Historical Willamette River Channel Change

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Introduction

Throughout the western United States, large rivers played a key role in early settlement. In the decade after 1850, the U.S. General Land Office (GLO) surveyed the landbase and rivers of much of the West. Engineers surveyed most habitable lands, and delineated the vegetation, stream channels, and wetlands along monumented section lines. The Willamette River network and its riparian vegetation were mapped in this first rigorous survey of the West. In 1895 and 1932, the U.S. Army Corps of Engineers surveyed the entire length of the river for navigation. These maps provide an excellent record of the historical locations and configuration of the Willamette River and its numerous side channels, tributaries, and islands. The river is composed of three channel types: primary channel (unbraided, or the portion of the channel with the most flow), side channel (channels connected to the mainstem at both ends; this includes the small channels that form islands), and alcoves or sloughs. The latter are “blind” channels, i.e., they are connected only at one end to a primary, side, or secondary channel (see Off-channel Habitats, pp. 26-27).

Changes in the River Channel

The morphology of the Willamette River differs greatly along its 170 mile (273 km) length in the Willamette Valley. Large hills and volcanic cones within the valley floor have blocked the river in places, confining the position of the river and creating extensive storage basins. These same landforms dammed huge lakes that inundated much of the Willamette Valley floor after a series of floods during the end of the last glacial period. Deposits of sediments and landform constraints created the template on which the modern Willamette River and subsequent human land use developed.

The southern end of the river from Eugene to Albany is an extensively braided channel, containing numerous side channels and islands. Tributaries, such as the Middle Fork Willamette River, Coast Fork Willamette River, McKenzie River, Long Tom River, Marys River, Calapooia River, Santiam River, and Luckiamute River, have delivered large amounts of sediment into a depositional basin created by the blockages of the Salem hills. Past floods have carved numerous channels through these sediment deposits. The northern or downstream end of the Willamette River is a simple meandering river channel with lower gradients than the upper river section. Complex braided channels are more localized, and lateral changes in the river channel are limited. The Willamette Falls exerts a major control on the river, and the 45 miles (72 km) below Willamette Falls is extremely low gradient and controlled by the backwatering effect of the Columbia River. Given these differences in basin geomorphology, it is not surprising that the channels of the upper Willamette River have changed more dramatically than the simpler meandering channel of the lower river.

During the period from 1850 to 1995, the total area of river channels and islands decreased from 41,000 acres to less than 23,000 acres (Table 4, Fig. 19) and the total length of all channels decreased from 355 miles to 264 miles (Table 5). The proportion of primary channel increased for the Willamette River as a whole, reflecting the elimination of islands and side channels in efforts to open the main channel for navigation. More than one-half of the area of small floodplain tributaries and more than one-third of the alcoves and sloughs were lost by 1995, and area of islands diminished by roughly two-thirds (Table 4, Fig. 18). Decreases in channel length were similar in trend but lower in magnitude for most channel types (Table 5, Figs. 24-27). These changes in the channels and floodplains differed along the Willamette River mainstem. The lower reach stretches from Portland to Newberg, the middle from Newberg to Albany, and the upper from Albany to Eugene. Overall, loss of channel complexity was least in the lower river section, variable and intermediate in the middle section of the river, and greatest in the upper river section (Figs. 18, 19). Gradient differs among these three sections of the river, but the overall landforms constraining the channel have the greatest influence on the history of channel change. The upper river is a broad unconstrained floodplain. From Albany to Newberg, the river runs through a series of basaltic outcrops and mountains within the floodplain, causing the river to bounce back and forth between these resistant hills. The Willamette is confined within a basaltic trench from Newberg to the mouth. These larger landforms have shaped the river and limited the degree of channel complexity and its historical change.

TOTAL RIVER AREA - PERCENT COMPOSITION OF CHANNEL

	Channel Types				Total area	
	Primary	Alcoves	Side	Islands	ha	acres
1850	35.2	1.6	8.9	54.2	16543.9	40880.0
1895	42.8	1.7	9.7	45.7	15281.7	37761.1
1932	45.9	1.1	9.5	43.5	13295.7	32853.7
1995	55.0	1.9	7.1	36.0	9197.3	22726.4

TOTAL RIVER AREA - % CHANGE VS. 1850

	Channel Types				
	Primary	Alcoves	Side	Islands	Total Area
1895	12.3	-0.9	0.3	-22.1	9.5
1932	4.7	-46.5	-14.7	-35.5	-0.9
1995	-13.3	-35.1	-55.6	-63.1	-22.3

Table 4. *Changes in area of channel features from 1850 to 1995 for the Willamette River from Portland to Eugene. Changes in island area are also documented. Calculation of the changes since 1850 is based on actual areas, not the percentages shown in the table above.*

TOTAL RIVER LENGTH - PERCENT COMPOSITION OF CHANNEL

	Channel Types			Total Length	
	Primary	Alcoves	Side	km	miles
1850	51.2	7.8	41.0	571.3	355.0
1895	55.1	8.9	36.0	492.2	305.8
1932	55.8	6.6	37.6	487.2	302.7
1995	64.8	11.8	23.4	424.1	263.5

TOTAL RIVER LENGTH - % CHANGE VS. 1850

	Channel Types			
	Primary	Alcoves	Side	Total Length
1895	-7.3	-0.9	-24.5	-13.8
1932	-7.1	-27.8	-21.8	-14.7
1995	-6.1	13.1	-57.7	-25.8

Table 5. *Changes in the length of the mainstem Willamette River, from Portland to Eugene, between 1850 and 1995. This table shows the absolute changes in length of each of these channel types as well as the percent change from 1850 to the present. Calculation of the changes since 1850 is based on actual lengths.*

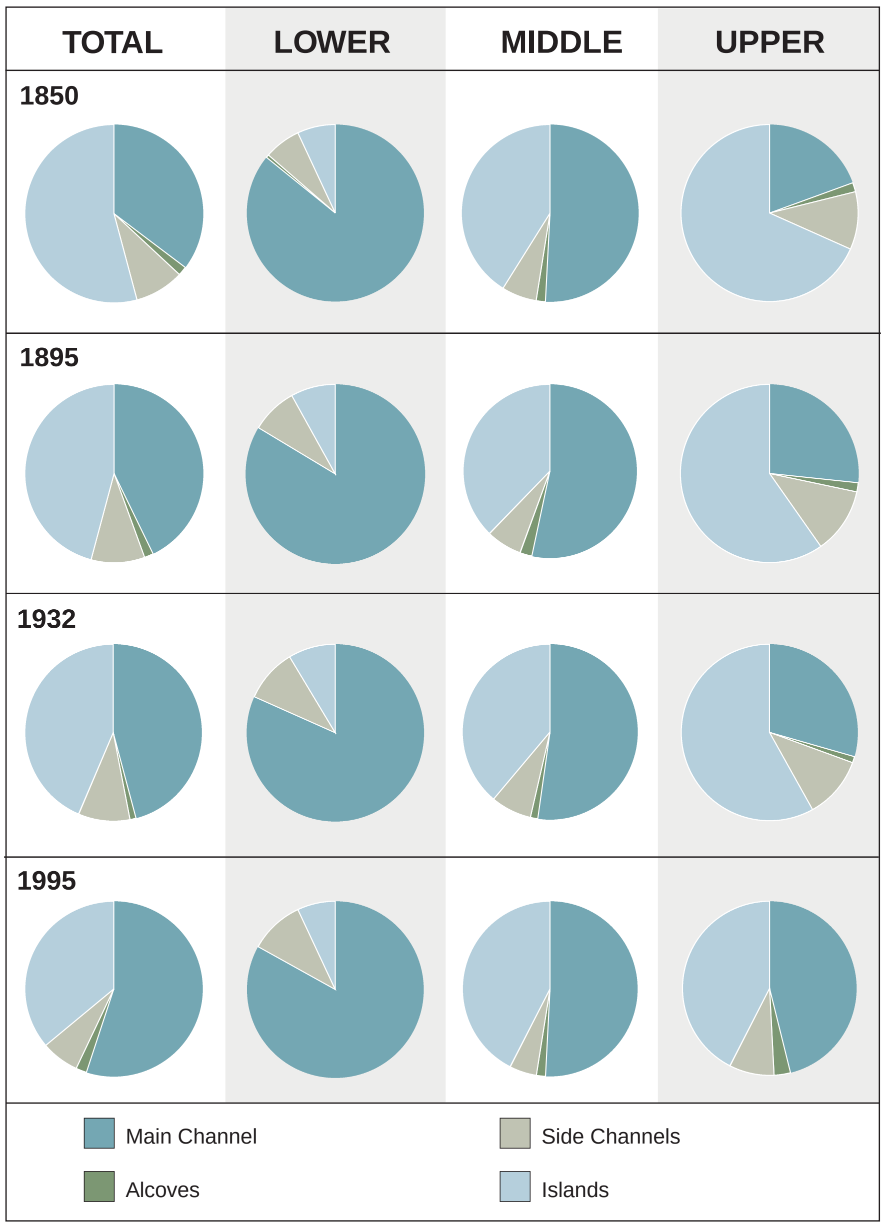
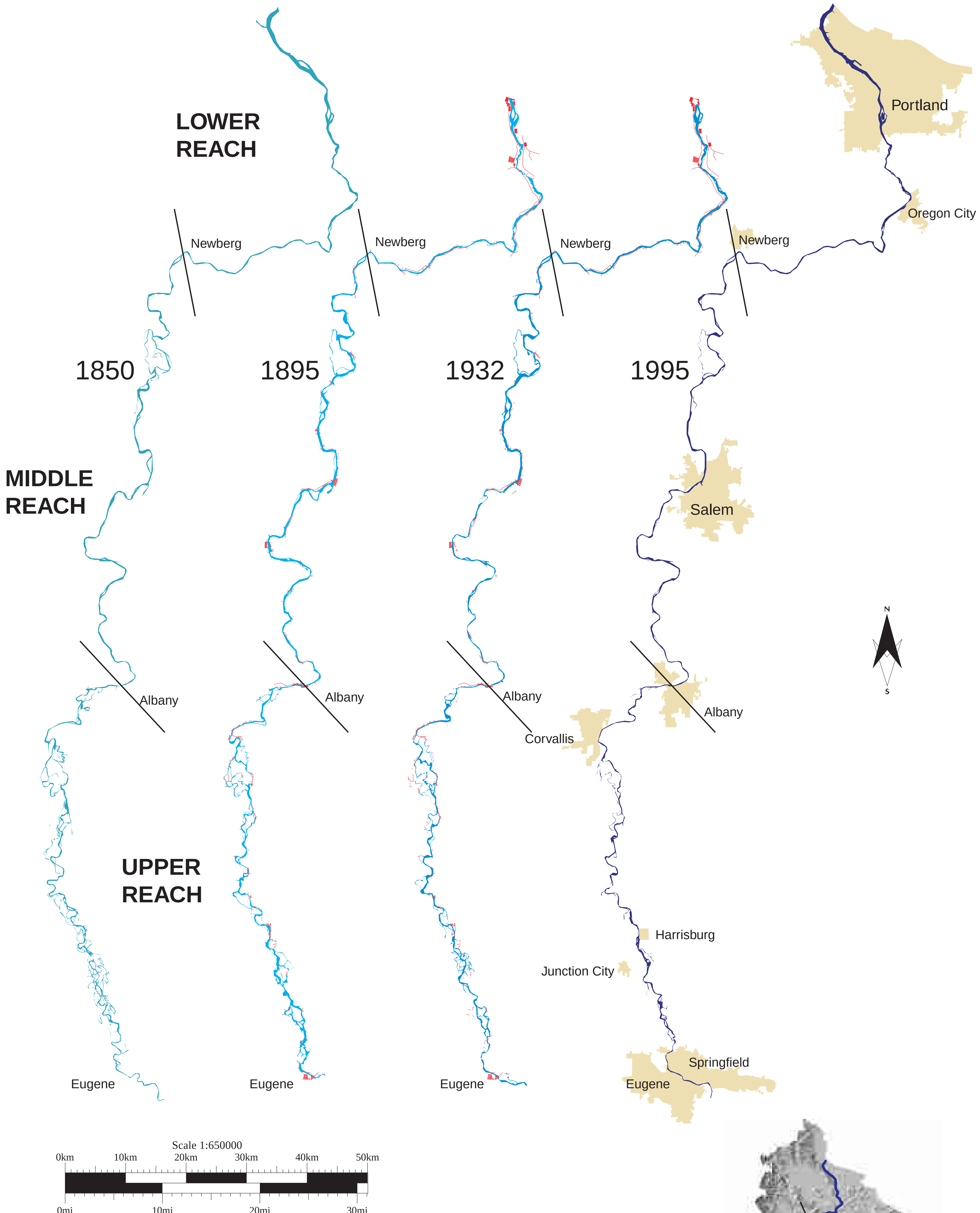


Figure 18. *Proportion of the channel composed of main (or primary) river, side channels, alcoves, and islands. The change in the percent composition of the river is shown for four mapping dates (1850, 1895, 1932, and 1995), as well as for three different reaches of the river.*



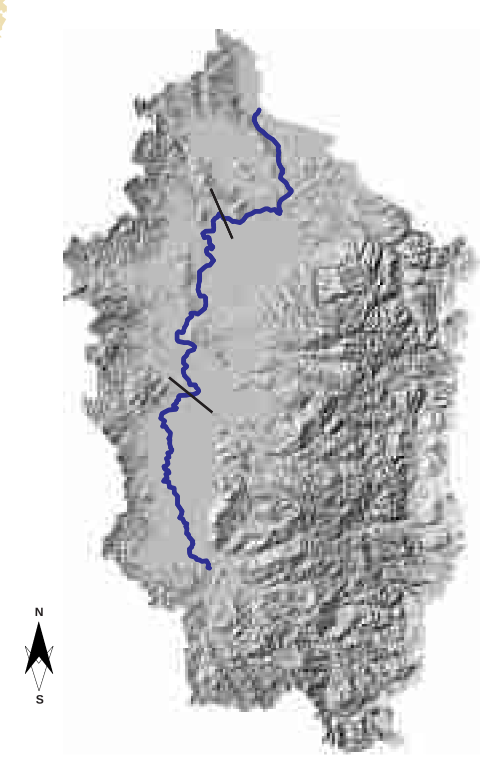


Figure 19. *The channels of the Willamette River in 1850, 1895, 1932, and 1995. More detailed maps for these dates are presented in Figures 220-227, pp. 166-173. Three different river reaches are indicated with lines. The upper river reach extends from Eugene to Albany. The middle river reach extends from Albany to Newberg. The lower river reach extends from Newberg to the mouth of the Willamette River where it enters the Columbia River in Portland. Near-river roads and railroads are shown in red on 1895 and 1932, 1995 UGBs are shown in tan.*

Major Changes in the Lower Reach of the Willamette River: Portland to Newberg

The lower reach of the Willamette River from Portland to Newberg has remained relatively constant geomorphically over the last 150 years. The position of the river channel today is essentially identical to the river in 1850. Total area of river channels and islands remained largely unchanged from 1850 to 1995 (Table 6, Fig. 18) and the total length of all channels increased slightly from 43 miles to 47 miles (Table 6). Though alcoves and sloughs were lost, area and length of side channels increased and islands are largely unchanged (Table 6). Overall, the lower section of the Willamette River is controlled by resistant geology and has experienced little historical change in complexity.

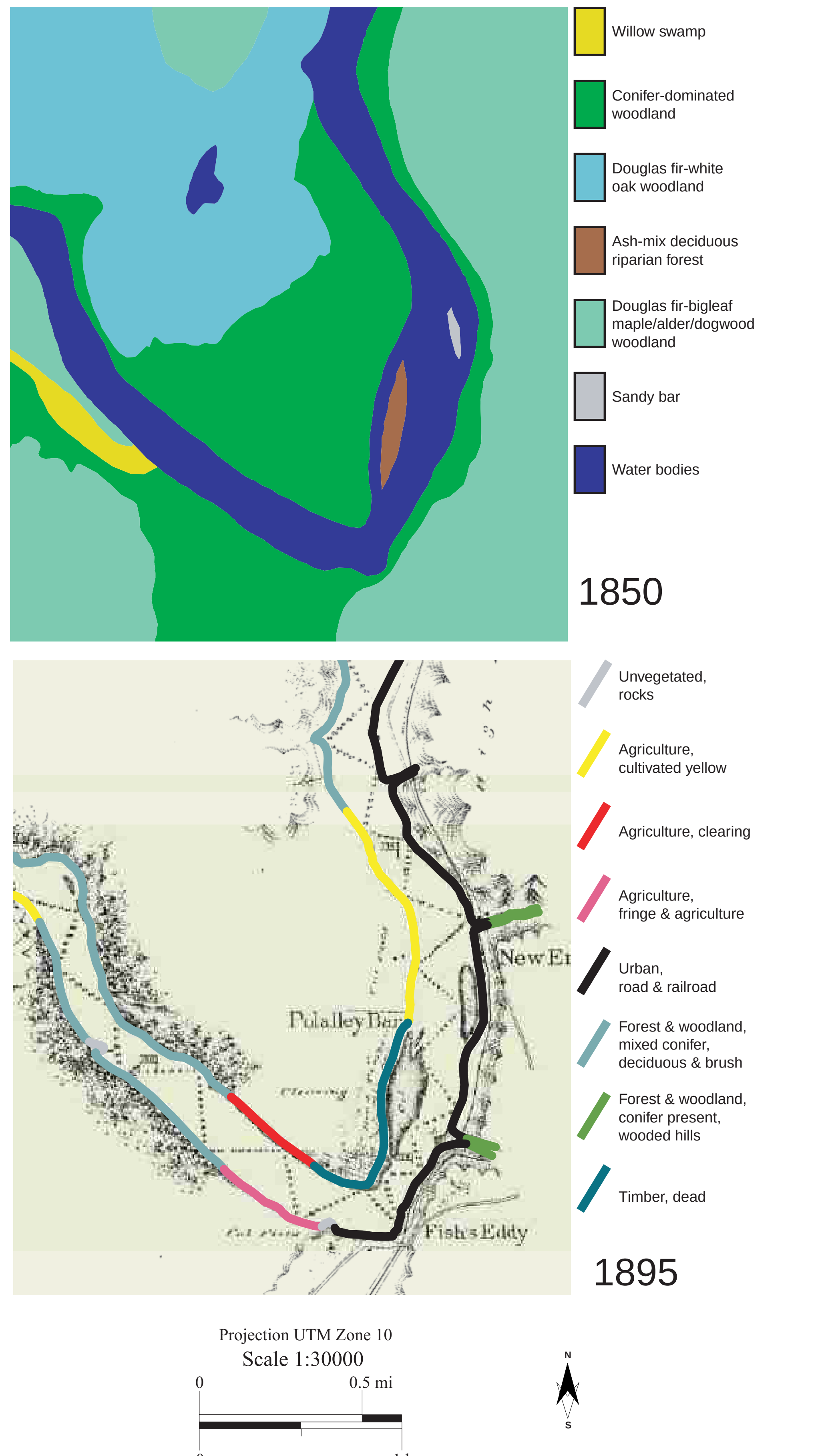
LOWER REACH - PERCENT COMPOSITION OF CHANNEL AREA						
	Channel Types				Total area	
	Primary	Alcoves	Side	Islands	ha	acres
1850	85.9	0.6	6.4	7.1	1714.7	4237.0
1895	81.6	0.2	9.7	8.5	1813.7	4481.6
1932	83.5	0.0	8.5	8.0	1952.0	4823.5
1995	83.0	0.1	10.0	6.9	1694.1	4186.1

LOWER REACH - % CHANGE IN AREA VS. 1850					
	Channel Types				
	Primary	Alcoves	Side	Islands	Total Area
1895	0.5	-72.2	60.1	27.3	4.1
1932	10.7	-100.0	51.2	27.9	12.8
1995	-4.6	-80.0	53.6	-3.0	-1.1

LOWER REACH - PERCENT COMPOSITION OF CHANNEL LENGTH					
	Channel Types			Total Length	
	Primary	Alcoves	Side	km	miles
1850	87.5	3.5	9.0	68.5	42.5
1895	82.3	0.5	17.2	73.0	45.4
1932	81.1	0.0	18.9	71.6	44.5
1995	79.7	0.7	19.6	75.9	47.1

LOWER REACH - % CHANGE IN LENGTH VS. 1850				
	Channel Types			
	Primary	Alcoves	Side	Total Length
1895	0.4	-85.5	102.7	6.7
1932	-3.1	-100.0	119.2	4.5
1995	1.0	-76.9	139.9	10.8

Table 6. *Percent composition of channel types in the lower river from Portland to Newberg. The area of major channel types, including islands, as well as change since 1850 are shown in these two tables. Changes are calculated using 1850 as a baseline. The portion of the river shown at right in Fish Eddy provides an example of these patterns.*



An example of this section of the river is illustrated in Figure 20. Resistant basalt bedrock lines much of the bank and channel from the sharp bend at Fish Eddy downstream to the exposed bedrock around Rock Island. Even small gravel bars downstream of Fish Eddy appear at the same location in each river map since 1850, indicating a thin veneer of gravel over an elevated section of bedrock. The simple, unchanging channels of the lower reach differ markedly from the multiple channels associated with the extensive alluvial sediments in the upper Willamette Valley. These less dynamic reaches serve as excellent reference points from which we can measure errors between mapping efforts at different times over the last 150 years. Persistence of river margins in such reaches permits development of older floodplain forests, but the lower risk of flood damage makes such reaches more desirable for human development. Aquatic communities in these reaches are not exposed to rapidly changing channels, but the lack of extensive floodplains reduces the potential refuge during major flood events.

MIDDLE REACH - PERCENT COMPOSITION OF CHANNEL AREA						
	Channel Types				Total area	
	Primary	Alcoves	Side	Islands	ha	acres
1850	50.7	1.7	6.5	41.0	4746.0	11727.5
1895	53.4	2.3	6.7	37.6	5534.8	13676.5
1932	52.2	1.5	7.4	38.9	4999.3	12353.2
1995	50.7	1.7	5.0	42.6	4171.2	10307.1

MIDDLE REACH - % CHANGE IN AREA VS. 1850					
	Channel Types				
	Primary	Alcoves	Side	Islands	Total Area
1895	22.8	53.5	19.0	7.1	23.2
1932	8.3	-9.6	20.2	0.0	9.1
1995	-12.1	-15.5	-33.1	-8.6	-14.5

Table 7. *Percent channel composition for the reach of the Willamette River from Newberg to Albany. Changes are calculated using 1850 as a baseline.*

Major Changes in the Middle Reach of the Willamette River: Newberg to Albany

The middle section of the Willamette River from Albany to Newberg includes a series of confined channel locations interspersed within broader floodplains. Historical changes in the river channel have been more spatially variable along this reach of the mainstem. Total area of river channels decreased by 14% from 1850 to 1995 and the total length of all channels was largely unchanged (Table 7). The proportion of primary channel, secondary channels, and islands in terms of area or channel length did not change greatly, though area of primary channel, side channels, alcoves, and islands all decreased as a function of loss of channel area (Table 7, Fig. 18). Overall, length of the different channel types did not change greatly, but area decreased. The increase in alcoves between 1850 and 1895 may have been due

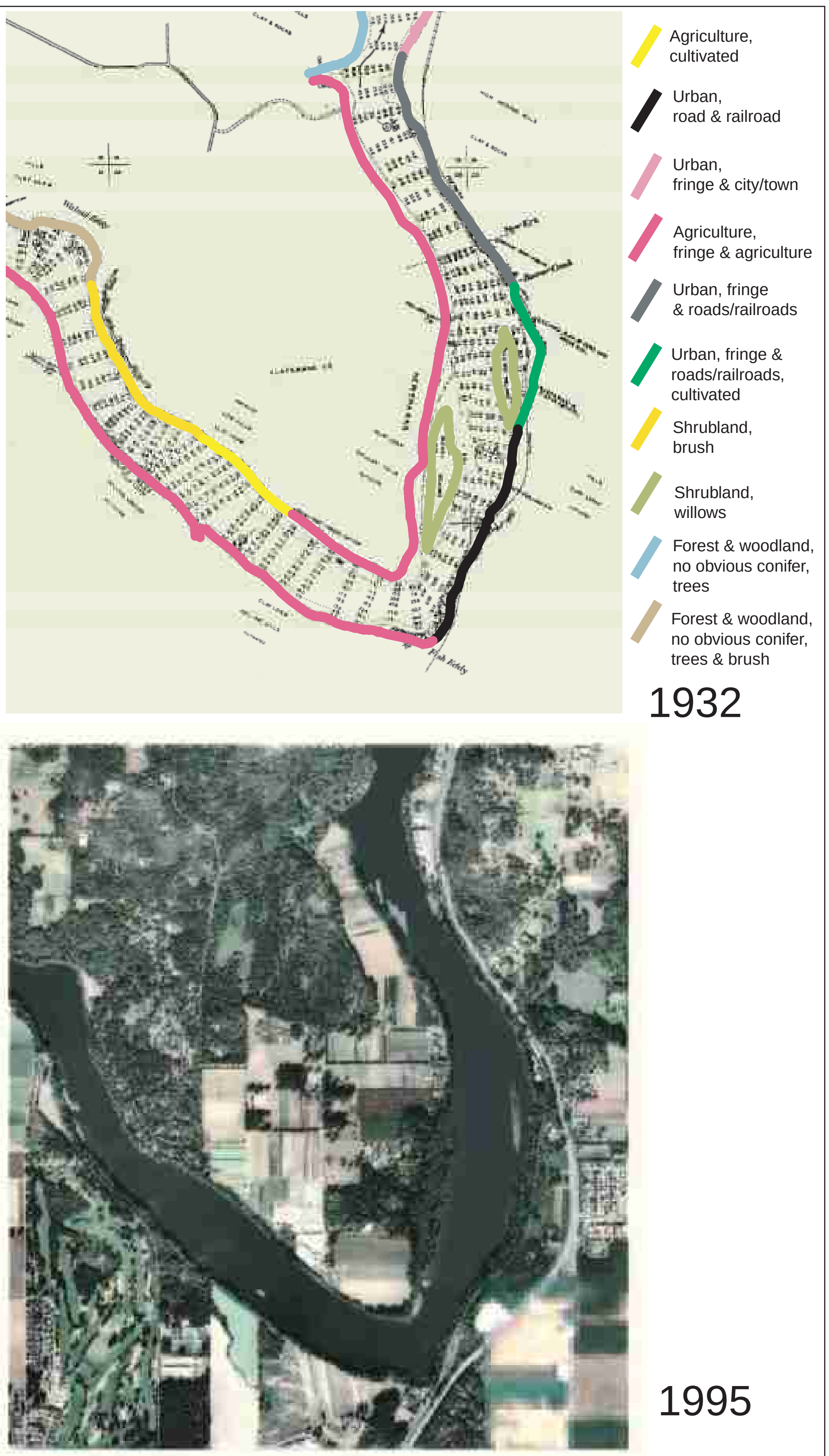


Figure 20. *The Willamette River at Fish Eddy, upstream of Willamette Falls. Maps from 1850 (upper left), 1895 (lower left), and 1932 (upper right), and the photos from 1995 (lower right) show channel configuration and streamside vegetation. The different legends reflect both changes in land use as well as different strategies for mapping.*

MIDDLE REACH - PERCENT COMPOSITION OF CHANNEL LENGTH					
	Channel Types			Total Length	
	Primary	Alcoves	Side	km	miles
1850	70.4	8.3	21.3	163.3	101.5
1895	61.9	12.1	25.9	181.1	112.5
1932	70.3	6.0	23.7	163.3	101.4
1995	69.9	9.2	20.9	163.0	101.3

MIDDLE REACH - % CHANGE IN LENGTH VS. 1850				
	Channel Types			
	Primary	Alcoves	Side	Total Length
1895	-2.5	62.5	34.7	10.9
1932	-0.1	-27.8	10.9	0.0
1995	-0.9	10.8	-2.1	-0.2

to differences in mapping intensity between the GLO (1850) and the USACE (1895).

The confluence of the Santiam and Luckiamute Rivers represents an important habitat type of the Willamette River and illustrates some of the changes observed in the middle section of the Willamette River (Fig. 21). Tributary junctions are dynamic areas in a river network. The combined energy of the flows of the tributaries and the mainstem create an abrupt increase in the power of the river. The variety of channel types and sizes also creates diverse habitats for aquatic organisms and riparian wildlife. Deposits of sediments from the tributaries are reworked by the flow of the river, and floods cause major shifts in channel position.

The Santiam and Luckiamute Rivers enter the Willamette River on opposite sides. Between 1850 and 1932 both the mainstem and the mouth of the Santiam River shifted several hundred meters (Fig. 21). As the channel shifts, it creates new gravel bars and floodplains. Federal agencies and local municipalities expend large amounts of money and time trying to control the position of rivers in tributary junction environments. The confluence of the Santiam and Luckiamute offers an example of a river situation presenting many options for restoring floodplain forests and maintaining floodplain functions. A large portion of the land in the vicinity of the confluence of these two rivers is owned by the state of Oregon. Future management of these lands could recognize the restoration goals of the state and lower the costs of continually fighting the natural tendency of a river to shift at the junctions of major tributaries.

Major Changes in the Upper Reach of the Willamette River: Albany to Eugene

The Willamette River upstream of Albany is a complex network of braided channels that dissect deposits of river sediments and glacial flood deposits. This section of the river has exhibited the greatest loss of channel complexity and floodplain function along the mainstem Willamette River. During the period from 1850 to 1995, the total area of river channels and islands decreased from just under 25,000 acres to slightly more than 8,000 acres and the total length of all channels decreased from 210 miles to 115 miles (see Table 8 and p. 82 for illustration). Area of islands has decreased by approximately one-third and the proportion of primary channel increased from 19% to 46% of the total area (Table 8, Fig. 18), reflecting the elimination of islands and side channels. In terms of area, 70-80% of the islands and side channels have been lost in this reach, and 40% of the alcoves and 20% of the primary channel has been lost by 1995 (Table 8). Decreases in channel length were similar in trend but slightly lower in magnitude for primary channels and alcoves.

UPPER REACH - PERCENT COMPOSITION OF CHANNEL AREA						
	Channel Types				Total area	
	Primary	Alcoves	Side	Islands	ha	acres
1850	19.3	1.8	10.5	68.4	10083.2	24915.5
1895	26.6	1.7	11.8	59.8	7933.2	19603.0
1932	29.4	1.1	11.4	58.1	6344.4	15677.0
1995	46.0	3.1	8.4	42.4	3331.9	8233.2

UPPER REACH - % CHANGE IN AREA VS. 1850					
	Channel Types				
	Primary	Alcoves	Side	Islands	Total Area
1895	8.3	-21.8	-11.4	-31.2	0.1
1932	-4.3	-60.3	-31.8	-46.6	-16.5
1995	-21.3	-41.4	-73.5	-79.5	-39.8

UPPER REACH - PERCENT COMPOSITION OF CHANNEL LENGTH					
	Channel Types			Total Length	
	Primary	Alcoves	Side	km	miles
1850	34.7	8.4	56.9	339.5	210.9
1895	41.6	9.1	49.4	238.1	148.0
1932	39.2	8.8	51.9	252.4	156.8
1995	54.2	18.7	27.1	185.2	115.1

UPPER REACH - % CHANGE IN LENGTH VS. 1850				
	Channel Types			
	Primary	Alcoves	Side	Total Length
1895	-16.0	-24.0	-39.2	-29.9
1932	-15.9	-21.7	-32.2	-25.7
1995	-14.7	21.7	-74.0	-45.4

Table 8. *Percent channel composition for the reach of the Willamette River from Albany to Eugene. Changes are calculated using 1850 as a baseline. Data shown include both lengths and areas (the latter include islands).*

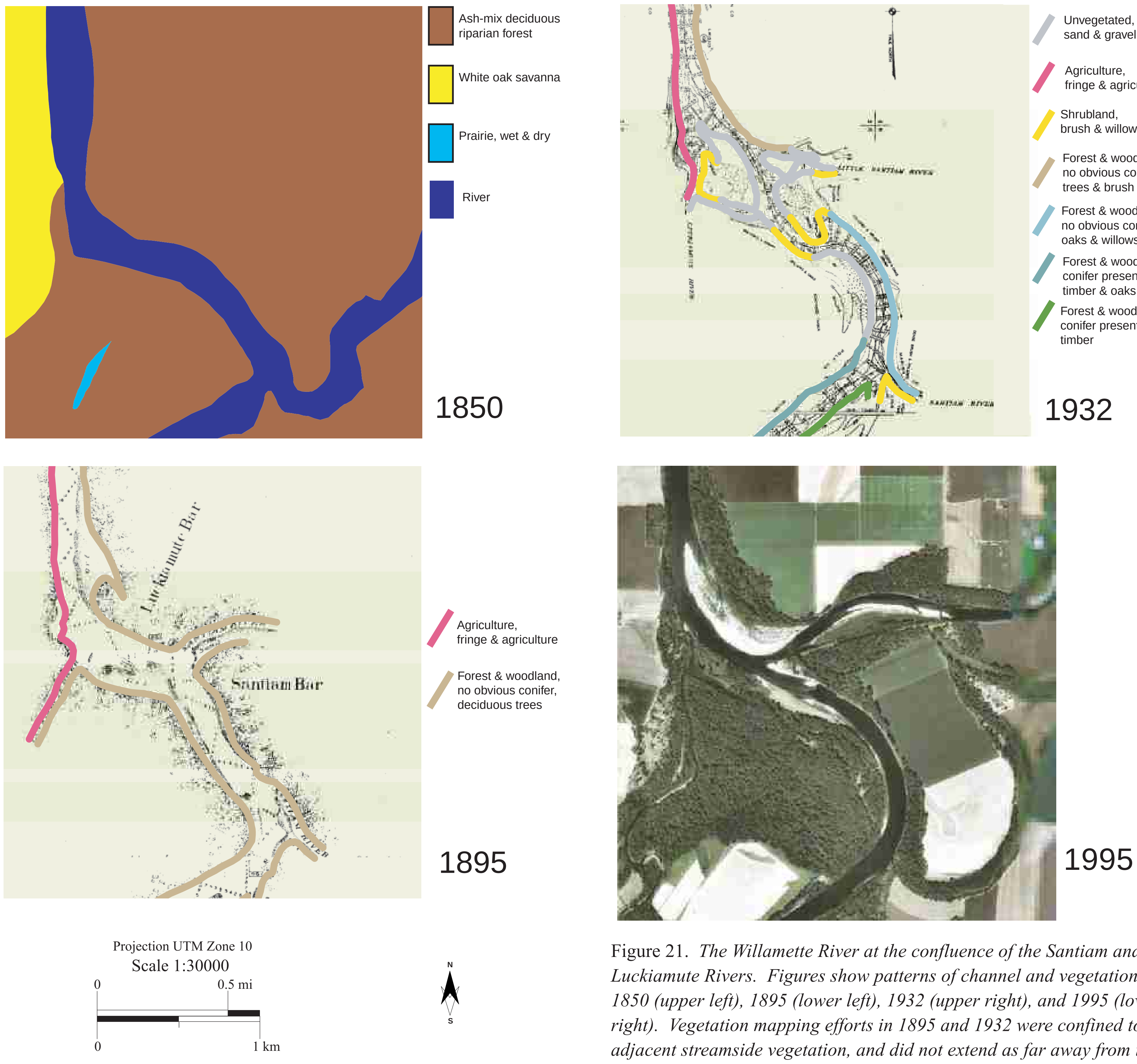


Figure 21. *The Willamette River at the confluence of the Santiam and Luckiamute Rivers. Figures show patterns of channel and vegetation for 1850 (upper left), 1895 (lower left), 1932 (upper right), and 1995 (lower right). Vegetation mapping efforts in 1895 and 1932 were confined to adjacent streamside vegetation, and did not extend as far away from the rivers as the 1850 survey or 1995 photos.*

In 1850, Corvallis was located on a major meander in the Willamette River (upper left portion of Fig. 22). Between 1850 and 1895, the river channel cut through the neck of the meander on the west side and created a new mainstem channel, leaving the old river channel as a smaller secondary channel. The U.S. Army Corps of Engineers also worked continuously upstream of Corvallis to close off smaller side channels and keep the mainstem fixed in place and open for navigation. As a result, the channel network in this reach became increasingly simplified. Today, the Willamette River between Corvallis and Harrisburg is largely a single channel with a few remnants of a previously braided network. Habitat for aquatic organisms and riparian areas no longer offers the diverse array of depths and velocities that previously characterized this portion of the river. Refuge for aquatic life during floods has been greatly reduced, and the mosaic of channel surfaces that support a complex patchwork of floodplain vegetation is now simplified.

Major Changes in Channel and Islands of the Willamette River: Harrisburg Area

The dynamic nature of river channels and the ecological importance of complex river networks commonly are overlooked by the public and river management agencies. The upper Willamette River is an excellent example of the simplification of a diverse river system, changing from a complex braided network in 1850 to a more simple, straightened channel today. But even the mapping of the historically complex channel pattern for these four dates underestimates the full dynamic extent of the Willamette River and its floodplain.

Over the last 150 years, the Willamette River upstream of Harrisburg has changed from the network of braided channels observed by surveyors in the first river survey in 1850. By 1895, several meanders had been cut off but the mainstem had not changed appreciably. However, more than half of the smaller lateral channels had been eliminated. Superimposition of river maps for these two dates illustrates the extent of river modification that occurred before the start of the 20th century (Fig. 23). The area between the extreme western side of the river and extreme eastern side is shaded, delineating the total active channel, the alluvial portion of the river and associated riparian-dependent zones. The combined historical channel area includes all historical channels and their lateral migration; it is larger than the area represented for any single year of record. This total area of channels and islands decreased by one-third over the 45-year interval between 1850 and 1895.

By 1932, the mainstem of the Willamette had been straightened, losing sinuosity and the habitat diversity associated with variation in river velocities. Side channels, small tributaries, alcoves, and islands create diverse habitats with different depths, velocities, and sediments. These off-channel areas also serve as critical biotic refuges during large winter floods. Low flow habitats are restricted primarily to the main channel of the Willamette. Floods that once enriched these complex networks of channels and off-channel habitats now have greater potential for detrimental biotic effects because more than half of the refuges for aquatic and riparian communities have been lost.

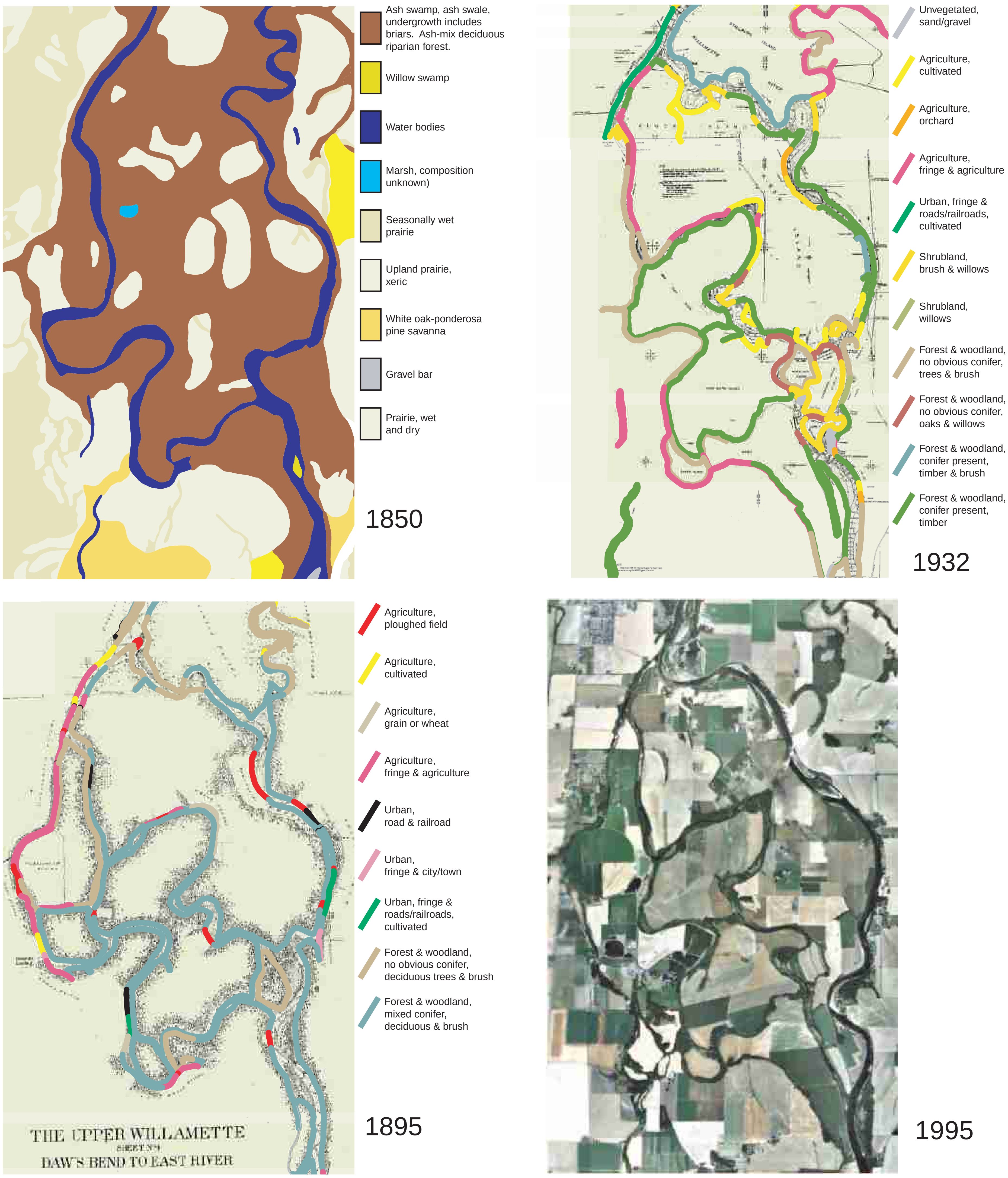


Figure 22. *The Willamette River from Corvallis to Peoria showing channel and streamside vegetation for 1850 (upper left), 1895 (lower left), 1932 (upper right), and 1995 (lower right). Note the change from riparian hardwood forests and prairie to farmland, and the southern edge of Corvallis at top of the 1995 air photo.*

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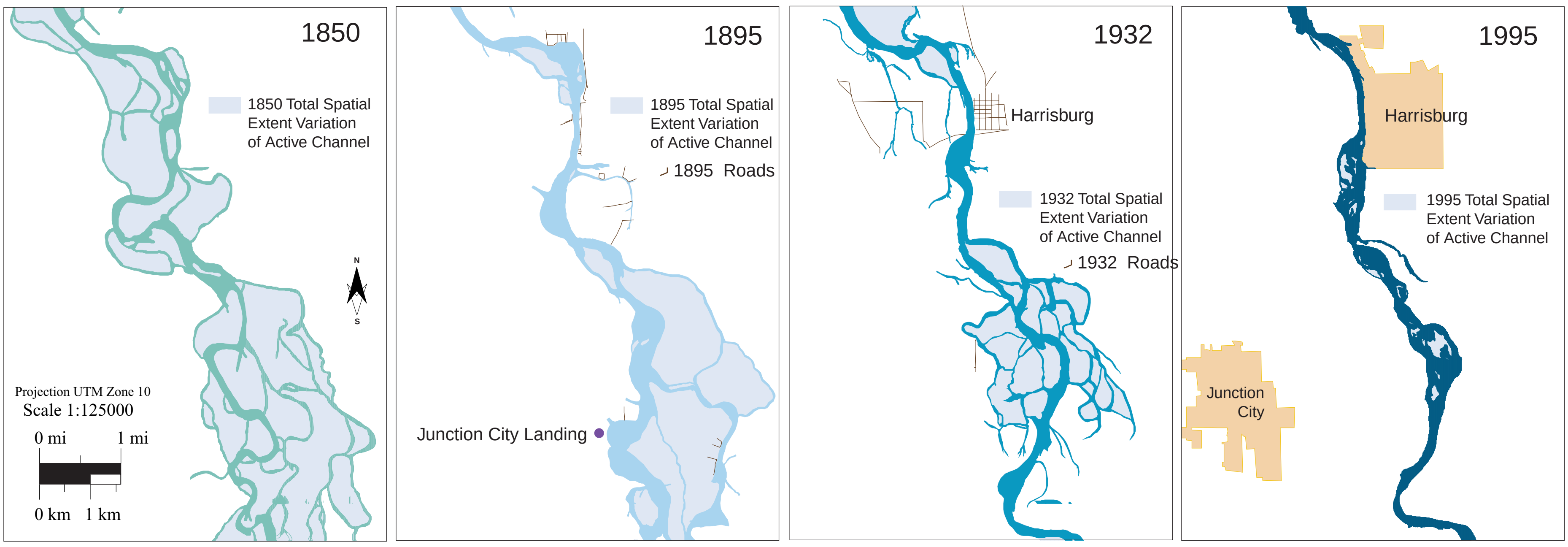
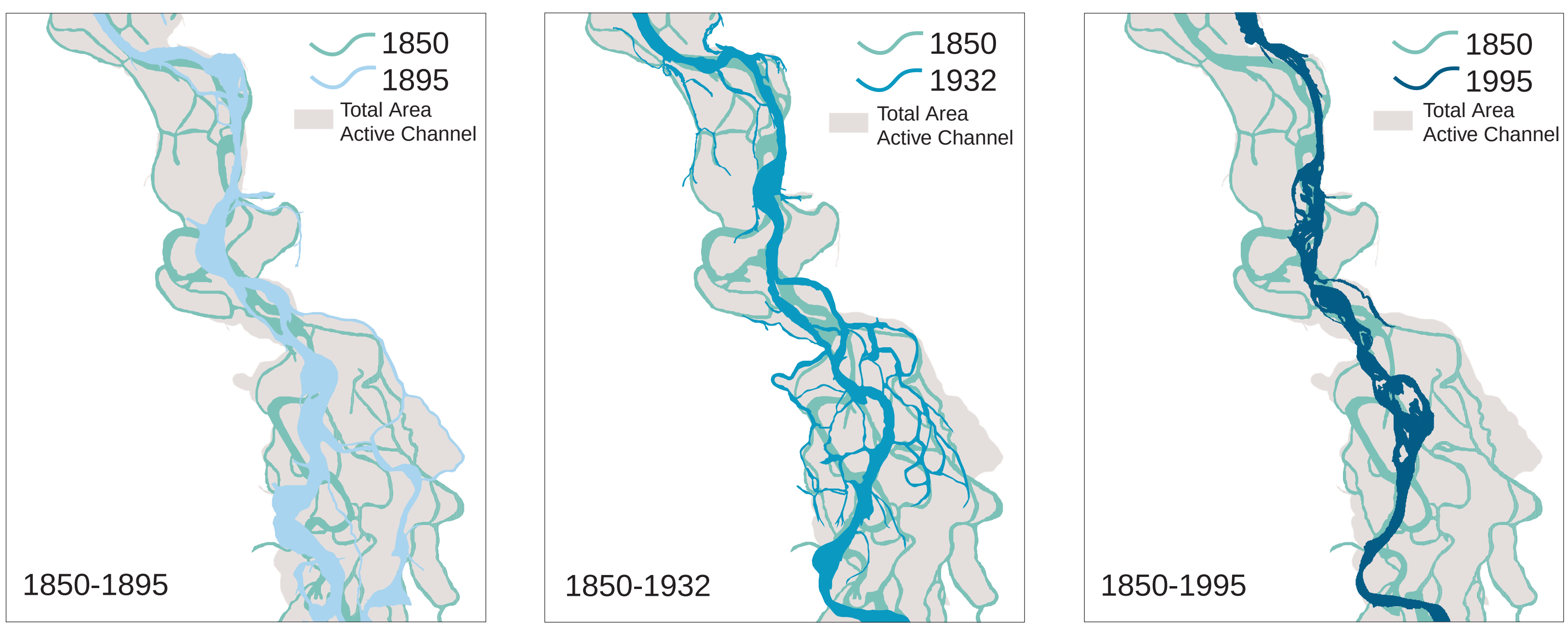
S
Projection UTM Zone 10
Scale 1:90000
0 mi 2 mi
0 km 3 km

The channel of the Willamette River in this reach in 1995 is a straight single channel with few alcoves and floodplain tributaries (Fig. 23). Most of the sinuosity and channel complexity that the Willamette River had in 1850 has been eliminated. The total area of channels and islands is less than one-fifth the comparable area in 1850. Loss of channels and islands has greatly reduced the potential productivity of the river and the diversity of habitats that originally characterized this section of the Willamette River.

Historical mapping of river channels has documented the simplification of world rivers and loss of ecological potential.[37,38] Channel dynamics in large rivers influence riparian resources and human communities along the river to a greater extent than channel losses alone would indicate. All river channels that have occurred in this reach of river between 1850 and 1995 encompass an area of 9.6 mi^2 (25.1 km^2), approximately 20% more than the area of the most complex channel network in 1850. Over multiple decades or centuries, meandering of lowland rivers and formation of lateral channels during major floods extends well beyond the boundaries of the river at any single point in time. If the people of Oregon want to maintain the ecological health of the Willamette River or restore its floodplains and riparian forests, future development of the lands surrounding the Willamette River must consider carefully the dynamic nature of large rivers.





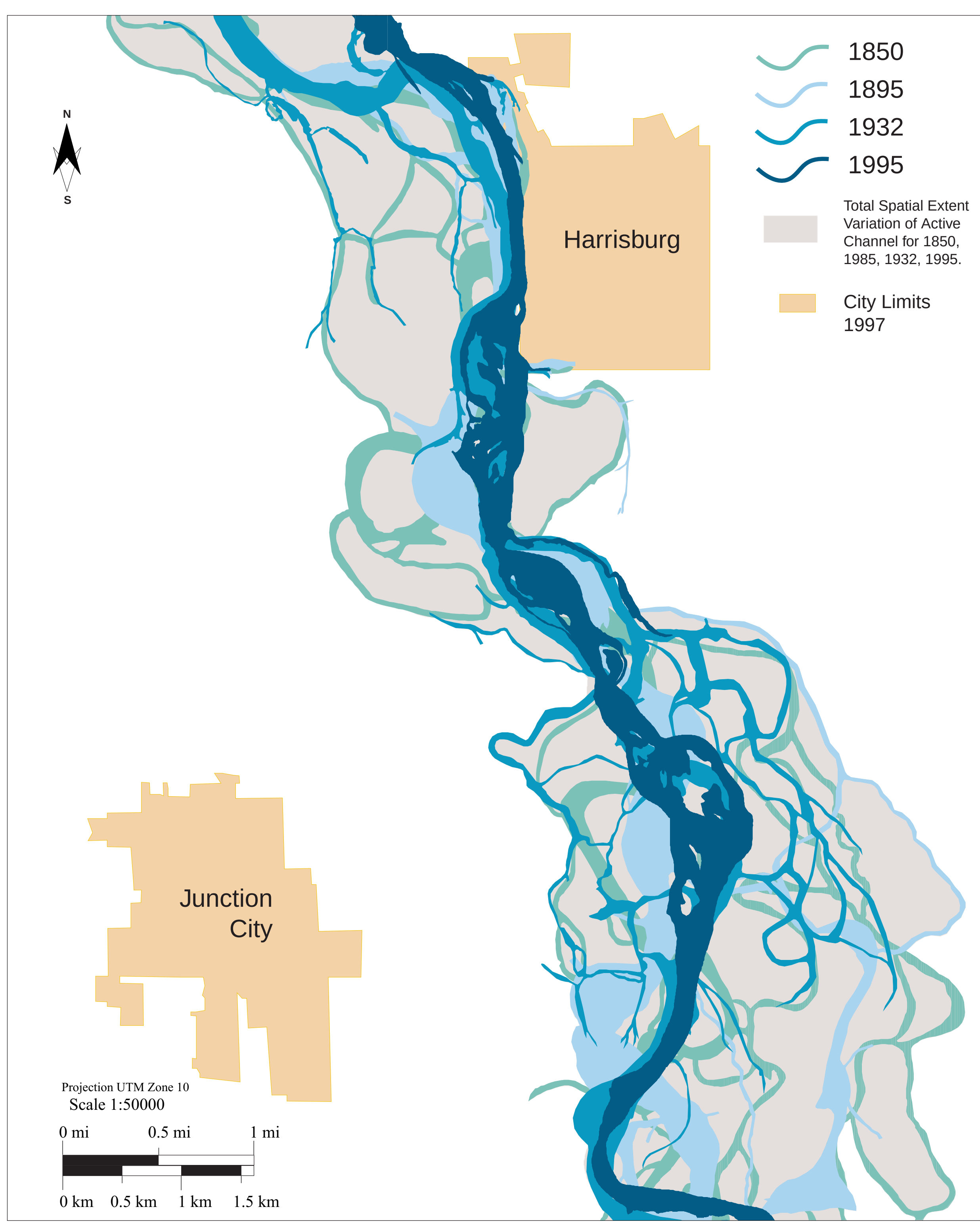
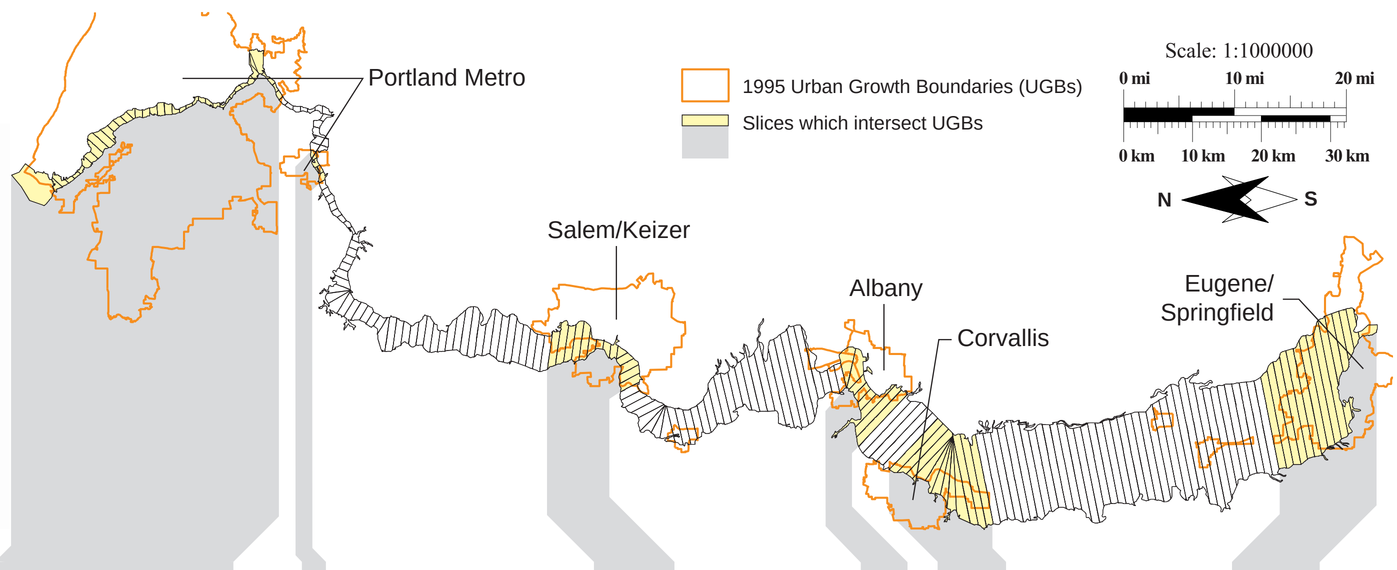


Figure 23. *Changes in the Willamette River in the Harrisburg area. Comparisons of 1850, 1895, 1932, and 1995 active channel configurations.*



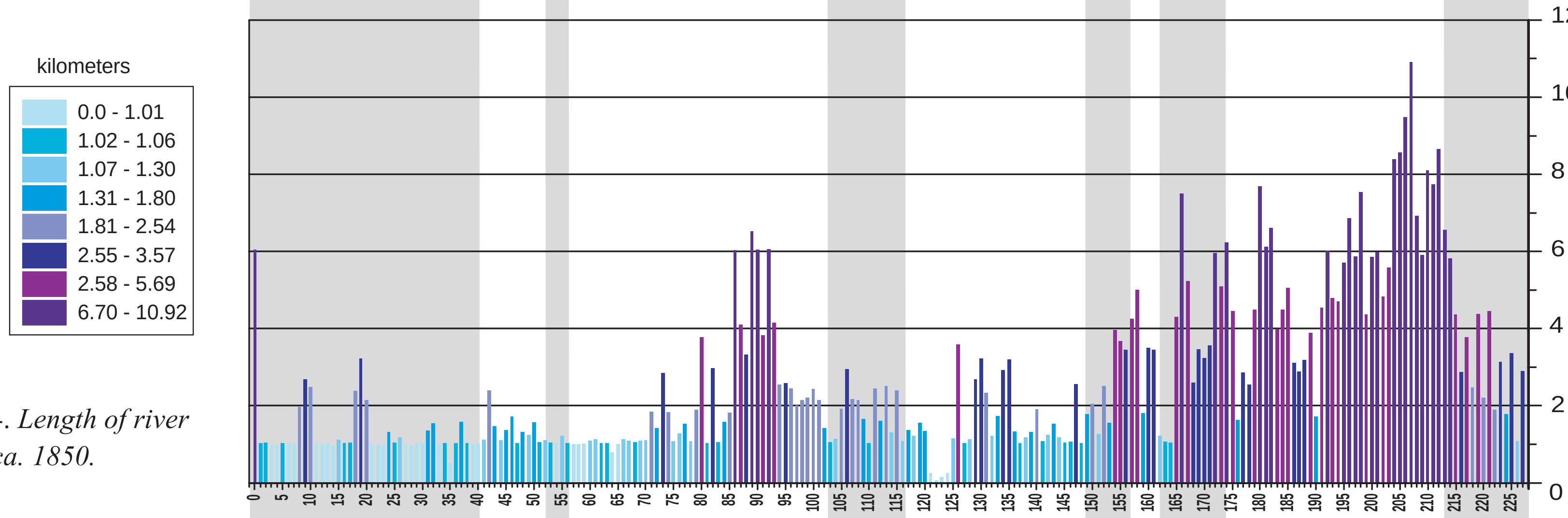


Figure 24. *Length of river channel ca. 1850.*

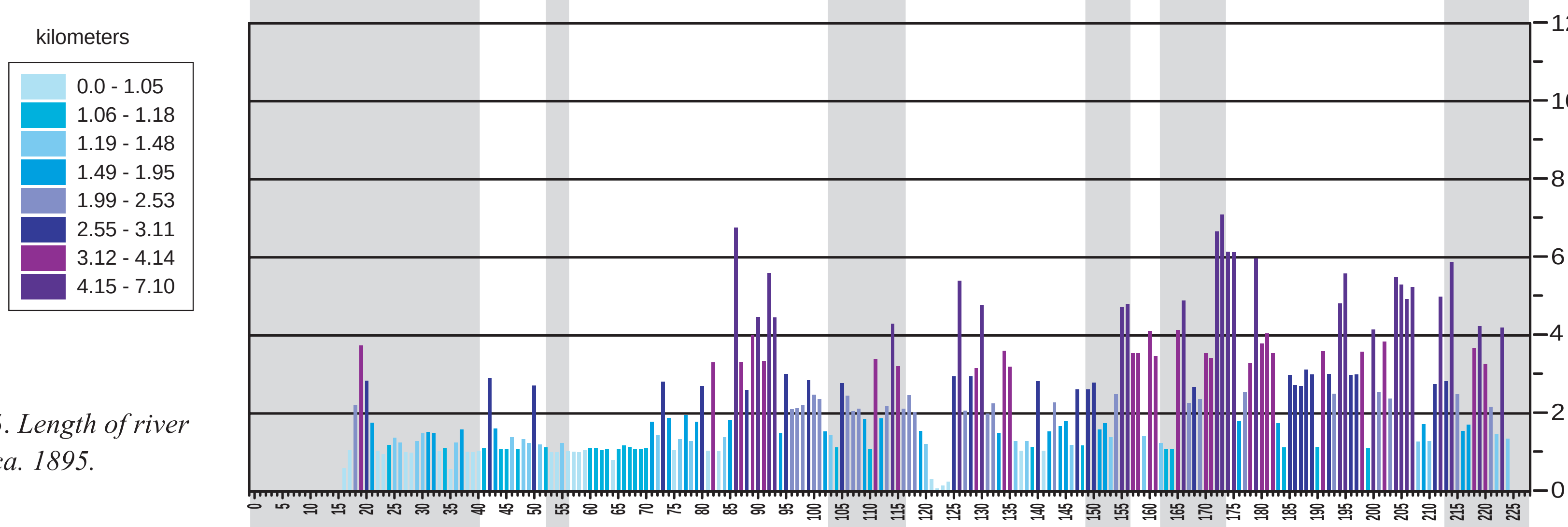


Figure 25. *Length of river channel ca. 1895.*

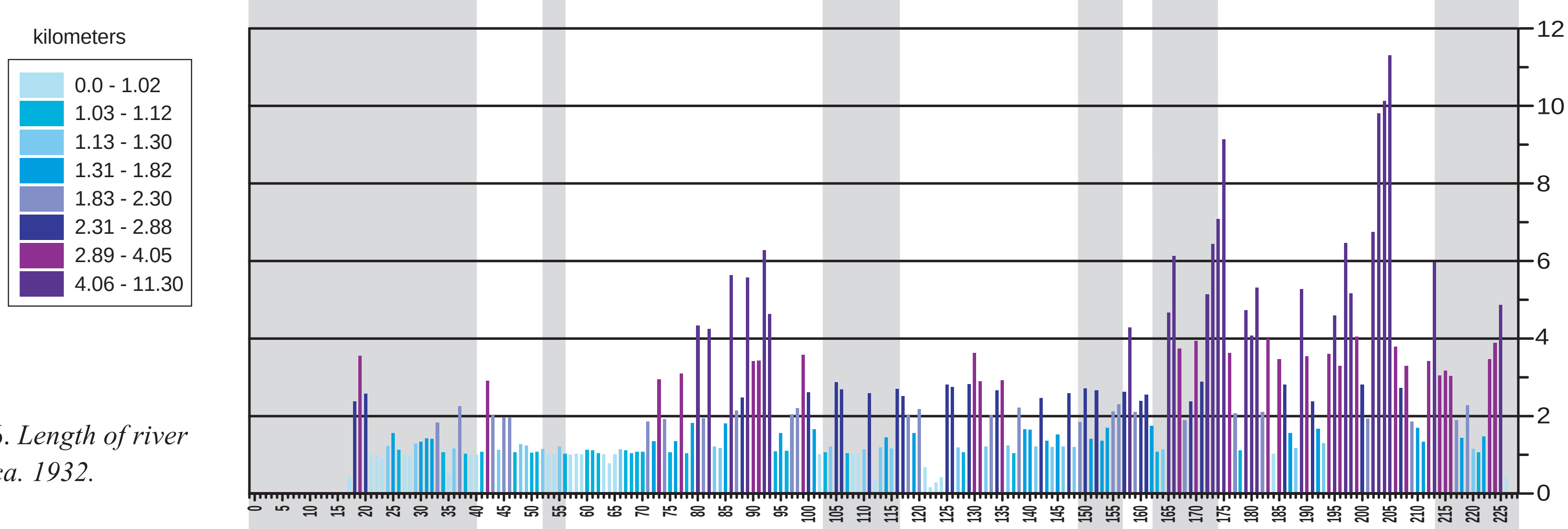


Figure 26. *Length of river channel ca. 1932.*

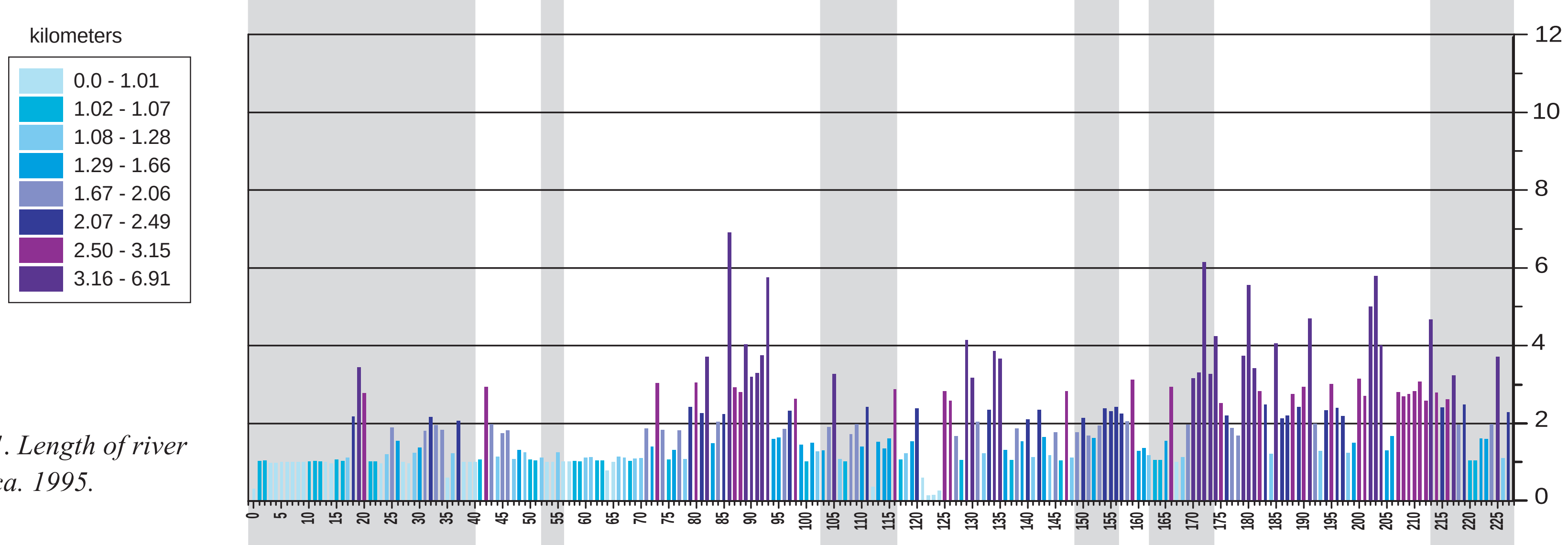


Figure 27. *Length of river channel ca. 1995.*

Figures 24-27. *Longitudinal patterns of length of all channel types per 1 km slice of floodplain for the mainstem Willamette River. Note: See pp. 132-33 for description of spatial framework used in these figures.*