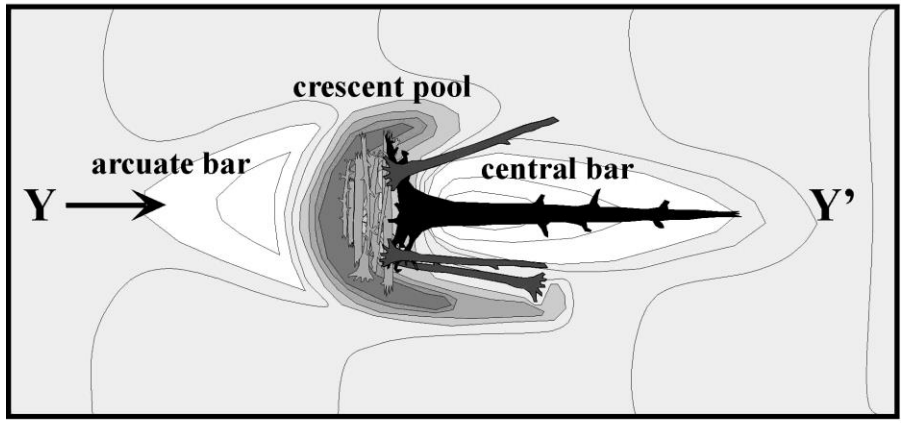


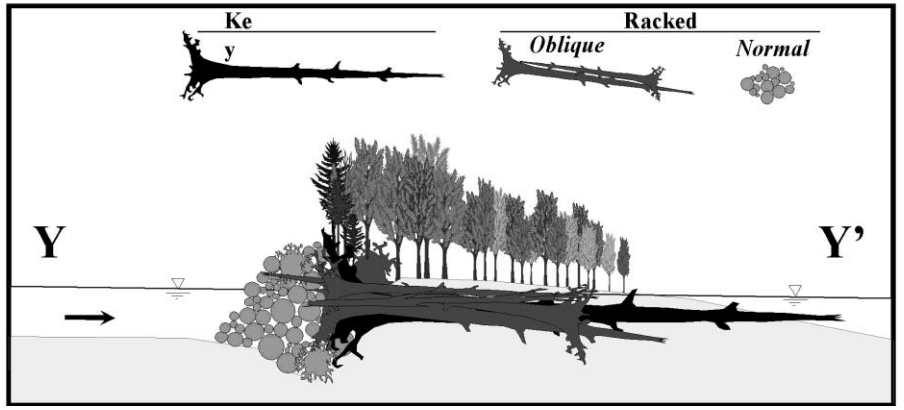
(Fetherston 2005)

Wood Jam Forested Islands

- Large “key member” size trees (>1 m diameter)
- Wood jam alluvial patches provide forest “refugia”
- Both alluvium and nurse logs are colonized forming forested islands

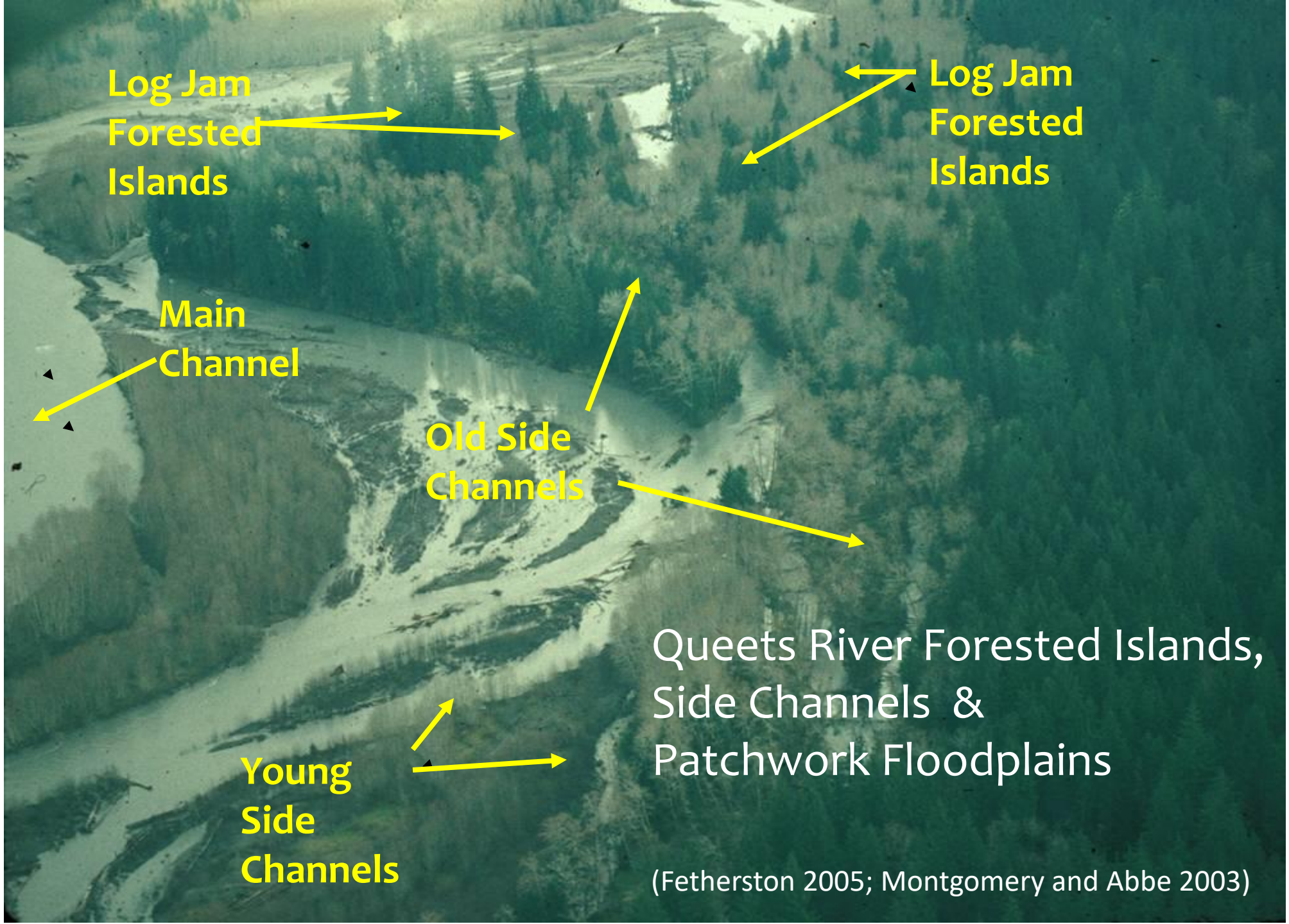






(Abbe & Montgomery 2003)


Wood Jam Forested Island & Split Channels
(Kitlope River, British Columbia)
Log Jam Forested Island
Channel Split
(Fetherston 2000)



Queets River Forested Islands, Side Channels & Patchwork Floodplains

(Fetherston 2005; Montgomery and Abbe 2003)

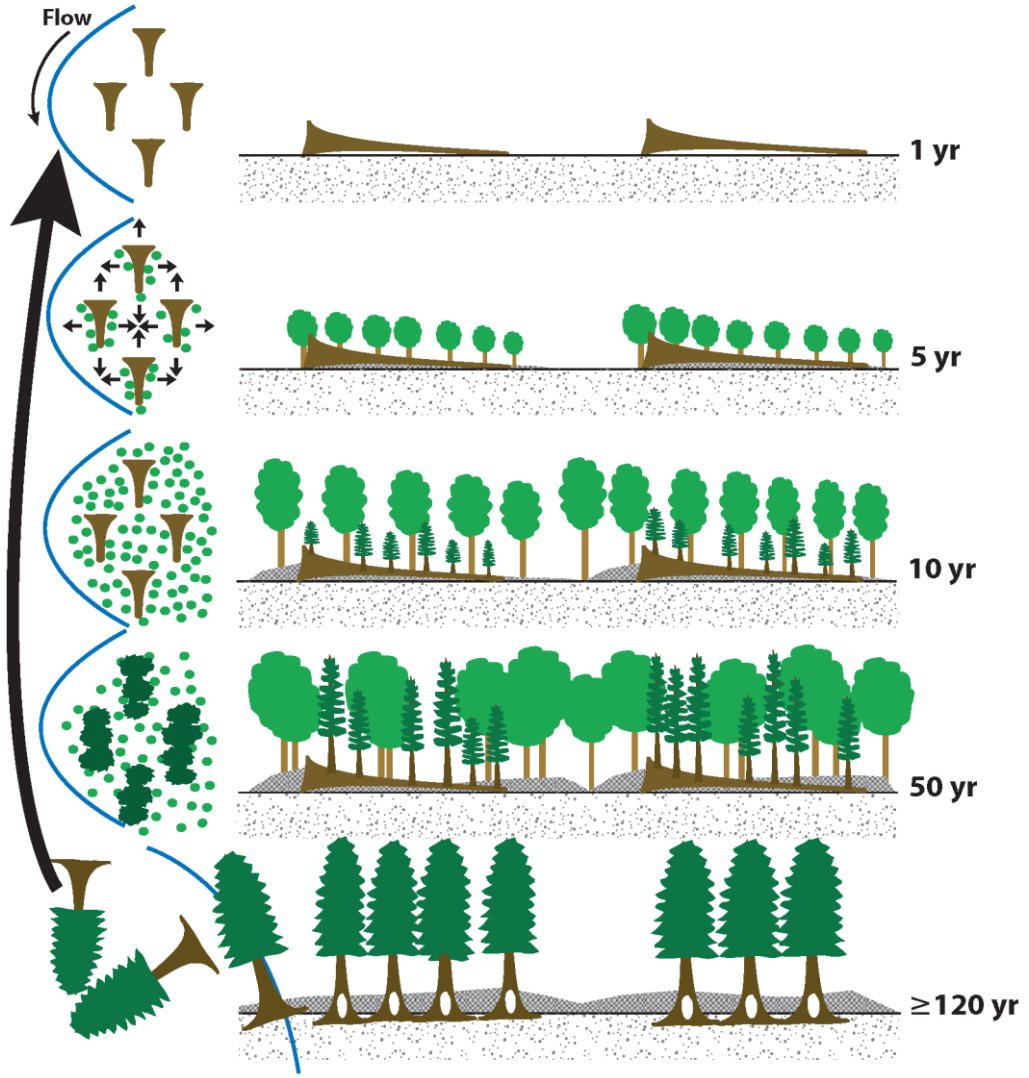
A Critical Ecological Process: The Floodplain Large Wood Cycle

- Foundational tree species—large diameter trees (> 1m diameter)
  - Have strong roles in structuring their ecosystem
  - Large trees form stable wood jams
- Generates and maintains river valley anabranching channel network, forested islands and patchwork floodplains
- Cycle tends toward a self-reinforcing state.

(Collins, Montgomery, Fetherston & Abbe 2012)

Floodplain Large Wood Cycle

Forested Islands & Patchwork Floodplain Development



- Log jam island formation
- Log jam forested island refugia, vegetation colonization
- Increased roughness, floodplain aggradation, & vegetation facilitation
- Large tree recruitment to channel

(Fetherston 2005; Montgomery and Abbe 2006; Collins, Montgomery, Fetherston & Abbe 2012)

Hoh River
(river km 65-68)

• Forested islands

•Diversity of stable main and perennial secondary channel habitat

•Stable jams at main channel secondary channel splits.

• Diversity of floodplain forest, age, composition and structure.

Cowlitz River
(river km 2007-2010)

Similar to the Upper Quinault River

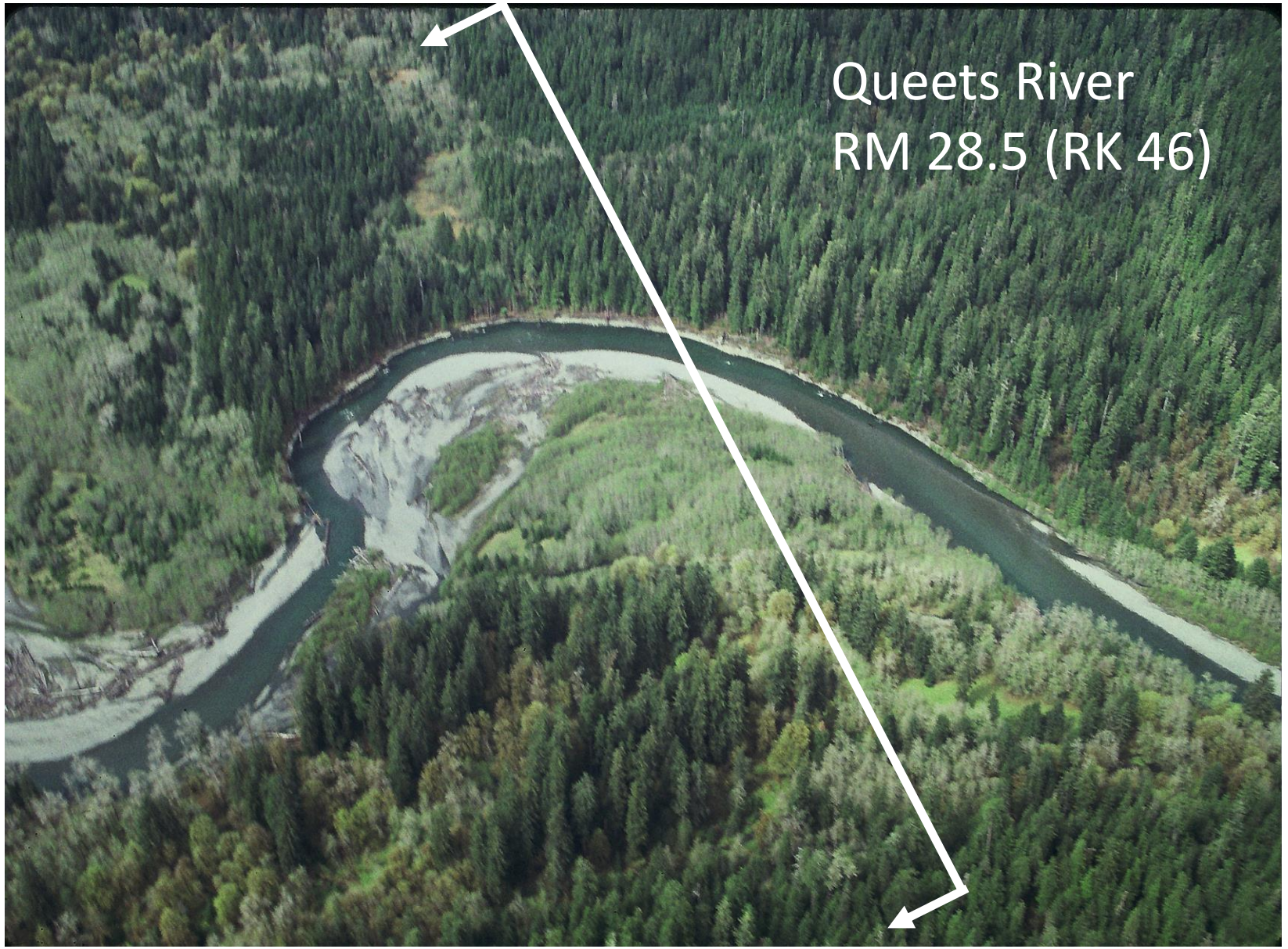
•Braided, unstable main channel and shifting, ephemeral secondary channels.

•Unstable pieces and accumulations of fluvial wood.

• Floodplain forest dominated by young, ephemeral red alder stands.

(Collins, Montgomery, Fetherston & Abbe 2012)

Spatial and Temporal Dimensions
River Valley Forest Restoration & Riparian Buffer Zones

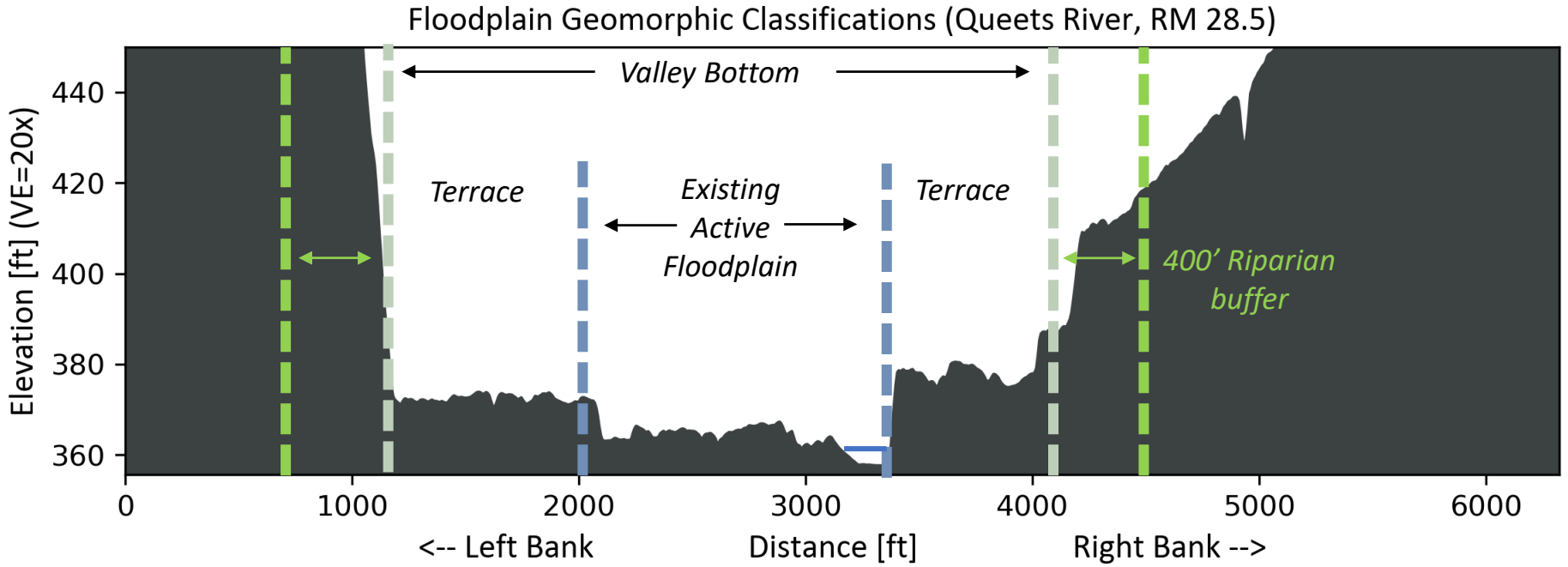


Channel Migration, Large Wood Recruitment & Riparian Forest Buffers

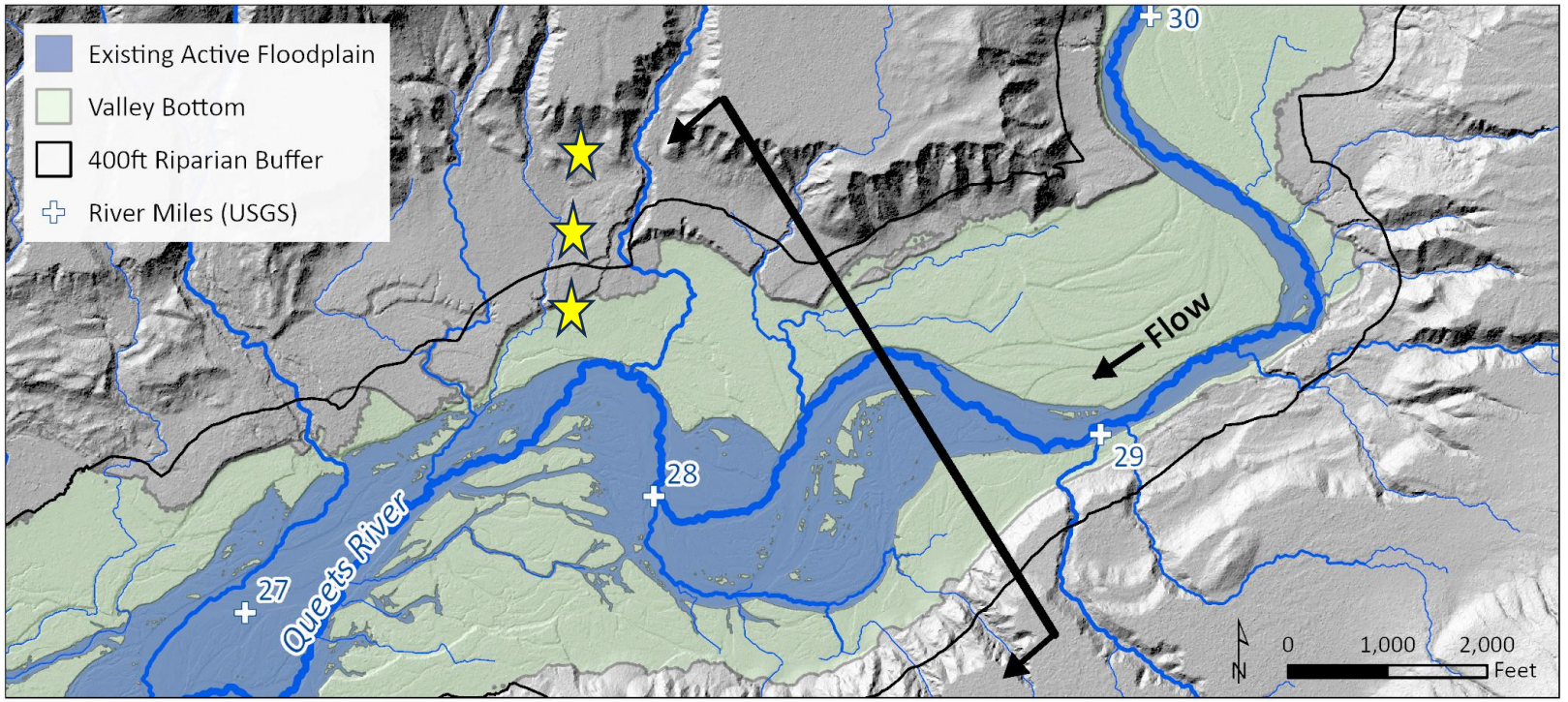
- Need geomorphic and ecological process based spatial and temporal scales

- Queets River Channel Migration and Valley Patch Type Half-lives
  - River kms 45-46 (Fetherston 2005)
    - Channel migration 4.2 m / year
    - Active valley half-life 300-400 years
  - River kms 1-42 (O'Conner et al., 2001)
    - Channel migration 7.5 ±2.9 m/yr
    - Active valley half-life 300-500 yrs
  - River kms 1-42 (Latterell et. al 2006)
    - Channel migration rate 3-28 m / year (1939-2002) throughout Queets river valley
    - 21-401 years Pioneer bars to Mature Terrace forests half-life
    - Mature terrace patch types forest half-life 401 years

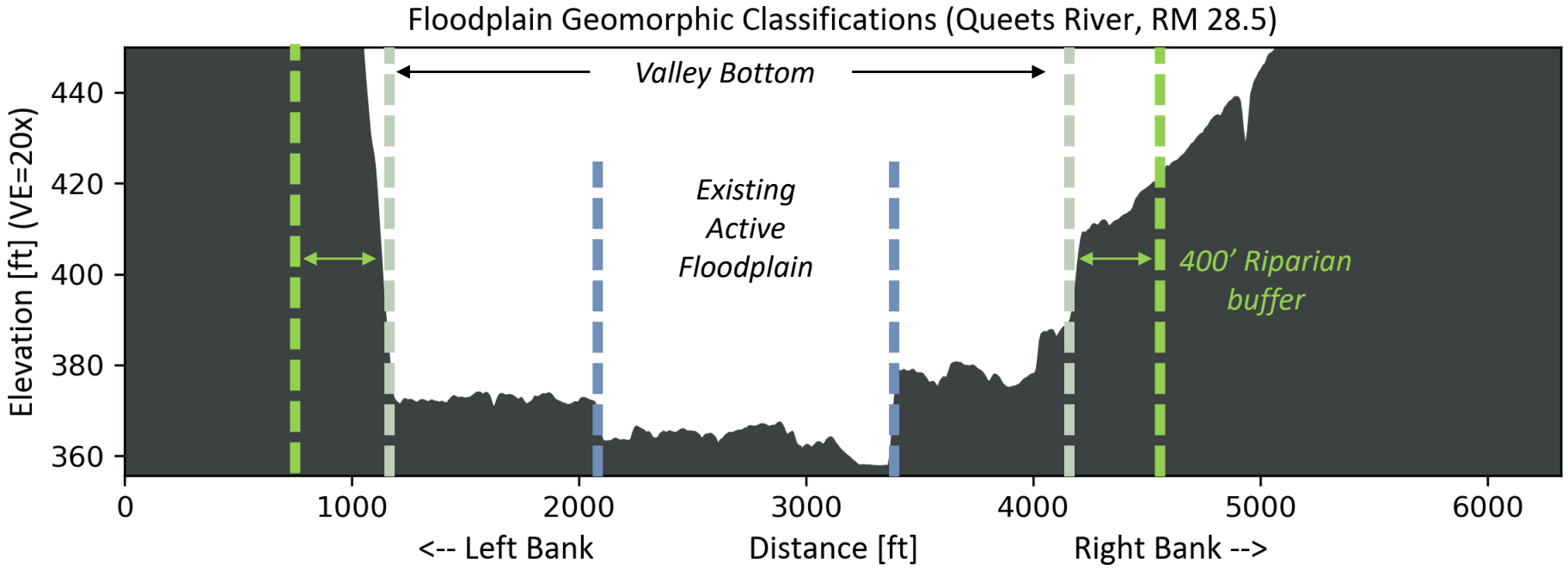
- Defining a geomorphic, ecologically-based area for river and river valley forest conservation

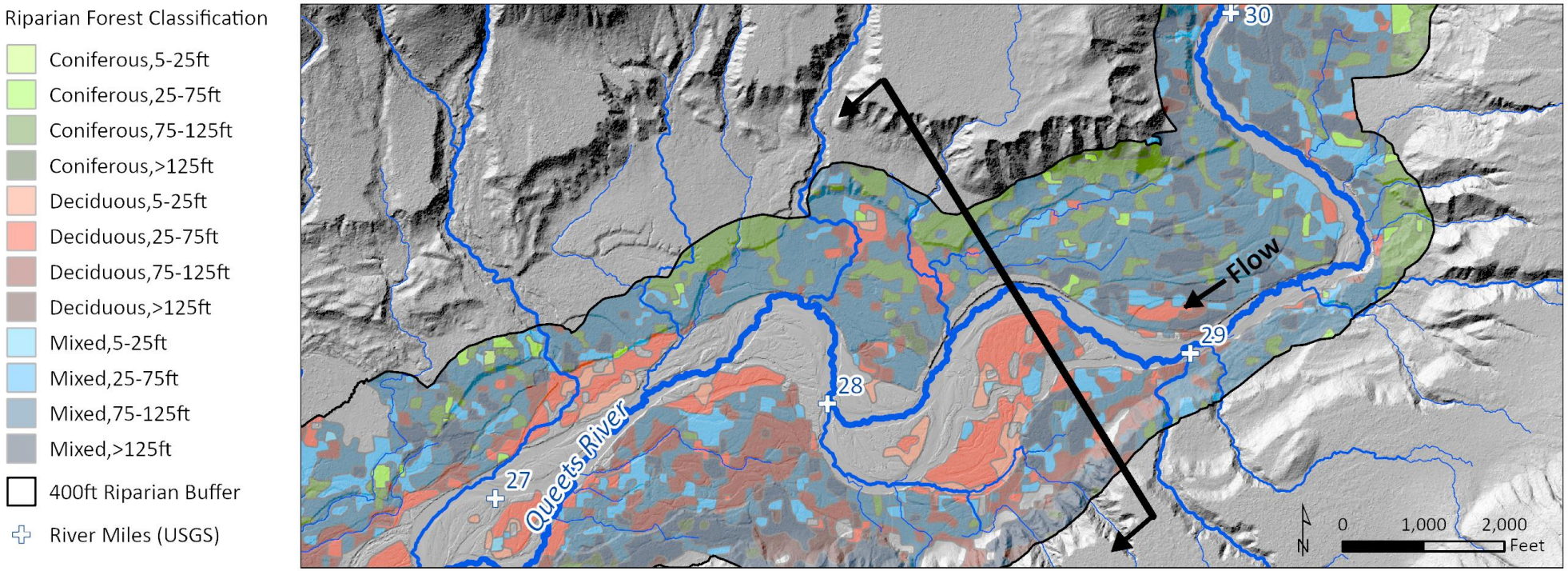


★ Approximate locations of Paleoecological Hollow/seep sample sites (Greenwald and Brubaker 2011)



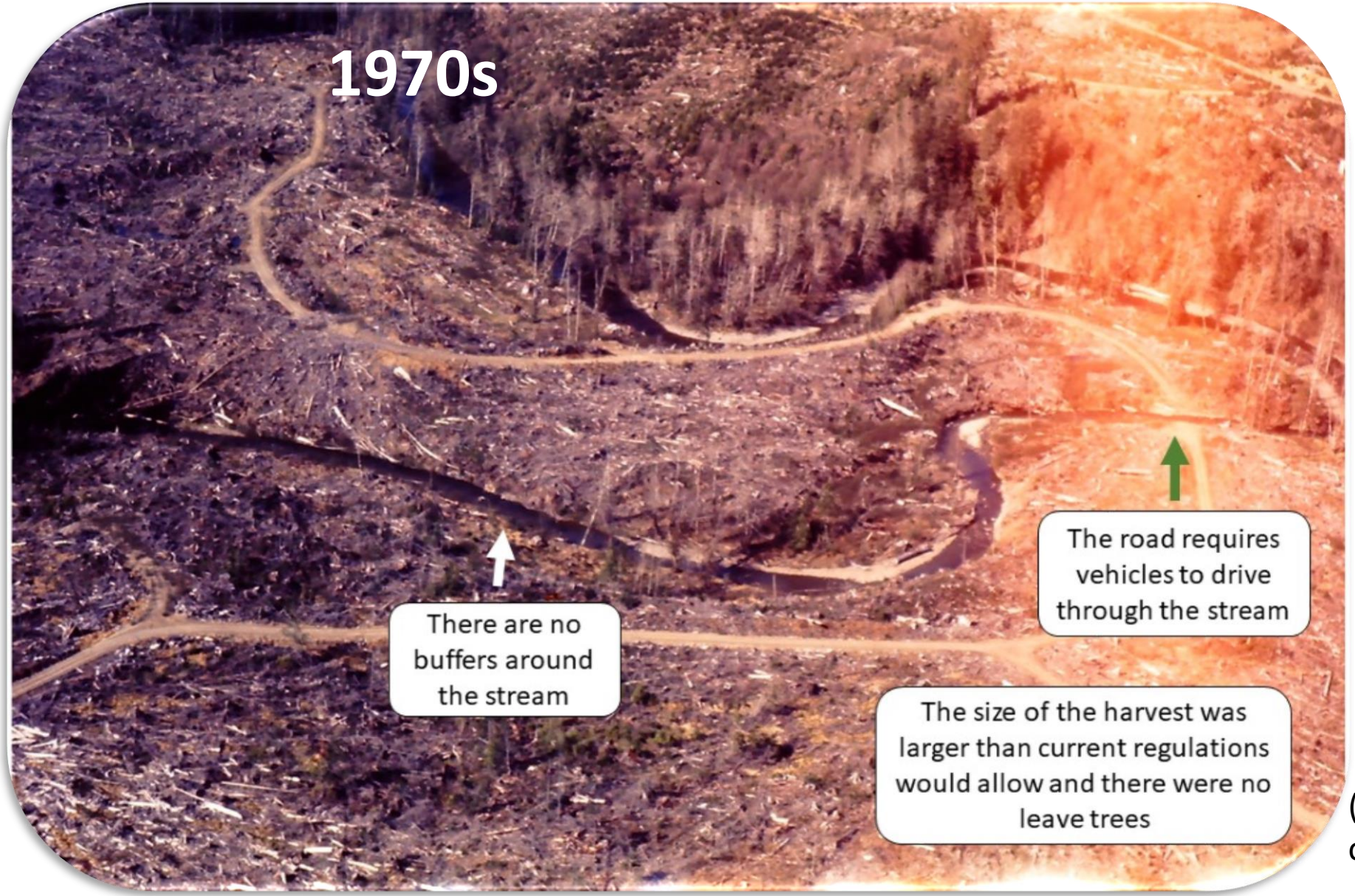
(Fetherston & Moore)





(Fetherston & Moore)

Olympic Experimental Forest Past Management
The Problem



(Photo courtesy of Kyle Martens)

The Problem

1850 (Analog)

- Anastomozing Channel (Taiya River, AK)
- Extensive mature floodplain forest side-channel network
- Forest and wood stabilized channel banks

Upper Quinault River

- Shallow Braided River Channel
- Immature red alder dominated floodplain forest
- Loss of forest channel bank stability
- Loss of majority of side-channels
- Very limited functional salmon habitat

(Tim Abbe)

Upper Quinault River Restoration: Project History

The 2008 *Salmon Habitat Restoration Plan – Upper Quinault River* has served as the guiding document (QIN 2008).

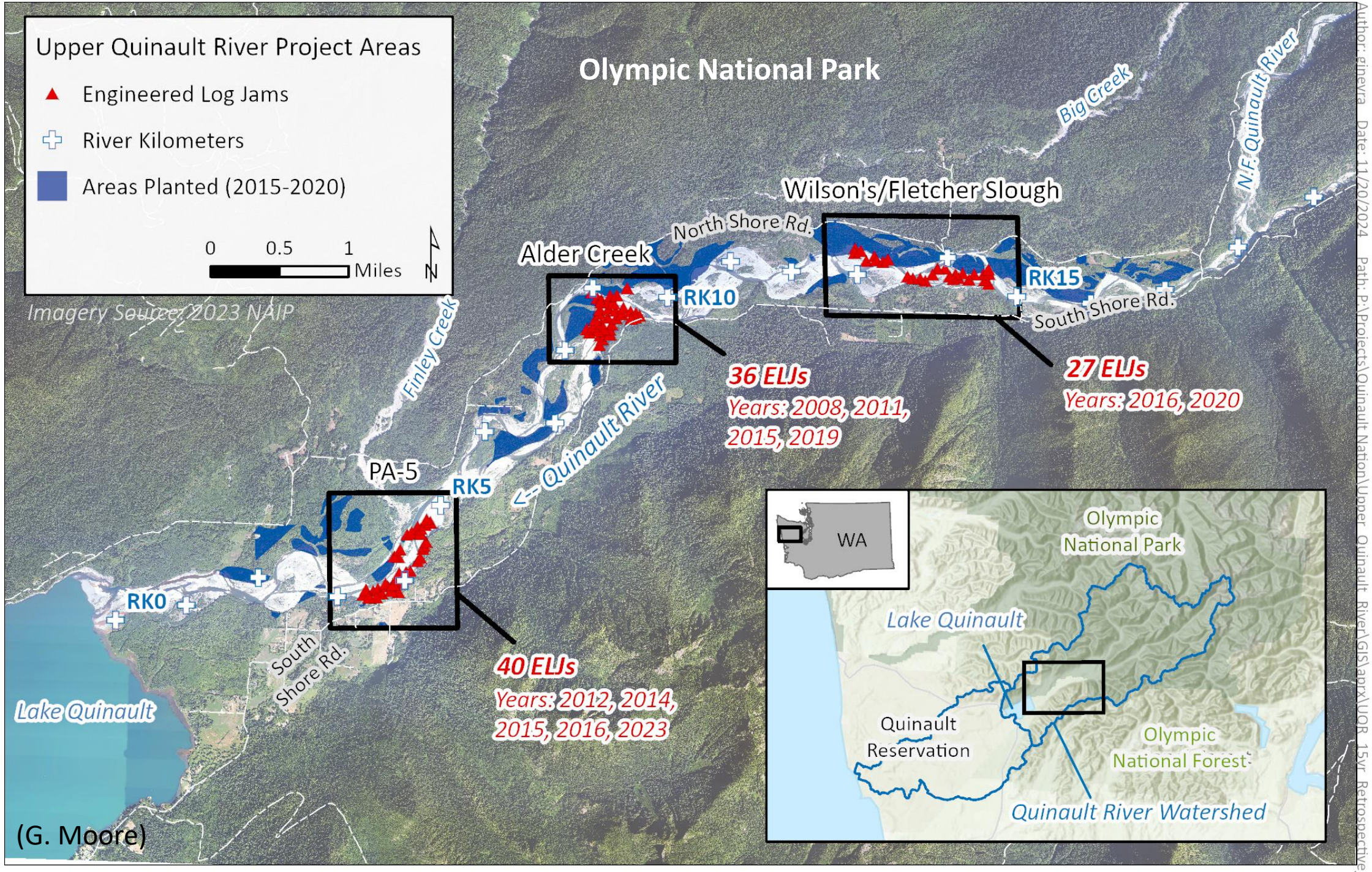
The restoration program was initiated on the ground in 2008 to restore Blueback salmon habitat.

Restoration Strategic Goals:

- Reintroduction of in-channel large wood with Engineered Log Jams ELJs
- Creation of forested islands in the main channel
- Initiate development of anabranching multiple channel network
- Protect and enhance existing side channel salmon spawning and rearing habitat
- Silvicultural restoration of floodplain and terrace forests
- Restore Floodplain Large Wood Cycle
- Implement an integrated river engineering and floodplain forest silvicultural restoration design

Pre-project conditions - The Upper Quinault Valley in 2008

(Scott Katz)



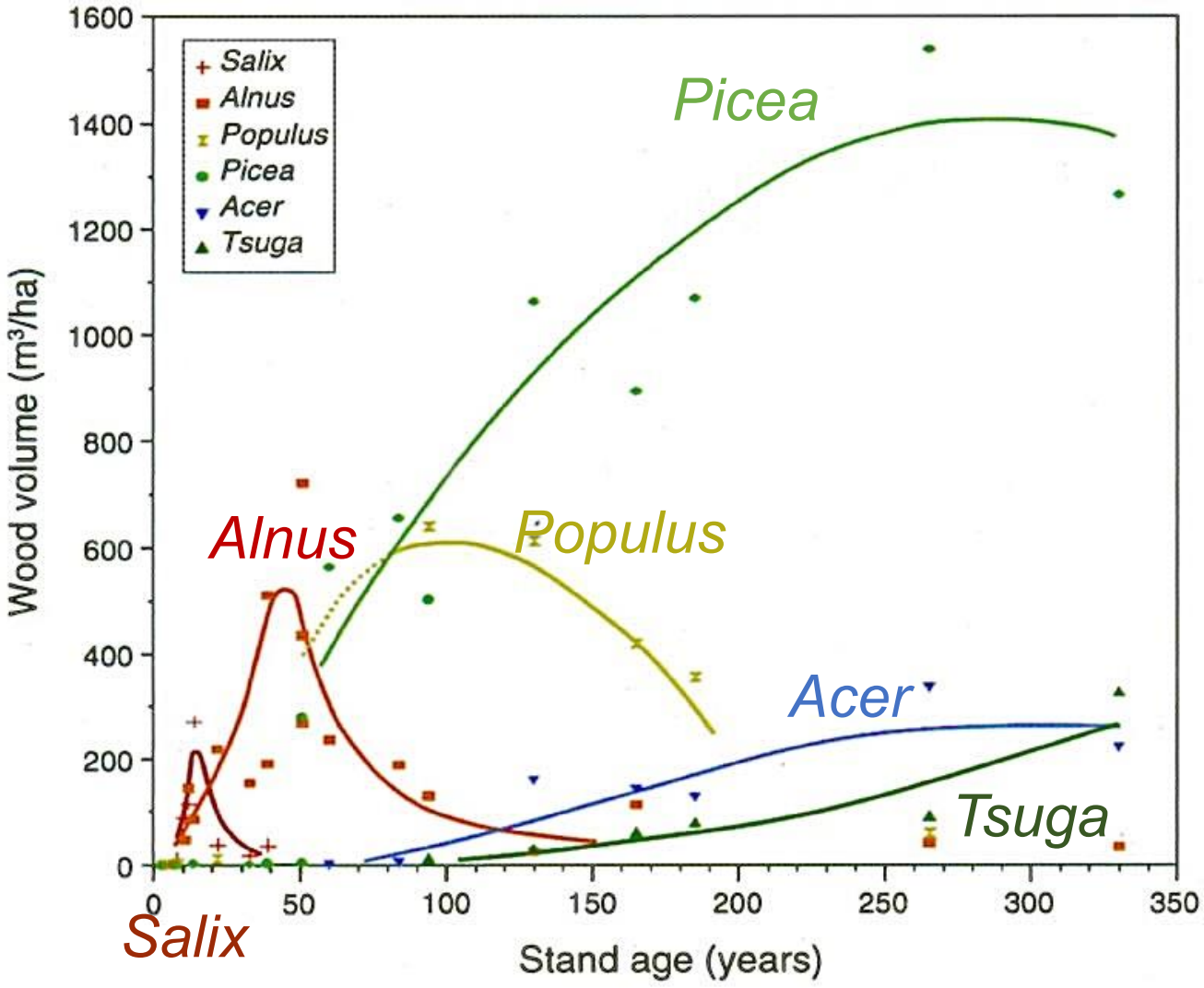
Author: ginevra Date: 11/20/2024 Path: P:\Projects\Quinault Nation\Upper Quinault River\GIS\aprx\UQR_15yr_Retrospective

Upper Quinault River Restoration by the Numbers To-date

METRIC	Quantity
Forested acres planted	924
Plants installed	167,340
Acres of Invasives Surveyed	1,199
Acres of invasives treated	929
ELJs constructed	103
Acres of floodplain forest stabilized	169
ELJs planted	68
Acres of ELJs forested islands planted	10
Side channel miles protected	5.6
ELJ's forming perennial pools (as of Nov 2023)	26

Queets River Forest Succession

Floodplain Forest Development or Succession, Queets River (Van Pelt et al 2006)



Coastal River Valley Forests
Four Types of Silvicultural Treatment Strategies and Designs

1. Red alder deciduous floodplains
    - Variable density silvicultural treatments with conifer inter-planting
    - Integrate ELJ floodplain stabilization measures

2. Mixed conifer deciduous floodplain and terrace forests
    - Variable density silvicultural treatments with conifer inter-planting
    - Integrate ELJ floodplain stabilization measures

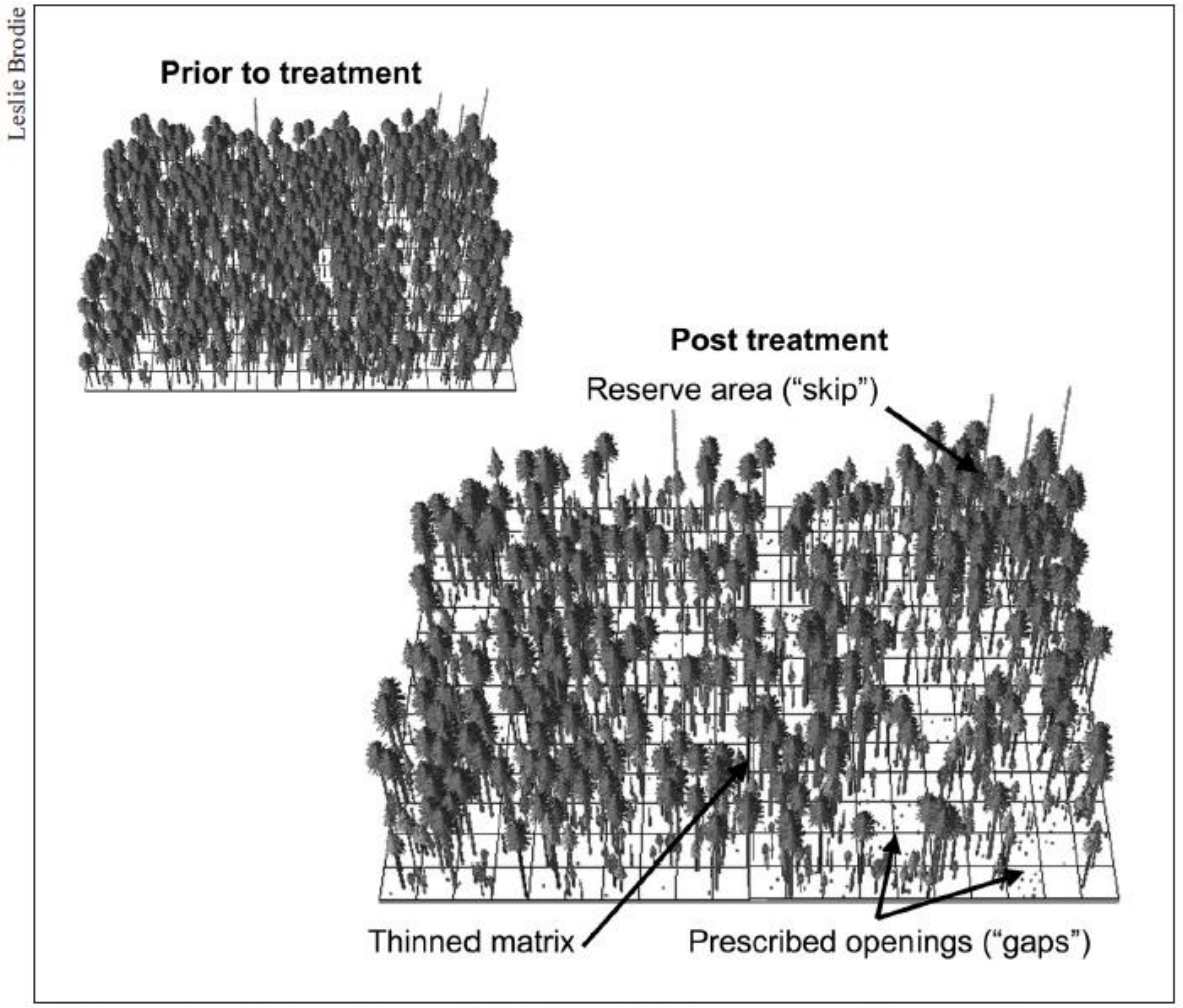
3. Broad braided active channels
    - ELJ forested island plantings
    - Restoration of patchwork floodplain forest

4. Pole size conifer dominated terrace forests
    - Variable density silvicultural treatments

Variable Density Thinning with “skips and gaps” layout

- Goal is to accelerate the development of old growth forest composition and structure
- Objective is to create greater vertical and horizontal stand complexity
- Key to unit treatment layout is skips (untreated patches) and gaps (atand canopy openings)
- Layout embedded within a thinned matrix forest

- Harrington et al. 2005; Brodie 2009; Franklin et al. 2018; Emmingham et al. 2000; Brodie & Harrington 2020; Case et al. 2023



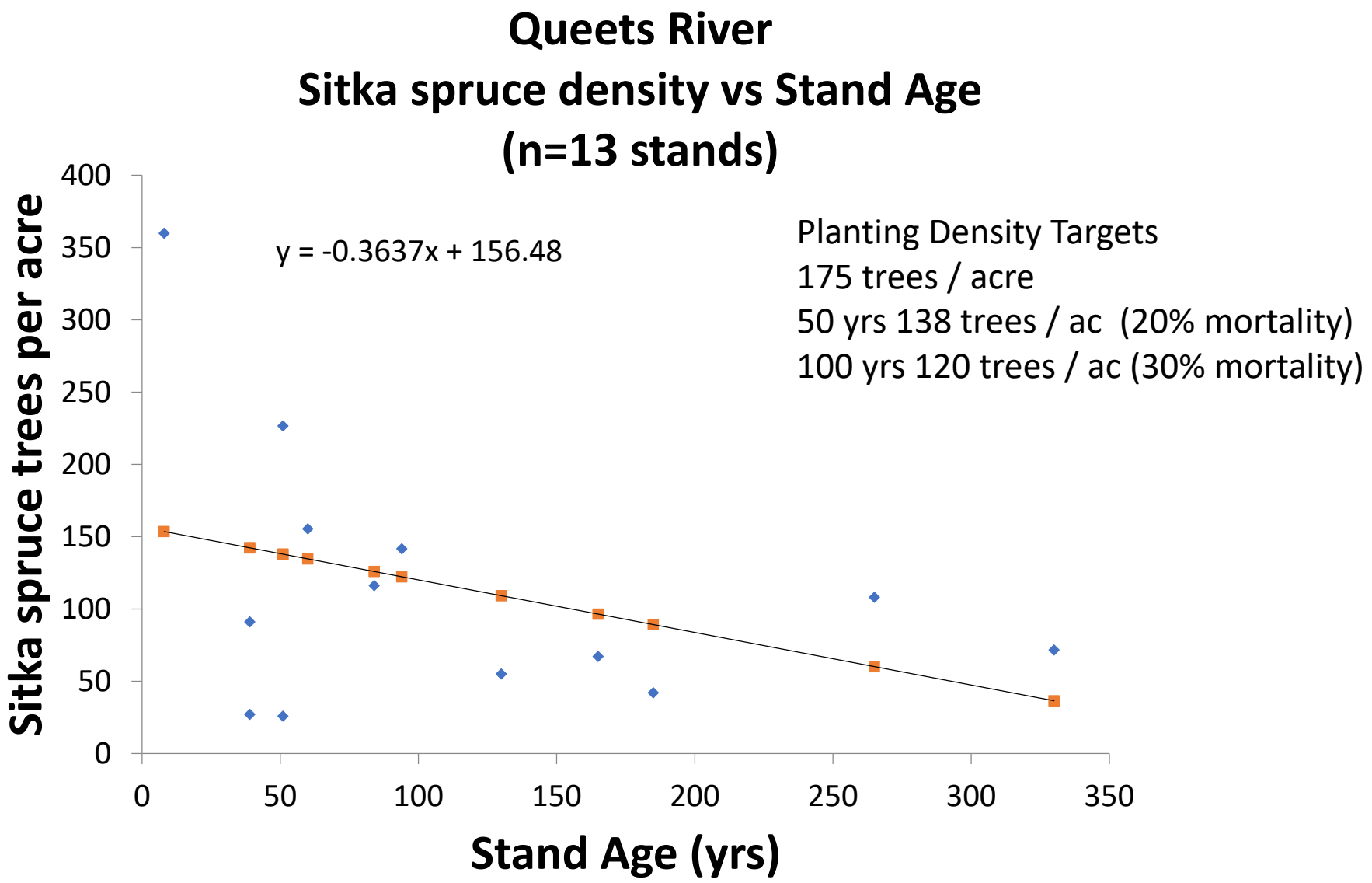
A diagram of a stand before and after thinning with skips and gaps. Snag height is exaggerated for visibility.

(Brodie 2009)

Silvicultural Types 1 & 2. Deciduous and mixed conifer deciduous floodplains and terraces

- Goal to accelerate the development of old growth terrace forests
- Variable Density Silvicultural Restoration with “Skips and Gaps” Designs
- Skips and gaps layout
  - Cut canopy gaps 0.25-0.5-acres
- Thin red alder canopy matrix 30-40%
- Inter-plant Sitka spruce to a conifer stem density of 175 trees / acre
  - Mixed conifer-deciduous terraces plant Sitka spruce and western red cedar
- Unique barren sites plant Douglas-fir

Sitka spruce target density reference



Planting Density Targets
175 trees / acre
50 yrs 138 trees / ac (20% mortality)
100 yrs 120 trees / ac (30% mortality)

(data from VanPelt et al. 2006)

Quinault River Alder Creek Reach
Integrated ELJ River Engineering and Forest Restoration

(2003)

Pre-Treatment 2006 Floodplain Terrace Mosaic

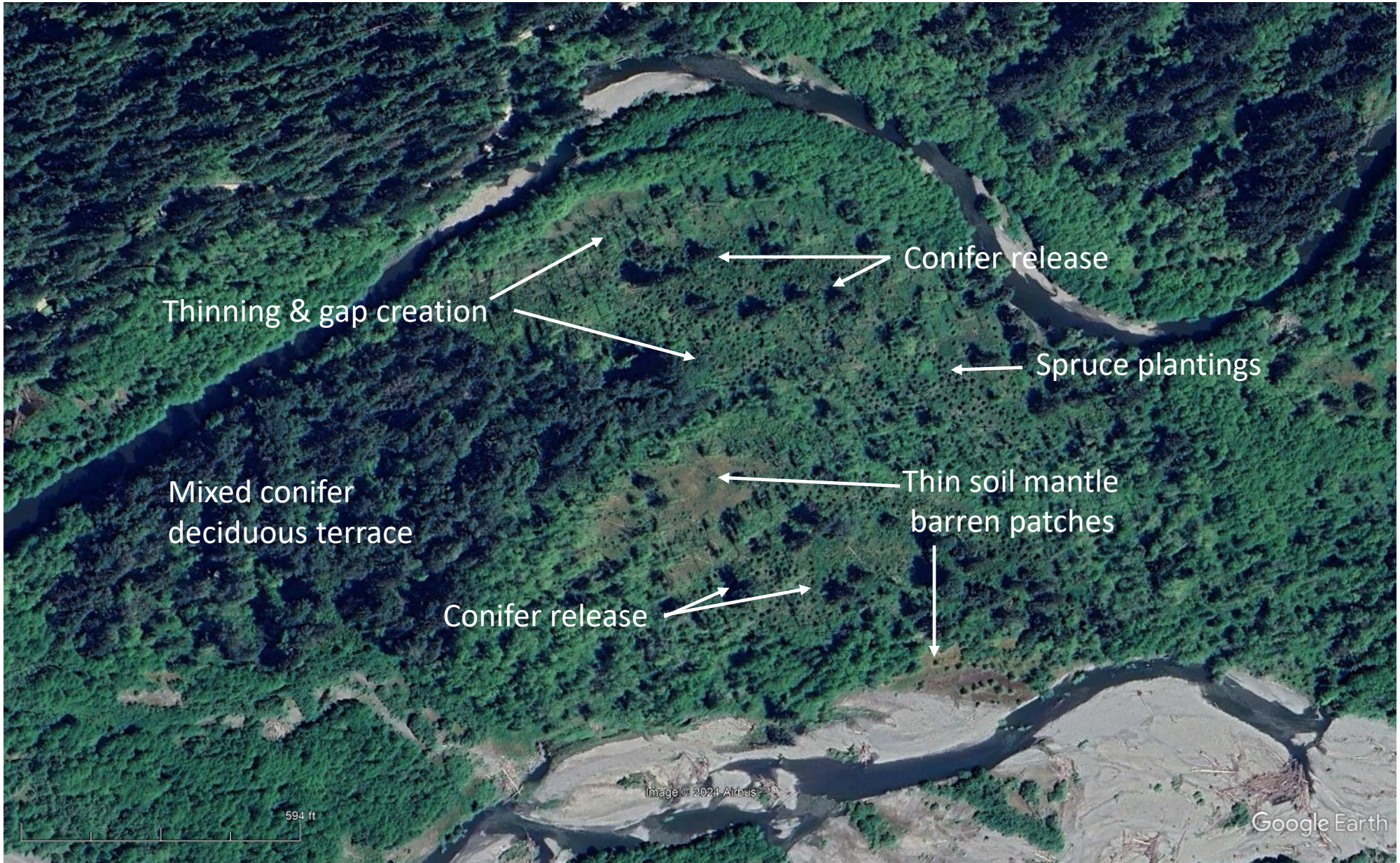
(9/11/2006)

Floodplain Vegetation Mosaic

Silvicultural Types 1 & 2. Variable density red alder floodplain forest thinning and gap creation “skips and gaps” design

Silvicultural Type 2. Advance conifer regeneration release & cultivation of “Elite Tree” trees

2024 8–years Post Treatment
Floodplain Forest Mosaic

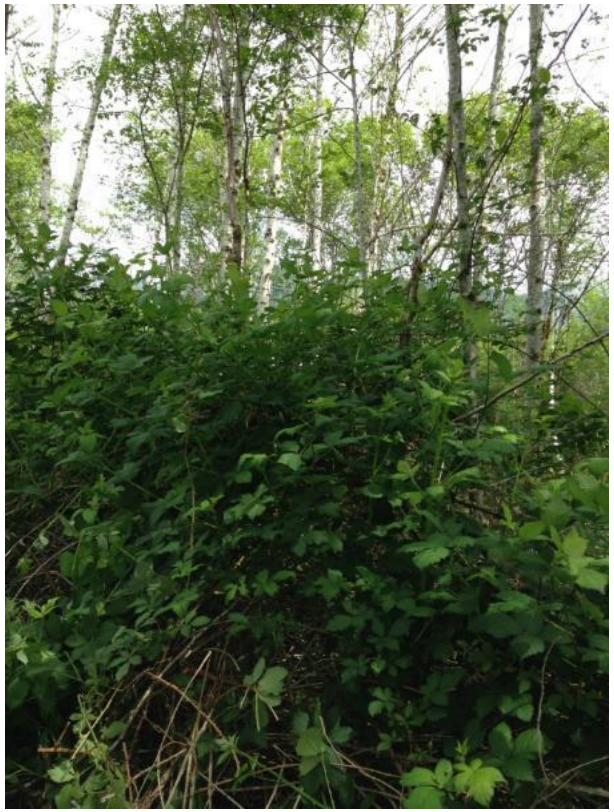


(7/6/2024)

Invasive Plant Treatment Program
Himalayan & Evergreen Blackberry, Knotweed, Reed Canary Grass

Himalayan & Evergreen Blackberry

BEFORE



AFTER

Ongoing Forest Monitoring Program
(n=49 Permanent Plots)
Hemispheric Photo Analyses—Photosynthetic Available Radiation (PAR)

True color original

Post processing

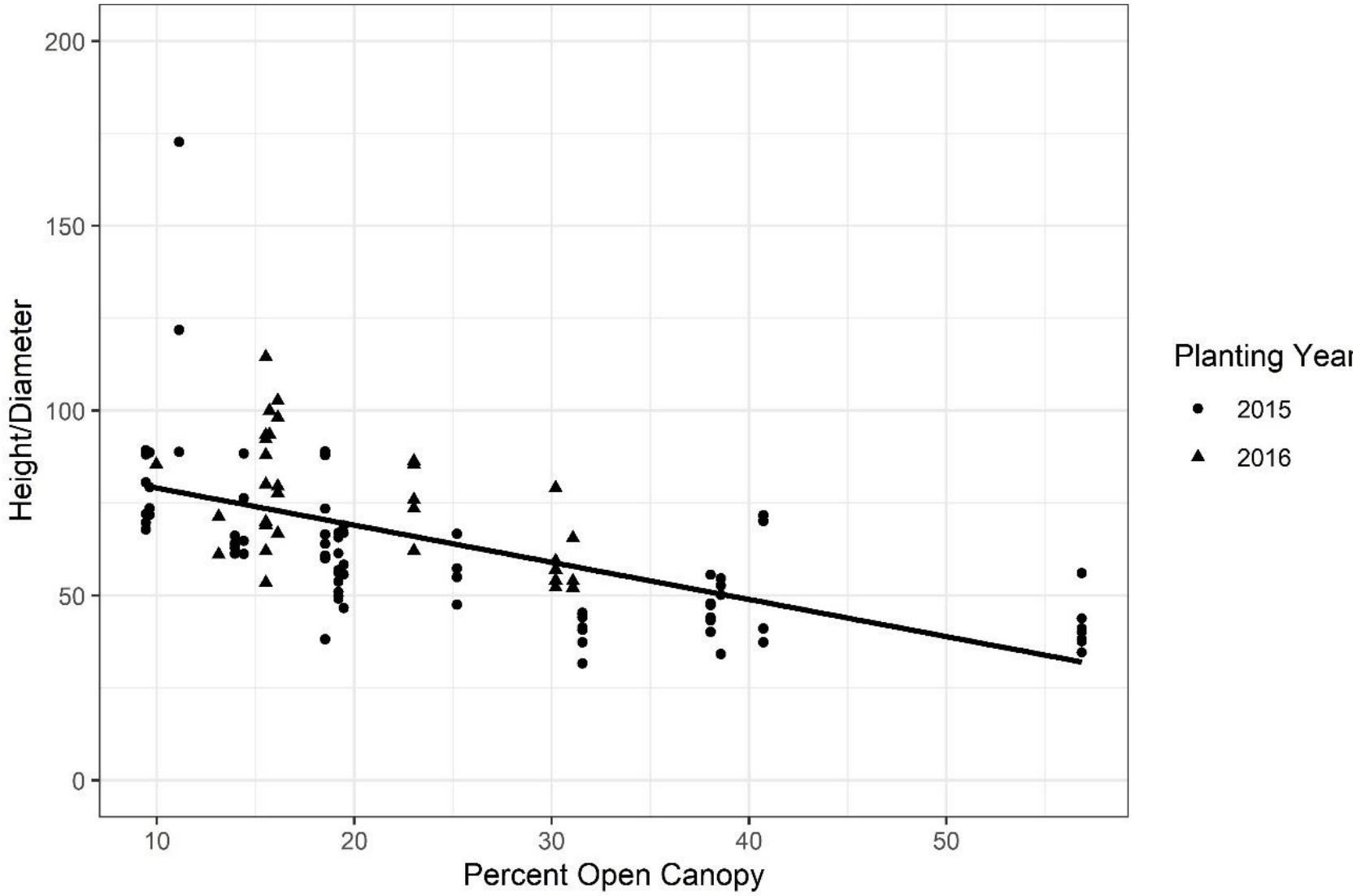
Sitka spruce vigor relative to available light (PAR) 6-7 yrs post planting

Height/Diameter Ratio Analysis

<60 tree seedlings are vigorous

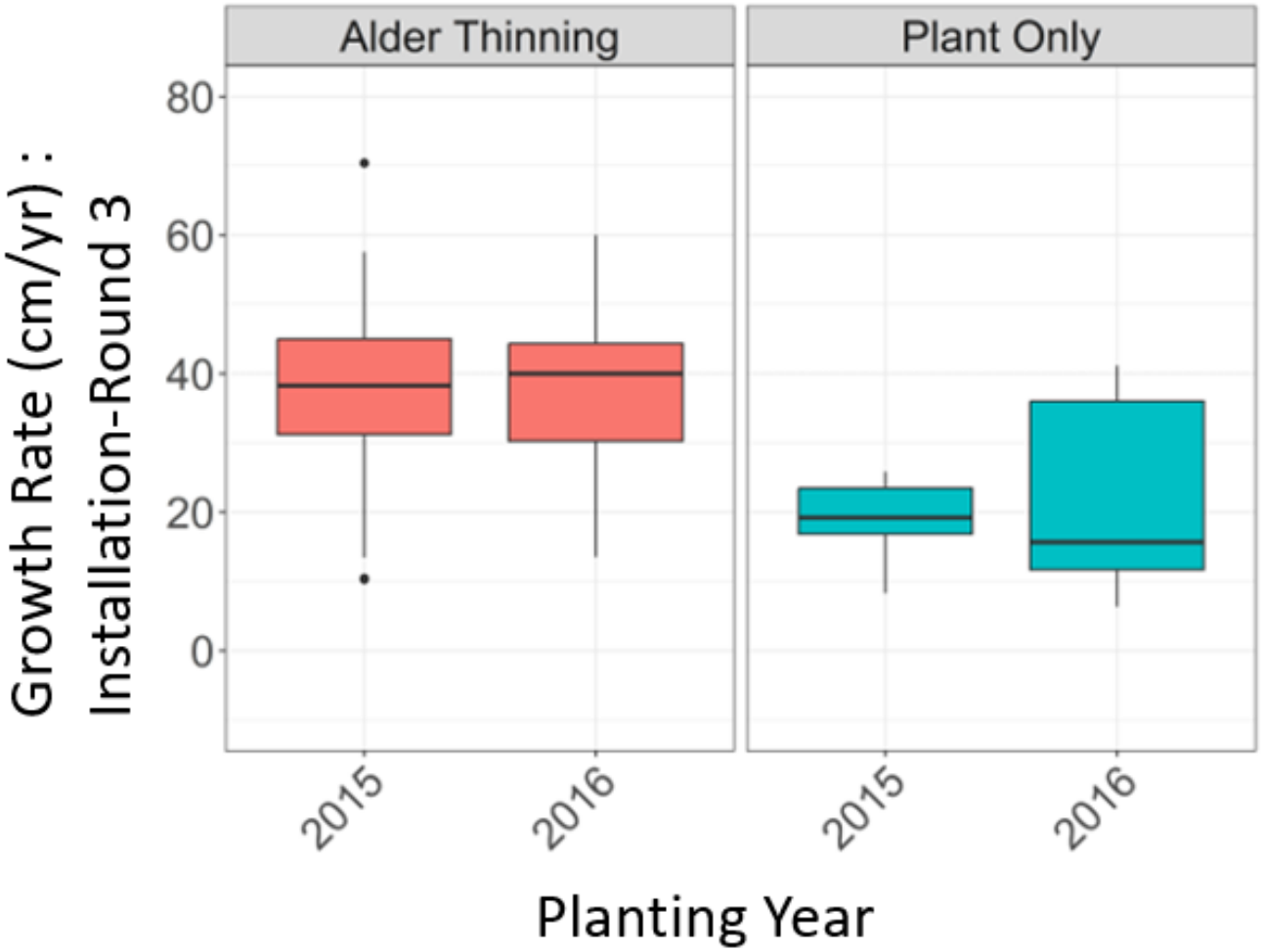
60-100 are adequate

>100-120 are at risk



(Fetherston and Jay)

Tree Seedling Height Growth Rates & Canopy Thinning



(Fetherston and Jay)

Floodplain Silviculture Lessons Learned

1. Silvicultural thinning increasing PAR by opening canopy >35% can significantly increase the growth rate and seedling vigor compared with no silvicultural canopy treatment (low PAR conditions).
2. Elk Browse and Herbivory Disturbance is local and often significant
3. Importance of Planting Stock Selection and Procurement Considerations
4. Control invasive shrubs to reduce plant competition, improving tree seedling growth, vigor and survival

Alder Creek Reach
Integrated ELJ River Engineering and Forest Restoration

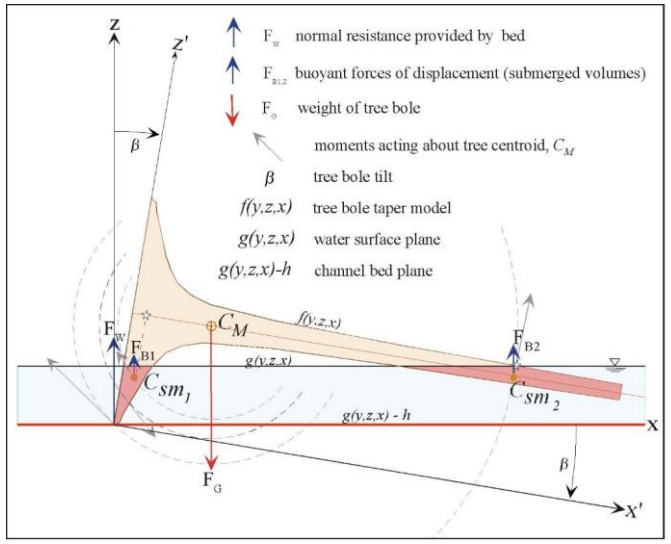
(2003)

Silvicultural Type 3. Engineered Log Jam Forested Islands

2008 ELJ forming a pool and 15yr old forested island

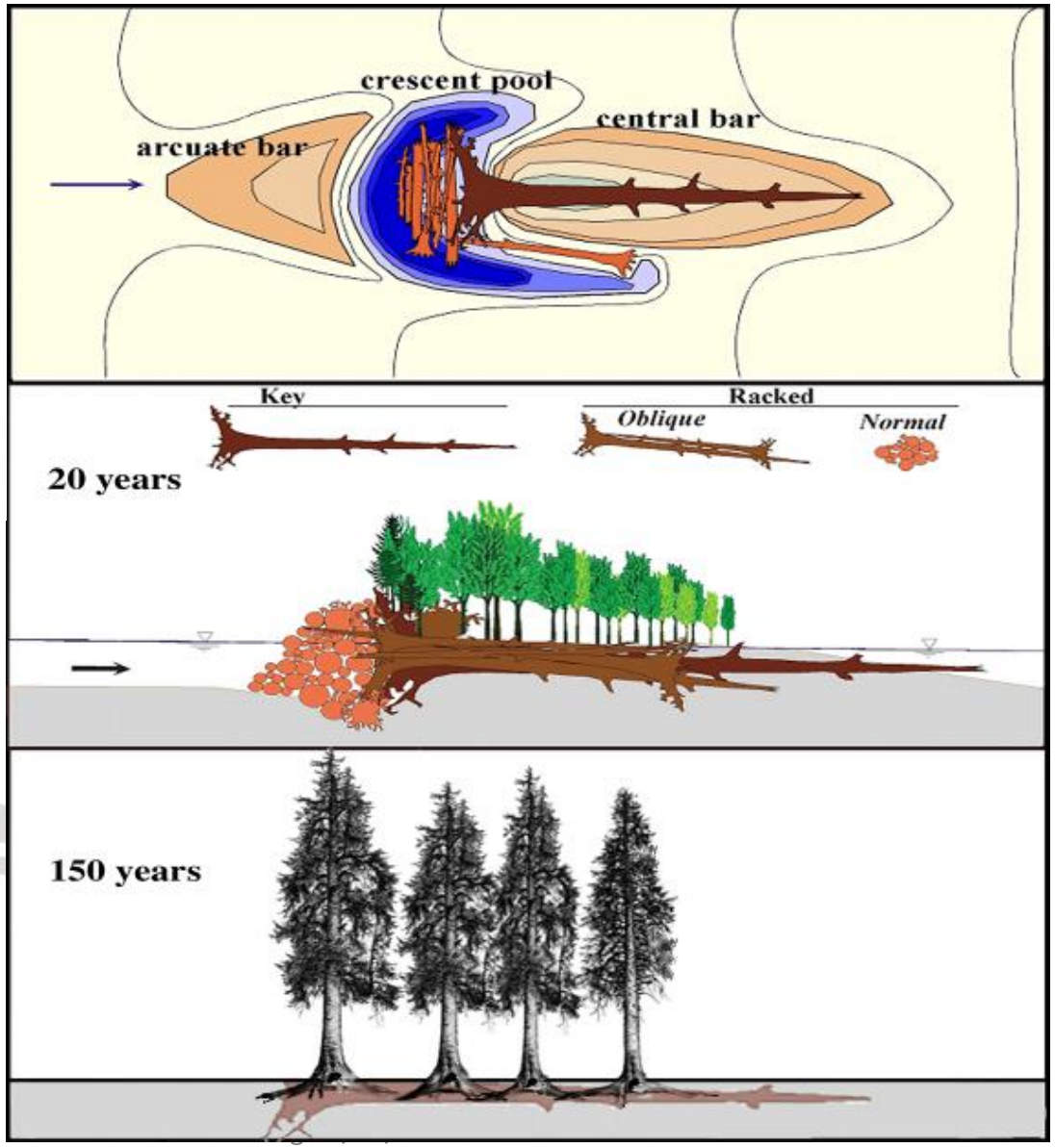
(Photo taken 5/4/23)

Engineered Logjams – analogs of natural logjams



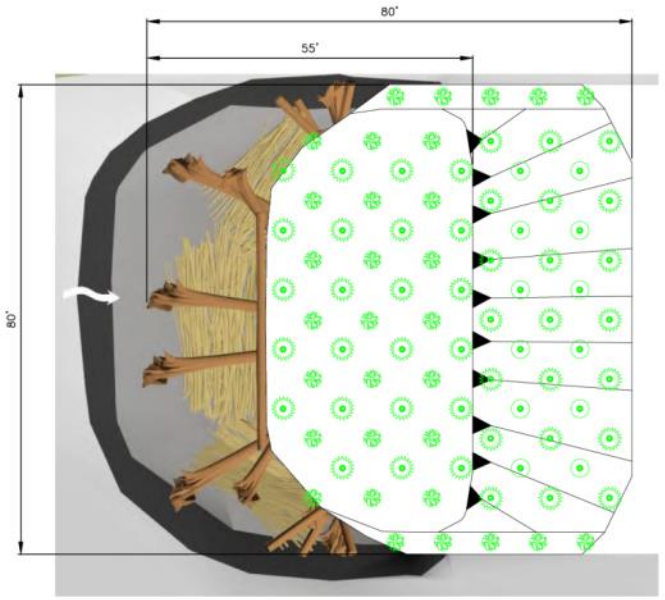
Initiation and evolution of a logjam hard point

(Abbe & Montgomery 1996)

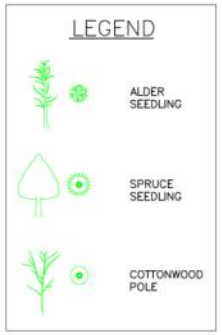


(Tim Abbe)

ELJ Island Forest Planting Plans



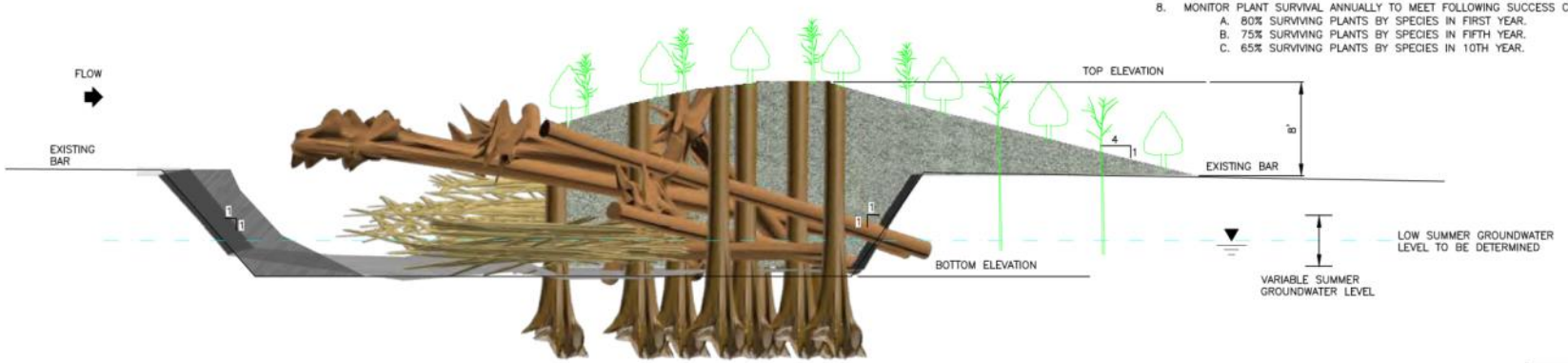
TYPE 1 ELJ PLAN
NTS



ELJ TYPE 1: PLANTING SPECIFICATIONS						
COMMON NAME	SCIENTIFIC NAME	PLANT MATERIAL	SEED ZONE	PLANTING SPACING (O.C.)	PLANTING AREA (SQ FT)	# OF PLANTS
ELJ SIDE BANK: CHANNEL BED TO 1.5 METERS ELEVATION						
RED ALDER	ALNUS RUBRA	BARE ROOT 1-0, 91-122 CM HT	GRAYS HARBOR COASTAL ZONE	8 FT O.C.	283	10
ELJ TOP: CHANNEL BED 1.5 TO 2.5 METERS ELEVATION						
RED ALDER	ALNUS RUBRA	BARE ROOT 1-0, 91-122 CM HT	GRAYS HARBOR COASTAL ZONE	10 FT O.C.	1725	17
SITKA SPRUCE	PICEA SITCHENSIS	PLUG 1+, 71-76 CM HT, 10 MM CALIPER	030-0.5 ("WOODS RUN COLLECTION)	10 FT O.C.		17
ELJ DOWNSTREAM SLOPE: 1 METER > CHANNEL BED TO 2 METERS ELEVATION						
BLACK COTTONWOOD	POPULUS BALSAMIFERA SSP. TRICHOCARPA	LIVE POLES 2.6-6 CM DIAMETER	QUINAULT/QUEETS RIVER FLOODPLAINS	10 FT O.C.	2408	24
SITKA SPRUCE	PICEA SITCHENSIS	PLUG 1+, 71-76 CM HT, 10 MM CALIPER	030-0.5 ("WOODS RUN COLLECTION)	10 FT O.C.		24

ELJ NOTES:

1. DURING ELJ CONSTRUCTION, MIX WOOD SLASH AND CHIPS INTO UPPER 18 INCHES OF ELJ SURFACES AS SOIL AMENDMENT.
2. LAYOUT PLANTING APPROXIMATELY PER ELJ GRID PATTERN AS DIRECTED BY FOREST ECOLOGIST.
3. PLANT RED ALDER AND SITKA SPRUCE SEEDLINGS WITH DIBBLE OR SHOVEL AS SHOWN IN DETAIL 3, SHEET XX.
4. COTTONWOOD POLES TO BE PLANTED WITH EXCAVATOR ASSISTANCE AS DIRECTED BY FOREST ECOLOGIST.
5. ALL COTTONWOOD POLES AND RED ALDER SEEDLINGS TO BE ENCASED IN TREE PROTECTORS.
6. ELJ PLANTING SURFACES (TOP AND SLOPES) TO BE BACKFILLED WITH A LIGHT MIXTURE OF ORGANIC MATERIAL (SLASH/CHIPS) AND ALLUVIUM.
7. RELEASE RED ALDER AT 4–5 YEARS.
8. MONITOR PLANT SURVIVAL ANNUALLY TO MEET FOLLOWING SUCCESS CRITERIA:
   A. 80% SURVIVING PLANTS BY SPECIES IN FIRST YEAR.
   B. 75% SURVIVING PLANTS BY SPECIES IN FIFTH YEAR.
   C. 65% SURVIVING PLANTS BY SPECIES IN 10TH YEAR.



TYPE 1 ELJ PROFILE
NTS

DRAFT

0% PRELIMINARY DESIGN
Nov-25-2014

IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT PLOTTED TO ORIGINAL SCALE.

Resource Consultants, Inc.

Natural Systems Design

NAME OR INITIALS AND DATE	
DESIGNED	KLF
CHECKED	---
DRAWN	BGG
CHECKED	---

GEOGRAPHIC INFORMATION	
LATITUDE	47°32'00"N
LONGITUDE	123°45'00"W
TN/SC/RG	724N/53O/R8W
DATE	03/07/2014

JEFFERSON COUNTY REACH RESTORATION

ELJ TYPE 1 PLANTING PLAN

12

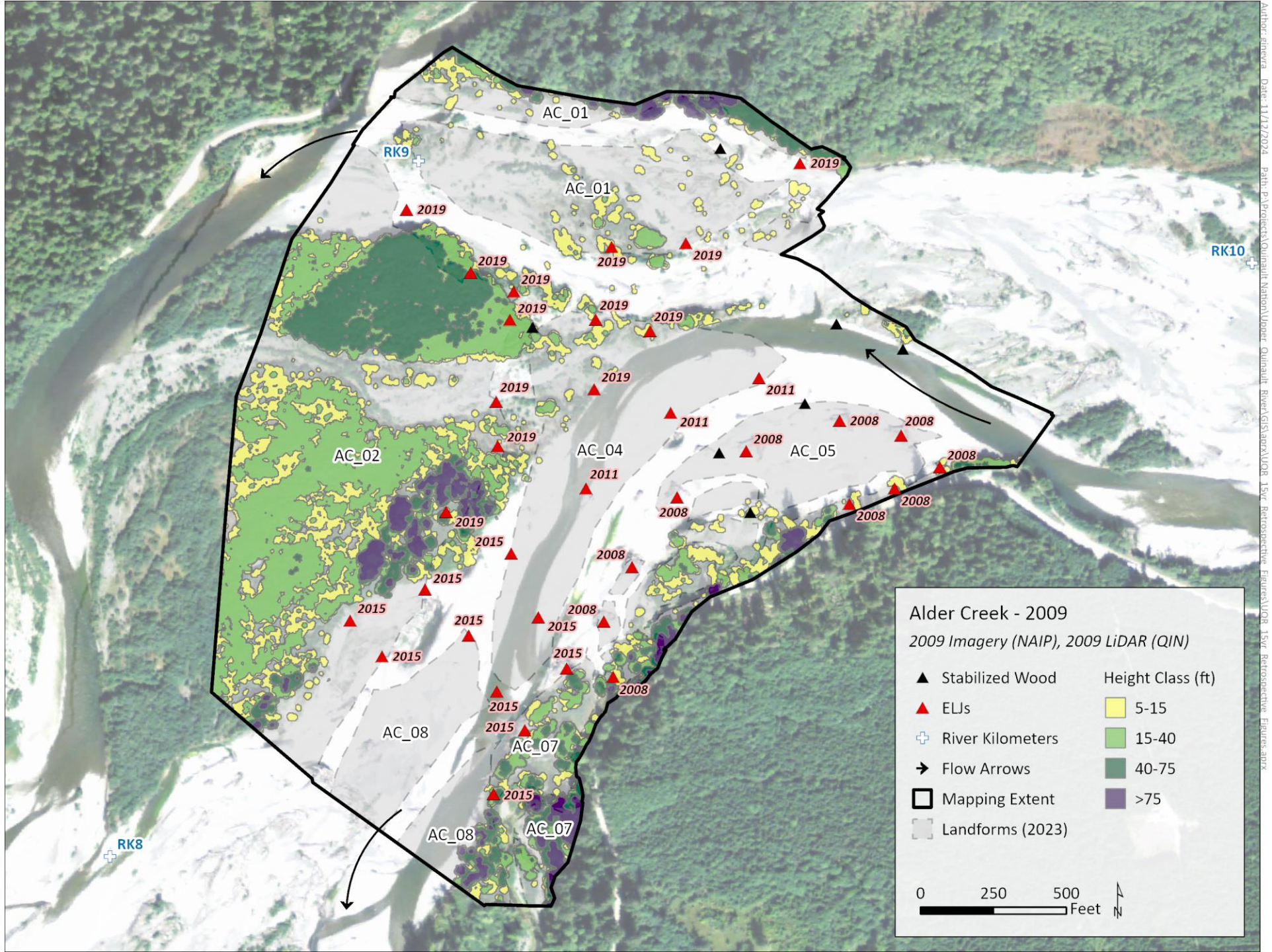
SHEET 12 OF 21

2008 ELJ Planting Designs

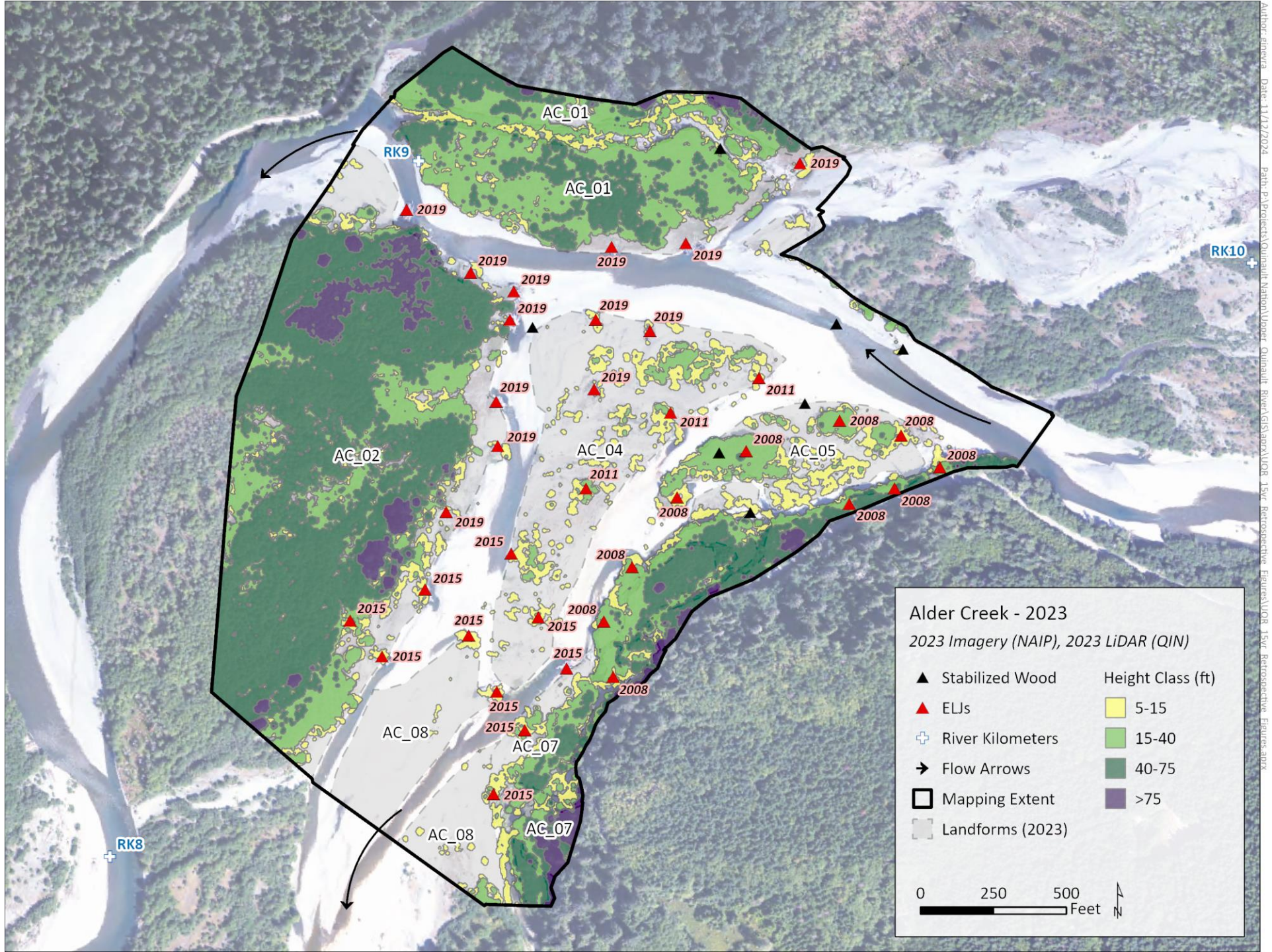
ELJ 3 yrs Post Planting & Slash Incorporation Oct 19, 2011

2016, 8 yr old planted ELJ forested island, Facilitated Vegetation Colonization, Alder Creek

2024, 15 yr old planted ELJ forested island & adjacent developing floodplain vegetation, Alder Creek



(Moore and Fetherston)



(Moore and Fetherston)

Alder Creek Reach River and Forest Restoration

(2008)

Alder Creek Project Area - November 2021
(image from QDNR)

Scott Katz

ELJ Forested Islands, Anabranching Channel and Patchwork Floodplain

Alder Creek Project Area - November 2021
(image from QDNR)

Scott Katz

Silvicultural Type 4. Silvicultural Restoration of Dense 20-80 yr old Conifer Dominated Terraces & adjacent valley toeslopes

- Connie Harrington & Leslie Brodie. 2020. Guide to Variable-Density Thinning Using Skips and Gaps USDA/USFS
- The Nature Conservancy Ellsworth Preserve upland forest restoration designs and 13 years of results. (Case et al. 2023)

Coastal Olympic River & Valley Forest Restoration Efforts

- Upper Quinault River Restoration Program
  - Quinault Indian Nation
- Middle Fork Hoh River Resiliency Plan
  - Jefferson County
  - Hoh Indian Tribe
- Queets Clearwater Basin Resiliency Plan
  - Quinault Indian Nation
- Washington DNR Olympic Experimental Forest River and Floodplain Forest Restoration Initiatives
- Willapa Bay Reserve, The Nature Conservancy
  - Upland forest restoration (Case et al. 2023)

When the Salmon Return

"It has been said that the salmon will return when we all work as hard to protect them as they do to reach their spawning grounds–so we need to come together to protect and restore their natural habitat… We all have a stake and we all have responsibilities. Together, we can bring the salmon home."

Fawn Sharp

Quinault Indian Nation

(from the Forward to: McNulty, Tim. 2024. Salmon Cedar Rock & Rain–Washington's Olympic Peninsula)

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Dave Bingaman, Quinault Indian Nation
C & V Reforestation, Silviculture Contractor
Brian Collins
David Montgomery, University of Washington


Questions?
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