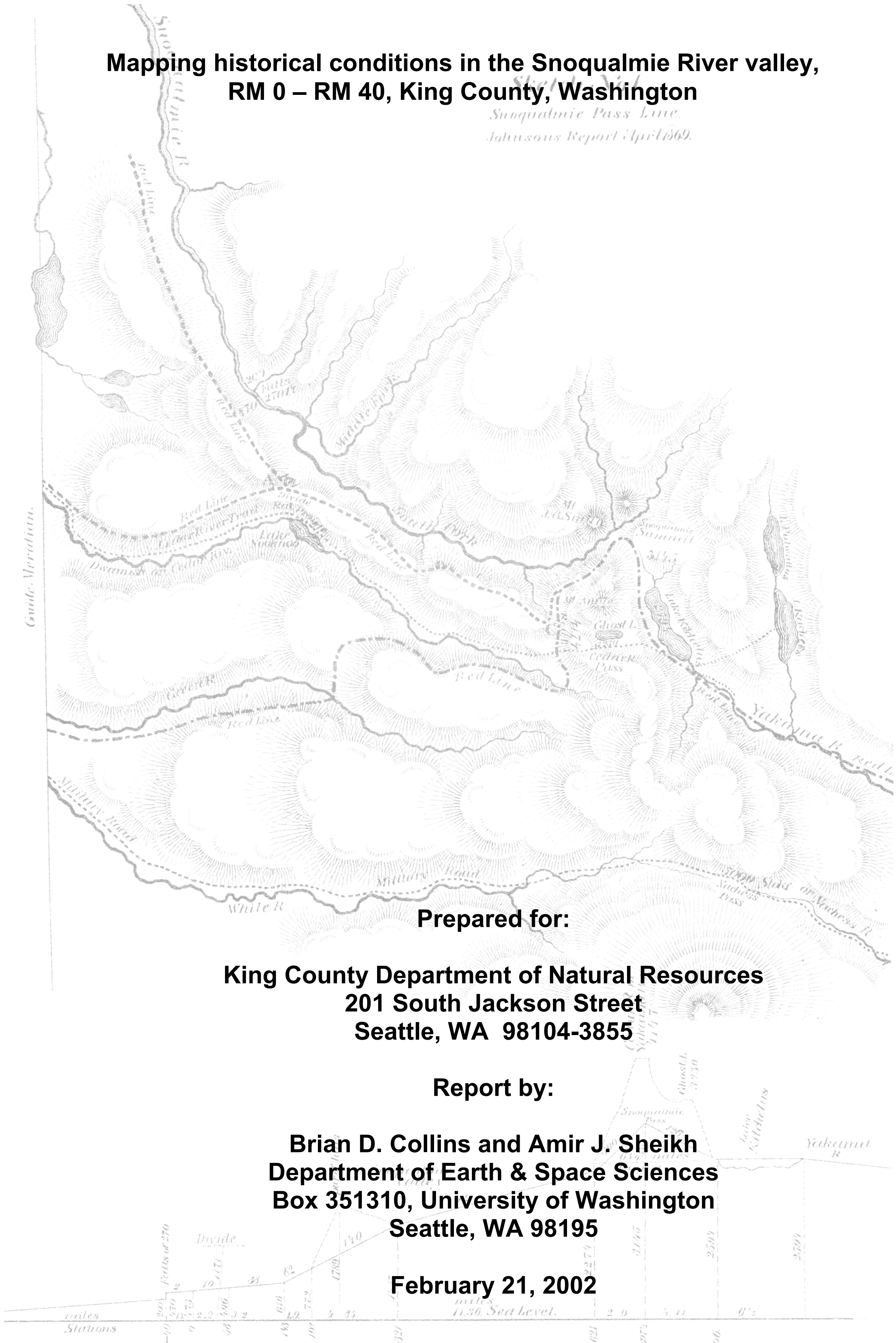

Mapping historical conditions in the Snoqualmie River valley, RM 0 – RM 40, King County, Washington

Prepared for:

King County Department of Natural Resources
201 South Jackson Street
Seattle, WA 98104-3855

Report by:

Brian D. Collins and Amir J. Sheikh
Department of Earth & Space Sciences
Box 351310, University of Washington
Seattle, WA 98195

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SUMMARY

Archival materials, including maps and field notes from the General Land Office (GLO) cadastral survey from 1871-1873 and aerial photographs from 1936, were entered into a GIS (geographic information system). In combination with a DEM (digital elevation model) constructed from lidar (light detection and ranging) imagery, these and other materials were used to map the channel, wetland, forest, and oxbow ponds in the Snoqualmie River valley prior to Euro-American settlement, or around 1870. To evaluate subsequent change, conditions were also mapped from 1936 and 2000 aerial photos.

The river can be broken into several morphologically distinct segments. Throughout most of the study area, Holocene (post-glacial) deposition by the Snoqualmie River has built up the river and its meander belt as much as 6 m above the valley bottom. Along the lower river (RM 2-12), the channel is relatively straight with little or no meander belt; nearly the entire valley is several meters lower in elevation than the riverbanks. Upstream, the meander belt is ~ 1 km wide, with valley-marginal lowlands narrower than in the downstream segment. Exceptions are where the Tolt River alluvial fan (RM 23-27), and the Raging River fan and a fan north of Tokul Creek (RM 35.5-39.5) narrow the meander belt.

Historically, wetlands occupied low areas marginal to the meander belt. Seasonal flooding and tributaries replenished these valley wetlands. Historical records indicate that a large wetland complex between about RM 4 and RM 11 was primarily shrubs and small trees including scattered, small Sitka spruce. Ponds and wetlands also occupied many oxbows created by historical channel avulsions. Hardwoods, including red alder (*Alnus rubra*), willow (*Salix spp.),* vine maple (*Acer circinatum*), bigleaf maple (*Acer macrophyllum*), black cottonwood (*Populus trichocarpa*), and Western crabapple (*Malus fusca*), dominated the pre-Euro-American-settlement forest, reconstructed from GLO field notes. Western redcedar (*Thuja plicata*) and Sitka spruce (*Picea sitchensis*), while less common, were the largest trees. Combining lidar and georeferenced GLO field data in a GIS shows that tree species grew in distinct

elevation ranges relative to the riverbank, with spruce, willow, and alder being most tolerant of flooded conditions, growing 1-4 m lower than the riverbank. Forest composition varied with distance from the river, with alder and willow more dominant in immediate streamside areas.

Since ~1870, only a few additional oxbows have been created, because the river migrates relatively slowly and so avulses relatively infrequently; most oxbows that now exist were created prior to the earliest mapping in ~1870. Valley wetlands, on the other hand, are substantially diminished in area, in 2000 being less than one-fifth (19%) the pre-settlement wetland area. In the entire valley bottom, forest cover in 2000 is about one-sixth (16%) its mapped pre-settlement extent.

This historical data, which includes an inventory of ponds and floodplains, can be applied to various restoration opportunities, including: (1) hydraulically reconnecting the river to oxbow ponds and wetlands where that connection has been lost; (2) planting along the river and oxbow ponds and wetlands; (3) restoring ditched floodplain tributary creeks; and (4) restoring valley wetlands.

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Introduction

Scope

This report describes historical channels, wetlands, and riparian forests of the Snoqualmie River valley downstream of Snoqualmie Falls. Landscape descriptions in this report were developed to further a comprehensive description of salmonid physical habitat conditions in the river and valley floor prior to Euro-American settlement. The information was developed to help King County identify and prioritize protection and restoration actions. Specific work products, and their potential applications, include:

(1) Geographic Information System (GIS) mapping of channels, water bodies, and wetlands in ~1870, 1936, and 2000. This mapping characterizes the historical riverine landscape and landscape processes, providing a broad context for habitat restoration planning and a foundation for more site-specific planning.

(2) Characterization of the pre-settlement forest, including the sizes, distributions, and factors influencing the locations of trees. This information provides a tool for forest restoration.

(3) Background data for evaluating the feasibility of restoring floodplain features. Detailed topography from lidar (Light Detection and Ranging) imagery, and historical map information on the ages and origins of features to help direct efforts to maintain, recreate, or create a connection with the river.

Methods

Collins et al. (2003) describe methods used to characterize historical conditions. Briefly, in the Snoqualmie River valley, the pre-Euro-American settlement mapping (hereafter referred to as "~1870 conditions") relies primarily on information in 1871-1873 General Land Office (GLO) cadastral survey maps and field notes. The "~1870 conditions" map does not show the local land clearings from the Euro-American settlement that had occurred by that time. Clearings shown on the GLO map are infrequent and small by the early 1870s; the intent of the mapping is to focus on conditions immediately prior to widespread settlement and commercial forest clearing.

The GLO maps were georeferenced and brought into a GIS by mapping corners and quarter corners to current Public Land Survey (PLSS) data. Because the GLO maps are based on field data along section lines or along navigable rivers only, we also drew on detailed topography from a DEM made from lidar and on 1:9,600-scale 1936 and 1:10,000-scale 1938 georeferenced aerial photos. Bearing tree records in the GLO field notes (for detail see Collins and Montgomery 2002, and Collins et al. 2003) were also georeferenced to current PLSS data. We created the 1936 layer from aerial photos, and the 2000 layer from ortho-rectified 1:12,000 scale color aerial photos. There was no field checking.

Mapping Assumptions

Mapping in the ~1870 GIS layer reflects important assumptions, simplifications and extrapolations, including the following:

(1) *Forest cover.* The continuous extent of forest cover is assumed based on the continuous forest cover described in GLO notes along section lines. However, this simplification neglects the presence of any natural (non-wetland) meadow clearings in the valley forest, either within section interiors or along section lines but not included in field notes.

(2) *Oxbow ponds and wetlands.* The ~1870 mapping includes several oxbow ponds and wetlands not shown on GLO maps. This is likely because the GLO survey lines did not cross the features, and thus would have been missed in the field. We mapped these features that were not included on the GLO maps, based on their presence on later mapping (e.g., 1921 USGS Sultan Quadrangle 1:125,000-scale topographic map, 1936 or 1938 aerial photographs) and the absence of evidence for river migration or avulsion which could have created the features in the intervening time. For some of the oxbow ponds and wetlands that *were* shown on GLO maps, we modified the feature's dimensions and shape, because the

GLO mapping was based on the map drawers' extrapolations from incomplete section-line data, and we could use more complete (but more recent) aerial photo and topographic data.

(3) *Valley wetlands.* Wetlands not associated with, and larger in scale than river oxbows, and occurring in low-elevation areas generally marginal to the river meander belt, in this report are called "valley wetlands" to distinguish them from oxbow wetlands. These wetlands are incompletely drawn on the GLO maps. This is in part because of inconsistencies within and between maps, and in part because, as with the oxbow features, the features were not crossed by section lines and were not field surveyed by the GLO. We used topographic information and 1930s aerial photographs to modify the boundaries of wetlands between section lines. A few wetlands not shown on GLO maps were added in cases where section lines did not cross them, and so they would have been missed by the GLO survey. Similar to the logic described used to add several oxbow features, we added these wetlands based on later evidence for their prior existence.

(4) *Wetland vegetation.* We mapped each wetland as emergent, scrub-shrub, or forested, based on the available data. Data included description in the GLO notes, and appearance of wetland remnant areas on 1936 or 1938 photos. However, our categorizations have varying levels of certainty, due to incomplete information, or in some cases no information. For example, some oxbows the GLO mapped as ponds may have been mapped by modern field workers as wetlands. In addition, oxbow wetlands by their nature change in state through time, with a common natural history that includes transition through time from open water to wetland and eventually meadow and forest (e.g. Strahler, 1960).

(5) *Floodplain creeks.* The GLO maps are weakest in showing the locations of floodplain tributary creeks, because these streams, unlike navigable rivers, were not "meandered," or followed in the field and mapped by measuring distances and taking bearings. Instead, their location is only known where they are encountered along section lines; otherwise, the GLO cartographers sketched their location. In many cases, these locations are clearly wrong in context of modern topography. In drawing small streams on

the ~1870 layer we made use of the stream locations along surveyed section lines, but then relied on relict stream topography shown on the 1936 and 1938 aerial photos and lidar DEM. In some cases, there was no basis for redrawing the streams, and they were left as shown on the GLO map. Thus, small streams shown on the ~1870 conditions map may be incorrectly located, or may have been missed altogether; it is also possible that some streams we mapped from relict features on the 1930s photos may have been relict already by ~1870.

We generally mapped wetlands in the 1936 and 2000 layers if they were visible on aerial photographs, and if they were shown on published National Wetland Inventory (NWI) and King County wetland mapping. We included only those wetlands having natural vegetation; in other words, we excluded areas that had been converted to agricultural or other uses that would in the modern regulatory framework be mapped as wetland based on their hydrology or soils.

Certainty Levels and Uses of Landscape-Scale Mapping

Codes for the various mapping situations described above, and listed in Table 1, were assigned to each channel, wetland, and pond in the completed ~1870 conditions GIS layer. A relative certainty level is associated with each source code, coarsely categorized as “high,” “medium,” and “low.” This information is important for users of the GIS layers, because it indicates the assumptions and interpretations, and associated uncertainties, associated with each.

Mapping is intended primarily to characterize historical landforms and hydrologic features, how they varied along and across the valley bottom, and how the landscape has changed through time. Because of limitations inherent in interpreting historical conditions, historical mapping should be considered as a starting point for more site-specific characterization, which could include more detailed historical and site investigations than was possible for this landscape-scale treatment.

Table 1. Mapping situations for features on ~1870 GIS coverage, and associated relative certainty levels.

CODE	FEATURE	CERTAINTY
	Large Channels (e.g. rivers, associated sloughs, large tidal channels that were depicted as polygons in source material)	
C1	(i) Meandered by GLO and (ii) consistent with topography.	H
C2A	(i) Meandered by GLO, but (ii) necessary to locally refine boundaries because location is inconsistent with topography (e.g. river goes uphill).	M
C2B	(i) Sketched (not meandered) by GLO; (ii) adjusted channel location and shape between GLO control points using topography and more recent aerial photographs.	M
	Small Channels (e.g. floodplain creeks and small tidal channels depicted as lines in source material)	
CR1A	Shown on (i) GLO (near section line) maps and (ii) early maps or aerial photographs.	H
CR1B	Shown on (i) GLO (not near section line) or USC&GS maps and (ii) early maps or aerial photographs and (iii) only minor adjustments for consistency with photos.	H
CR2A	Shown on (i) GLO (not near section line) or USC&GS maps and (ii) on earliest topographic maps or early aerial photographs and (iii) channel is adjusted using photo or map location.	M
CR2B	Shown on (i) GLO (not near section line) maps and (ii) channel has been filled or abandoned, and visible as relict channel on earliest topographic maps or early aerial photographs and (iii) Channel is adjusted using relict channel location on photos or topographic information.	M
CR2C	Shown on (i) GLO (near section line) and (ii) not shown on early maps and photos.	M
CR3A	(i) Not shown on GLO but (ii) relict channel shown on earliest topographic maps or early aerial photographs and (iii) reasonable from topography & hydrologic features to infer a channel would have been present. Location may be locally adjusted using photographs or topographic map information.	L
CR3B	(i) Shown on GLO (not near section line) and (ii) necessary to adjust location, no information on early photographs or maps for informing the adjustment.	L
CR3C	(i) Shown on GLO (not near section line) and (ii) not adjusted, no information on early photographs or maps for adjusting location.	L

Table 1 (continued). Mapping situations for features on ~1870 GIS coverage, and associated relative certainty levels.

CODE	FEATURE	CERTAINTY
	Wetlands	
W1A	(i) Mapped by GLO, (ii) consistent with topography, and (iii) shown on earliest topographic maps or photos OR (iii) if created >GLO, shown on later photos.	H
W1B	(i) In field GLO field notes, (ii) consistent with topography, and (iii) shown on earliest topographic maps or aerial photos	H
W2B	(i) Not mapped by GLO, (ii) consistent with topography, and (iii) shown on earliest topographic maps or aerial photos.	M
W2A	(i) Wetland mapped on GLO adjacent to polygon; boundary extended because: (ii) consistent with topography, and (iii) shown on early topographic maps or aerial photos.	M
W3	(i) Not mapped by GLO; (ii) mention of wetland in GLO field notes, but ambiguous, and necessary to make substantial extrapolation based on topography OR (iii) wetland mapped or apparent on later topographic maps or aerial photographs.	L
	Ponds	
P1	(i) Mapped by GLO and (ii) shown on early maps or aerial photos, and (iii) consistent with topography. Boundary may have been locally adjusted using topographic map or aerial photo information. OR (iv) if created >GLO, shown on later photos.	H
P2A	(i) Mapped by GLO, but (ii) necessary to substantially alter shape and size, based on topography and aerial photo and topographic map information.	M
P2B	(i) Not mapped by GLO, but (ii) present on early aerial photos or maps, and (iii) no evidence feature was artificially created prior to early maps or photos.	M

GEOLOGIC AND TOPOGRAPHIC SETTING

The Pleistocene history of the Snoqualmie River valley profoundly affects the modern topography, the historical channel behavior, and associated valley-bottom landforms. Sub-glacial fluvial erosion sculpted the broad, low-gradient valley (Booth 1994). The lidar DEM shows the river elevation and associated meander belt is higher in elevation than the surrounding valley floor (Figure 1). This presumably resulted from the Snoqualmie River depositing sediment throughout the post-glacial (Holocene) period. As a consequence, extensive areas along the valley margins are lower than the riverbank by 2-3 m and as much as 6 m.

We divided the river into the following segments for analysis and reference (Figure 1):

(1) Lower River (RM 0-RM 2). The river is relatively straight. The valley bottom is dominated by large oxbow lakes and marshes created by the Skykomish or Snoqualmie rivers.

(2) Duvall Segment (RM 2-RM 12). The valley bottom is mostly lower in elevation than the streambanks, and historically included extensive wetlands. The meander belt is narrow or absent, and the river relatively straight (Figures 1 and 2).

(3) Lower Meandering Segment (RM 12-RM 23). The meander belt is well developed and includes numerous oxbow lakes and wetlands. Low-elevation areas marginal to the meander belt are present but narrower than in the Duvall Segment (Figure 1 and 2).

(4) Tolt Fan Segment (RM 23-RM 27). The Tolt River has built an extensive Holocene fan into the Snoqualmie River valley, forcing the river toward the west valley wall. The river pattern is straight (Figure 1).

(5) Upper Meandering Segment (RM 27-RM 36). Similar to the lower meandering segment.

(6) Upper Fan Segment (RM 36-RM 39.5). River migration is limited by the alluvial fans of the Raging River and immediately upstream of the Raging River on the north valley wall (downstream of Tokul Creek).

(7) Falls Segment (RM 39.5-RM 40.3). Upstream from Tokul Creek to Snoqualmie Falls, the river becomes progressively more confined by bedrock valley walls.

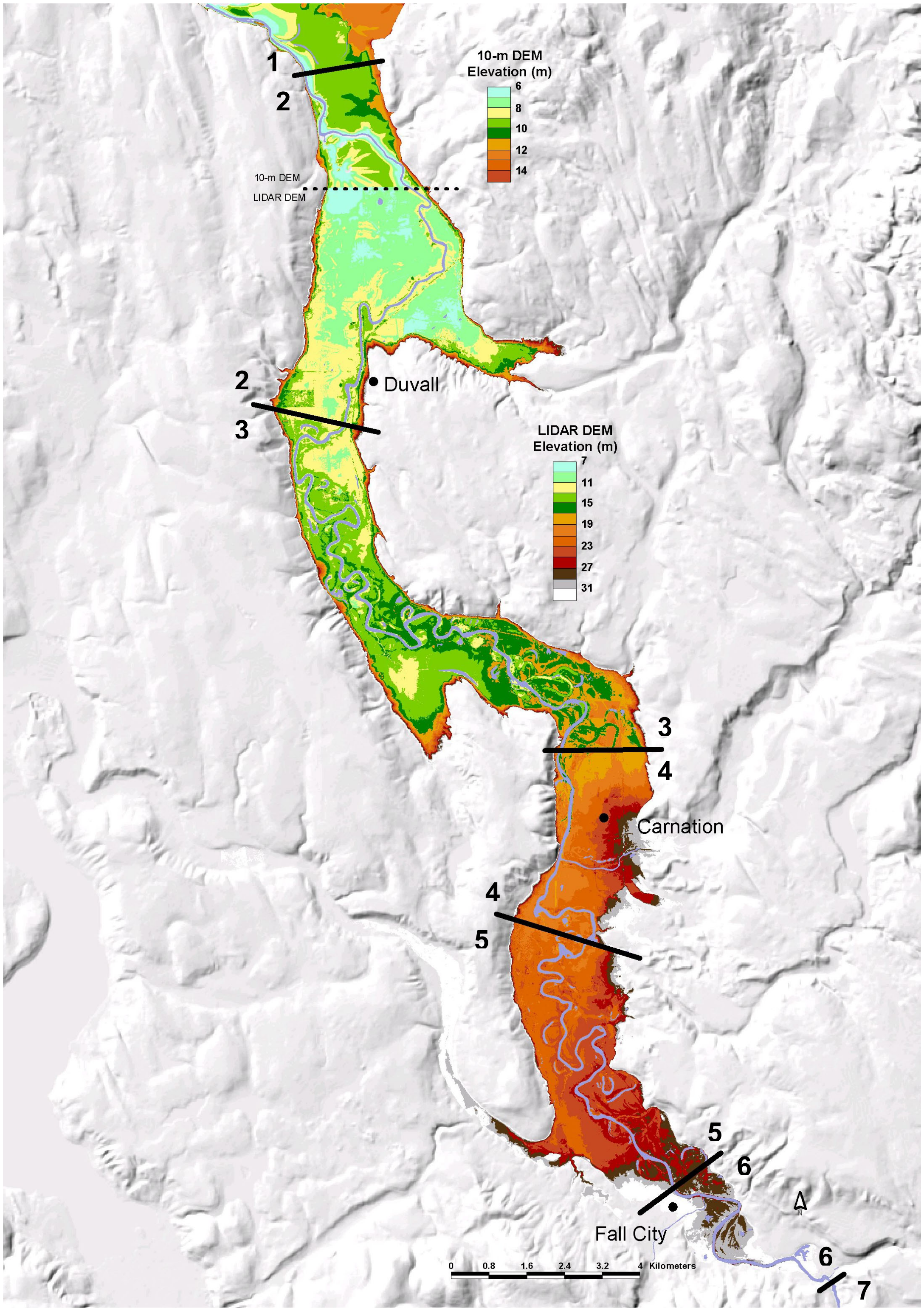

Figure 1. Analysis segments used in this study, and locations of towns in the Snoqualmie River valley.

PRE-SETTLEMENT (~1870) LAND COVER AND HYDROLOGIC FEATURES

Segment Descriptions

(1) *Lower River (RM 0-RM 2).* The lower two river miles are dominated by large oxbow depressions, relict from the Snoqualmie or Skykomish rivers, now filled by ponds or wetlands. These features appear to have been created prior to the GLO mapping, and one is shown by the GLO.

(2) *Duvall Segment (RM 2-RM 12).* The most notable wetland feature in the Snoqualmie valley and the dominant characteristic of the Duvall segment was an extensive system of marshes that occupied nearly the entire valley from RM 2 to RM 12 (Figure 3). The GLO field notes indicate that the area was primarily a thick growth ("…almost unpassable…") of shrubs and small trees (see Appendix 1 for more detail on this and other wetlands). The shrubs were described as hardhack, crabapple, willow, alder, and tule. A few areas are described as "cranberry marsh." The tree cover was described as "…a few scattering scrubby spruce and cedar" or "…a few scattering scrubby spruce, entirely worthless." From this information the area appears to have been primarily a scrub-shrub (rather than forested or emergent) freshwater wetland. This interpretation is supported by images of a 3-km^2 remnant of the marsh shown on 1938 aerial photographs, which suggest a brushy marsh with scattered conifers (Figure 4). Bearing tree data (see later, "Forest Conditions") also support the description of marsh tree cover as spruce having a small diameter, and small-diameter alder, maple, and vine maple.

The marsh system was characterized in the GLO notes as seasonally "subject to overflow to the depth of 8 feet," which is consistent with the modern elevation being several meters below the riverbank (see cross sections in Figure 2). The valley likely has subsided since these soils were drained and ditched. However, 1873 field observations of flooding depths, prior to any draining, indicate the area was naturally lower than the riverbed. On April 4, 1873, the water was described as "… 6 to 18 inches deep." In addition, unditched wetlands elsewhere in the study area are also lower than the riverbanks.

The DEM shows subdued, sinuous topography within this marsh, presumably created by ancient river meanders, and the water depth would have varied locally and seasonally. It appears likely water was present in summer, with perennial ponds present locally in the 1936 images and mapped on the 1873 cadastral survey maps. However, other than for these mapped features, the information available to describe the amount and location of perennial water is incomplete (see Appendix 1).

(3) *Lower (RM 12-RM 23) and* (4) *Upper (RM 27-RM 36) Meandering Segments.* The 20-river-mile length of these two segments includes nearly all of the oxbow wetlands and ponds in the Snoqualmie River valley. More than 40 oxbow features were mapped within the two segments (as indicated above, two additional oxbows are between RM 0 and RM 2). A number of valley wetlands also formed within the lower-elevation valley margins, outside the elevated meander belt. Within the meander belt, topography was highly irregular in a cross-valley direction, with depressions corresponding to oxbows that were formed recently enough to persist as ponds or wetlands, or swales that are presumably much earlier oxbows that have largely filled in (e.g., cross section RM 21.9 in Figure 2).

One of the prominent valley wetlands in Figure 3 is on the south valley wall about midway between Duvall and Carnation. The extent of this wetland was mapped using the GLO survey notes; the survey was discontinued along section lines because of the "impassable swamp." The wetland is partially coincident with the area mapped as the "Ames Lake Creek peat area" by Rigg (1958), which is significantly larger than the area we mapped, suggesting the wetland may have been larger than we have mapped. While this marsh has been drained, portions of several of the larger valley-marginal wetland areas remain in the current landscape.

(4) *Tolt Fan Segment (RM 23-RM 27).* The Tolt River created a Holocene alluvial fan, which has pushed the Snoqualmie River to the west valley wall (Figure 1). The river pattern is straight. The lack of oxbow lakes or relict channels suggests little historic river migration; while the slope of the Tolt River fan is low, it effectively acts to topographically confine the Snoqualmie River.

(6) *Upper Fan Segment (RM 36-RM 38.5).* Similar to the Tolt River segment, in this segment the Snoqualmie River is relatively confined by the alluvial fans of the Raging River on the south and the fan complex downstream of Tokul Creek on the north valley side, which limit channel migration.

(7) *Falls Segment (RM 36-39.7-RM 40.3).* Above Tokul Creek the Snoqualmie River is confined between sheer valley walls.

In-Channel Wood

The Army Engineers made early investigations of Puget Sound rivers, and also submitted annual reports on their activities, which in the last decades of the 19th century and the first decades of the 20th century emphasized removing snags to improve navigation (see Collins et al. 2002, for background). The engineers do not appear to have focused their efforts on the Snoqualmie River; with few exceptions they concentrated their attention in the Snohomish River only as far upstream as the town of Snohomish.

The Army Engineers' first recorded description of the Snoqualmie River, and thus likely their first examination of the river, was in 1880. Unlike most other rivers (e.g. the Skagit, Snohomish, and Stillaguamish) their description of the Snoqualmie did not include wood. This may suggest wood was not abundant enough to create problems for navigation; it may instead reflect earlier, undocumented clearing of in-channel wood that may have been carried out by settlers. Assistant Engineer Robert Habersham's report on navigation conditions from a field investigation in August 1880, indicates:

> "From [Snohomish City] within 3 miles of Fall City, on the Snoqualmie, the highest settlement on the river, a distance of 40 miles, boats can carry 3.5 feet during high stages, and 18 inches at all times. This portion of the Snoqualmie runs between banks from 10 to 30 feet high, with an average width of 250 feet….The obstructions are: Kelsay's Riffle, 6 miles above the Forks; Little Island Bar, 11 miles above the forks; Toalt Riffle, 30 miles above the Forks; and Sanawa Riffle, at the head of navigation…" (U. S. War Department 1881).

The river was thereafter irregularly snagged, which may imply snags did not accumulate rapidly. In 1887, the first reported snagging operation, 708 snags were taken from the Snohomish and Snoqualmie rivers combined (snags removed from both rivers are grouped together in the Army report) from August 22 to October 26 (U. S. War Department 1888). The next reported snagging operation was in 1893:

> "…as far as Tolt River, the practical head of navigation, where there had never been any snagging done before" (U. S. War Department 1883).

The crew removed 400 snags from the Snoqualmie and cut down 28 trees leaning over the river. The snagging was resumed the next year, on October 25 when 125 snags were removed from the two rivers:

> "Work was prosecuted on [the Snohomish] and its tributary, the Snoqualmie, to a point called Tolt River, about 40 miles up from salt water, till November 7, when the fall rains and consequent freshets caused too high water to do profitable snagging" (U. S. War Department 1895)

Snagging continued on an irregular basis into the first decade of the 20^{th} century; 75 snags were removed in 1901, 2 snags in 1903, 199 snags in 1905, and 1,494 snags in 1908. The Annual Reports lack information on the location of these snagging operations.

There is insufficient information to assess whether snags in the Snoqualmie were more or less abundant than in other north Puget Sound rivers (Table 2). One problem in comparing snagging between rivers is that available records only sometimes indicate the snagging locations. Another problem is that the extent of navigation, and thus the length of channel regularly snagged, varied considerably between rivers. The three-decade totals in Table 2 do show a rough correspondence between river basin size and the number of snags removed.

Forest Conditions

While the Army field investigations and snagging records provide little insight into wood loading, the GLO field notes indicate the common names (Table 3) and diameters of trees that grew immediately streamside, which would over time contribute dead wood to the channel. Surveyors were instructed to establish survey points with bearing trees at "meander" points where section lines intersected the banks of navigable rivers (White 1991). We call bearing trees at these meander points "streamside" in this analysis, to distinguish them from trees more distant from the river, which we call "valley bottom."

Tree frequencies in Figure 5 are biased against smaller-diameter species such as vine maple, since bearing trees were greater than 7.5 cm in diameter (see Collins and Montgomery 2002, for detail). However, a field investigation using early 1870s instructions to GLO surveyors show that the GLO bearing tree data provide reasonable estimates of basal area (Collins and Montgomery 2002).

Most streamside trees were hardwoods (Figure 5): alder (red alder, *Alnus rubra*), willow (*Salix spp.),* vine maple (*Acer circinatum*), maple (bigleaf maple, *Acer macrophyllum*), cottonwood (black cottonwood, *Populus trichorcarpa*) , and crabapple (Pacific crabapple, *Malus fusca*). Conifers accounted for only 7% of streamside trees. Because bearing trees underestimate the frequency of small-diameter species such as vine maple and alder, conifers probably accounted for even less than 7% of trees. However, the few conifers accounted for 43% of streamside basal area (Figure 5), indicating that conifers were the largest trees and would have provided nearly half the dead wood biomass to rivers from immediate streamside forests. Cedar (western redcedar, *Thuja plicata*) alone, which accounted for 4% of stems, comprised 27% of streamside basal area, and averaged 97 cm (38 inches) in diameter (Figure 6A); spruce, which averaged 91 cm (36 inches) in diameter, accounted for only 2% of stem number, but 14% of basal area. Maple (average diameter 54 cm or 21 inches, range of 10-132 cm or 4-52 inches) and cottonwood (average diameter 54 cm or 21 inches, range of 8-152 cm or 3-60 inches) were the dominant hardwoods by basal area, both accounting for 18% and 15% of the total, respectively. Alder was the third hardwood having an average diameter substantially greater than 15 cm, averaging 35 cm (14 inches).

Conifers were somewhat more abundant in the forest more distant from the river ("valley bottom" in Figure 5), but still accounted for only 21% of bearing trees (compared to 7% in streamside areas); they accounted for 46% of basal area (Figure 5). Cedar was the largest tree, averaging 91 cm (36 inches) and ranged in diameter from 8 to 305 cm (3-120 inches; Figure 6A). Similar to the streamside forest, maple and cottonwood were the largest hardwoods (mean = 58 cm or 23 inches and 58 cm or 23 inches, respectively). However, because the Snoqualmie River migrated slowly (see later), bearing trees from the immediately streamside area are most representative of the dead wood that would enter the river.

Trees were distributed predictably relative to the riverbank elevation (Figure 6B). Data in Figure 6B are from comparing the present-day elevation shown on lidar DEM for bearing tree points to the present-day riverbank elevation nearest to the point. The elevation distribution of spruce (Sitka spruce, *Picea sitchensis*) shows a tolerance for seasonally-inundated sites, generally occurring 1-2 m below the river bank elevation, and alder and willow occurred as much as 4 m below the riverbank elevation.

In summary, the immediately streamside forest was dominated by a variety of hardwoods. Of these, only maple, cottonwood, and alder were typically of a large enough size as to be expected to create stable in-channel wood. The few conifers immediately streamside, primarily cedar and spruce, could be quite large [diameter ranges of 15-244 cm (6-96 inches) and 13-203 cm (5-80 inches), respectively]. Cedar, spruce, maple, and cottonwood would be expected to have been the most common key pieces in jams. Observations in the Snohomish River (Collins et al., 2002) indicate hardwoods with a broadly shaped crown, such as maple, are likely to form snags within the main channel.

Table 2. Snags removed from four north Puget Sound rivers, 1880-1910 (from Annual Reports of the Chief of Engineers).

RIVER	DRAINAGE AREA (km^2)	1881-1890	1891-1900	1901-1910	TOTAL 1881-1910
Skagit	7,800	776	21,553	14,369	36,698
Snohomish (including Snoqualmie and Skykomish)	4,645	920	2,898	6,527	10,345
Nooksack	2,072	1,462	758	1,850	4,070
Stillaguamish	1,770	87	956	1,021	2,064

Table 3. Trees and shrubs recorded as bearing trees in GLO field notes, and probable common and scientific names. Trees are listed in decreasing frequency of occurrence.

NAME USED IN GLO FIELD NOTES	PROBABLE SPECIES
Alder	Red alder *(Alnus rubra)*
Vine maple	Vine maple *(Acer circinatum)*
Maple	Bigleaf maple *(Acer macrophyllum)*
Willow	Willow spp. *(Salix spp.)*
Crabapple	Pacific crabapple *(Malus fusca)*
Cottonwood	Black cottonwood *(Populus trichocarpa)*
Spruce	Sitka spruce *(Picea sitchensis)*
Cedar	Western redcedar *(Thuja plicata)*
Hemlock	Western hemlock *(Tsuga heterophylla)*
Barberry, Bearberry	Indian plum *(Oemleria cerasiformis)*
Hazel	California hazel *(Corylus cornuta californica)*
Fir	Douglas-fir *(Pseudotsuga menziesii)* Grand fir *(Abies grandis)*
Cherry	Bitter cherry *(Prunus emarginata)*
Dogwood	Western flowering dogwood *(Cornus nutallii)*
Elder	Elderberry spp. *(Sambucus spp.)*

Table 4. Summary of forest tree conditions suggested by GLO bearing tree records from 1873.

SUMMARY OF FOREST TREE CHARACTERISTICS
• Hardwoods more common than conifers, especially in streamside areas.
• Red alder and willow had a greater dominance in streamside areas than farther from the river.
• Common hardwoods include red alder, willow, vine maple, bigleaf maple, black cottonwood, and Pacific crabapple.
• Conifers were the largest trees, especially western redcedar and Sitka spruce.
• Species had distinct elevation ranges relative to the streambank, with Sitka spruce, willow, and red alder being most tolerant of flooded conditions.
• Sitka spruce was the dominant tree in valley-marginal shrub-scrub marshes.

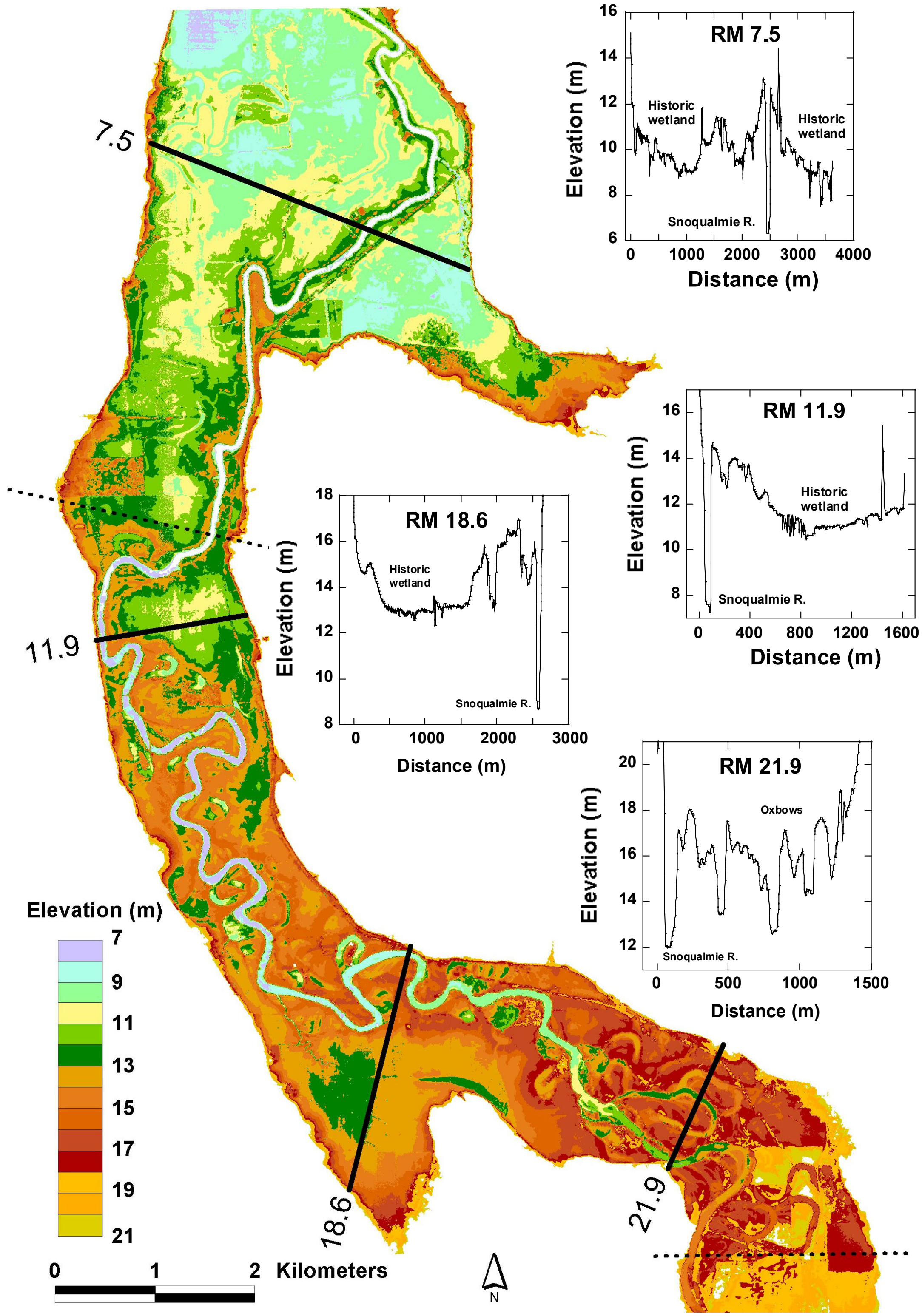

Figure 2. Topography and representative valley cross-sections in study segments 2 and 3.

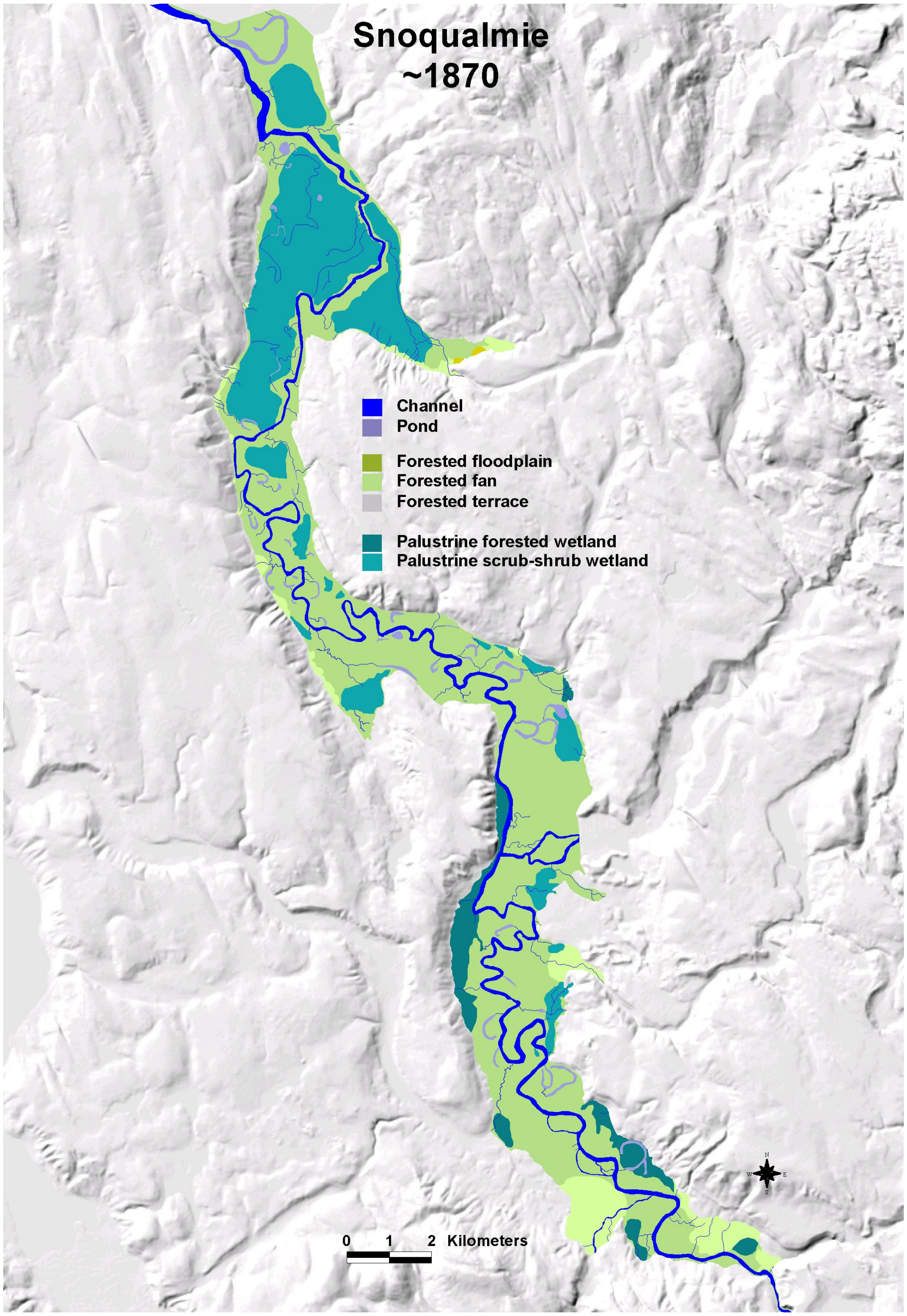

Figure 3. Environmental conditions interpreted to exist in the Snoqualmie River valley ~1870.

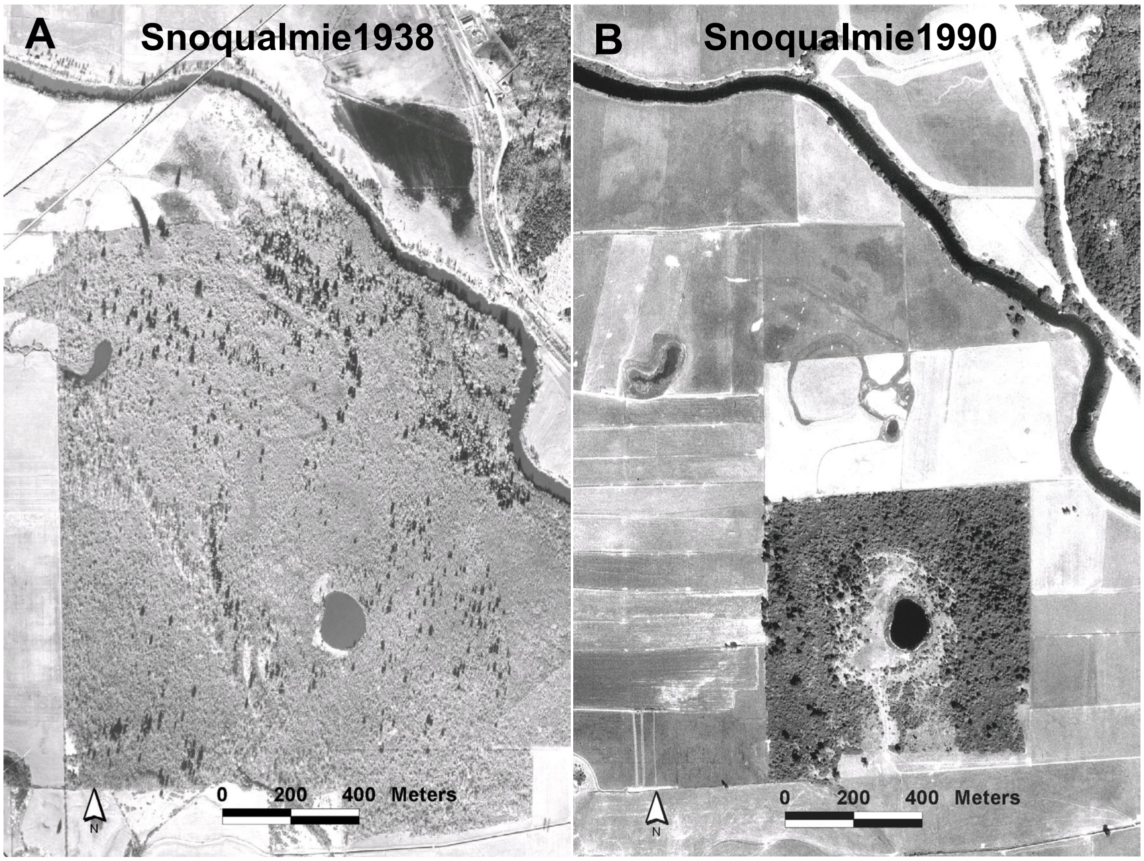

Figure 4. Remnant of historical wetland-pond complex at approximately RM 6 along the Snoqualmie River (see Figure 3) in 1938 and 1990. Photo also shows wetland on the north side of the river in 1938.

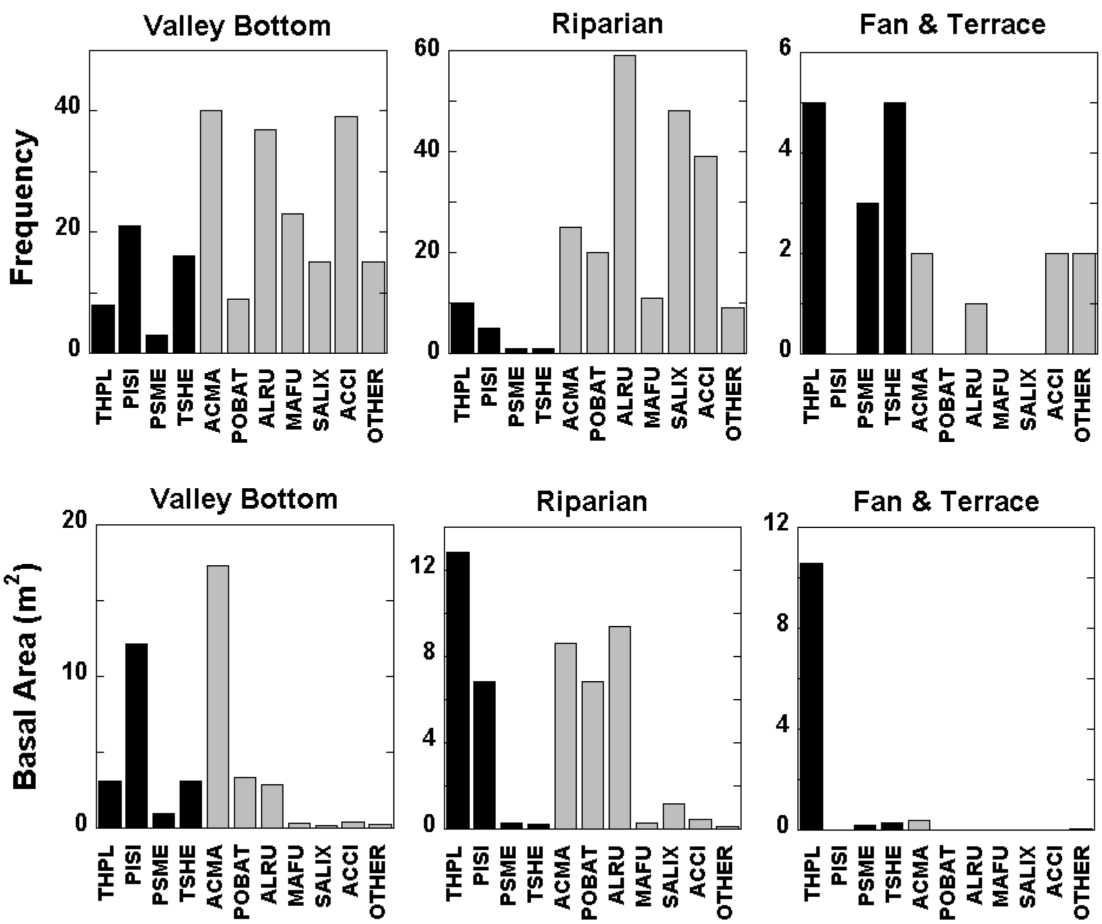

Figure 5. Bearing trees from GLO field notes. Top tier, from left to right: frequency of trees in valley bottom forest, stream-adjacent forest, and alluvial fans and river terraces. Bottom tier, left to right: cumulative basal area in same geomorphic settings as for frequency graphs. Conifers have dark-shaded bar. THPL: western redcedar (*Thuja plicata)*; PISI: Sitka spruce (*Picea sitchensis)*; PSME: Douglas fir (*Pseudotsuga menziesii)* may also include some Grand fir *(Abies grandis)*; TSHE: western hemlock (*Tsuga heterophylla)*; ACMA: bigleaf maple (*Acer macrophyllum)*; POBAT: black cottonwood (*Populus trichocarpa)*; ALRU: Red alder (*Alnus rubra)*; MAFU: Pacific crabapple (*Malus fusca)*; SALIX: Willow (*Salix spp.);* ACCI: vine maple (*Acer circinatum)*. "Other" species include: dogwood *(*western flowering dogwood*, Cornus nuttallii)*, hazel (beaked hazelnut*, Corylus cornuta var. californica*); bearberry or barberry (Indian plum, *Oemleria cerasiformis)*; chittemwood (cascara*, Rhamnus purshiana*), cherry (bitter cherry, *Prunus emarginata);* elder (red elderberry*, Sambucus racemosa*).

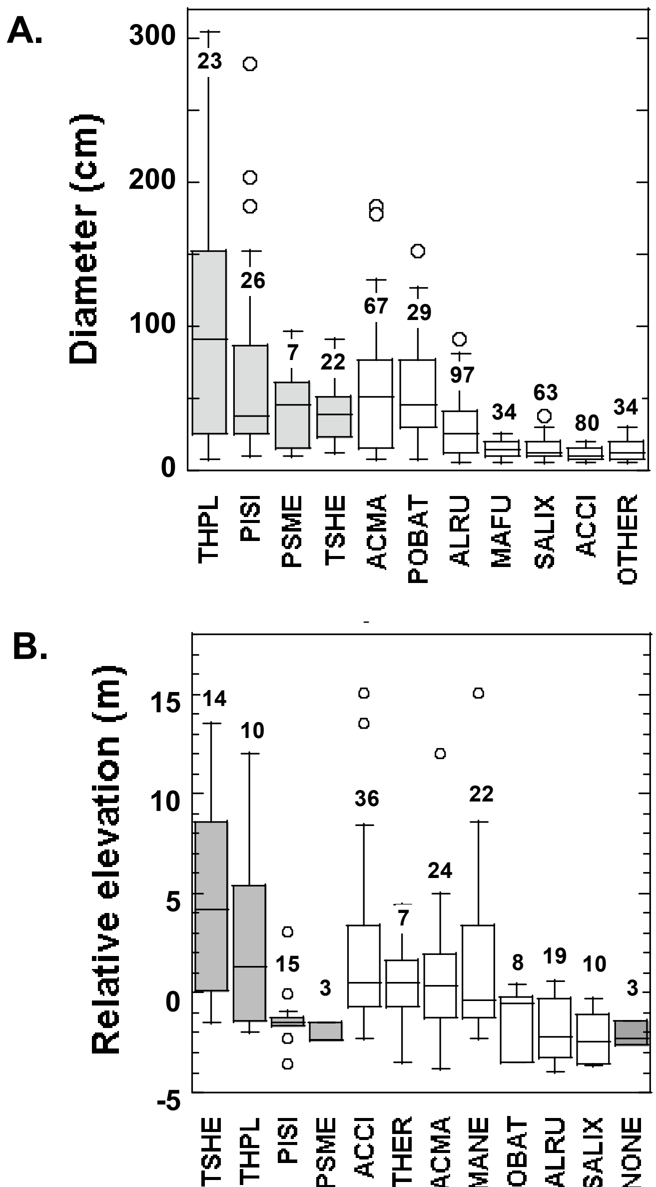

Figure 6. A. Distribution of diameters of GLO bearing trees in the Snoqualmie River valley. B. Elevation of GLO bearing trees relative to the riverbank. Conifers have shaded bars. In both plots, numbers are sample size for each species. Species abbreviations are as in Figure 7. Conifers have shaded boxes. Each box encloses 50% of the data with the median value displayed as a line. The lines extending from the top and bottom of each box indicate the minimum and maximum values, excepting outliers (circles), or points with values greater than the inner quartile plus 1.5 times the inner two quartiles. Numbers are sample size.

HISTORICAL CHANGES

Much of the pre Euro-American settlement forest had been cleared, and much of wetland area cleared and drained by 1936 (Figure 7). Riparian vegetation remained along river channels and oxbows in some areas in 1936 (Figure 8). In contrast to the change in forest and valley wetland area, there was little change in the Snoqualmie River and its associated oxbows (Figure 9). By 1936 the river had cut off (avulsed) only eight meander bends. Notable on the 1936 photographs are numerous large gravel bars in the Tolt River and downstream in the Snoqualmie River (Figure 7), presumably reflecting high sediment yields in the Tolt River watershed from upstream forest clearing.

The area of forest and valley-marginal wetland continued to diminish through the 20th century (Figures 10 and 11). Similar to the previous map period, there was little change in the channel or associated oxbow water bodies; in the 64-year period between 1936 and 2000, one meander bend avulsed (Figure 9). Also notable is the increase in urbanized area between 1936 and 2000 (Figure 11). Most development was concentrated on the Raging River fan and the fan on the north valley side, downstream of Tokul Creek in the upper watershed, and on the Tolt River fan in the Carnation area (Figure 10).

Meander avulsion continued to be uncommon (Figure 9), although that few river changes occurred in the 1936 to 2000 period may in part reflect the establishment of bank revetments in the 1960s and 1970s, (as documented by King County mapping. However, there was little revetment present prior to 1936, when there was relatively little channel change. This relatively slow rate of meander avulsion means that most about three quarters 35 of 48) of oxbow ponds and wetlands mapped from 2000 photographs were created prior to 1873.

The small rate of change to the river contrasts with the extensive historical changes to wetlands and forests, which have been greatly diminished (Figure 11), the area of “valley” wetlands in 2000 was 19% that in ~1870. The valley’s forest cover in 2000 was 16% that mapped for ~1870.

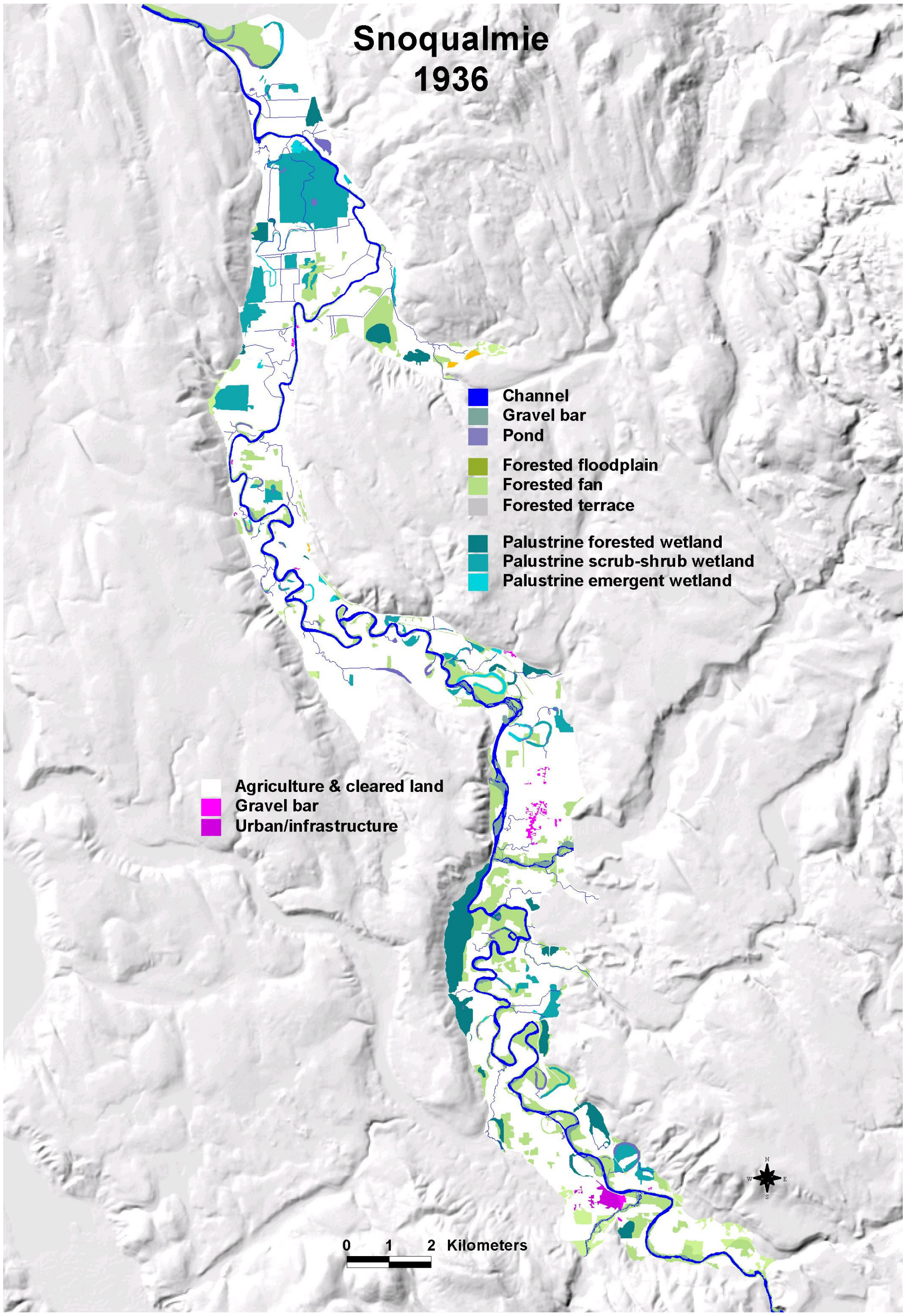

Figure 7. Land use/land cover and hydrologic features in the Snoqualmie River valley, from 1936 aerial photographs. Portions of the northern study area are from 1938 photographs, and in the southernmost from 1941 photographs.

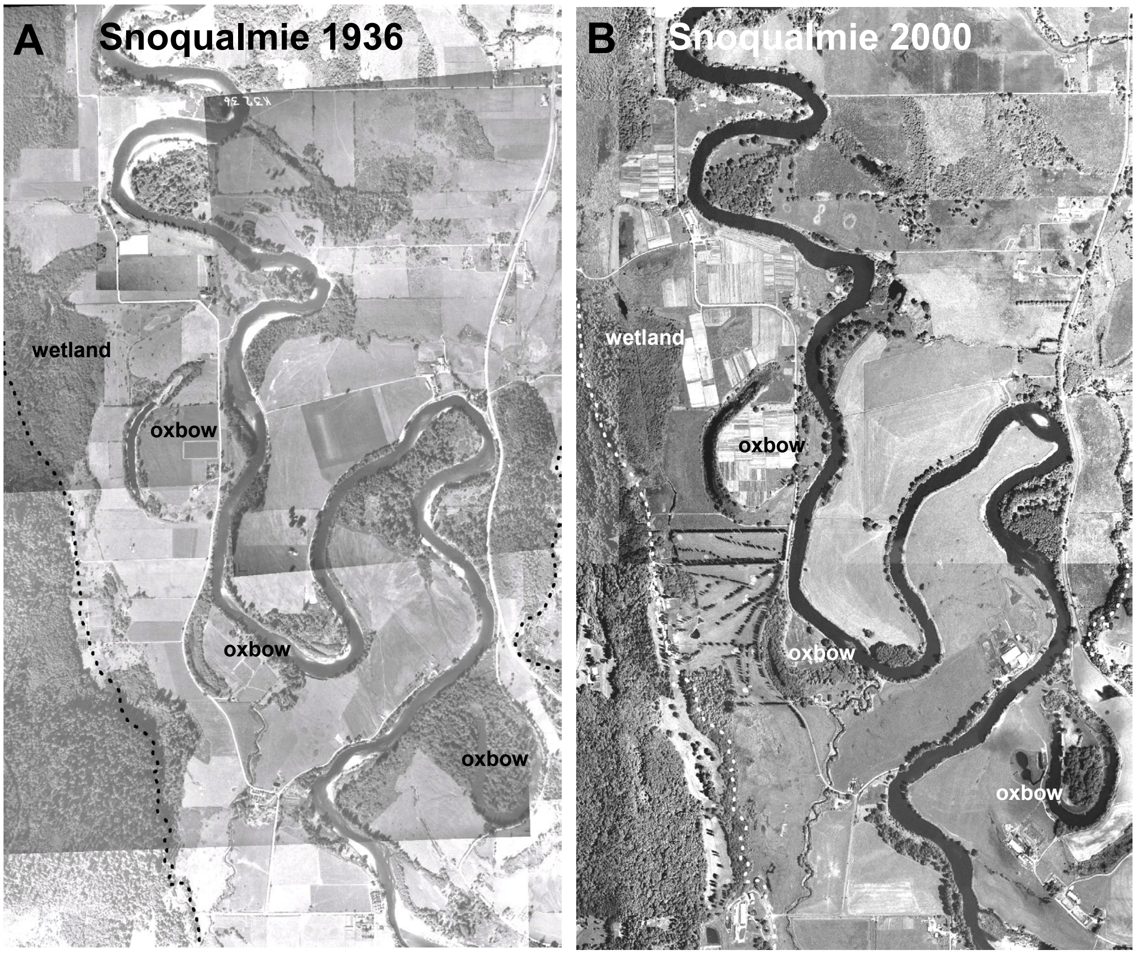

Figure 8. Aerial photographs from A. 1936 and B. 2000 showing change to forest cover in the Snoqualmie River valley, RM 29 to RM 34. Relatively little change has occurred to the channel or oxbow lakes in this time period.

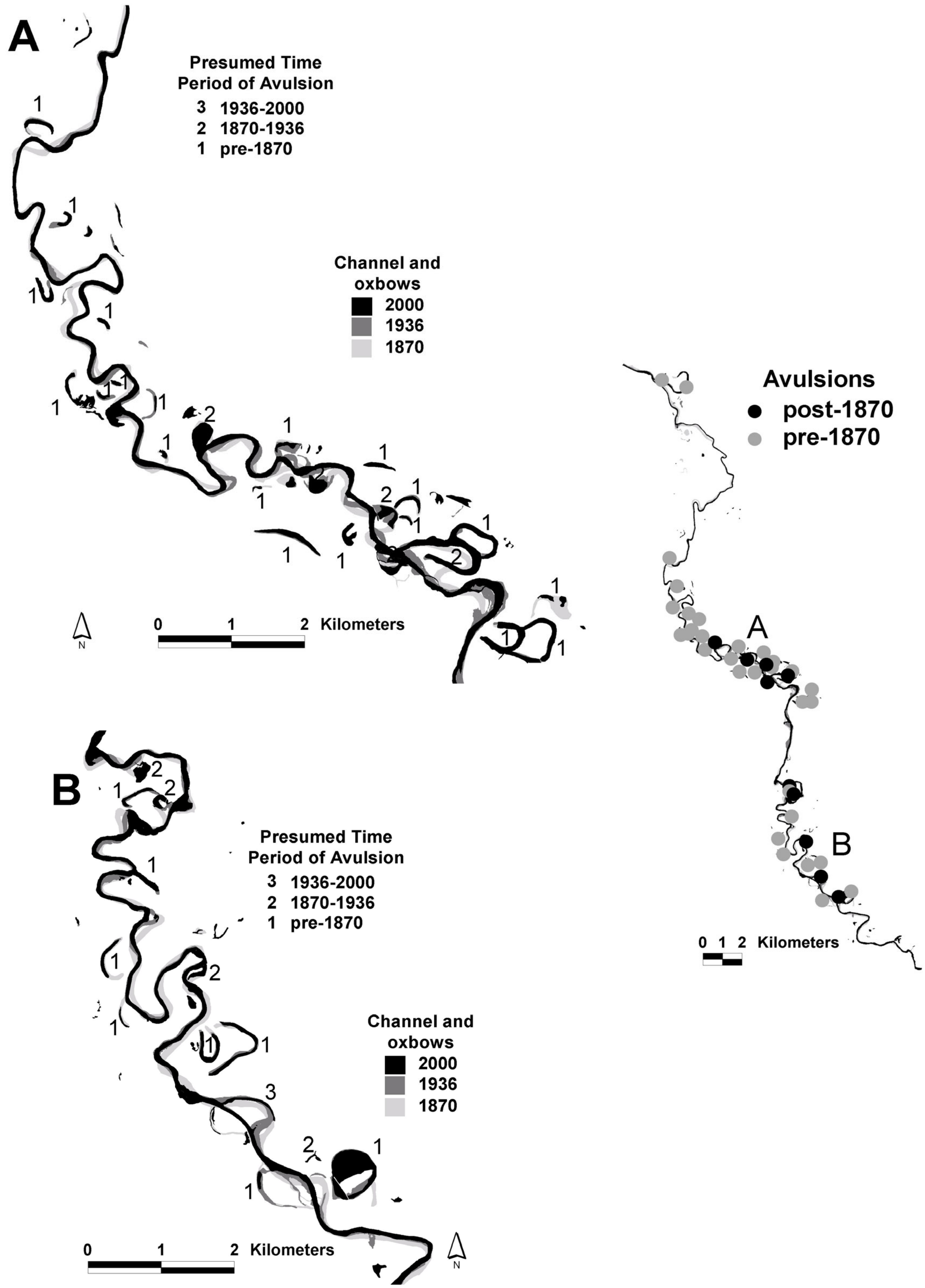

Figure 9. Historical channel positions and time periods of oxbow creation.

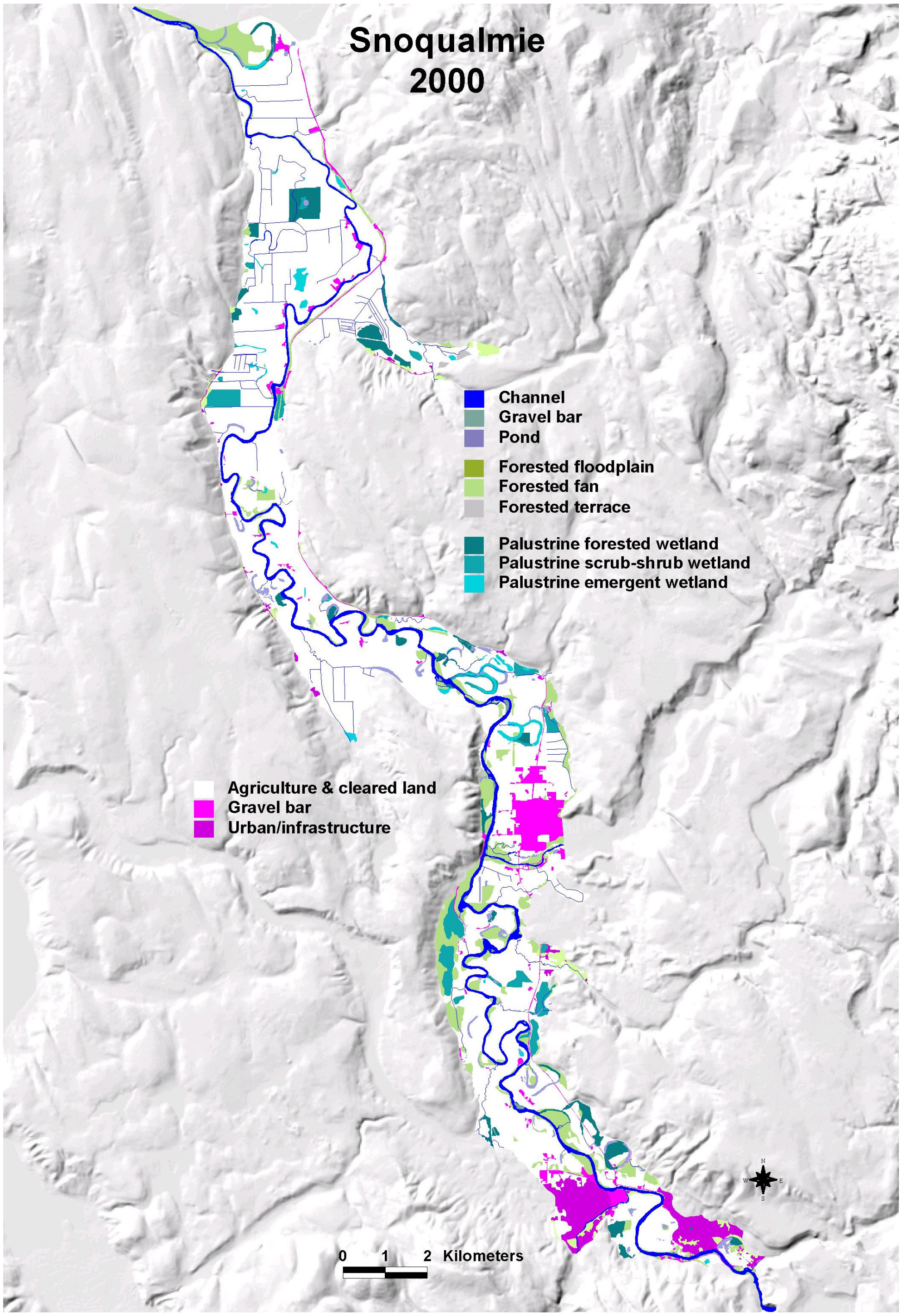

Figure 10. Land use/land cover and hydrologic features of the Snoqualmie River valley, mapped primarily from 2000 aerial photographs. Portions of the northern study area were mapped from 1990 photographs.

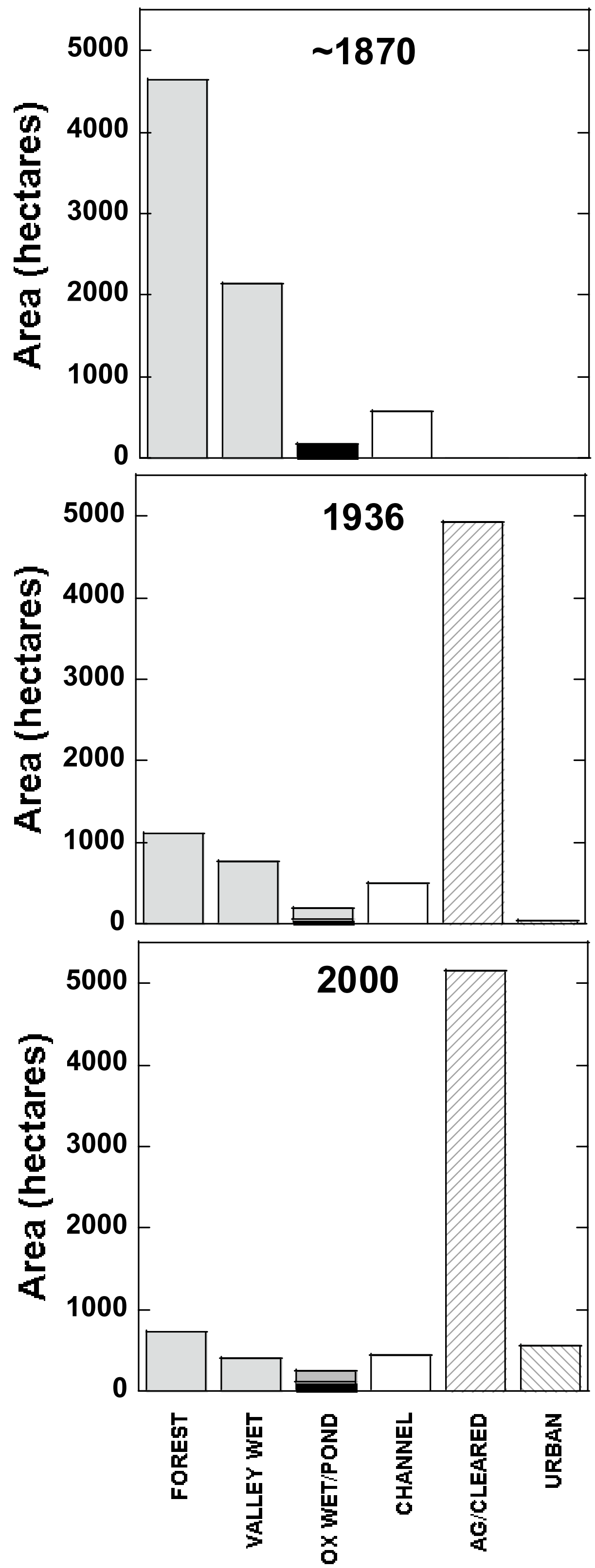

Figure 11. Areal extent of forest, valley wetlands, oxbow ponds (black bar) and oxbow wetlands, agricultural or cleared land, and urbanized land, measured from mapping for ~1870, 1936, and 2000. In the ~1870 mapping, oxbow wetlands were not distinguished from oxbow ponds as they were in the later years.

Application to Restoration Planning

Historical data can be applied to several types of restoration activities:

(1) *Reforestation.* Data from GLO field notes provide information about tree species that grew in historical forests and their locations with respect to riverine and topographic variables.

(2) *Connecting the river with oxbow ponds and wetlands.* River bend avulsion forms oxbow ponds. Through time, oxbows become isolated from the river as sedimentation plugs the river-proximal ends of the oxbow. Most oxbows then exist for some period of time as ponds or wetlands with a tie creek connecting to the river channel, until eventually filled by sediment. The longevity of oxbow features is largely a function of the sedimentation rate, and spatial patterns of sedimentation. On the Snoqualmie, tie creeks connected many oxbows to the river prior to land use changes by settlers. Field investigations of topography, and detailed site-specific historical investigations can reveal the historical hydrologic connection between the oxbow and channel, as part of evaluating the feasibility of reestablishing the hydrologic connection. Table 5 and Figure 12, which include an inventory of historical and current oxbow features, is a starting point for such evaluations.

(3) *Restoring Valley-Marginal Wetlands.* Historical information provides a starting point for assessing the feasibility of restoring wetlands that exist or formerly existed in low-elevation areas outside the meander belt.

(4) *Restoring Tributary Creeks.* Numerous floodplain creeks have been straightened and channelized. Site-specific studies using field surveys, soils and hydrologic information, the 1936 aerial photos, and local knowledge can improve knowledge of the historic location and pattern of these streams for programs to reestablish historical creek morphology.

General conclusions regarding restoration planning (Table 6) include the following. The relatively slow rate of river migration and avulsion has implications for programs to reestablish streamside forest buffers. Abundant oxbow lakes are relatively static, and there is potential for improving or establishing their use as off-channel habitat by connecting them to the river and riparian planting. The low elevation of formerly extensive valley-marginal wetlands would facilitate their “passive” restoration.

Table 5. Inventory of historical off-channel water bodies and wetlands. Numbers in "ID" refer to the analysis reaches in Figure 1; each site is referenced to Figure 12. "Earliest source" is the earliest map source that shows the feature. The "historic area" is the area on the interpreted ~1870 map, except for features that were created more recently than that date (e.g. oxbow ponds and wetlands created by later avulsions). "Historical map source" and map certainty refer to Table 1.

ID	Type	Year Feature Created	Earliest Source	Historic Area (ha)	2000 Area (ha)	Historical Map Source	Historical Map Certainty
1A	Oxbow pond-wetland complex	<1870	1936	4	5	P2B	M
1B	Oxbow pond-wetland complex	<1870	1870	32	21	P1	H
2A	Valley wetland	<1870	1870	142	0	W1A	H
2B	Valley wetland	<1870	1870	11	0	W1A (36%) W2A (64%)	H (36%) M (64%)
2C	Valley wetland	<1870	1936	2	3	W3	L
2D	Valley wetland-pond complex	<1870	1870	1029	148	W1A (95%) W2A (5%)	H (95%) M (5%)
2E	Valley wetland	<1870	1870	289	50	W1A (53%) W2A (47%)	H (53%) M 47%)
3A	Oxbow wetland	<1870	1870	4	3	P1	H
3B	Valley wetland	<1870	DEM	59	0	W3	L
3C	Oxbow pond	<1870	1870	2	2	P2B	M
3D	Oxbow pond-wetland complex	<1870	1870	1	1	P2B	M
3E	Oxbow pond	<1870	1870	1	1	P2A	M
3F	Oxbow pond	<1870	1870	1	1	P2A	M
3G	Oxbow pond	<1870	1870	3	3	P2B	M
3H	Oxbow pond-wetland complex	<1870	1870	1	1	P2A	M
3I	Valley wetland	<1870	NWI/DEM	30	0	W3	L
3J	Oxbow pond	<1870	1870	4	7	P2A	M
3K	Oxbow pond	<1870	1870	2	1	P1	H
3L	Oxbow pond	<1870	1936	1	1	P2B	M
3M	Oxbow pond-wetland complex	<1870	1936	1	5	P2B	M

Table 5 (continued). Inventory of historical off-channel water bodies and wetlands.

ID	Type	Year Feature Created	Earliest Source	Historic Area (ha)	2000 Area (ha)	Historical Map Source	Historical Map Certainty
3N	Oxbow pond	<1870	1870	2	1	P2B	M
3O	Valley wetland-pond complex	<1870	1936	5	0	P2B	M
3P	Oxbow pond	<1870	1870	1	1	P2B	M
3Q	Valley wetland-pond complex	<1870	1936	3	2	W2B	M
3R	Oxbow pond	1936-2000	2000	NA	3	P1	H
3S	Valley wetland	<1870	NWI	9	0	W3	L
3T	Oxbow pond-wetland complex	<1870	1870	4	3	P2B	M
3U	Oxbow pond	<1870	1936	1	<0.5	P2B	M
3V	Oxbow pond	<1870	1936	2	2	P2B	M
3X	Valley wetland	<1870	1870	67	0	W1A (73%) W2A (27%)	H (73%) M (27%)
3W	Oxbow pond-wetland complex	1870-1936	1936	6	5	P1	H
3Y	Oxbow pond	<1870	1870	6	6	P2B	M
3Z	Oxbow pond	<1870	1870	3	3	P1	H
3AA	Oxbow pond-wetland complex	<1870	1870	1	2	P2B	M
3AB	Oxbow wetland	1870-1936	1936	3	4	W1A	H
3AC	Oxbow wetland	1870-1936	1936	6	4	W1A	H
3AD	Oxbow pond-wetland complex	<1870	1870	1	1	P2B	M
3AE	Oxbow pond-wetland complex	<1870	1870	3	3	P2A	L
3AF	Valley wetland-pond complex	<1870	1936	23	26	W3	L
3AG	Oxbow pond-wetland complex	1870-1936	1936	14	20	P1	H
3AH	Oxbow pond-wetland complex	<1870	1870	8	8	P2A	M
3AI	Oxbow pond	<1870	1870	9	2	P2A	M
3AJ	Valley wetland-pond complex	<1870	1870	58	11	W1A (71%) W2A (29%)	H (71%) M (29%)
3AK	Oxbow wetland	<1870	1870	9	10	P1	H
3AL	Valley wetland	<1870	1870	11	0	W3	L

Table 5 (continued). Inventory of historical off-channel water bodies and wetlands.

ID	Type	Year Feature Created	Earliest Source	Historic Area (ha)	2000 Area (ha)	Historical Map Source	Historical Map Certainty
3AM	Oxbow wetland	<1870	1870	9	10	P1	H
4A	Valley wetland	<1870	2000	31	8	W3	L
4B	Valley wetland	<1870	1936	41	0	W3	L
4C	Oxbow pond-wetland complex	1870-1936	1936	3	4	P1	H
5A	Valley wetland-pond complex	<1870	1870	140	59	W1A (6%) W2A (94%)	H (6%) M (94%)
5B	Oxbow pond	<1870	1870	3	2	P1	H
5C	Oxbow pond	1936-2000	2000	NA	3	P1	H
5D	Valley wetland	<1870	1936	7	3	W3	L
5E	Oxbow pond-wetland complex	<1870	1870	2	3	P2B	M
5F	Oxbow pond	1936-2000	2000	NA	<0.5	P1	H
5G	Oxbow pond	<1870	1870	6		P2B	M
5H	Valley wetland-pond complex	<1870	1870	48	32	W1A (35%) W2A (19%) W3 (42%)	H (35%) M (19%) L (42%)
5I	Oxbow pond	<1870	1870	3	1	P2B	M
5J	Oxbow wetland	1870-1936	2000	NA	2	W3	L
5K	Oxbow pond-wetland complex	<1870	2000	2	2	W3	L
5L	Oxbow pond	<1870	1870	6	6	P2B	M
5M	Oxbow pond	<1870	1870	9	7	P1	H
5N	Valley wetland	<1870	1870	24	9	W3	L
5O	Oxbow pond	1870-1936	2000	NA	1	P2B	M
5P	Oxbow pond	1936-2000	2000	NA	3	P2B	M
5Q	Oxbow pond	1870-1936	1936	1	1	P1	H
5R	Valley wetland-pond complex	<1870	1936	64	22	W3	L
5S	Oxbow pond-wetland complex	1870-1936	1936	5	1	P1	H
5T	Oxbow pond-wetland complex	<1870	1936	11	25	P2A	M
6A	Valley wetland-pond complex	<1870	1870	25	17	W1A (4%) W2A (96%)	H (4%) M (96%)
6B	Valley wetland-pond complex	<1870	2000	17	11	W3	L

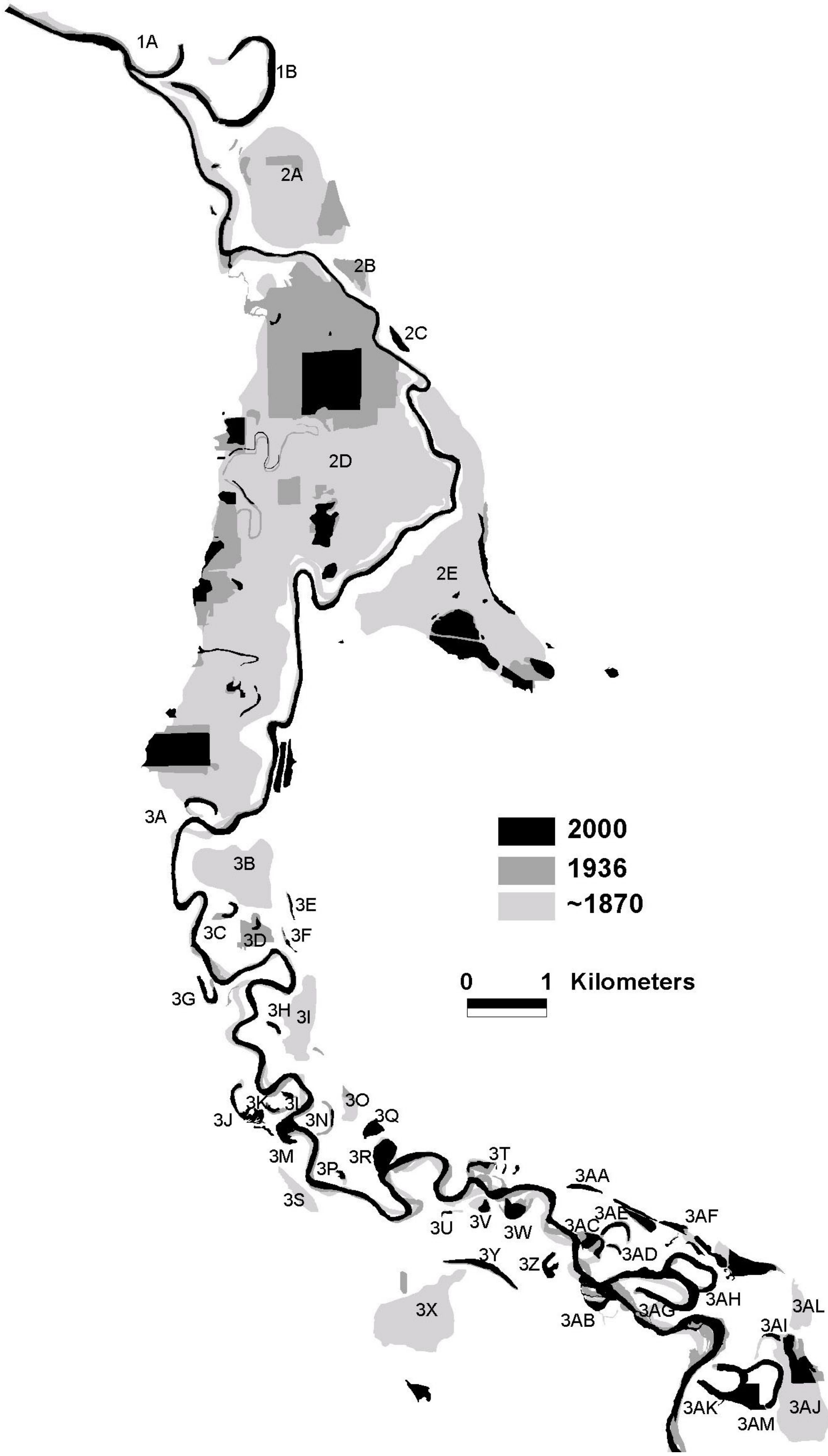

Figure 12. Index map for inventory of floodplain wetlands and ponds in Figure 5.

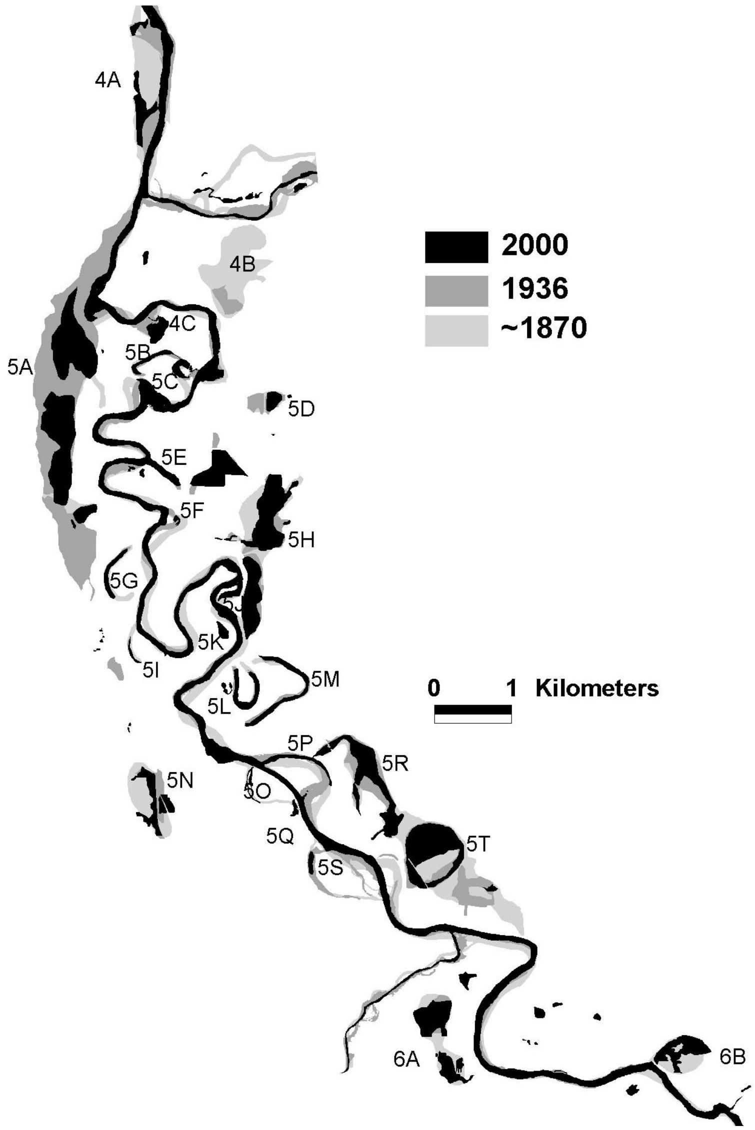

Figure 12 (continued). Index map for inventory of floodplain wetlands and ponds in Figure 5.

Table 6. Summary of restoration opportunities and considerations.

CONCLUSIONS RELEVANT FOR RESTORATION
River Channel
• Relatively slow rate of migration and avulsion, and oxbow lake creation.
Oxbow Lakes & Wetlands
• Oxbow lakes and wetlands were, and are, abundant.
• Oxbow features are relatively static, most having been created earlier than the first map in 1873.
• Potential reconnect ponds and wetlands to the river. and for riparian planting.
Floodplain Tributary Creeks and Sloughs
• Potential to restore natural morphology to channelized and straightened creeks.
Valley-Marginal Wetlands
• Historically extensive, especially in lower part of river.
• Topography favors “passive” restoration.

ACKNOWLEDGMENTS

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This report was reformatted and edited in December 2004. The content was not changed except for the wetland descriptions added as Appendix 1. Wetland descriptions in Appendix 1 are from: Collins, B. D. and A. J. Sheikh. 2003. Historical aquatic habitat in river valleys and estuaries of the Nooksack, Skagit, Stillaguamish, and Snohomish watersheds. Final project report to National Marine Fisheries Service, Northwest Fisheries Science Center, Seattle, WA. University of Washington Department of Earth and Space Sciences, May 1, 2003.

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APPENDIX 1: WETLAND DESCRIPTIONS

SNQ260601 *(1,016 hectares).* The marsh system was characterized in the GLO notes as seasonally "subject to overflow" by as much as 8 feet of water, which is consistent with the modern elevation of the lowland area being several meters below the riverbank. At the time of the survey on April 4, 1873, the water was described as "… 6 to 18 inches deep [underlining added]." Descriptions on the GLO field notes include: Between S. 1 and S. 2 (T26NR6E) "…low scrubby open timber….subject to overflow at high water to the depth of from 6 to 8 feet [underlining added]. Timber in the last ¼ mile [moving north] low scrubby pine undergrowth crabapple willow & hard hack." Between S. 1 and S. 12, T26NR6E, "[moving east, at 41 chains] leave scrubby spruce timber & enter cranberry marsh N & S." "Mostly cranberry marsh, subject to overflow to the depth of 8 feet [underlining added]. Timber a few scattering scrubby spruce & cedar. Undergrowth hard hack & tule." Between S. 11 and S. 14, T26NR6E, "[moving east, at 34.5 chains] Enter swamp almost impassable [underlining added]." "[at 60 chains] Leave spruce swamp enter open marsh." "…land level, low swampy. Subject to overflow to the depth of from 2 to four feet [underlining added]. Timber, a few scattering scrubby spruce entirely worthless. Undergrowth alder & crabapple with hard hack & tule," on April 10, 1873. Between S. 2 and S. 11, T26NR6E, "[moving east, at 46.5 chains] Foot of hill, enter [illegible] swampy bottom." "[at 50 chains} Leave spruce & cedar timber & enter open swamp." "…low level swamp and subject to overflow in winter to the depth of from 2 to 4 ft [underlining added]. Timber a few scattering scrubby spruce & pine. Undergrowth same with spruce alder crabapple willow & hard hack & nettle." Between S. 11 and S. 12, (T26NR6E), "Land level & swampy water on it to the depth of from 6 to 18 inches at time of high water it is subject to overflow to the depth of from 4 to 8 feet [underlining added] ….timber none. Saw a few scattering scrubby spruce. Undergrowth hard hack & willow with tule," on April 5, 1873. Between S. 26 and S. 35, T27NR6E, "Land unfit for cultivation. This land is subject to inundation 2 to 6 feet [underlining added]." Between S. 35 and S. 36, T27NR6E, "[moving north, at 2 chains] open swamp [illegible word] unfit for cultivation." "[at 40 chains] This corner cannot be witnessed owing to the depth of water [underlining added] and absence of timber." "Land level soil dark rich brown. Timber sparse Spruce Maple & Cottonwood. Undergrowth Hard Hack and Maple. Plants Wild [illegible] and Cranberry," on August 10, 1871.

The DEM shows some subdued, sinuous topography within this marsh, presumably created by ancient river meanders, and the water depth would have varied locally. The notes, plat maps, and more recent mapping and photos also show several perennial ponds, which are accounted for separately as ponds. Given the depths of winter inundation described by GLO surveyors, we have assumed that a conservative estimate is that most (at least 75%) of the area would have been inundated in winter.

SNQ260701 Cherry Valley Area Marsh (289 hectares). The GLO field notes describe the area as "swamp" (between S. 7 and S. 8, T26NR7E), and between S. 6, T26NR7E and S. 31, T27NR7E as "hard hack thicket & marsh ground" on September 23, 1873. Between S. 6 and S. 7, T26NR7E, "[moving east, at 22.5 chains] It being impracticable to extend the line further on account of swamp…" on May 27, 1874.

SNQ270601(142 hectares). We used the boundaries for the marsh as drawn on the GLO plat map. The GLO survey approached this marsh from four directions but turned back in each case because the marsh was "impenetrable. The corner to S. 23, S. 24, S. 25, and S. 26, T27NR6E, was described as being in an "impenetrable marsh." The marsh between S. 23 and S. 24 was not surveyed because of this. Similarly, between S. 25 and S. 26, at 27.5 chains, they wrote "Impenetrable open marsh…" ceased surveying, and described the line as "…<u>land subject to overflow 1 to 10 feet </u>[underlining added]." Between S. 23 and S. 26, at 41 chains, "Low bottom <u>subject to inundation by water 2 to 6 feet in depth</u> [underlining added]," and at 60 chains, "the edge of an inaccessible marsh," in August 15, 1871.

SNQ270602 (11 hectares). The GLO field notes describe the marsh between S. 25 and S. 36, T27NR6E, as "[at 18.5 chains] Open marsh…this marsh is impenetrable…" on August 11, 1871. The GLO also mapped nearby *SNQ270603* (3 hectares).

SNQ250701 (67 hectares). The extent of this wetland was mapped using the GLO survey notes, which record the surveyors approaching the wetland from each direction, and then avoiding it as an "impassable swamp." They wrote, between S. 12, T25NR6E and S. 7, T25NR7E, "[at 64 chains, moving north] Enter swamp…almost impassable." Then [at 74.5 chains] "at this point the swamp becomes impassable." Between S. 1 and S. 2 or T25NR6E, [moving east, at 74.3 chains] Margin of impassable swamp." Travelling between S. 6 and S. 7, T25NR7E, [at 48.5 chains} "enter swampy ground" and [at 63 chains] "impracticable to extend line" on October 20, 1873. The wetland is partially coincident with the area mapped as the "Ames Lake Creek peat area" by Rigg (1958), which is significantly larger than the area we mapped. We interpret the field references to the wetland's impassability as indicating significant winter inundation; we assume three-quarters of the area was winter inundated.

SNQ250702 (three wetlands totaling 24 hectares). About 5 hectares of the area is mapped as wetland on the Carnation USGS topographic map. The SSURGO data base shows the area as having hydric soil and King County maps the area as wetland.

SNQ250704 (55 hectares). The GLO survey crossed this feature between S. 9 and S. 10, T25NR7E: "[traveling north, at 4 chains] enter swampy ground…[at 49.2 chains] enter hard hack swamp…[at 62.5 chains] south side of marshy lake." The line was described as "Land level subject to overflow fr. 1 to 7 ft [underlining added]. Covered with c-apple V Maple Alder & C" on October 10, 1873.

SNQ250705 (171 hectares). About one half the area is mapped as wetland on the current Fall City and Carnation USGS topographic maps. The wetland is elongate in a north-south direction, and is crossed in an east-west direction by the line between S. 20 and S. 29 and by S. 29 and S. 32, neither of which make mention of the wetland, but the plat map shows a wetland drawn along the boundary between S. 29 and S. 32. King County mapping shows the area as wetland. The recent USGS Fall City and Carnation topographic sheets shows 49 hectares as wetland, which we have taken as an estimate of winter inundated area.

SNQ250707 (7 hectares). Mapped wetland was not crossed by a GLO survey line. The SSURGO data shows it as a hydric soil, and King County wetland mapping shows it as wetland. About 2 hectares of the area is mapped as wetland on Fall City USGS topographic quadrangle; we have used this latter number as an estimate of winter inundation.

SNQ250708 (47 hectares). The GLO survey crossed a small part of the marsh along the line between S. 33 and S. 34, T25NR7E, and recorded "[moving north, at 52.5 chains] E. end of cranberry marsh" on June 1, 1865. The SSURGO data shows it as a hydric soil, and King County wetland mapping shows it as wetland. About one-half (25 hectares) of this area is mapped as wetland by the recent Fall City USGS topographic quadrangle; we have used this latter number as an estimate of winter inundation.

SNQ240703 (90 hectares). Crossed by lines between S. 9 and S. 10, S. 10 and S. 11, S. 11 and S. 14, and S. 13 and S. 13, T24NR7E but not described as wetland. The SSURGO data shows it as a hydric soil, and King County wetland mapping shows it as wetland. Most of the area we have mapped as wetland is mapped as such on the USGS Fall City topographic quadrangle. Twenty-four hectares of this area is mapped as wetland by the recent Fall City USGS topographic quadrangle; we have used this to estimate the extent of winter inundation.

SNQ240704 (26 hectares). The GLO survey mentions "swampy ground" beginning 3.5 chains moving eastward between S. 13 and S. 23, T24NR7E on August 16, 1867. The wetland, as we have mapped it, is also crossed by the survey line between S. 15 and S. 14 T24NR7E, surveyed in August 17, 1873, but not noted. The SSURGO mapping shows part of the map unit as hydric soil, and King County wetland mapping shows the entire area as wetland.

SNQ240705 (17 hectares). The GLO survey does not cross this wetland mapped in S. 24 of T24NR7E. About one-half of the wetland is mapped on the Snoqualmie USGS topographic map. King County mapping shows the map unit as a wetland. About one-third (6 hectares) of this area is mapped as wetland by the recent Snoqualmie USGS topographic quadrangle; we have used this as an estimate of winter inundation.

Several wetland map units fall completely within sections and so were not visited by the GLO surveyors. We mapped them using soils, King County wetland mapping, topography or the 1936 aerial photographs. We assume that none were inundated in summer or winter. *SNQ260604* (30 hectares). Within S. 25. We mapped this wetland on the basis of hydric soils and topography. *SNQ240702* (14 hectares). The GLO survey does not cross this wetland mapped in S. 9 of T24NR7E; we map it based on King County wetland mapping. About two hectares are shown as wetland on the Carnation USGS topographic map, which we take as an estimate of winter wetted area. *SNQ260605* (two wetlands totaling 8 hectares). Within S. 36; mapped using hydric soils and King County wetland mapping; 3 hectares are mapped as wetland on the USGS Carnation topographic map.

Several wetland map units were crossed by the GLO surveyors and were not identified as wetlands, and we mapped them as wetlands using soils and topography or the 1936 aerial photographs. We assume that none were inundated in summer or winter. *SNQ250706* (41 hectares). Crossed by GLO between S. 21 and S. 28, but not mentioned. We map it using hydric soils and wetland mapping. *SNQ250703* (11 hectares). The GLO survey crossed the wetland on the line between S. 3 and S. 10,and does not make mention in the notes on October 11, 1873. We map it using hydric soils and wetland mapping. *SNQ260606* (9 hectares). The GLO surveyors did not mentioned the area in their notes between S. 36, T26NR6E, and S. 1, T25NR6E, on April 1, 1873; we mapped it using King County wetland mapping. *SNQ260602* (83 hectares): the GLO surveyors did not note this as a wetland between S. 23 and S. 24, T26NR6E; we mapped it using hydric soils and topography.