

STREAM CAPTURE IN THE CENTRAL OREGON COAST RANGE AND ITS
RELATIONSHIP TO TECTONIC AND STRUCTURAL GEOLOGY



by

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 DILUVIAL STREAM CAPTURE IN THE CENTRAL WILLAMETTE BASIN NORTH OREGON
 ITS ROLL [REDACTED] LOCAL GEOLOGY

Approved: Patricia F. McDowell
 [Signature]

Stream development in the central Oregon Coast Range has been influenced by tectonic and volcanic processes. Capture by the existing Willamette River system has modified the drainage history of the region. Clark and Higgins (1964) first studied the features that were evidence of stream capture. Morphological, pedogenic and geological evidence support a shift of the Pacific Northwest coast-draining streams into the Willamette valley to the west.

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Stream development in the central Oregon Coast Range has been influenced by geological and tectonic processes. Capture by the evolving Willamette River system has reduced the drainage basins of the Yaquina, Alsea and Siuslaw Rivers. This study examines the features that are evidence of stream capture. Morphological, pedogenic and geological evidence support a shift of the divide between coast-draining streams and the Willamette Valley to the west.

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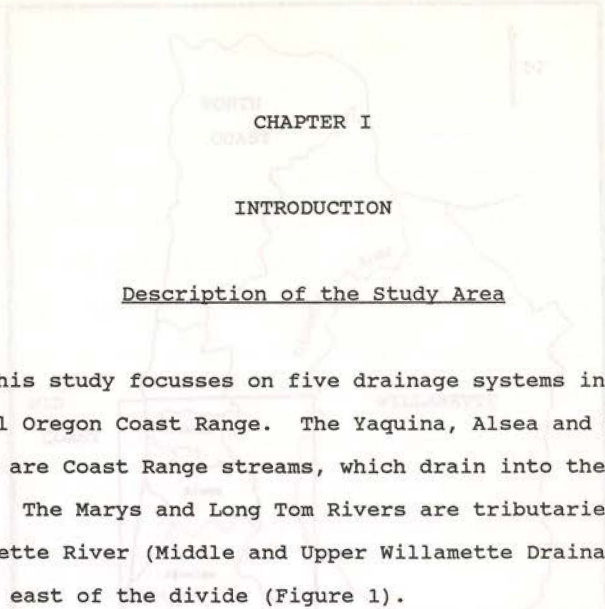
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CHAPTER I

INTRODUCTION

Description of the Study Area

This study focusses on five drainage systems in the central Oregon Coast Range. The Yaquina, Alsea and Siuslaw Rivers are Coast Range streams, which drain into the Pacific Ocean. The Marys and Long Tom Rivers are tributaries of the Willamette River (Middle and Upper Willamette Drainage Basin) east of the divide (Figure 1).

The central Coast Range is a highly dissected mountain range with steeply incised rivers (McDowell 1987). Slopes of 30% or more are common. The moderate relief (1200 m maximum regional relief) is largely the product of fluvial erosion. The divide between the two major drainage basins (Coast and Willamette) is located toward the eastern edge of the Coast Range. Only the Siuslaw River originates much farther to the east. The course of the Siuslaw across the whole range, and the deeply incised meanders of all three rivers, indicate antecedent stream systems, which typically evolve in uplifting areas.

Figure 1. Drainage basins of western Oregon and approximate location of the study area.

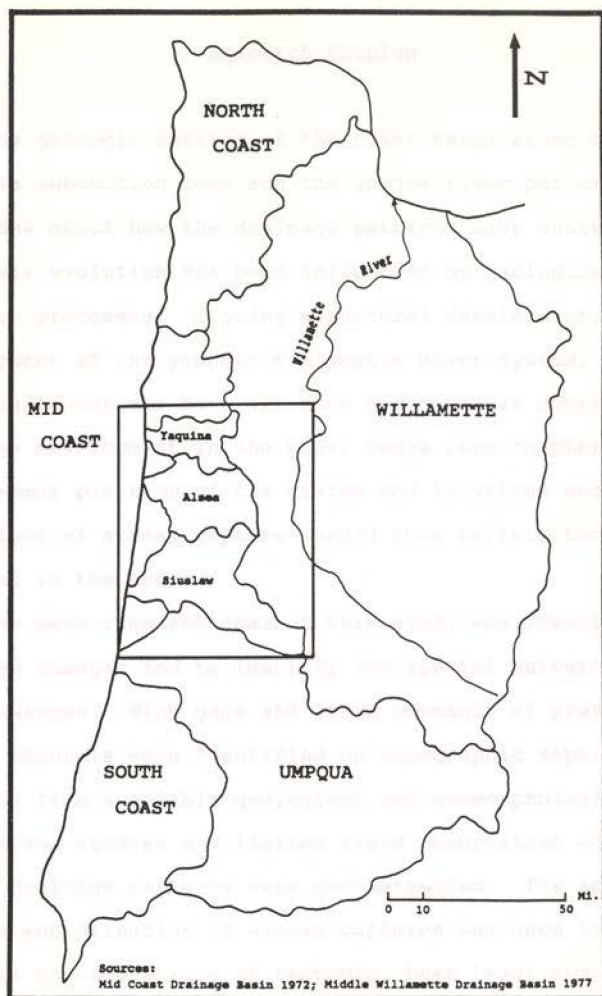


Figure 1. Drainage basins of Western Oregon and approximate location of the study area.

reviewed. Studies on Research Problem related to geological processes and basin studies in other areas will

The geologic setting of the Coast Range along the Cascadia subduction zone and the unique river pattern raise questions about how the drainage patterns have evolved and how their evolution has been influenced by geological and tectonic processes. Ongoing structural development, development of the younger Willamette River system, and lithologic controls have all been suggested as controls of drainage development in the Coast Range (see chapter 2). The present position of the divide and locations and directions of stream capture should thus reflect tectonic movement in the area.

The main research goal of this study was identify major drainage changes and to identify the spatial pattern of these changes. Wind gaps and other remnants of previous stream channels were identified on topographic maps. Evidence from available geological and geomorphological surveys and studies and limited field observation was used. Former drainage patterns were reconstructed. The spatial pattern and direction of stream captures was used to evaluate the importance of tectonic, base level and lithologic controls on the drainage system development.

In chapter 2 previous studies on the geological setting and geomorphological processes in the Coast Range will be

reviewed. Studies on stream development related to geological processes and case studies in other areas will also be discussed. Chapter 3 describes the methodology of this study and chapter 4 the analysis of the data. In chapter 5 the outcome of the analysis and its further implications will be discussed.

CHAPTER II

REGIONAL GEOLOGY AND GEOMORPHOLOGY AND THEORETICAL

BACKGROUND

In this chapter literature dealing with the effects of tectonic movements on stream systems, the geological and tectonic situation of the Oregon Coast Range, and geomorphological research in the study area will be reviewed. All three types of studies are important to understand stream capture in the geologically active environment of western Oregon.

Geological Setting of the Oregon Coast Range

The Oregon Coast Range is one the geologically youngest regions of Oregon and the North American West Coast. It was uplifted above sea level during middle Eocene to late Oligocene time. By the middle of the Miocene, about 15 million years ago, most of the Coast Range had emerged from the Pacific Ocean (McKee 1972). The location on the active western continental margin of North America makes this area

one of the most interesting places for geological and tectonic research.

The Oregon Coast Range is close to the subduction zone between the Pacific Plate and the North American Plate (Figure 2). The position of the small Juan de Fuca Plate between the two larger plates and the lack of recent seismic activity in Oregon have led to different hypothesis about the location of the subduction zone and the type of movement (Seely et al. 1974; Ando and Balazs 1979; Reilinger and Adams 1982; Taber and Smith 1985; Heaton and Kanamori 1984; Heaton and Hartzell 1987). One of these, the Imbricate Thrust Model, was constructed by Seely and others (1974). According to this model the Coast Range is a stack of sediment layers. Each one was thrust underneath rocks previously accreted to the east.

The earliest rock formations date back to early Eocene (Baldwin 1981), about 55 million yrs B.P.. Eocene and Pliocene sedimentary rocks are interfingered with basalt flows, pyroclastic and epiclastic rocks from volcanic events during the Tertiary (Snively 1964). Figure 3 shows a generalized geological map of the Coast Range and the study area. Within the study area most lithological units are older Cenozoic sedimentary rocks and minor volcanic rocks (Baldwin 1981). In the northeastern part basaltic and andesitic flows and tuff of the same period are exposed

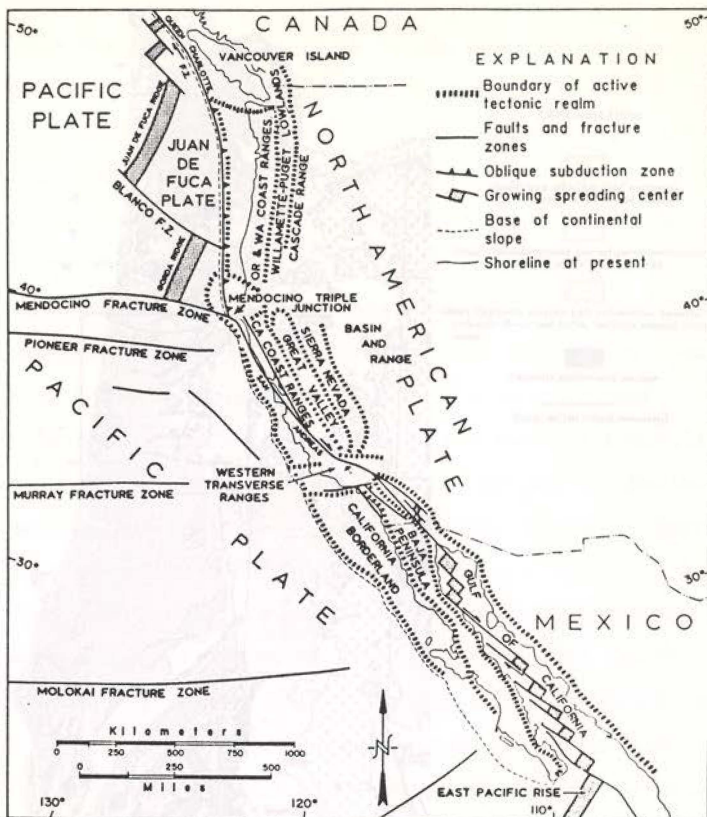


FIGURE 1.1 Map showing active tectonic realms along the western margin of the conterminous United States. Boundaries between realms are transitional. Base map modified from Drummond *et al.* (1981).

Figure 2. Tectonic setting of the Oregon and Washington Coast Ranges. Source: Crowell 1986, 22.

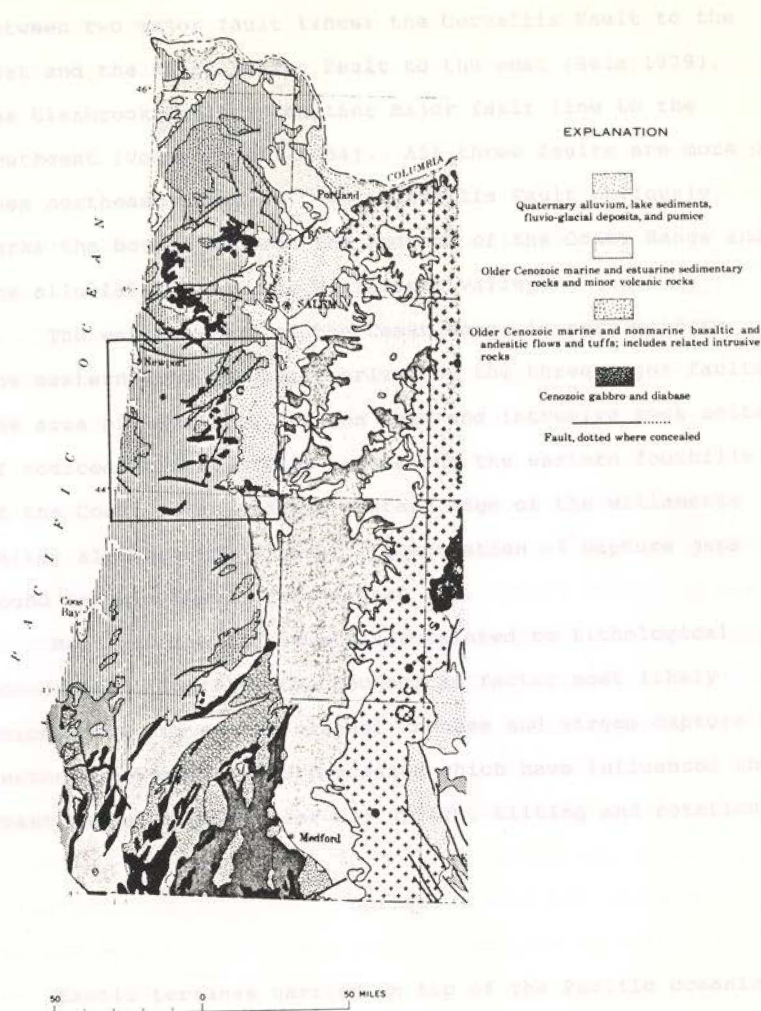


Figure 3. Geologic map of Western Oregon and approximate location of study area.

between two major fault lines: the Corvallis Fault to the east and the Kings Valley Fault to the west (Bela 1979). The Glenbrook Fault is another major fault line to the southeast (Vokes et al. 1954). All three faults are more or less northeast trending. The Corvallis Fault obviously marks the border between the bedrock of the Coast Range and the alluvial fill of the Willamette Valley.

The western part of the Coast Range is very uniform. The eastern half is characterized by the three major faults, the area of lava flow between them and intrusive rock units of noticeable size. This area along the eastern foothills of the Coast Range and the western edge of the Willamette Valley also has the highest concentration of capture gaps found in this thesis (see Figure 11).

Most capture points are not related to lithological boundaries. Instead, the geological factor most likely responsible for stream channel changes and stream capture is tectonic movement. The processes which have influenced the Coast Range in particular are uplift, tilting and rotation.

Uplift

Exotic terranes carried on top of the Pacific oceanic plate were accreted to the western edge of the North American continent (Drake 1982). This "docking" was

completed around middle Eocene time. By imbricate thrusting, older sediment wedges were repeatedly pushed up by the younger, underthrusting ones (Seely et al. 1974). The result are packets of sediment layers divided by fault zones, which dip landward in an increasing angle away from the subduction zone. At the same time sedimentation and erosion were taking place, making the picture more complex and less observable. If sedimentation is high during imbricate thrusting, rapid continental accretion is the result, which was the case in western Oregon and Washington during this first episode of uplift.

Uplift of turbidites (deep sea sediment) and pillow basalts occurred during mid to late Eocene time. By middle Oligocene time this second episode of uplift had moved the shoreline west of the present-day Coast Range, so that the deposition of marine sediments in the area ended and erosion began. The range at that time did not reach any significant height, and it did not form a barrier for the Miocene Columbia River Basalts on their way west. During middle to late Miocene time a third episode of uplift was caused by thrusting. Faulting and folding released the pressure imposed by the colliding plates in addition to the underthrusting of wedges (Snively et al 1980). During Miocene time, the position of the subduction zone and the angle under which the Pacific Plate pushed against the

continent changed (Cole and Armentrout 1979). This may have caused uplift during this fourth episode.

Marine terraces indicate uplift and emergence during the Pleistocene (Armentrout and Cole 1979). Today Pleistocene marine terraces can be found up to an elevation of 1,600 ft. (McKee 1972). Eustatic sea level change accounts for only 400 ft. of this difference. Therefore, additional tectonic uplift during this fifth episode must be responsible for their modern elevation.

Tilting

There is evidence of tilting of the Oregon and Washington Coast Ranges in the recent past. A rate for landward tilting of 3×10^{-8} rad/yr was calculated for the past 10 to 50 years through observations along levelling lines (Reilinger and Adams 1982). The results are in agreement with those derived from gauge analysis, tilted marine strata and deformed sedimentary strata. Reilinger and Adams (1982) concluded from the tilting rates that subduction is still occurring, but aseismically. The rate of tilting is also lower than at other subduction zones. A more recent study on tilting rates revealed additional tilting directions (Vincent 1989). Down-to-the-north tilting from Coquille to Newport and down-to-the-south

from Tillamook to Astoria suggest less uplift between Tillamook and Newport than along the rest of the coast line (Figure 4).

For the area of this thesis this implies greater uplift in the Siuslaw and Alsea areas than in the Yaquina area. The rates have been approximately constant for the last 60 years. The relatively high rate and long wavelength of the tilt signal suggests short-term, interseismic deformation, and not a long-term (~ 25 MA) deformation reconstructed from marine terrace elevations (Vincent 1989). However, the results only prove relative and not absolute uplift. The Coast Range could theoretically be subsiding as a whole. For an improved 3-dimensional model, more levelling points have to be established.

Rotation

Paleomagnetic records indicate that the Coast Range has been rotated 50° to 70° east (i.e. clockwise from its original position) since Eocene times (Simpson and Cox 1977; Heller 1983).

The evidence of rotation at several points gives clues about the coherence and size of the rotated block. One of the models (Simpson and Cox 1977) suggests that the Coast Range and the Klamath Mountains rotated in one block.

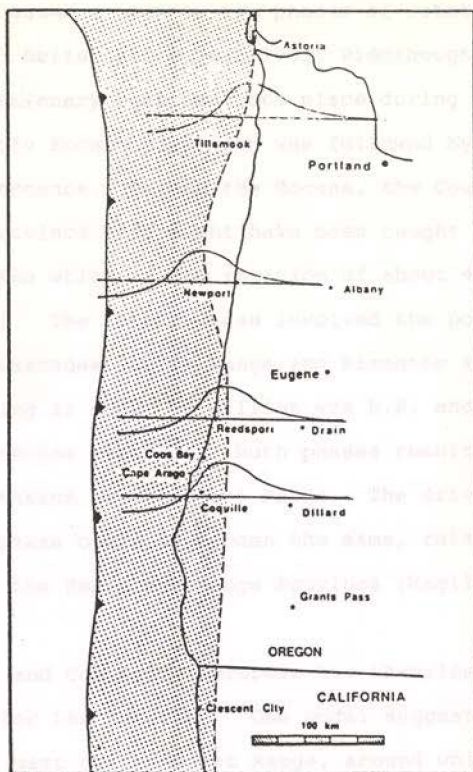


FIGURE 11. Model showing possible location of locked zone (stippled area) and the resultant uplift pattern (taken from a simple dislocation model--[Savage, 1983])

Figure 4. Uplift pattern along the Oregon Coast Range. Highest rates of uplift do not correspond with the coastline. The lowest uplift rate is indicated for the coastal area around Newport. Source: Vincent 1989, 44.

Several authors propose two phases of rotation (Magill and Cox 1981; Heller and Ryberg 1983; Riddihough et al. 1986). Accretionary rotation took place during the first phase in middle Eocene time, and was followed by a period of tectonic quiescence. During the Eocene, the Coast Range was a seamount province that might have been caught between two active trenches which caused rotation of about 46° (Magill and Cox 1981). The second phase involved the post-Oligocene rotation of Cascades, Coast Range and Klamaths as one single block, starting at about 20 million yrs B.P. and resulting in a 27° clockwise rotation. Both phases result in 73° clockwise rotation of the Coast Range. The driving force during this phase could have been the same, related to the extension of the Basin and Range Province (Magill and Cox 1981).

Simpson and Cox (1977) propose two theories about a pivot point for the rotation. One model suggests a point in the southern part of the Coast Range, around which the Coast Range would have swung landwards. The second model indicates a pivot point near the northern end of the range.

Magill and Cox (1981) also refer to a northern pivot point in their theory and in addition to a hinge point between the Klamaths and the Sierra Nevada for post-Oligocene rotation. There is no mention of post-Miocene rotation of the Coast Range.

Summary

Although most researchers agree on past tectonic impact, only the most recent study (Vincent 1989) provides a description of present-day movement. The detailed process leading to the deformation is still poorly understood and quantitative assessments are incomplete. The results of this thesis support vertical movement--uplift and tilting in particular--but give little indication of rotation. Concentration of capture along the eastern edge of the Coast Range could be related to coastal uplift, eastward tilting, faulting and lithological differences. Furthermore, the structural development of the Willamette Valley as the capturing system is of importance. The subsurface geology and structural development of the valley is still poorly understood.

Geomorphological Studies in the Oregon Coast Range

Geomorphological studies covering the study area of this thesis have been scarce. A general outline of geomorphic processes is provided in McDowell (1987). More detailed studies with different emphases have concentrated on parts of the area (Baldwin 1949; Balster 1966; Niem 1976; Feiereisen 1981; McDowell and Roberts 1987; McDowell 1989; Allen 1990).

Geomorphic processes for the Oregon and Washington coast ranges are similar, due to their tectonic setting and climatic conditions (McDowell 1987). The dominant sediment transfer processes on the hillslopes are probably soil creep and debris flow. Denudation rates are high, and mass movements and fluvial processes are accelerated by tectonic processes and the mild wet climate. Stream capture is frequent in the interior zone. The coastal zone has been strongly influenced by eustatic sea level changes.

River profile analysis supports uplift in the Coast Range (Rhea 1988). This analysis was based on data digitized from large-scale quadrangle maps. More than 90% of anomalous features in river profiles correspond with structural or lithologic changes (formation contacts, position of intrusions, faults, and fold axes).

A detailed analysis of drainage basin morphology in the central Coast Range by Niem (1976) concentrated on two pairs of streams: the Siletz and Yaquina Rivers on the western side of the divide, and the Luckiamute and Marys Rivers on the eastern side. The Yaquina and Marys Rivers are also part of the study area of this thesis. Niem provided quantitative data, such as stream order, stream length, drainage characteristics, basin shape and relief and longitudinal profiles. She used the 15' topographic quadrangle maps (mostly 1956 and 1957). Her study mainly

described the fluvial pattern, including climate and vegetation cover. Very few conclusions are drawn from stream capture, although several capture points are listed (see chapter 4).

A study by Feiereisen (1981) concentrated on the alluvial stratigraphy of the lower reaches of the Siuslaw and Alsea Rivers. Although those two rivers lie within the study area of this thesis, the lower reaches of the streams show very little evidence of stream capture.

The geologic study of the Long Tom River in relation to the Siuslaw River by Baldwin and Howell (1949) provides very important information about stream capture and previous river systems in the southern part of the study area. Their reconstruction of the former drainage system was confirmed and extended in this thesis. Geological field evidence suggests a stage of alluviation caused by a rise in base level during or after the early Pliocene. Capture of the Long Tom (a former tributary of the Siuslaw River) by the Willamette River system probably took place after this stage. The higher elevation of alluvial fill in the Coast Range suggests uplift after the Long Tom capture. Baldwin and Howell do not accept uplift as the only reason for this capture, because a river like the ancient Long Tom / Siuslaw should have been able to keep up with the uplift. During a phase of alluviation like this, a small landslide would be

sufficient to change the stream course. The latest channel changes of the Long Tom are assigned to Pleistocene or Holocene time. Absolute dating of the fluvial deposits was not done.

A recent study by Allen (1990) focussed on the effects of tectonic movement and stream capture in the northern Oregon Coast Range. He explains the almost circular streamcourse of the Nehalem River by updoming and exposure of volcanic rocks. Either the Nehalem River captured other streams in clockwise direction or a formerly east-flowing tributary of the river was diverted to the north to join the Nehalem headwaters. Evidence for the study came from topographic maps (stream gradients, barbed tributaries) and geologic surveys. The findings of this thesis made clear that not only processes in the Coast Range, but also developments along the borders of the Willamette Valley are of importance for stream capture in the study area.

Two studies are available on the Quaternary geomorphology of the Willamette Valley (McDowell and Roberts 1987; McDowell 1989). They help to understand the relationship between the Coast Range and the Willamette Valley.

During the late Miocene, after uplift of the Coast Range, the Willamette Valley became a depositional center of lacustrine and fluvial sediments (McDowell and Roberts

1987). Local uplift and deformation led to the damming of lakes within the valley and thus probably disturbed the fluvial pattern as well. Stages of deposition and successive downcutting are documented in gravel terraces. Pleistocene deposits of bedded silts and fine sands are attributed to two phases of flooding from Glacial Lake Missoula. Dating attempts place them in a time frame of 34,000 to 13,000 yr BP. Deposits of these floods do not extend above 400 ft. above sea level, so they had not direct influence on the Coast Range rivers. After 13,000 BP, channels were re-established, leading to shifts and captures in alluvial streams on the Willamette Valley floor. Evidence indicates that minor fluvial adjustments in the Willamette River system occurred between the mid-Holocene and the late Holocene (McDowell 1989). The external controls responsible for the development of the Willamette Valley were also responsible for processes in the Coast Range. Regional uplift, base level fluctuation, and mass movements may have affected the relationship between coast-draining streams and the Willamette River system. Catastrophic floods and glacial input probably had little or no effect on Coast Range rivers.

Effects of Tectonism on Drainage Systems

The Effects of Neotectonism

An overview on neotectonics and field studies (Summerfield 1987, 387) comes to the conclusion that "the effects of crustal deformation on drainage are still only poorly understood, but a number of researchers have now begun to adress this problem in a systematic way". Up to the present, only a few scholars have tried to assess relationships between tectonic movement and drainage quantitatively. In many regional studies tectonic impact is mentioned, but not specified. The study of these relationships is important, because it helps us understand the genesis and history of landforms in relation to crustal deformation. On the other hand tectonic controls can be recognized through morphological evidence.

It is sometimes very difficult to differentiate between climatic and tectonic control on the evolving landscape. A number of approaches have been used. Some authors have tried to simulate changes in models, while others have used field methods, most often involving research on stream terraces. Frequently geomorphological research is done in conjunction with geological data or several methods are combined. Some authors simply deduce structural control

from stream patterns. Many of the authors cited below, who worked in specific study areas more or less comparable to the Oregon Coast Range, did not go into much detail about their methods. The following section gives a summary of theoretical and case studies concerning the interaction between tectonics and fluvial landforms.

Drainage Patterns

A system of classifying drainage patterns according to their structural controls was developed by Zernitz (1932) and modified by Howard (1967). Drainage patterns may reveal stream capture in several ways. Most typically stream captures are reflected in a trellis pattern (rectangular junctions). A drainage pattern showing traces of an older unlike pattern, referred to as palimpsest (Howard 1967), probably also has experienced some stream capture. Further, anomalous ponds, marshes or alluvial fills are generally considered signs of uplift. Geologic or climatic change in general is held responsible for misfit streams.

Experimental research on the changes in drainage pattern during uplift was conducted by Phillips and Schumm (1987). With a steepening of the slope the pattern changed from dendritic to subdendritic, subparallel and finally parallel. With increasing slope, the time for full

development of the pattern decreases and the drainage density increases. Uplift and tilting can also lead to the disruption of a drainage pattern (Schumm 1986).

Channel Patterns

Stream table experiments on the impact of uplift and subsidence on a single river channel show that a braided channel responds to anticlinal uplift across the channel with degradation and terrace formation in the central part of the uplift (Ouchi 1985). Subsidence leads to aggradation. A meandering channel responds to slope steepening with an increase in sinuosity. Bank erosion and point bar growth occur downstream of the uplift and upstream of the subsidence. Water floods bars where the slope is flattened upstream of the uplift and downstream of the subsidence. After movement has stopped the channel changes until a new equilibrium is reached (Figure 5).

Downstream from an uplifted area sinuosity first increases in meandering rivers to cope with the steeper slope and later meanders are cut off and the channel straightens out again.

The examples backing up Ouchi's experimental findings come from the Rio Grande, the San Joaquin Valley and the Texas coastal plain. According to Ouchi the Rio Grande has

TABLE 1. RESPONSE OF EXPERIMENTAL CHANNELS TO UPLIFT AND SUBSIDENCE

Cross section no. Reach	2.5 I	3.0 A	3.5 I	4.0 I	4.5 I	4.65 I	5.0 I	5.5 I	6.0 I	6.5 I
				B			C		D	
Braided channel										
Uplift										
Subsidence										
Meandering channel										
Uplift										
Subsidence										

Note: the center of the deformation is at cross section 4.65. Reach A: upstream reach from the uplifted or subsided area, where no significant uplift or subsidence occurred. Reach B: upstream half of the uplifted or subsided area (from cross sections 3.5 to 4.65). Reach C: downstream half of the uplifted or subsided area (from cross sections 4.65 to 5.75). Reach D: downstream reach from the uplifted or subsided area, where no significant uplift or subsidence occurred.

Figure 5. Response of experimental meandering and braided channels to uplift and subsidence. Source: Ouchi 1985, 508.

not been able to cope with domal uplift in the area and therefore aggradation has occurred. There is other evidence for uplift in terrace remnants and the thalweg profile. Subsidence in the San Joaquin Valley is evident in the warping of a clay layer and an increase in sinuosity. In the Texas coastal plain, subsidence is apparent in longitudinal profiles, increased sinuosity and cut off meanders (Ouchi 1985).

Incised meander patterns (Schumm 1986) and valley shape (Neef 1966; Keller 1986) are also important indicators of tectonic movement. Incised meandering valleys indicate that uplift has been experienced by an antecedent meandering stream. The ratio of valley floor width to valley height reflects the difference between broad floored (high ratio) canyons and v-shaped canyons (low ratio). This ratio indicates "whether the streams are actively downcutting in response to active tectonics or are being eroded laterally in response to relative stability of the front" (Keller 1986, 139).

Elements Indicating Tectonic Movement

The results of experimental studies show that many elements in the fluvial landscape can indicate present or recent tectonism. However, the consequences of crustal

deformation are far more subtle than those of faulting (Summerfield 1987).

Moreover the effects of aseismic tectonic deformation on channel morphology and behaviour are frequently very similar to those associated with variations in discharge and the type and quantity of the sediment load (Schumm, 1986). A major difficulty therefore lies in differentiating changes associated with tectonics from those related to hydrological and sedimentological variables. (388)

It is very difficult to distinguish between the effects of climatic changes on sedimentary load and the influence of tectonic movement. Independent evidence for the rate of neotectonic uplift is needed. Artificial channels are particularly sensitive, but they are hard to find.

Changes in sinuosity are one criterion (Summerfield 1987; Schumm 1986). Sinuosity increases on an uplifting surface as the result of change in stream gradient, measured as stream gradient index (Keller 1986). The stream gradient is highly sensitive to changes in slope (indicating uplift), but also rock resistance. The index can be computed from small scale topographical maps.

Schumm (1986) probably gives the most complete list of indicators for tectonic movements besides channel and drainage changes. Local meanders or braided patterns may indicate tectonically-caused aggradation or degradation. Widening or narrowing of channels can indicate tectonic movement or lithological differences. Ponds or alluvial

fills may reflect subsidence. Variations of levee height or discontinuous levees point to local differences in erosion.

Anomalous curves and turns can be a sign of stream capture or a superposed stream system. Elbows of capture are "the sharp changes of direction between longitudinal and transverse reaches of the stream, . . . and the resulting pattern of drainage with straight channel segments and near right-angle bends is called a trellis drainage pattern" (Selby 1985, 125). Water gaps and wind or air gaps are also remnants of stream capture.

Uplift also produces superimposed drainage systems.

Superimposed or superposed rivers are those which have been let down onto an underlying structural system from an overlying one. . . . The drainage gradually incises itself until it is superimposed upon the underlying structures. . . . because of tectonic tilting of the landscape, one river may erode into the drainage basin of another. (Selby 1985, 125).

In the longitudinal profile active tectonics can produce knickpoints, convexities or concavities, channel depth variations and aggradation or degradation.

Most evidence in field studies comes from river terraces and valley floor deformation (Schumm 1986).

"Unpaired terraces form where a channel is predominantly migrating laterally across a valley - particularly across a wide valley - so that incision is of less significance" (Selby 1985, 288).

Complex response of stream systems makes tectonic interpretation of terraces difficult, however. Schumm (1973) showed that one single event of lowered base level will produce two sets of terraces, the first one during the initial downcut, the second one when stream degradation moves upstream and the material from upstream reaches is deposited further downstream.

Where the rate of deformation is low, it is reflected by geomorphic features that react to small changes. Gradients and longitudinal profiles of terraces, stream channels and meander characteristics, the valley floor profile, longitudinal profile and thalweg profile reflect minor changes as well as major deformations. Concentration of erosion on one side of a valley indicates uneven uplift or tilting of the landscape.

The more localized and concentrated these features are the more likely they are related to tectonic movement or lithological differences and not climatic changes.

As alluvial channels adjust to changes in hydrology and sediment load as well as to active tectonics, channel pattern change alone is not sufficient evidence for active tectonics. Nevertheless, "anomalous reaches that are not related to artificial controls or to tributary influences may reasonably be assumed to be the result of active tectonics." (Schumm 1986, 85)

Methods for Geomorphic Study of Tectonic Changes

Panizza and Castaldini (1987) provide detailed guidelines for studies of general impact/hazard assessment of tectonic processes.

The authors distinguish between the direct type of modifications brought about by neotectonics (earthquake cracks etc.) and the indirect type (scarps, asymmetrical valleys and river bends). They describe study methods and examples for the two types of problem.

Mountainous and plain sectors have to be researched separately. "In mountainous sectors undergoing active erosion, it is generally possible to identify outcrops of disjunct and folded structures. . . . in alluvial plains . . . loose deposits may cover the tectonic structures" (177). It may be necessary to apply both methods. Certain areas of study may include both types of terrain.

According to Panizza and Castaldini (1987) research should be divided into four phases: (A) bibliographical research and regional remote sensing; (B) detailed aerial photograph interpretation; (C) field survey; and (D) final synthesis.

The first phase leads to a map of the Plio-Quaternary terrain and tectonic elements (scale: 1:100,000 to 1:250,000) combined with selected lineaments, seismic

epicenters and other documents. Only active tectonic elements and lineaments connected with them should go on the Phase-A synthetic map.

Phase B, the detailed aerial photograph interpretation, is aimed at the identification of morpho-neotectonic lineaments and their statistical analysis. All hypotheses should be checked in the field studies of Phase C. Phase D, the final synthesis, produces the final synthetic map showing active tectonic elements and tectonic elements held to be active, especially those derived from field investigations and qualified lineaments, which might be linked to possible active tectonic elements.

The same procedure applies for studies in alluvial plains.

Neef (1966) gives less detailed advice and refers to accurate levelling, knowledge of the younger sediments and airphotos. Keller (1986) names aerial photographs, satellite or other imagery or topographic maps as sources for the identification of tectonic processes.

Examples of Geomorphic and Drainage Pattern Studies of Tectonic Change

Very few authors have followed the steps outlined by Panizza and Castaldini (1987). Too often they do not

elaborate enough on how they obtained their data or information. Every researcher uses and combines different features as indicators and different methods and tools. Their research questions are usually very specific. At the same time resource and time constraints as well as limited access to the study area require different procedures.

Drainage Basin Morphology

Several studies deal with the overall drainage basin morphology of the respective study area (Hare and Gardner 1985; Harvey and Wells 1987; Maroukian and Lagios 1987; Rhea 1989).

In the subsiding Sperkhios Basin, Greece, Maroukian and Lagios (1987) identified a fault trellis pattern. An east-west trending fault zone divides the drainage basin into two asymmetrical halves. Most of the more than 20 major tributaries join the elongated central trunk of the river at right angles.

Uplift may also be deduced from rectangular patterns (Hare and Gardner 1985) or transverse patterns (Harvey and Wells 1987).

One way to identify a tectonically active area is to compare the general topography with that of adjacent areas. The northern part of the Sperkhios Basin (Figure 6) is

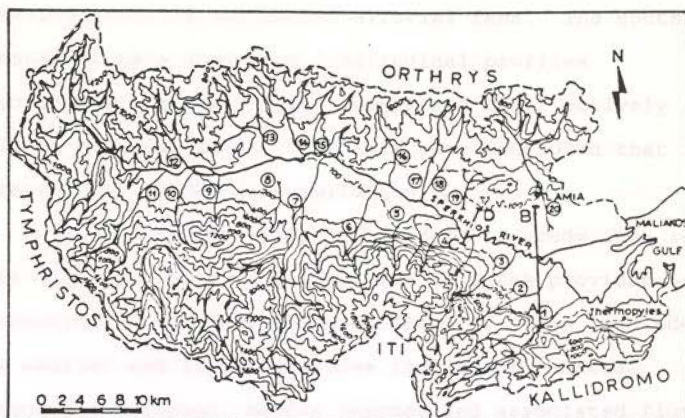


Fig. 2. Topographic map of the Sperkhiios River basin with the two gravity profiles A-B and C-D. The numbers correspond to the fans that are shown in fig. 4. Contours are in meters.

Figure 6. Differential tectonism in the Sperkhiios basin is revealed by uneven landscape and drainage network. The basin itself is an asymmetrical trough controlled by major east-west trending faults. Source: Maroukian and Lagios 1987, 135.

characterized by low topography and gentle slopes dipping to the south, while the southern one has a rugged landscape with steep to very steep mountain fronts. The northern tributaries have v-shaped valleys with gentle slopes and broad watersheds. They are well developed valleys with extensive inactive coalescent alluvial fans. The southern tributaries have disturbed longitudinal profiles (knickpoints), steep slopes, gorges and still actively building alluvial fans. From this they concluded that the southern part is actively uplifting.

Hare and Gardner (1986) divided their study area in Costa Rica into four surfaces, each of which provides information on the deformational history. They concluded from smaller and larger features (accordant summits, rectangular drainage, marine benches and associated fluvial terraces, barbed tributaries, elbows of capture and superimposed meanders of several major rivers) that two of the surfaces had been uplifted.

Channel Morphology

On a smaller scale evidence can be found in valley and channel morphology. Rhea (1989) studied morphological differences in two channel segments of the Edisto River in South Carolina. The upper channel is wider, trends in a

slightly different direction, and lacks abandoned meanders which are abundant in the lower channel. This indicates a different fluvial history for the two reaches, which were later combined to one stream through capture.

Longitudinal river profiles or projections thereof may also be used to establish uplift (Ritter 1972 & 1974; Reed 1981; Maroukian and Lagios 1987; Rhea 1989).

Along a mountain front capture occurs because of the different channel slopes. Mountain bred streams have steeper slopes and will therefore be captured by headward eroding basin streams (Ritter 1972). This theory is applicable to the study area of this thesis. The Willamette River tributaries (i.e. basin streams) have been capturing Coast Range streams (i.e. mountain bred streams). Because of their different lithology, Ritter was able to distinguish gravels from each system after capture. Knickpoints in the longitudinal profile and terraces with different slopes indicate the merging of two different channels.

Uneven uplift of the Piedmont Plateau of Virginia and Maryland led to oversteepened reaches in the longitudinal profiles of rivers crossing the rim of the plateau (Reed 1981). As an example, the Potomac river has a very irregular bottom profile below a certain level, which is related to turbulent flow during rapid downcutting. The tributaries that enter the Potomac above the discontinuity

descend into the river without an increase in gradient. Those that enter below descend to the river over rapids and waterfalls (hanging tributaries). The projections from the smooth part of their profiles lie 45-40 meters above the present level of the Potomac River.

The systematic northward increase in the discontinuities in river profiles at the fall line and the prevalence of terraces on the north side of the Potomac are both consistent with a northward increase in uplift of the piedmont relative to the coastal plane and cannot be easily explained simply as the result of adjustments to lower base levels. (Reed 1981, 450)

In a similar study, Bull and Knuepfer (1987) compared stream gradient indexes for different reaches of the Charwell River, New Zealand. The piedmont reach shows steeper gradients than the basin reach.

Rhea (1989) examined the profiles and courses of six rivers in South Carolina. Four of the rivers have steep slopes with convex regions downstream. These convexities coincide with positions of 90° course changes and with corners and edges of the uplifted region observed on the digitized topography. Convex inflexions can be caused by changes in discharge, surface lithology, both of which the author rules out, or ground deformation. Her theory is supported by the alignment of two rivers, which used to be connected. Now they show radical changes in their courses at the edge of the uplifted area.

Fluvial effects of tectonic uplift and resulting stream

capture are also evident in the Kalahari, Africa (Thomas and Shaw 1988). Streams that are more aggressive due to tectonic uplift capture others. The large valley of the Limpopo River in comparison to its small catchment and channel, the rapid evolution of the Victoria Falls, an abrupt turn of the captured Kafue River and a 2 km wide gap on the watershed between the two rivers are important indicators for uplift in parts of the Kalahari. While uplift severed the Limpopo channel, downwarping connected the northern reach of the ancient Limpopo with the Zambezi (Figure 7).

Harvey and Wells (1987) studied the Aguas and Feos stream systems in Spain. Differential uplift led to the capture of an older stream system by the more aggressive superimposed system (Figure 8).

Reheis (1985) considers the capture of the Shoshone River as possible indication of uplift in the Bighorn Basin.

Fluvial Deposits

Fluvial deposits are studied more frequently than erosional features. Most commonly authors concentrate on the correlation and dating of terraces (Ritter 1972; Reed 1981; Hare and Gardner 1986; Reheis 1985).

Mapping of terraces and analysis of the composition of the gravel is one possible method. Ritter (1972) found

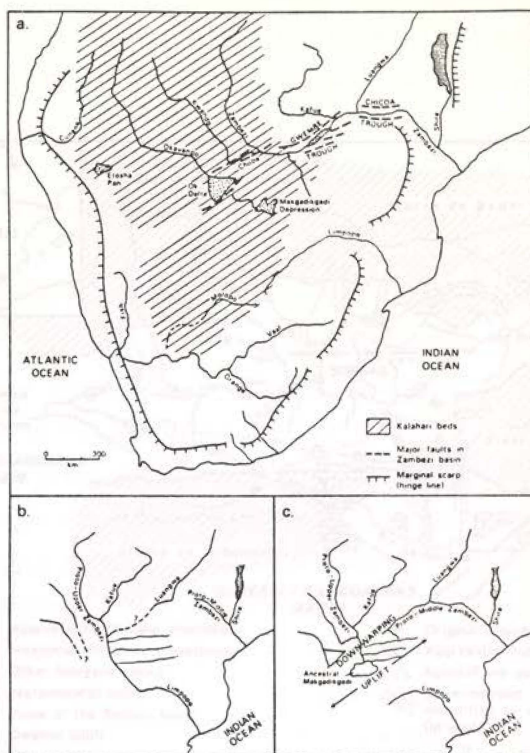


Fig. 1. Present day drainage in southern Africa. Earlier patterns are represented in b) and c): b) post-dates the division of Gondwanaland; c) existed prior to the union of the proto-Middle and proto-Upper Zambezi rivers, during the Pliocene - early Pleistocene.

Figure 7. Present and former drainage systems of the Limpopo and Zambezi Rivers. Source: Thomas and Shaw 1988, 612.

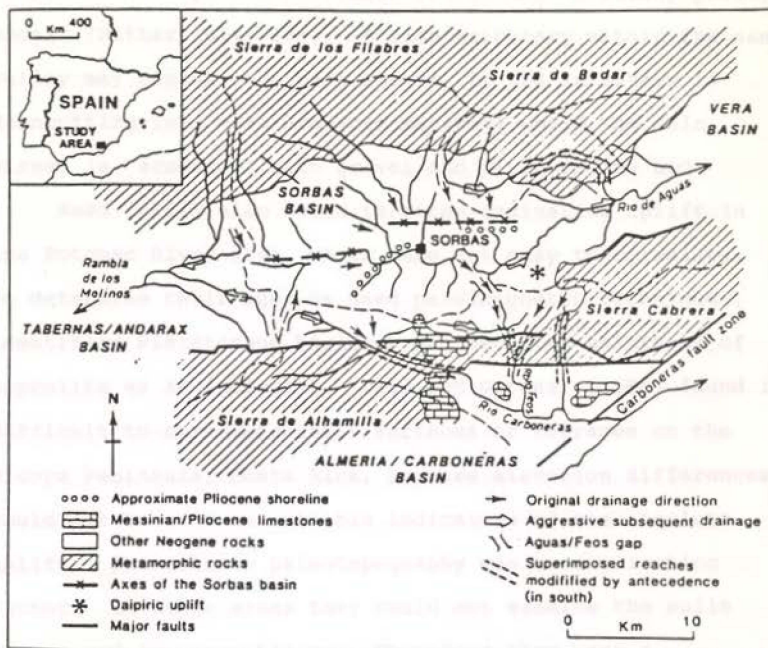


Figure 1. Summary map of Sorbas basin showing major features of drainage-pattern evolution; inset shows location.

Figure 8. Stream capture by differential uplift in the Sorbas basin, Spain. Source: Harvey and Wells 1987, 689.

deposits from streams of different origin than the ones which presently occupy the valleys, which indicates capture.

An unpaired terrace and differences in composition and slope of the layers of terraces led to the "envalley piracy model" (Ritter 1974, 134). A side tributary within the same valley may capture the main stream, if the tributary is downcutting into more erodable material while the main stream is "armoured" with gravel and fixed in its bed.

Reed (1981) also found terraces indicating uplift in the Potomac River area, which were not easy to correlate. To determine their ages he used paleomagnetic techniques, identified Pleistocene boulders and used the thickness of saprolite as an indicator. Hare and Gardner (1986) found it difficult to correlate their surfaces or terraces on the Nicoya Peninsula, Costa Rica, because elevation differences could not be used as reliable indicators of the absolute uplift. The unknown paleotopography was a complicating factor. In other areas they could not examine the soils because of inaccessibility. Therefore they used a statistical approach, overlaying the study area with a grid, at whose nodal positions they collected their data. The summary statistics suggested systematic changes in elevation along the remnant trend (subparallel to the Middle American Trench). The systematic variations suggested differential uplift. The deformation can be modelled using linear

regression analysis. Thus, they were able to refine already existing models.

Reheis (1985) found evidence for folding, faulting and uplift in the gradients of fluvial terrace surfaces in the northern Bighorn Basin. She projected and reconstructed the gradients of the Pliocene and Pleistocene terrace surfaces and found that some first converged with the modern stream, which is normal, but then they diverged from it downstream, for which a tectonic explanation (anticlinal uplift) is likely. She worked with geologic maps, her own photogeologic interpretation and topographic maps. By dating volcanic ash outwash in terraces she could estimate long-term incision rates. With the help of these rates dating of other deposits is possible.

Harvey and Wells (1987) found faulted Quaternary terraces as evidence for continued uplift. The original fluvial pattern of river systems was analyzed with the help of gravel sequences and the observance of outcropping marine Pliocene rocks at an elevation of around 600 m. High-level terrace gravels were traced from one river to the other through the wind gap. The terrace remnants were assigned different ages due to sedimentology, lateral continuity, height differences between horizontally eroded bases and degree of soil development.

In the Zambezi basin exotic material in certain terraces as well as possible lacustrine developments cannot be accounted for by the present day system or by its fluvial activity (Thomas and Shaw 1988). They can only be explained as a part of a former drainage system. Additional evidence came from water-trimmed dunes and ichthyological studies.

Mills and Wagner (1985) analyzed terrace deposits with the objective to "determine whether the degree of weathering increases steadily with increasing elevation, or whether discontinuities occur in the ages of deposits, and if so, at what elevations they occur" (133). From their findings they conclude that the stream terraces are unpaired and discontinuous, but merely as a result of climatic changes and not tectonic movement.

Other Approaches

It is very important to exclude the possibility that another factor, besides tectonism, caused the observed geomorphic features. This can be either climatic or lithological variation. Maroukian and Lagios (1987) could exclude lithologic influence, since the surface features did not correspond with the underlying structures. Some authors came to the conclusion that the fluvial pattern was more determined by climate than tectonism (Bull and Knuepfer

1987). Besides field work other tools like aerial photos (Basher et al. 1988, Rhea 1989) or LANDSAT images (Rhea 1989, Hare and Gardner 1986) can be analyzed for lineaments. Very few authors mention topographic maps as a valid tool. Rhea (1989) used digitized topography.

Some studies included methods from other fields of research, like physical gravity observation (Maroukian and Lagios 1987), paleomagnetic techniques (Reed 1981, Rhea 1989), seismic reflection and refraction studies (Rhea 1989), archeological and ichthyological studies (Thomas and Shaw 1988).

Implications for this Thesis

Considering the size of the area of this thesis, the inaccessability of parts of the Coast Range, and the time constraints, topographic maps were chosen as the basic data source. They allow coverage of a large area, which could not be achieved by field research. In combination with air photos they also provide a better basis for morphological analysis.

Comparison with adjacent areas to find morphological differences (see Maroukian and Lagios 1987) was inconclusive. This is probably also related to the size of the study area and the variations within it. Longitudinal

profiles may have provided insight, but no previous work has been done for the full reaches of all rivers of the study area.

Thus, drainage pattern, channel pattern, terrace deposits and longitudinal profiles did not provide the obvious evidence they provided in some of the studies mentioned above. The best indicator of tectonic movement and its impact on the stream systems in the Coast Range and adjacent areas lies in the distribution of morphological gaps. These gaps or 'capture points' are assumed to be remnants of former stream systems. On the basis of these points previous stream patterns were reconstructed for the study area and interpreted in respect to tectonic movements.

A quantitative analysis of the time frame in which drainage derangements occurred will have to be done in the future in field research (i.e. carbon dating or other dating methods). As slope is a factor for the time of development of a stream pattern it is difficult to estimate how long it took for the Coast Range streams to reach their present stage. Existing studies do not emphasize the time scale of these developments. The responses to tectonic movement may be categorized into changes on a short time scale and changes on a long time scale. Changes in channel geometry and channel pattern probably occur over relatively short periods (100s to 1,000s of years). Drainage basin

CHAPTER III

METHODOLOGY

The main objective of this study was to find remnants of previous stream channels, such as wind gaps, water gaps, terraces and anomalous channel patterns. In order to find evidence of stream capture in the Coast Range, 7.5' topographic maps (scale 1:24,000) of the study area were examined. The quadrangles cover the watersheds of the Siuslaw, Alsea and Yaquina Rivers including the streams which drain into the Willamette watershed east of the divides with those three. All of these maps were published in 1984, with the exception of the Monroe quadrangle (1969). The 15' quadrangles (scale 1:62,500) for the area are from the late 1950s and are out of print today. The 7.5' maps are not only more recent, but also much more detailed. Some of the capture points would not have been found or recognized as such on the larger scale maps. However, 15' topographic maps and drainage basin maps were used to obtain an overview of the regional distribution of capture points. Visual image rather than quantitative methods served as the basis for the initial identification of capture points.

Each drainage basin was examined separately, following the main coast-draining river upstream and generally in a north-south zigzag pattern eastward. It was essential to keep careful records including quadrangle name, Township, Range and Section (divided into quarters of quarter sections) as well as the names of the streams for later reference.

Xerox-copies of all quadrangles were used as working maps to record capture points and to outline the streamcourses.

Three data sets were produced. The first data set contained all capture points (over 300) found in the scanning of the 7.5' maps. The points were continuously numbered for each drainage basin. The initial of the main coast-draining stream (i.e. S for Siuslaw, A for Alsea and Y for the Yaquina River) served as a prefix to the number of the point. The first listing included the location, names of creeks or streams that seem to have been connected and the stream or watershed they currently drain into. After the initial compilations the first data set was reviewed and all data that could be used to evaluate capture were recorded. This included the relative alignment of the two streams on each side of a gap and the possible continuation of this alignment to other gaps. The elevations of the gap, the origin of both streams, and the highest peaks close to the gap were noted. Other morphological features like terraces, cut-off meanders or meander cores, unusual

confluences and barbed tributaries, widening or narrowing, flattening or steepening of valleys, falls etc. were also recorded.

Then objective criteria for determining whether a morphological gap was a convincing capture point were listed. Ten streams were picked at random to test the initial criteria, so that they could be refined.

Four main criteria were found to be valuable. The following characteristics are associated with gaps that are convincing capture points.

- 1) There exists a windgap at an elevation significantly lower than the surrounding peaks and relatively close to the elevation of the existing streams or valleys. The gap should be lower than half the distance from the main valley (a wide valley with a flat floor) to the ridge.

- 2) The gap is fairly wide in the cross section and has a flat surface (see Figure 9).

- 3) At least one of the streams bends away from the gap, because its headwaters have been captured and redirected into the capturing stream

- 4) Streams on opposite sides of the gap are aligned or parallel to each other, which indicates that they once flowed in the same direction.

Figure 9 shows an idealized capture point that fulfills all of the above criteria.

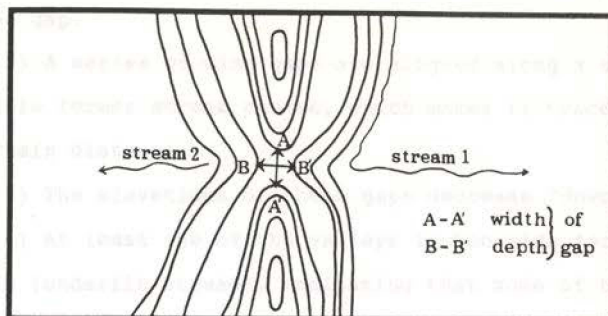


Figure 9. Schematic plan view of an obvious capture point.

These four criteria were applied to data set 1 to reduce it, resulting in data set 2. To have a somewhat objective outcome of this analysis weights were assigned to the criteria. A positive response on criterion 1 (elevation of gap) was assigned 3 points, and each positive response on criteria 2 through 4 received 1 point each. If the respective gap scored less than 3 points on the first 4 criteria, it was not taken over into data set 2.

Another set of criteria was used to evaluate data set 2 and reduce it to data set 3. Gaps included in data set 3 had one or more of the following characteristics.

- 1) On a larger scale the modern stream shows an elbow of capture, a significant bend away from the original

direction indicated by the aligned streams on opposite sides of the gap.

2) A series of wind gaps are aligned along a single possible former stream course, which makes it traceable for a certain distance.

3) The elevations of these gaps decrease "downstream".

4) At least one of the valleys is too wide for its stream (underfit stream), indicating that some of the upstream reach has been captured by another drainage, while the other (capturing) stream eroded a steep narrow valley.

5) The "underfit" stream/s is/are in close proximity to the gap.

6) There exist one or more terraces at the same or similar elevation as the gap.

7) The soil survey shows a relict fluvial soil and/or the geologic map shows fluvial deposits in the gap.

If any of these criteria were fulfilled, one point was added to the score in data set 2. The goal was to come up with a number for each capture point in data set 3. A high number would indicate a very definite capture point, fulfilling most of criteria for capture, a lower number would characterize a less significant point.

Other geomorphological features in the vicinity of the gap or the captured/capturing stream that support capture

were kept on a separate list for further reference in support of the capture points.

At this stage it became obvious that many of the original points had been chosen merely for their alignment. The most important factor was actually the elevation, size and morphology of the gap. Where the 'general' elevation was hard to determine because of variations and irregular topography, 1 to 2 points could still be assigned for elevation, if the gap was otherwise convincing.

Another important criterion was the presence of a valley close to the elevation of the gap - rather than the proximity of a stream. The original criterion of several gaps at similar elevations proved to be misleading, because it put inadequate emphasis on ridges of even height with several notches. It became also clear that a wind gap does not require streams that can be connected easily by a pencil line. But more often parallel streams and streams that bend away from each other would be connected by a gap.

The resulting list (data set 3) was a reduction to about 25% of the original number of possible capture points. The ratings of points in data set 3 showed greater differences than the ratings in data set 2, and they were therefore more useful for relative evaluations of capture points.

The next step was to map all of these points directly on the 7.5' and 15' topographic maps and on a base map for the whole study area (see Figure 11).

All points were then checked against geological maps, and soil surveys to determine the influence of lithological and structural control and to find remnants of former stream courses. Vellum overlays were made from the 15' topographic and geological maps to show the gaps in their relation to lithological boundaries, dikes, faults and alluvial deposits. The final decision to keep a point in data set 3 was made after air photo observation.

It proved to be most efficient to go through all of these steps area by area. The whole study area is covered by several geological maps of different ages on a 1:62,500 scale. Soil surveys based on airphotos are available by county (Benton, Polk and Lane Counties). At this point the soil survey for Lincoln County is still in preparation. Fortunately, parts of this county are covered in Corliss (1973). For the remaining area copies of the preliminary maps of the respective sections were obtained through personal contact with the Lincoln County office of the Soil Conservation Service in Newport, Oregon.

Air photos are available for all capture points from different years in different resolutions and qualities (black and white or color). Stereoscopic observation was

used to appraise the gap morphology, especially the presence of hanging valleys and the steepness of slopes.

After consulting these sources and other authors about the capture points I tried to reconstruct former stream courses. If the capture point was convincing on a small scale, the larger area was examined for more evidence. If the course seemed to have been reversed at some point in time, barbed tributaries would support this hypothesis. Some points of the Siuslaw area were observed in the field, but there was not enough time for extensive field research.

The 71 points that remained in data set 3 after this are the basis for this study. A detailed analysis for all of them, either in groups or separately, and a reconstruction of the former stream pattern is given in chapter four.

flowed up, a narrow gorge or ravine cut through resistant rocks by an antecedent stream" (1928).

The origin of the **CHAPTER IV** or wind gap can have two causes (Figure 10). Assuming that stream A is the

capturing and stream B **DATA ANALYSIS** idea, one possibility is that B diverted the waters of A into its own system.

where the gap is today. In this case an "anomalous point in

the b The methods described in chapter III were used to find possible capture points, especially between watersheds.

Then the origin of each was determined and the previous drainage conditions were reconstructed.

'Capture point' in this thesis is defined **capture** morphologically. It refers to a gap in a mountain ridge,

which connects two valleys, but no longer carries an active stream. The capture point is presently on the drainage divide between two streams or two tributaries of one stream.

In his description of stream capture or stream piracy Bloom (1978, 275) addresses these features as "wind gaps, notches that mark the former drainage line" of a stream system that has been diverted. Bates and Jackson (1984, 564) define

wind gap as "a former water gap, now abandoned (as by piracy) by the stream that formed it; a pass that is not occupied by a stream". In their terminology a water gap is "a deep pass in a mountain ridge, through which a stream

is now deeper, because since the capture discharge is lower

flows; esp. a narrow gorge or ravine cut through resistant rocks by an antecedent stream" (559).

The origin of the capture point, or wind gap, can have two causes (Figure 10). Assuming that stream A is the capturing and stream B the captured stream, one possibility is that A diverted the waters of B into its own system, where the gap is today. In this case an "anomalous bend in the beheaded stream" (Whittow 1984, 81) or 'elbow of capture' is common. Usually the capturing stream will incise more deeply than the captured stream, because its base level is lower and it rejuvenates faster than the captured stream. For this reason the valley portion that fell dry between the streams will be well above the steeply cut valley of stream A (see Figure 10 (a)).

Bates and Jackson (1984, 230) use the term 'hanging valley' not only in connection with glacial troughs, but also for "a tributary stream valley, whose mouth is notably higher than the floor of the main valley, as a result of more rapid deepening of the latter." The difference between the common usage of the term and its connection with wind gaps is that the stream that originates in the hanging valley does not flow down into the more deeply incised valley, but continues to flow in the other direction in its own previously formed valley. It has lost the ability to incise deeper, because since the capture discharge is lower.

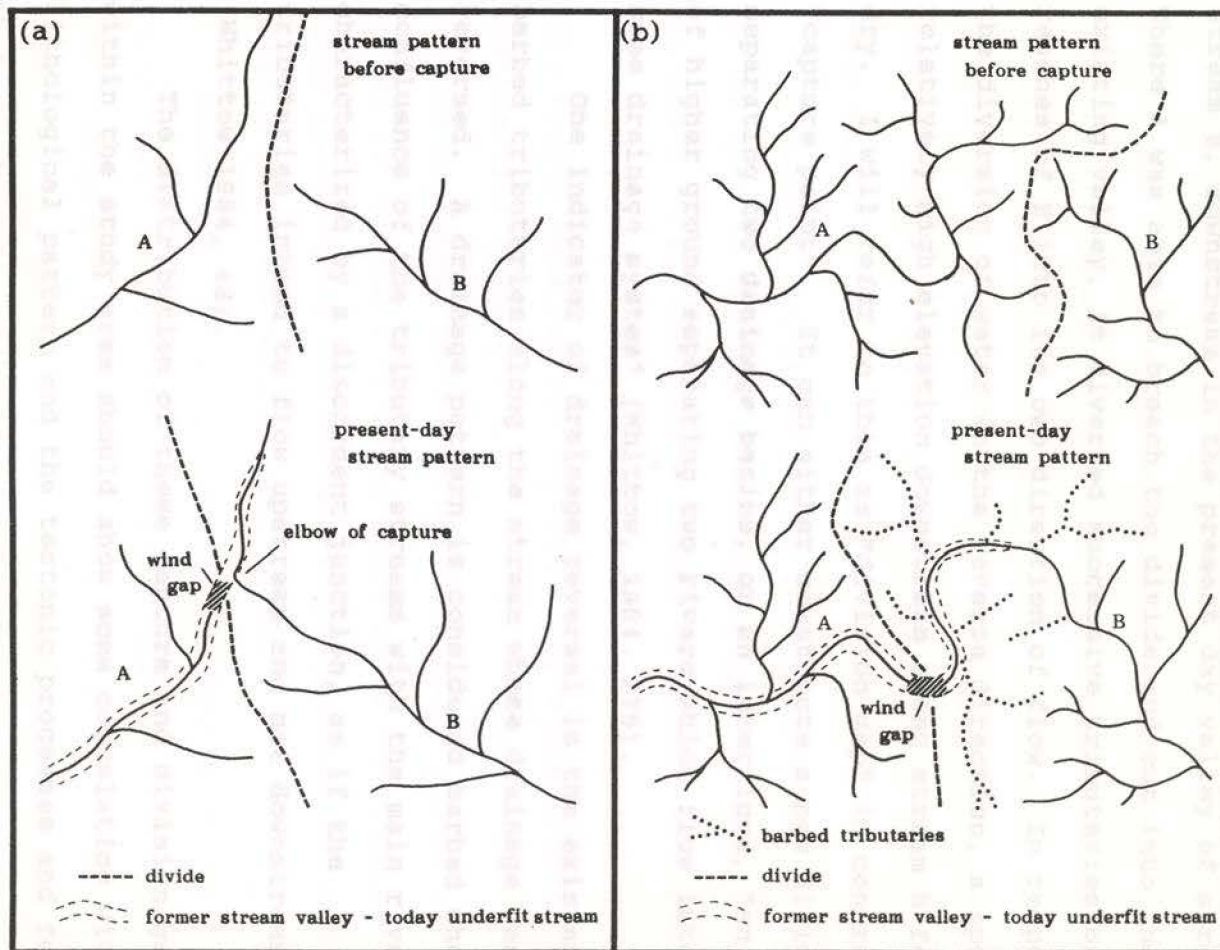


Figure 10. Idealized division gap (a) and idealized capture gap (b).

Another scenario (see Figure 10 (b)) would set the actual capture farther upstream along the previous course of stream B, downstream in the present day valley of stream A. Where A was able to breach the divide and cut into the existing valley, it diverted successive tributaries or reaches of B into its own direction of flow. In response to the diversion of water in the reverse direction, a spot of relatively high elevation downstream along stream B fell dry. I will refer to this as "division gap" in contrast to "capture point". It can either constitute a new divide, separating two drainage basins, or an interfluvium, "an area of higher ground separating two rivers which flow into the same drainage system" (Whittow, 1984, 275).

One indicator of drainage reversal is the existence of barbed tributaries along the stream whose drainage was reversed. A drainage pattern is considered barbed when "the confluence of the tributary streams with the main river is characterized by a discordant junction, as if the tributaries intend to flow upstream and not downstream" (Whittow 1984, 48).

The distribution of these capture and division gaps within the study area should show some correlation with the lithological pattern and the tectonic processes and features that are known or assumed to exist in the area.

Distribution of Possible Stream Capture Points

The first scanning of the study area for capture points led to data set 1, which contains over 300 candidate gaps (102 for the Yaquina River, 82 for the Alsea and 157 for the Siuslaw). For reasons of simplicity all capture points will be associated with the Yaquina, Alsea and Siuslaw Rivers, even if they are located beyond their present day watersheds.

For the first reduction of this number, the criterion of distance of the gap to the ridges and the valley bottom was used. This reduced the number of points to about 100 (see Table 1). A few points were found later and added. This second data set was the basis for a preliminary map of distribution (Figure 11).

As expected, the hypothetical capture points are not spread out randomly over the study area. Most points are found along the divide between the Willamette River and the Pacific Coast drainage or east of it.

About 88% (93 out of 105) of the points fall within a north-south band between longitude $123^{\circ} 45'$ and $123^{\circ} 15'$ West, which corresponds to an area about 26.5 miles wide along the eastern slopes of the Coast Range and the western foothills of the Willamette Valley (see Figure 11).

TABLE 1. Distribution of possible capture points in the three watersheds of the study area, data set 2

	Siuslaw	Alsea	Yaquina
Within watershed	4	12	8
On divides	15	12	9
Outside watershed	<u>8</u>	<u>13</u>	<u>22</u>
Total	27	39	39

TABLE 2. Grouping of capture points, data set 3

	Siuslaw	Alsea	Yaquina
Headwater captures	8	4	1
Former patterns	<u>11</u>	<u>14</u>	<u>9</u>
Total capture points	19	18	10
Geological/lithological features	1	4	5
Uncertain origin	<u>2</u>	<u>2</u>	<u>10</u>
Total features	22	24	25

Figure 11. Distribution of possible capture points in the three watersheds of the study area, data set 2.

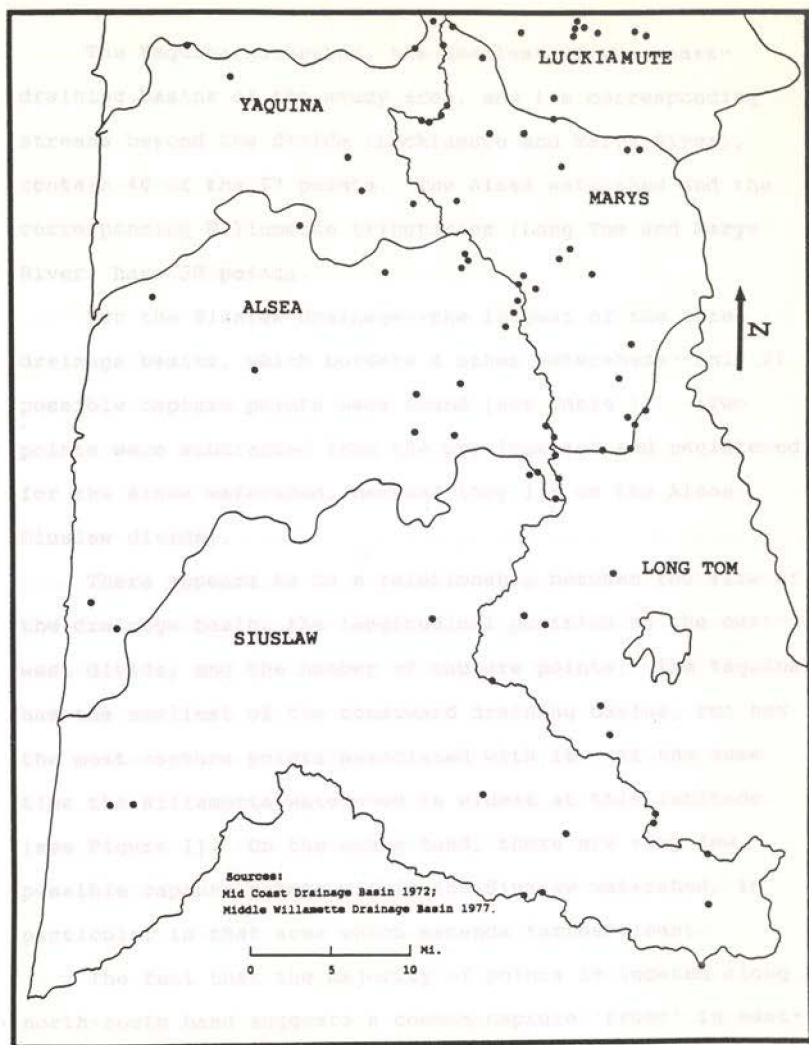


Figure 11. Distribution of possible capture points from data set 2.

The Yaquina watershed, the smallest of the coast-draining basins of the study area, and its corresponding streams beyond the divide (Luckiamute and Marys River), contain 40 of the 97 points. The Alsea watershed and the corresponding Willamette tributaries (Long Tom and Marys River) have 30 points.

For the Siuslaw drainage--the largest of the three drainage basins, which borders 4 other watersheds--only 27 possible capture points were found (see Table 1). (Two points were subtracted from the previous set and registered for the Alsea watershed, because they lie on the Alsea-Siuslaw divide).

There appears to be a relationship between the size of the drainage basin, the longitudinal position of the east-west divide, and the number of capture points. The Yaquina has the smallest of the coastward draining basins, but has the most capture points associated with it. At the same time the Willamette watershed is widest at this latitude (see Figure 1). On the other hand, there are very few possible capture points within the Siuslaw watershed, in particular in that area which extends farthest east.

The fact that the majority of points is located along a north-south band suggests a common capture 'front' in east-west direction. This front seems to have reached different stages in the three respective watersheds. The general

direction of flow of the capturing streams supports this idea. For most of the actual capture points (which will be discussed later in this chapter) direction of capture indicates a common 'front'.

Most capture points are located where the divide has been shifted farthest to the west, i.e., they lie east of the Yaquina-Willamette watershed. Therefore west-draining streams have been captured by east-draining streams. Local and regional patterns in morphology, lithology and tectonics are responsible for the non-uniform distribution of capture points within this zone.

Within this band of capture points several clusters are noticeable (see Figure 11). While the Siuslaw and Alsea Rivers have their highest number of points along the divides, the Yaquina points are mostly located east of its watershed. This again indicates that capture here has progressed farthest from east to west. Furthermore, the Willamette watershed is not only expanding west- but also southward. The northern tributaries of the Willamette River, like the Luckiamute and the Marys Rivers, presumably started capturing Coast Range streams much earlier than those tributaries further to the South. Thus the Alsea and the Siuslaw Rivers have not lost as much of their drainage basins to capture as the Yaquina River has.

Along the Willamette - Alsea watershed capture points are clustered in two areas (see Figure 11). One is along the South Fork Alsea - Muddy Creek (Marys River) divide. The other one is to the North along the Crooked Creek / Greasy Creek (Marys River) divide. These tributaries seem to have been cut off at the divide (see Figure 29). The dendritic pattern is distorted at the headwaters. Some of the headwater tributaries of the South Fork Alsea and Crooked Creek seem to be missing.

In the Siuslaw area the presence of several capture points east of the divide, within the present day Long Tom drainage basin, coincides with a westward bend in the divide (see Figure 11).

Baldwin and Howell (1949) studied this area and drew conclusions about the former course of the Long Tom River. Their findings will be discussed later in connection with the Siuslaw basin.

Types of Capture Points

Each watershed will be discussed separately here in several steps. A short description of the drainage pattern and its significance will be given.

The points from data set 2 were further examined with the help of air photos and soil surveys. One group was

discarded after re-examination. The points were either too high or too narrow and there was no evidence from other sources - such as soil surveys and geological maps - that would have supported stream capture. They also did not fit into any distributional pattern with other more convincing points. Meander cut-offs were also omitted, because they do not seem to pertain to this thesis (see p. 64).

The remaining points (data set 3) were grouped into 4 sets (see Table 2).

4 + The first group of capture points was classified as "headwater captures". Most of these capture points involve small drainages and are not supported by geologic or pedologic evidence, i.e. they do not contain alluvial fill or soil types associated with drainage ways. However, on the topographic quadrangles and on airphotos a wind gap is more or less clearly distinguishable. The capture points of a second group are strongly related to faults, anticlines, lithological boundaries or landslides. These gaps are situated directly on or very near to these geologic features without fitting into the pattern of a former drainage way represented by alluvial fill. It is not evident, if the geologic setting induced captures or if these points just appear to be captures on the topographic map because of the underlying structure.

The third and most important group of stream captures were those that fit several criteria of being a former drainageway. These are low, broad and flat gaps within a ridgeline. They seem to connect the two streams on each side. The former presence of a stream may be evident from fluvial deposits and/or erosional features found on geologic maps. Thick depositional soil types appear only in the gap or soils that develop on floodplains or terraces mark the former course of the valley.

Most of these gaps are situated on the eastern slopes or the foothills of the Coast Range. They are predominantly low, aligned division gaps, which indicate reversal of one of the streams. They will be discussed in groups for each former reconstructed stream system.

Into the fourth group put capture points that fulfilled one or more of my criteria for no obvious reason. These are gaps for which there is neither geologic/lithologic evidence and which do not fit into any previous drainage pattern. On the map and on the airphoto, however, they appear as low, flat and broad windgaps. They will be discussed in connection with their respective watersheds.

Meander Cut-Offs

Each of the three river systems has large meanders and a few meander cut-offs were found during the research. Meanders are usually found very close to the mouth of the river, because the coastal zone experienced greater changes in baselevel and more meanders can be found here. They are not considered capture points as such, even though they have a similar morphology. They never occur close to a divide and do not represent part of a stream course totally different from the modern one.

A good example for a cut-off meander is capture point A 17 in the NE1/4 of the SE1/4 of section 1, T 14S, R 9W (Figure 12). Here the tributary originating north of Little Digger Mountain has cut its way through almost to the Alsea River. Eventually this will lead to a cut-off of the meander. The former channel loop will fall dry and become a gap with alluvial fill.

Headwater Captures

These gaps are usually situated between two short headwater reaches, of which at least one shows a significant bend away from the gap. I assume that in each of these cases the creek with the more active downcutting has cut



Figure 12. A 17 as an example for a meander cut-off.

back into the headwater of an adjacent creek. Therefore the gaps are fairly high and sometimes fairly small. They can occur anywhere within the stream system or on the divides. They do not represent previous major drainage ways. Many of the gaps in data set 2 turned out to be headwater captures and will therefore be listed separately.

To illustrate the different characteristics such a capture point may show, a few will be discussed in the following paragraphs.

Within the Alsea watershed A 11 is an example for a very wide, flat, low gap, which looks very convincing on the topographic map and the air photo (Figure 13). The gap could be either the result of a former meander loop or a headwater capture. If it had been a meander loop, we should at least find a soil that formed on the alluvial deposits, but neither alluvium nor that type of soil is mapped in the geologic and soil surveys. Therefore it is more likely that Brush Creek captured part of a tributary of Grass Creek.

A 42 (Figure 14) is different insofar as we find evidence in the soil survey. "Deep gravelly soils, that formed in alluvial and colluvial materials derived from basalt" (Alsea Soil Survey, 1973, 26) are mapped for the area within the gap. These soils have up to 15 to 50% pebbles and cobblestones in the A horizon, and 35 to 70% in the B horizon. The presence of this soil type supports the



Figure 13. A 11 as an example for a headwater capture or an old meander loop.

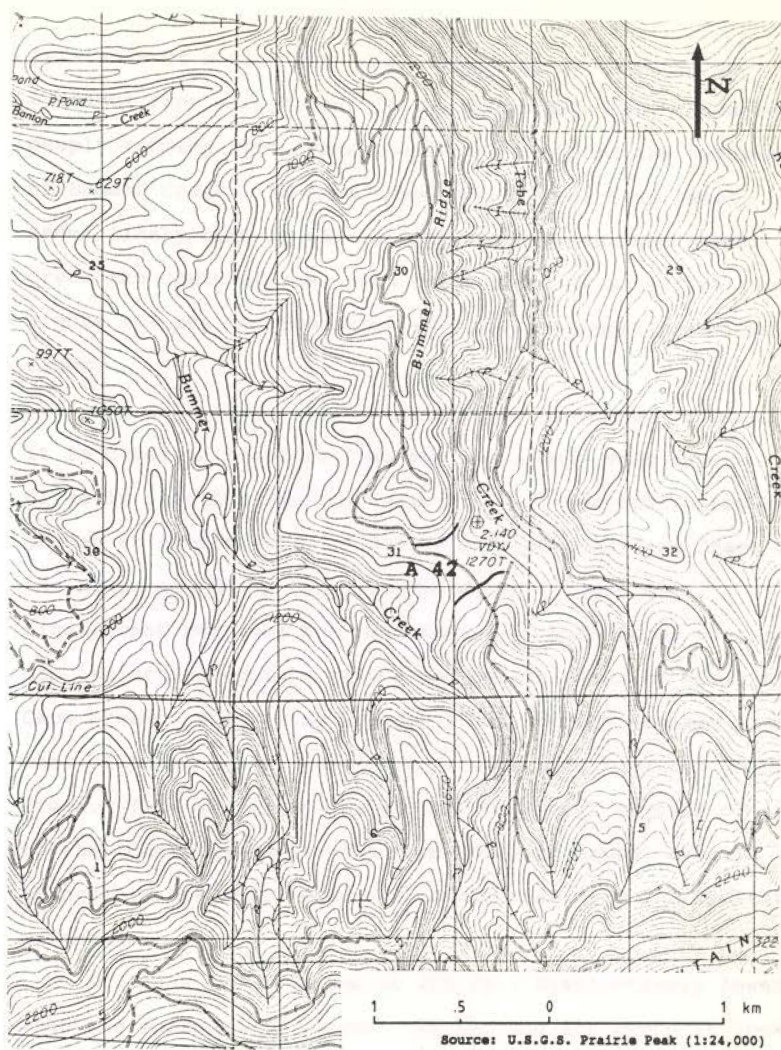


Figure 14. Location of capture point A 42.

existence of a wind gap here. Even though there is no evidence from air photos, it is conceivable that the more deeply eroding Tobe Creek could have captured the headwaters of Bummer Creek. As Tobe Creek has a lower base level, it seems likely that it was the capturing stream and Bummer Creek the captured one. The SW-NE trending anticline (see Figure 15) may be responsible for the rejuvenation of Tobe Creek.

Gap S 1a lies outside the Siuslaw watershed, however, it is close to the coast between two creeks that drain directly into the Pacific Ocean. A very low but narrow NW-SE gap at an elevation of 300 ft lies between Cape Creek to the South and China Creek to the North (Figure 16). Significant bends of the tributaries on both sides of the gap indicate a capture of the headwaters of China Creek by Cape Creek. The valley of Cape Creek is much steeper than that of China Creek, therefore it must have captured China Creek. This gap is an example for headwater capture close to the coastline, where the base level underwent drastic changes in the past through tectonic, eustatic and isostatic movements.

S 2 is a very low gap at 255 ft., distinctively lower than the surrounding ridges. On map and air photo it looks very low and broad, but also very long (Figure 17). It connects Maple Creek and the South Inlet of the Siuslaw

Figure 15. Topographic map of the Siuslaw National Forest, Oregon, showing the location of the anticline mentioned in the text.

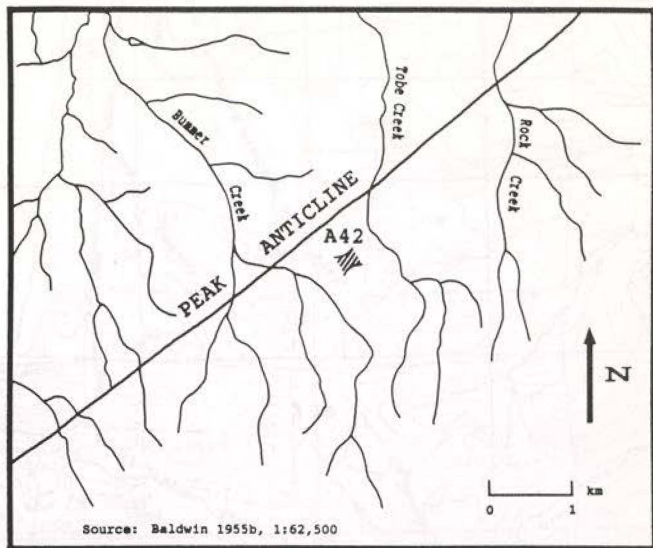


Figure 15. Headwater capture in proximity of an anticline.

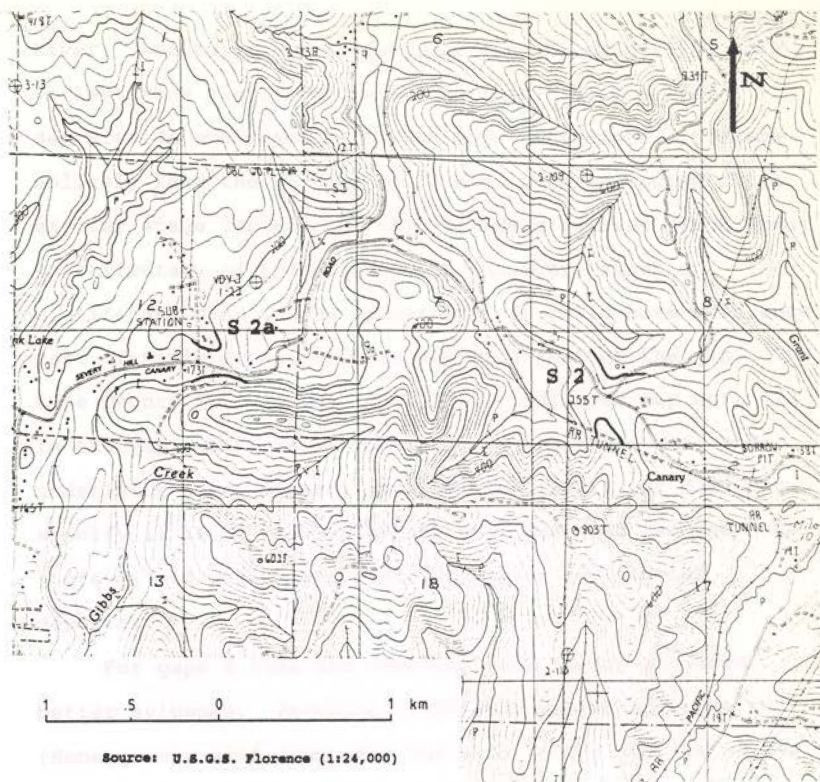


Figure 17. Location of capture points S 2a and S 2.

River. According to the geologic map (Baldwin 1955) both valleys show significant alluvial fill, but alluvial deposits do not reach up to the gap. Therefore, it seems unlikely that the streams could have been connected at an earlier stage (unless the fill has been removed since then). The tributary of the South Inlet, however, shows a significant bend to the northwest. It could have been once part of Maple Creek, flowing eastward through the gap. The Lane County Soil Survey (1987, 107) indicates map unit 110 in the gap, which is an open excavation, where soil and underlying material have been removed (123). It does not specify if it is rock or gravel that has been removed here. A gravel pit would be a good indication for fluvial deposits.

For gaps S 108b and 108c the soil survey provided better evidence. Patching (1987) has mapped the same soil (Honeygrove silt loam) for the area of gap 108b as on the terrace around Alma to the south. This area is filled with alluvium according to the geologic map (Vokes et al. 1951). Therefore it is assumed that the Honeygrove soil indicates similar parent material here, i.e. fluvial deposits, although Patching claims that it develops in colluvium (76). Honeygrove soil also occurs on terraces along the Siuslaw River. On the air photo this gap does not look convincing.

On the topographic map a significant bend in the tributary of Conger Creek towards the east (Figure 18).

Along the eastern tributary of Conger Creek lies gap S 108c. On the air photo it is low and wide. There is a significant bend in Conger Creek, the capturing stream, away from the gap. The Honeygrove soil is found again in this gap.

Gap S 147 is a case where there is neither geologic nor pedogenic evidence for a wind gap. My air photo interpretation favors a headwater capture by Rock Creek of Sandy Creek (see Figure 19). Where Rock Creek captured the headwaters of the north trending Sandy Creek and diverted them to the south, a divide was created between the two creeks.

Capture Points related to the Lithological and Geological Setting

In several instances the capture points were on or very near to major geological features. Sometimes the capture seems to have been favored by this. In other cases the low topography of a gap seems to stem from the geologic setting instead of fluvial erosion.

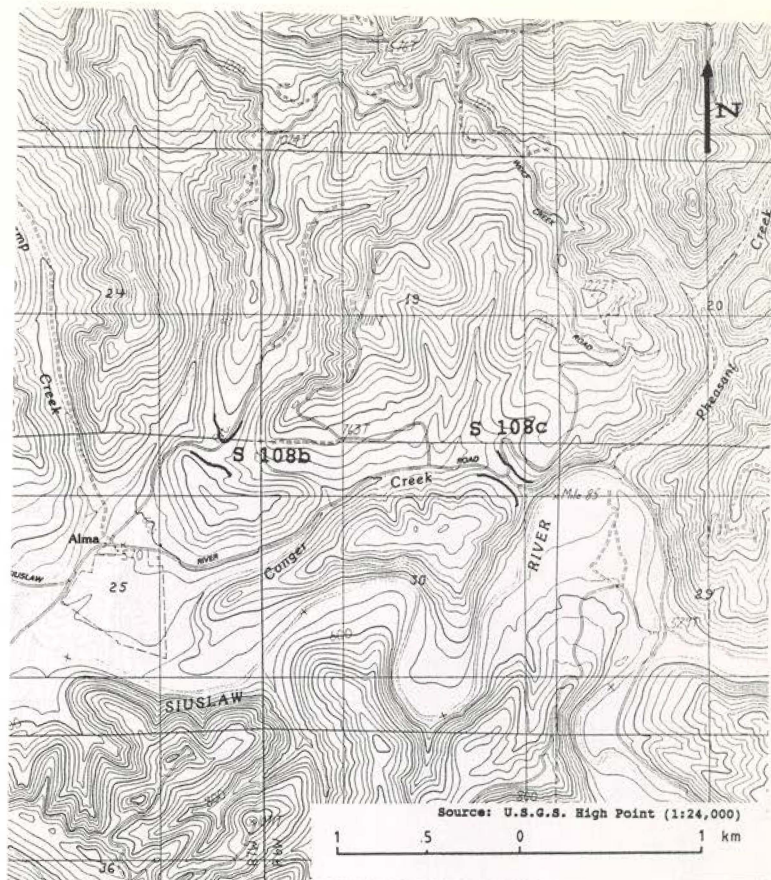


Figure 18. Location of capture points S 108b and 108c.

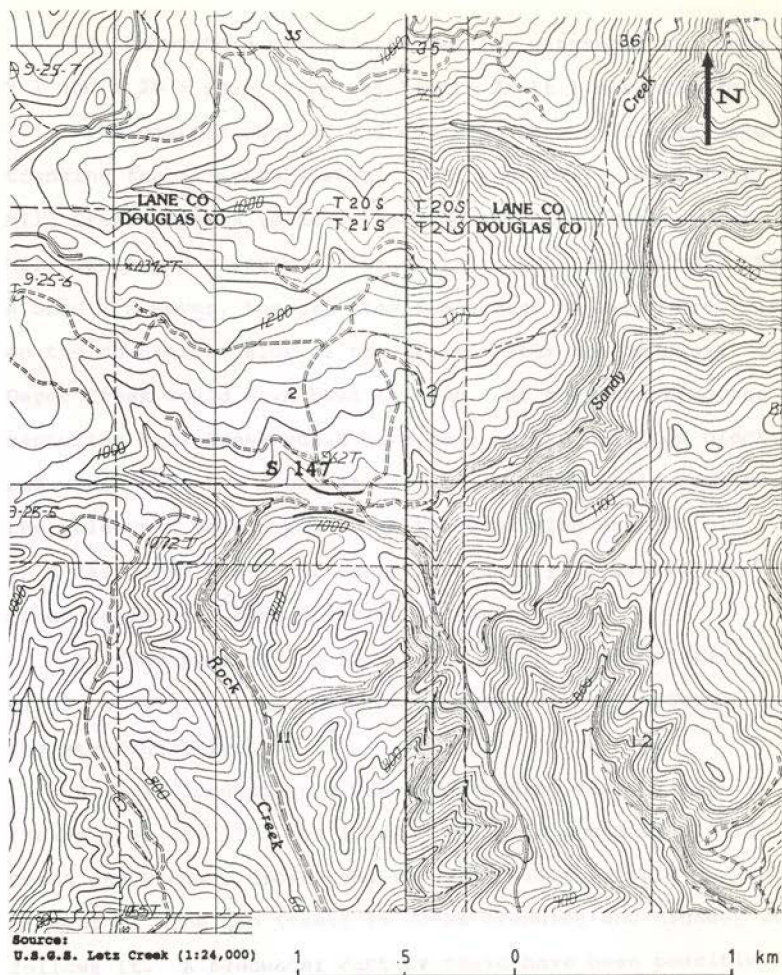


Figure 19. Location of capture point S 147.

In the western part of the Yaquina watershed two gaps - Y 1 and Y 2b - seem to be related to fault lines (Figure 20). The eastern edge of Y 1 corresponds with a north-south trending fault (Snively et al. 1973 and 1976). West Fork Mill Creek appears to have captured a former tributary of Mill Creek and diverted it to the northeast as indicated by a bend. However, the gap itself and most of Depot Creek is on the downthrown side of the fault. Thus the baselevel of Depot Creek would have been lowered. At the same time the capturing Mill Creek would have been on the uplifted block and would have had a higher baselevel. This would reverse the roles and make Depot Creek the capturing stream. In this case only the small eastern tributary of Little Depot Creek would have been diverted to the south.

Another possibility is that this gap is not of fluvial origin at all. It may only be a morphological reflection of the structural feature.

Y 2b is located on a WNW-ESE trending fault line (Snively et al. 1973 and 1976). The headwaters of Ollalla Creek and Simpson Creek seem to be parallel to this direction. The gap itself is SW-NE trending and Highway 20 follows it. A headwater capture could have been possible here, but this is very uncertain. The gap was also very hard to detect on the airphoto.

Figure 20. Map of the Yaquina watershed showing the location of gaps Y 1 and Y 2b in relation to fault lines in the area.



Figure 20. Location of capture points Y 1 and Y 2b in relation to fault lines in the area.

Gaps Y 14 in the Yaquina and A 52 in the Alsea watershed are probably related to mass movements (Figure 21). Y 14 is very flat but also fairly high and there are no bends in the creeks it divides. It may therefore be related to the huge landslide west of it (Bela 1979), which smoothed the topography that used to be much steeper. A 52b is related to an earthflow directly east of the gap. The slump and the uneven terrain are obvious on the air photo.

A number of gaps show a relationship with lithological borders. Gap Y 24 is situated on a dike. On the air photo it looks too narrow and does not appear to be a capture. The gap is only visible on the topographic map.

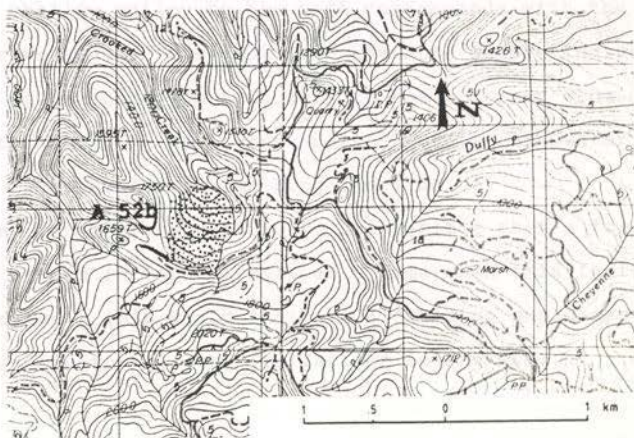
The bend in Oleman Creek near gap Y 57 is probably also related to intrusives near its headwaters and is not a sign of a capture at this location. As a stream capture it appears to be too high (1820 ft.).

Gap A 53 within the Marys River / Muddy Creek drainage lies along the contact zone of Eocene siltstones of the Tyee formation and Eocene and Miocene intrusives.

Out of a whole group of capture points along the South Fork of the Alsea River, some seem to be strongly related to lithological borderlines and structural faults. A 68b is on the contact zone between middle Eocene sandstone and post Eocene intrusives (Bela 1979). A 73 lies directly on the Glenbrook Fault, but it does not trend in the same direction



Source: U.S.G.S. Harlan (1:24,000)



Source: U.S.G.S. Flat Mountain (1:24,000)

Figure 21. Location of capture points Y 14 and A 52b in relation to landslides.

as the fault (SW-NE), but in a west-east direction (Vokes et al. 1954).

Within the Siuslaw area gap S 122 seems to be related to the Glenbrook Fault (Vokes et al. 1951). Even though its elevation of 1014 ft. is still fairly low compared to the ridge, it is not much wider than the road that cuts through (Figure 22). Observations on air photo and in the field showed that there is no alluvial fill, but bedrock on both sides of the road.

Two interpretations are possible for the origin of this gap. One is that this gap was not caused by stream capture, but is simply the surface expression of the fault. The rather shallow valley to the west corresponds with the downthrown side of the fault and the more deeply incised valley of the Long Tom tributary to the upthrown side. On the upthrown side the higher position of the headwater area caused rejuvenation on the Long Tom side.

On the other hand it would be possible that a former stream eroded in bedrock here at a time when this fault was very active. This would indicate a division gap caused by capture through the Long Tom farther to the east.

Figure 22. Location of capture point as shown in relation to the Glenbrook Fault.

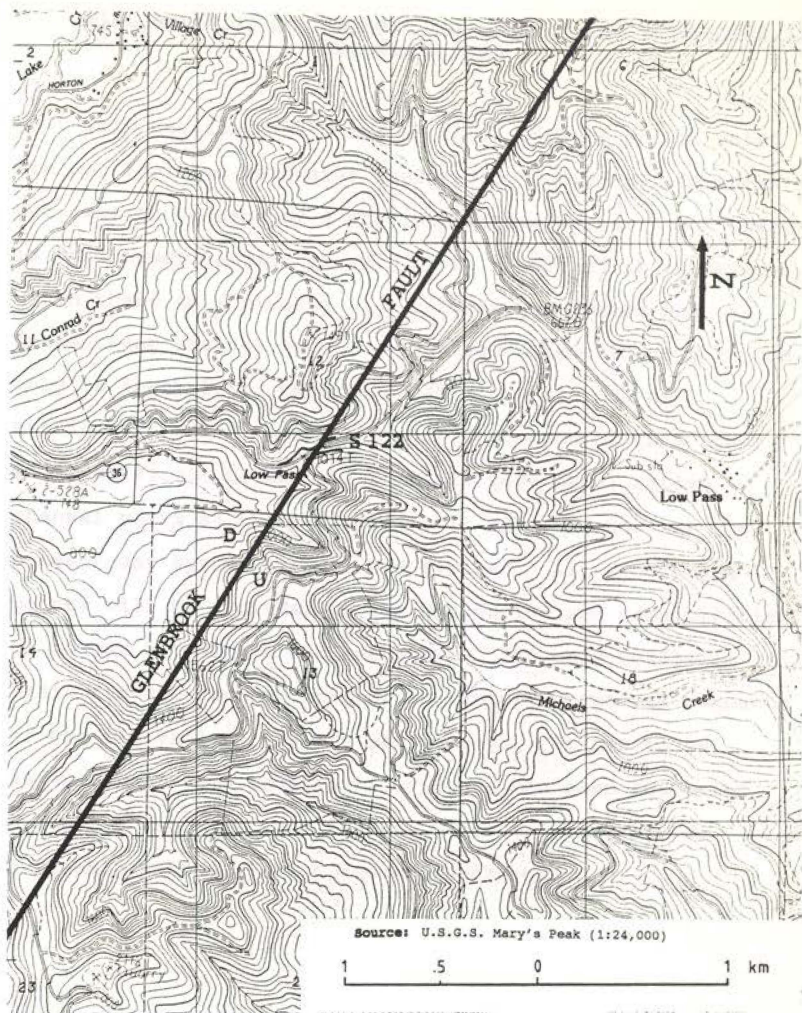


Figure 22. Location of capture point S 122 in relation to the Glenbrook Fault.

Discussion of the Dataset for each of the Watersheds in
the Study Area

This section will focus on those capture points which are not isolated headwater captures or geological features, but seem to be part of a previous stream system. Not always is the former pattern clear. Even if part of it is obvious, often there is a missing link between the former and the present-day channel network. Any reconstructed pattern can only be incomplete, because no absolute age can be attributed to its remnants within the reach of this study. It is difficult to say which points were still active channel parts at a certain point in time and how far the present-day system already had evolved. All convincing points will be included in the discussion and possibilities of former streamflow will be shown. The only available basis for the reconstruction are capture points as remnants of the old valleys and the new valleys. It has to be assumed that some additional evidence has been concealed since the captures took place. Other evidence may be available with different research methods.

The Yaquina River Area

Former Stream Systems

Figure 23 illustrates the position of the present-day divides between the Yaquina, the Marys River and the Luckiamute. The capture points shown here are those that were determined with relative certainty and those which are uncertain, but may fit into a previous stream pattern.

An attempt was made to reconstruct a former drainage pattern on the basis of these capture points (Figure 24). The pattern looks rather unnatural, but we have to assume that tributaries were distributed and incised differently than today and that larger meander bends developed recently and used to be fairly small stream valleys.

Assuming that the Yaquina, together with Little Elk Creek, formerly had a larger, farther east-reaching drainage basin, it must have been connected with parts of the Marys and Luckiamute Rivers to form one big west-draining stream system. From the initial observation it became clear that there is a common north-south "capture front" (p. 59), which has moved from east to west. Therefore the capture gaps on the divide between the Yaquina and the Willamette tributaries should be some of the most recent ones.

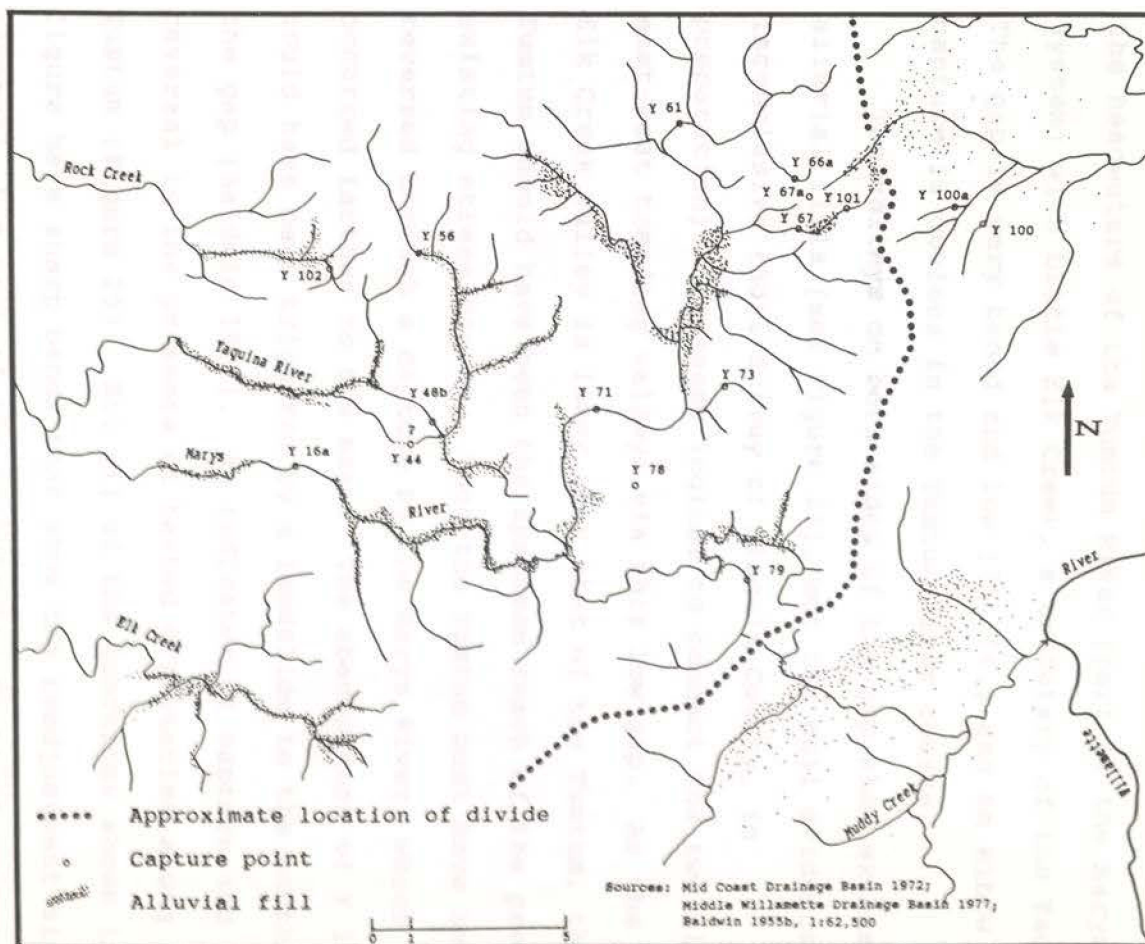


Figure 24. Reconstructed drainage of the Yaquina River.

Detailed Analysis of Gaps

Gap Y 16a is the one farthest to the west. It connects the headwaters of the Tumtum River (part of the Marys River system) with Little Elk Creek, a tributary of the Yaquina. The gap is very broad and low (761 ft.) and an elbow of capture is obvious in the Tumtum River course.

The valleys on both sides of the gap show extensive alluvial fills (see Figure 24), but the soil evidence is inconclusive (Soil Survey of Lincoln County, in preparation). It seems logical to connect the two alluvial east-west trending valleys via this low gap. As the Little Elk Creek valley is lower than that of the Tumtum, the Tumtum should have been the upstream reach of the pre-existing stream course. Thus the Tumtum must have been reversed through a capture by the Marys River, which occurred farther to the east. The abandonment of Y 16a could have been triggered by a landslide to the southeast of the gap (Baldwin 1955). An indicator of capture and reversal is the presence of barbed tributaries along the Tumtum (Figure 25). Not all of the junctions shown in this figure have sharp bends that show the readjustment since the reversal, but most of the tributaries do trend westwards in the original direction of flow and against the present one. In a flat, wide valley with a small meandering stream like

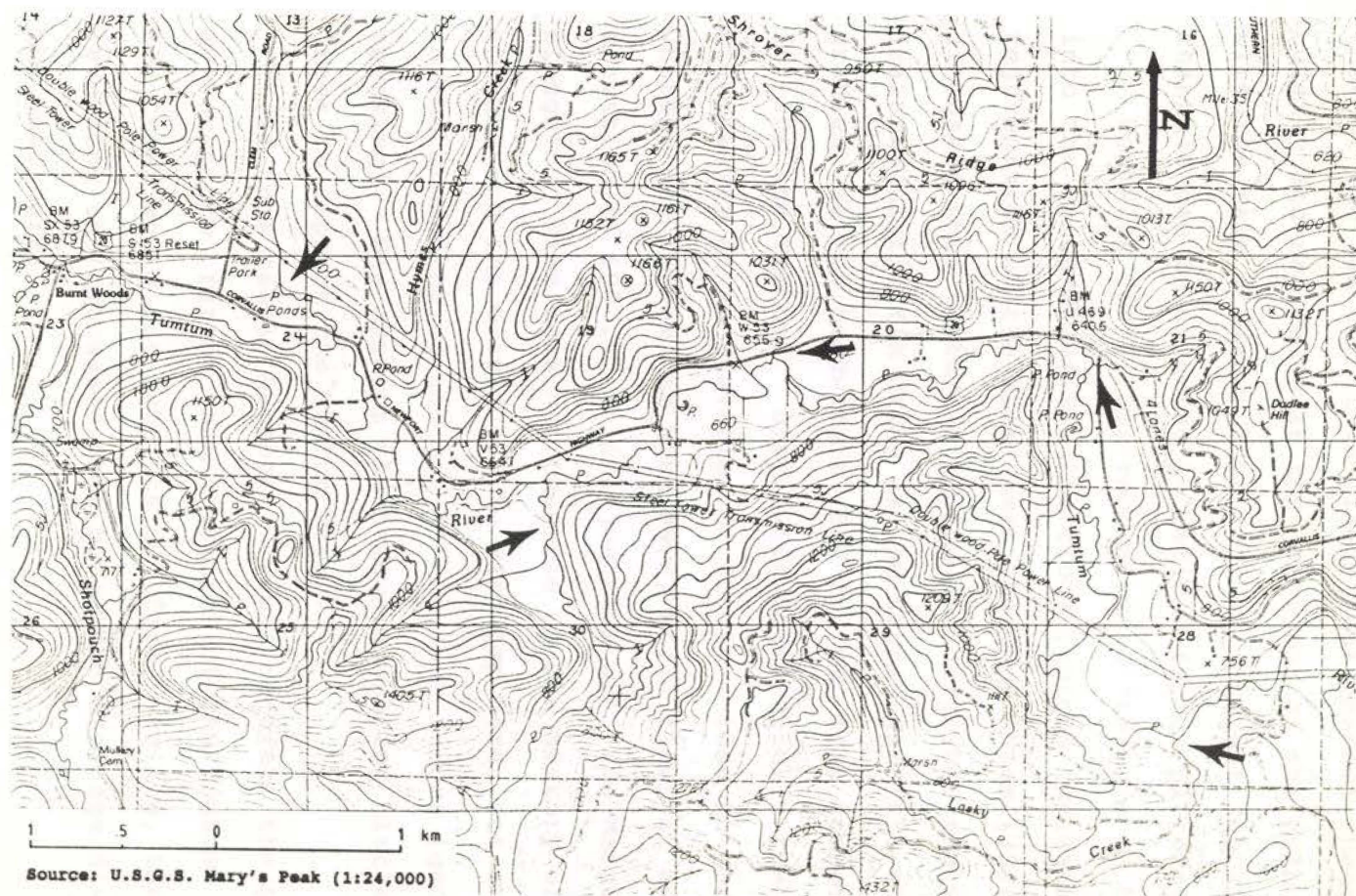


Figure 25. Barbed tributaries along the Tumtum River indicate a reversal of flow.

indicate a reversal of flow.

that of the Tumtum, it is likely that channel changes occur quickly and radically at the junctions of the tributaries with the main stream. Thus, not all present-day stream channels can be expected to reflect former patterns.

Bostwick (1959, 26) recognized a "terrace or bench cut into the valleysides at 11 o'clock [which] indicates rejuvenation of the area" near the gap. Niem (1976, 76) discusses this capture/division and describes the west-draining Little Elk Creek as the stream with the steeper gradient at its headwaters (800 ft. per mile compared to 200 ft. for the Tumtum). Little Elk Creek quickly reaches a wide valley at an elevation of 400 ft. close to the gap, whereas the Tumtum, as Niem says, still flows at an elevation of 600 ft. at its junction with the Marys near Blodgett. Niem does not theorize on the history of both streams and the origin of the wind gap here, but only refers to the breaching of the gap in the near future (geologically speaking). She expects the headward eroding Little Elk Creek to capture the Tumtum River.

If this really happens, I would describe the process as a 'recapture' rather than 'capture' of the Tumtum. Little Elk Creek would cut into its own former valley, thus reversing the processes that moved the drainage divide to the west here.

Gap Y 16a would have connected the Marys River with the Yaquina, if the Tumtum River was part of the Marys at the time. There is the possibility for another outlet of the Marys River through gap Y 44 or Y 48b (Figure 26).

Y 44 is at the end of 'Happy Hollow'. The gap is very low, wide and flat and could be a hanging valley either to the north toward Spilde Creek or to the west toward Young Creek.

Y 48b appears to be lower than Y 44 on the air photo and has a more channel-like morphology. It is 740 ft. high compared to Y 44, which has an elevation of 820 ft. Y 48b connects the West and East Forks of the Marys River with Spilde Creek and the Yaquina.

Even though other evidence of fluvial origin is missing here, the Y 48b gap seems fairly reliable, as two other authors have mentioned it. Both Rhea (pers. comm.) and Niem (1976, 77) refer to it as the "Summit Wind Gap". Unfortunately they do not elaborate on further evidence.

The downstream reach of the Marys River is believed to have been a former west-flowing tributary. Possible spots for a previous divide between this tributary and the Willamette watershed can be found northwest of Blodgett in the SE 1/4 of section 16 and in section 22 of T 11S, R 7W (USGS 7.5' Marys Peak). The valley of the Marys River is very steep and narrow here. But there is no other support

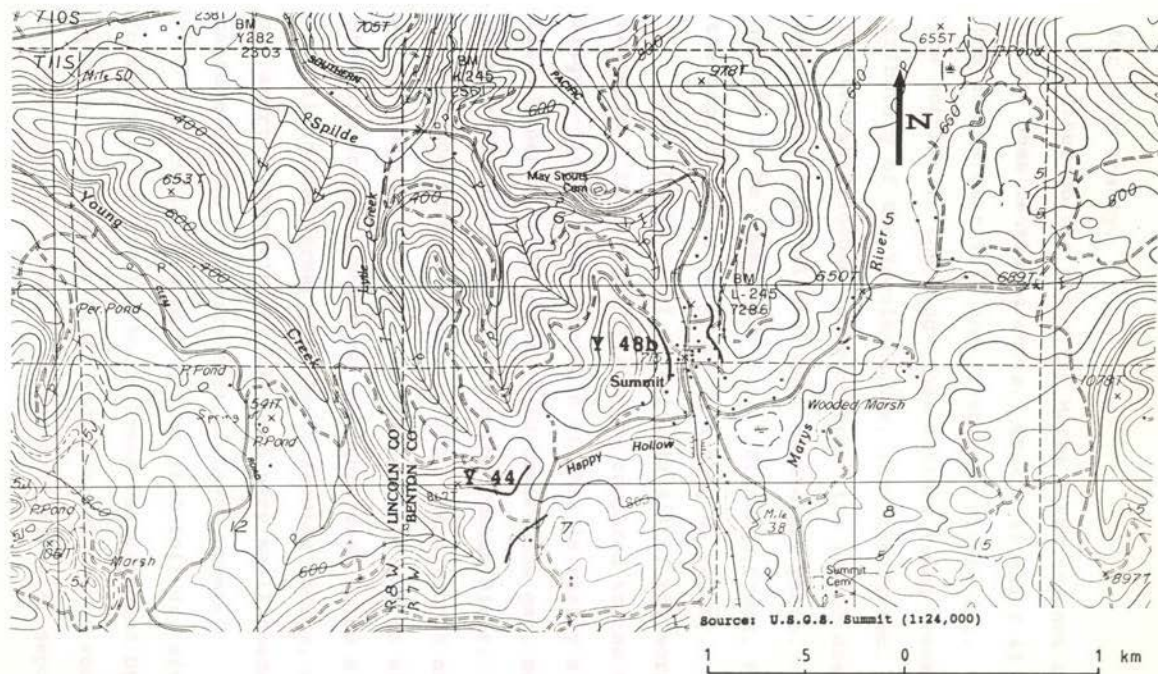


Figure 26. Location of capture points Y 44 and Y 48b: two possible connections between the Yaquina and Marys Rivers.

for this theory.

Other points along the Marys River are not as obvious as the ones mentioned above. Gaps Y 42 and Y 43 lie along the divide near Y 44 and Y 48b (see Figure 23). They are low notches in the ridge that divides Young Creek, a tributary of the Yaquina River, from the Tumtum. There is not enough evidence to reconstruct the former drainage. The points are indefinite as gaps on the air photo. Y 43 appears to be lower than Y 42. Ellmaker Creek, southeast of the gap, could actually be in a hanging valley.

Even though gap Y 34 fulfills all of the morphological criteria - it is wide, flat, low compared to the surrounding ridges - it is very uncertain if this is really a windgap. Lasky Creek flows southeastward toward the gap, before it makes a northward turn to join the Tumtum River. There is no evidence from the geologic map, the airphoto or the soil survey that it used to flow through this gap at all. One possible scenario would be that this used to be a meander core along the formerly westward flowing Tumtum, which was cut short. Otherwise it may be a very small headwater capture by the tributary east of Lasky Creek.

Y 79 could have been a spot that fell dry after the formerly north flowing Woods Creek was captured by the lower reaches of the Marys River and diverted to the southeast. The soil survey shows no evidence of alluvial deposits for

this gap (Soil Survey of Benton County 1975, 20). On the air photo it appears to be a very convincing gap.

Y 78 fits the same pattern. It connects a tributary of Norton Creek with Gellatly Creek, both tributaries of the Marys River. It is likely that either two branches or at least the headwaters of Gellatly Creek used to flow through this gap, before they were captured by the reversed Marys River. The gap looks like part of a former drainage way, both on the topographic map and the air photo. Gellatly Creek has a significant bend away from the gap towards the southeast. Following its headwaters upstream one encounters a spot that resembles a hanging valley in the southeast 1/4 of section 7, T 11S, R 6W (USGS 7.5' Kings Valley, 1984).

It is also thinkable that there was a connection between the former Marys River and Luckiamute River here. The Luckiamute would have been reversed, flowing south-southwestward via Vincent Creek into the west-draining Marys. The headwater capture by Gellatly Creek may have been caused by the NW-SE trending fault along which this creek flows (Bela 1979).

Its location makes Y 71 a better link between the Luckiamute and the Marys Rivers even though it is a strange capture point. It is on the divide between Norton Creek and Burgett Creek. Lacking evidence from soil survey and geologic map, on the air photo there appears to be a hanging

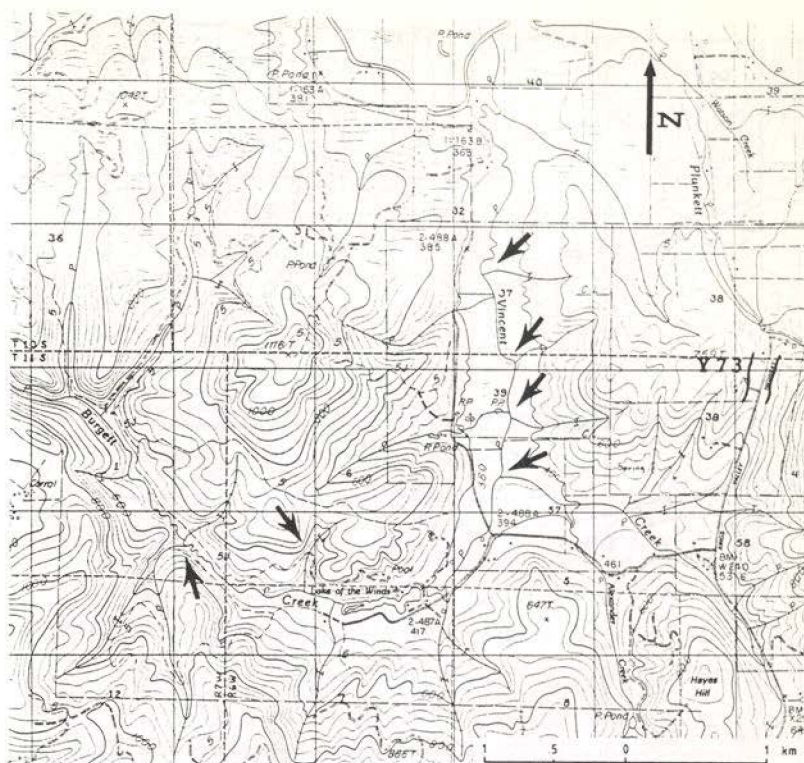
valley. This could have been the point, where the Luckiamute drained westward toward the Pacific via Norton Creek, the Tumtum River, through gap Y 16a and Little Elk Creek into the Yaquina River. This would imply a reversal of Burgett Creek and Vincent Creek, whose tributaries seem to be barbed (Figure 27).

One of these tributaries is connected to Plunkett Creek, a northwest flowing Luckiamute tributary, through gap Y 73. This gap is flat and wide enough for such a connection, but there is no further evidence from soil survey or geologic map. As the Luckiamute was reversed toward the east, the rejuvenating Plunkett Creek must have captured part of Vincent Creek.

Following the current channel of the Luckiamute downstream, four more gaps can be found (Figure 28).

Gap Y 67 appears to be an old meander bend rather than a capture point. Instead of following its old course the Luckiamute finally eroded through intrusive material in the southern 1/2 of section 33 and the northern part of section 4, T 9S & 10S, R 6W, and straightened out its course. There is, however, no other evidence than morphology.

Y 66a would have connected Maxfield Creek with Jont Creek, another tributary of the Luckiamute. Maxfield Creek originates in a valley that is much higher than the Fuller Creek Valley beyond this gap. This phenomenon could be



Source: U.S.G.S. Kings Valley (1:24,000)

Figure 27. Barbed tributaries along Burgett and Vincent Creeks indicate a reversal of flow. See also the location of Y 73.



Figure 28. Group of capture points along the Luckiamute River.

related to the King's Valley Fault, which extends into this area (Bela 1979). The pattern of the former stream system is hard to determine and there is no further evidence for stream capture.

To the southeast lies gap Y 67a, which is also of uncertain origin. Y 67, on the other hand, shows the same soil type in the gap as in the valleys it intersects (Knezevich 1975, 3) and it is located directly on a fault line (Vokes et al. 1954). The faulting might have led Maxfield Creek to change its course here.

Even though Y 101 lies directly on a fault line (Vokes et al. 1954), of which it could be a morphological expression, there also seems to be either a reversal of streamflow or a headwater capture present. Either Fuller Creek captured the headwaters of Maxfield Creek and diverted them to the Northeast, or Fuller Creek and maybe even Jont Creek were reversed, after they previously had drained through Maxfield Creek into the Luckiamute valley. It could have been one of the early captures by the Willamette system, leading to a step-by-step reversal of the whole drainage. The soil survey shows here Briedwell gravelly loam 0 to 7% slope. "The Briedwell series consists of deep, well drained soils on gravelly terraces" (Knezevich 1975, 17). This definitely supports a wind gap here.

Across the divide between the headwaters of Berry Creek are two very uncertain wind gaps (see Figure 23).

Both Y 100 and Y 100a indicate a course change of North Fork Berry Creek. The headwaters of Berry Creek might have been captured here by Staats Creek. It is unclear, what the former pattern might have been.

Most of the gaps described so far support the theory that the Yaquina watershed had a greater eastward extension and therefore the Marys River and the Luckiamute, or reaches of them, have been reversed. Gap Y 56 was part of the opposite process. It lies between the headwaters of the Yaquina and of the West Fork of the Marys River, which flow parallel to each other in southward direction up to this point. The topographic map (USGS 7.5' Summit, 1984) and air photo show that the Yaquina valley is much more deeply incised than that of the Marys. Especially downstream of the gap the Marys has a wide alluvial valley (see Figure 24). The alluvial fill ends in a westward bend towards the Yaquina River in this gap as a hanging valley at 726 ft. On the air photo the steep slope on the western side of the gap, or end of the valley, becomes evident, while the width and flatness of the former drainageway are also apparent. The soil survey indicates mixed alluvium in the gap (Knezevich 1975, 1). The present day tributary at this spot is too small to deposit extensive alluvial fill. The

headwater stream of the Yaquina used to be a tributary of the West Fork Marys River. In this case the coastward draining stream captured part of a Willamette Valley tributary. It is uncertain, at what stage of the fluvial development this capture took place. Y 56 is actually 14 ft. lower than Y 48b with an elevation of 740 ft.. Therefore the capture at Y 56 might have occurred later. Rejuvenation of the Yaquina could be related to the Nashville anticline, whose position is uncertain (Baldwin 1955). If Y 56 had been part of a west-trending valley, the next connection to old alluvial fill would be Y 102 between the Little Yaquina River and Rock Creek, a tributary of the Siletz River. At that point, however, the strong bend in the Little Yaquina seems to stem from a landslide in the area (Snively et al. 1973). Therefore Y 102 is very uncertain as a windgap.

Summary

The former drainage pattern which was reconstructed from these capture points shows that Willamette tributaries, like Berry Creek, slowly captured the headwaters of larger, west-flowing rivers. The diverted reaches increased and established the modern course of the Luckiamute and the Marys River. The actual capture points of this process are

concealed, because the rivers did not leave their valleys, but were reversed within them. Visible are only the gaps that mark the latest stage of capture, along the present-day divide, and those of smaller tributaries that were captured or lost along the way.

The Alsea River Area

Former Stream Systems

The Alsea watershed has a very complex, if not to say "crooked", drainage pattern. Topographically this is the region with the highest relief in the study area. Even though this first appeared to be an area of great possibilities for stream capture, it turned out to be rather stable compared to the Yaquina and Siuslaw basins. This may be the reason why little research has been done in this area.

Many of the capture points initially found for this area were later discarded. The remaining points allow for a reconstruction of former channel segments, but do not provide sufficient information for a the reconstruction of the general pattern. Points from the study by Niem (1976) were included as well (gaps N1 through N5)

Four clusters of capture points are worth discussing here (see Figure 29). One group is located in the northern part of the area, on the divide between the North Fork Alsea/Crooked Creek and Greasy Creek. Another group to the east connects Greasy Creek with Bull Run and Beaver Creek - all three of them tributaries of the Marys River. A third group lies along the headwaters of Muddy Creek and their divide with the Long Tom River. The most uncertain capture points are on the divide between the headwaters of the South Fork Alsea and the three surrounding watersheds (Siuslaw, Long Tom and Marys River).

Detailed Analysis of Gaps

A 51 and A 60 appear to be fairly small headwater captures (Figure 30). The general direction of capture seems to be towards the west to Crooked Creek and the Alsea system. This would speak for an extension of the Alsea drainage basin and against a westward moving 'capture front'. On the other hand both gaps are fairly high (1260 ft. and 1900 ft.) and the diverted reaches are short.

Examination of gaps A 52b and A 53 supports the idea that capture in this area is regional rather than part of a large-scale process. A 52b borders an earthflow (Bela 1979), whose uneven terrane is visible on the air photo.

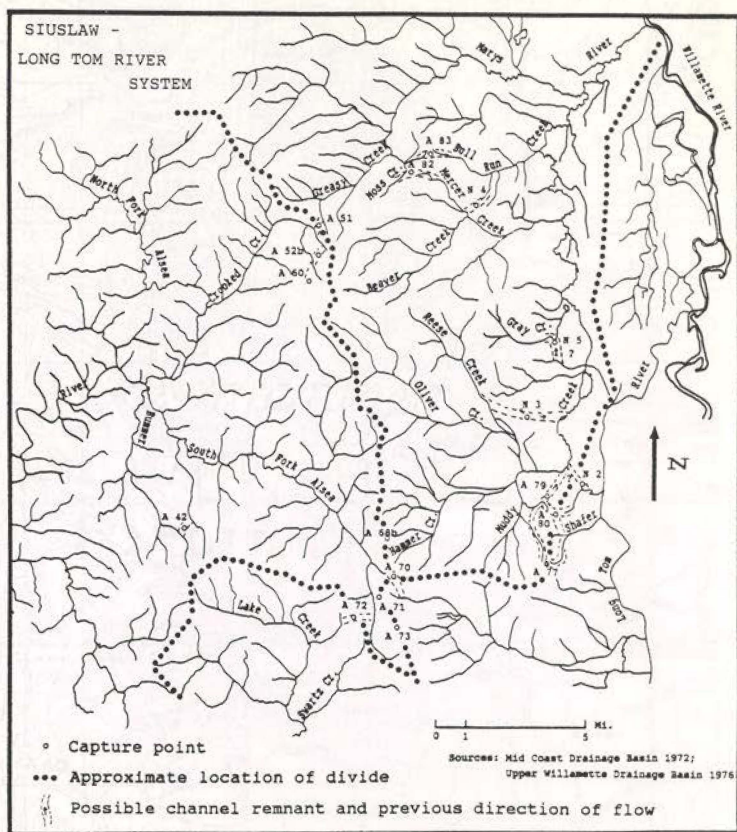


Figure 29. Present-day drainage of the Alsea-Marys River System and indications of a former stream pattern.



Figure 30. Group of capture points between Crooked Creek and Greasy Creek.

Either the gap itself is part of the slump topography or the earthflow intercepted the headwaters of Crooked Creek and diverted them to the northwest. A 53 is aligned with the lithological border between intrusive and sedimentary rocks (Bela 1979). There may not have been a capture here. On the air photo the gap is not distinguishable.

Even if these points are remnants of former valleys, this does not prove an eastward extension of the whole Alsea stream system. Only a very small portion of the stream system was affected by the captures. Greasy Creek might as well have been a part of the Alsea system once.

Another possible reconstruction would make Greasy Creek a former part of Bull Run Creek and a tributary of Muddy Creek (see Figure 29). Gap A 83 could either be a headwater capture to the southwest by Moss Creek or a division gap. The gap is broad enough to suggest that it once was part of a larger valley. Reversal of either creek seems possible, but the direction of the Greasy Creek tributaries implies a former eastward direction of flow.

Gap A 82 is higher and smaller. Judging from the air photo, Moss Creek could have been a tributary of Mercer Creek.

Niem (1976, 81) located another gap (N 4) in this area, which connects Bull Run Creek with Mercer Creek. Beaver

Creek could have been a tributary of Bull Run Creek, before it was captured and diverted to the east.

This second group of capture points (A 82, A 83 and N 4) marks internal shifts within the Marys River / Muddy Creek watershed. They may represent the steps that led to the expansion of this drainage basin at the expense of the Alsea basin.

Along the upstream reach of Muddy Creek, a number of points were located in the course of this study as well as by Niem (1976, 79) (see Figure 29). N 5 is clearly visible on the topographic map and on the air photo. It is located near a quarry and is still occupied by a small, partly channelized intermittent stream. This creek initially heads toward Muddy Creek and then flows north in a sharp bend through the gap between Maple Knoll and Pigeon Butte to join Gray Creek. It is possible that this water gap once contained a larger stream, maybe Muddy Creek. Whether the direction of flow was north- or southward is hard to say.

Niem's capture point in section 7, T 14S, R 5W (N 3), at 370 ft. would have connected Reese Creek with Muddy Creek, thereby shortcutting the southern bend of Muddy Creek. The gap is convincing on the topographic map and the air photo. Veneta silt loam indicates the presence of old gravelly alluvium here (Knezevich 1975, 39). The geologic

map (Bela 1979) shows no alluvial fills, but fluvial scouring of bedrock (sandstone).

N 2, another gap mentioned by Niem (1976, 79), lies in section 28, T 14S, R 5W. She seems to refer to a NW-SE trending gap within the same ridge as A 80 (see Figure 29). After air photo observation it seems possible that this was part of a former channel, which connected Muddy Creek with the Long Tom River.

Gap A 79 (N 1) provides a shortcut between two reaches of Muddy Creeek. It is a prominent stream gap at 330 ft., about 50 ft. lower and therefore more likely than N 2. It lies on a hidden fault line, which strikes in northeast direction and divides middle from late Eocene sandstones. Like N 2 and N 3 it is covered with Veneta silt loam, although no alluvial deposits are mapped on the geologic map (Bela 1979). Niem (1976, 79) also mentions this capture. She attributes it to the "drainage derangement produced during the Pleistocene".

The northeastern direction of the gap would imply a straighter channel for Muddy Creek than its present one.

Another, even wider and flatter gap lies to the southeast of A 79 within the low ridge near Monroe. This gap (A 80) is northwest trending at 490 ft., connecting Muddy Creek with Shafer Creek or another very short tributary of the Long Tom to the north. Even though this

gap is morphologically low, wide and flat, on the air photo it does not show the typical elongated valley shape. There is no evidence from soil types here for a former stream bed. In addition, A 77 and N 2 provide the same connections between the streams at a lower elevation (410 ft. and 370 ft.).

A 77 is an obvious wind gap. Not only on the map, but also on the air photo it appears to be flat, wide and very low. Both Belknap Creek and Shafer Creek are only small intermittent streams on both ends of the gap. The headwaters of Belknap Creek dissect an old terrace, which is indicated by Veneta silt loam (Knezevich 1975, 40). This gap also lies along a lithological border between late and middle Eocene sandstone, and on a dike.

It is very difficult to reconstruct the former channel pattern for this area (see Figure 29). Niem does not attempt a reconstruction either. Morphologically these are all perfect gaps. The general topography, however, is low and remnant valley sections are not easily distinguished from other low lying areas.

It is unclear whether the upper reach of Muddy Creek used to be part of the Long Tom, or vice versa. A significant link to any of the coast draining streams, like the Alsea, is missing. Therefore these gaps can hardly be associated with the reversal of the formerly west flowing

system. It seems likely that these captures occurred within the stream system as it is established today. They could have been part of the process that turned Muddy Creek and the Long Tom River into yazoo streams of the Willamette River.

Along the South Fork of the Alsea River is a group of capture points at fairly high elevations (1300 - 1600 ft.). Most of these points are not very convincing gaps, but they mark the very narrow divide between the Alsea and the Long Tom stream systems (see Figure 29). Gaps A 68b, A 70 and A 73 may actually be related to geologic boundaries (Bela 1979). A 68b and A 70 mark the borderline between intrusive and sedimentary rocks. A 73 lies on the Glenbrook Fault, but does is not aligned with the strike direction of the fault.

Unless these are very old captures and remnants of a stream system at a much higher baselevel, it can be assumed that they are imminent capture points. The Long Tom tributaries will probably capture parts of the South Fork Alsea in the near future (geologically speaking) and possibly reverse the whole reach down to Alsea Falls. At present the valley bottom of Hammer Creek, south of Glenbrook, is at an elevation of about 400 ft., while the valley floor of the Alsea River is around 900 ft. high. As soon as Hammer Creek has rejuvenated beyond gap A 68b at

1305 ft., it will have the lower base level of the two streams and most of the waters of the South Fork Alsea will be reversed and flow down the Hammer Creek valley into the Willamette valley. The same situation is possible for Ferguson Creek, when it will be able to capture at points A 70, A 71 or A 73.

A 72 seems to be a very small headwater capture by Lake Creek of the South Fork Alsea. The elevation differences between the main valleys of Lake Creek and the Alsea are not as great as those between the Alsea and the east draining streams.

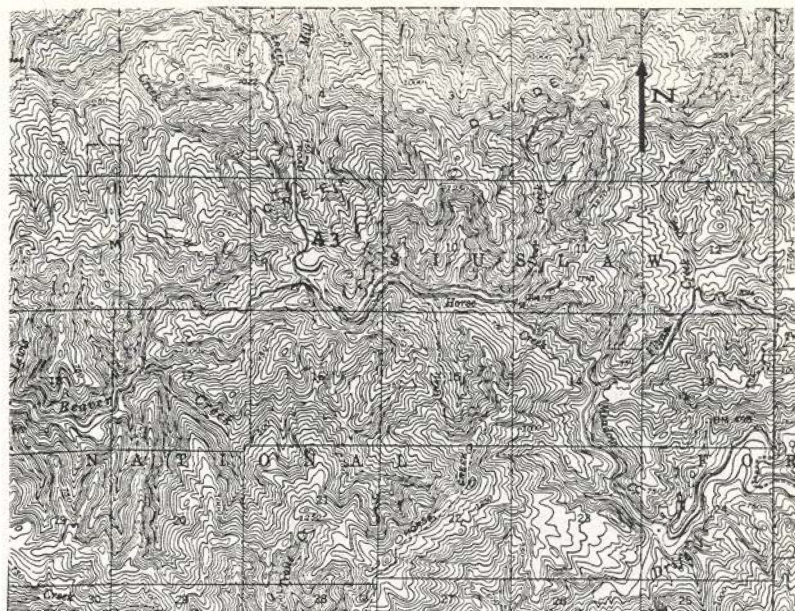
Gap A 76 is very narrow and high, but it fulfills the other criteria for wind gaps of elevation difference, bend in the stream and alignment of streams. On the air photo the gap also looks very much like a wind gap. The Alsea valley is very broad and flat, while the valley of 'The Hole', a tributary of Swartz Creek to the south, is very steeply incised. According to the geologic map (Vokes et al. 1951) there is no difference in underlying bedrock here. It is unclear from where the different valley shapes stem.

Capture Points of Uncertain Origin

In the western part of the Alsea watershed are two isolated capture points, whose origins are uncertain.

A 1 lies near the coast between the headwaters of Starr Creek and Drift Creek. On the topographic map and the air photo it looks like a very convincing headwater capture. However, the air photo also shows that Starr Creek is incised down to a much lower level than Drift Creek. Usually the capturing stream, in this case Drift Creek, incises below the level of the captured stream.

Gap A 3 between Beaver Creek and Horse Creek is also very uncertain (Figure 31). Even though it looks like a division gap, it is fairly high (924 ft.). Barbed tributaries along Horse Creek speak for a reversal of Horse Creek, so that it would have drained out westwards to Beaver Creek, before the gap fell dry. In the NE1/4 of section 23, T 12S, R 10W, the valley of Meadow Creek is very narrow. This may indicate the former location of the divide between Beaver Creek and Drift Creek before the capture by Drift Creek. This capture could have been initiated by the stronger uplift close to the coast. The gap also lies at approximately the same longitude as gaps Y 1 and Y 2b, two gaps in the Yaquina area which are strongly related to fault lines. A 3 is situated on a concealed part of the same fault as Y 1 (Snively et al. 1973) (see Figure 20, p.78).



0 1 2 km

Source: U.S.G.S. Toledo (1:62,500)

Figure 31. Barbed tributaries along Horse Creek indicate a reversal of stream flow.

Summary

It seems that the Alsea River system has not experienced dramatic captures to the same extent the Yaquina has, because it is located farther to the south and it has a slightly higher relief. The Muddy Creek area, where most captures occurred, has been lowered by faulting (Corvallis Fault; see Figure 3, p. 8) to such an extent that the evidence is hard to find in the generally low topography. The groups of capture points which were identified are most likely caused by regional variations in geology and fluvial erosion. In particular the capture points east of the divide between coast-draining streams and Willamette Valley tributaries seem to be fairly young. Channel movements on an open alluvial valley floor, probably during the Pleistocene, led to capture and stream diversion.

The points situated on the divide are so high that they qualify either as small headwater captures aided by their geological settings or as future capture possibilities. They are not convincing as former passageways of a large west-draining stream system.

The Siuslaw River Area

Former Stream Systems

Within the Siuslaw area convincing capture points are situated mostly on or not far east of the divide between the Siuslaw and the Willamette drainage basins (Figure 32). The involved streams are the southeastern tributaries of the Siuslaw River and the Long Tom River on the other side of the divide. This region coincides with the area analyzed by Baldwin and Howell (1949). With the exception of gaps S 151, S 154, S 133a and b, which connect Coyote Creek with the headwaters of the Siuslaw River and Wolf Creek, Baldwin and Howell discuss the same wind gaps from the geological point of view. Their findings and the findings of this study come to almost identical conclusions.

This thesis agrees with Baldwin and Howell (1949) that the Long Tom River used to be part of the Siuslaw River and therefore drained westward. Baldwin and Howell overlooked or disregarded the gaps along the southern reaches of Coyote Creek and the Siuslaw. The interpretation of those gaps determines the extension of a reconstructed Siuslaw drainage pattern. The fact that the southern branch of the Siuslaw River, Wolf Creek and Coyote Creek all flow parallel to each other in northwestern direction may lead to the conclusion

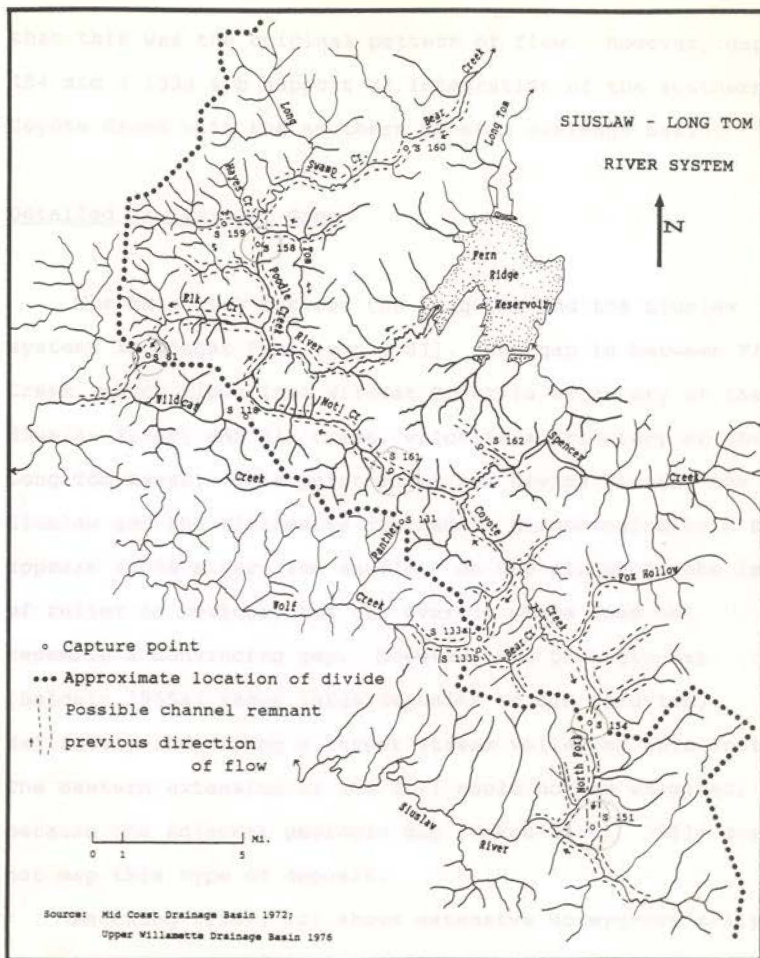


Figure 32. Present-day drainage of the Long Tom - Siuslaw River System and indications of a former stream pattern.

that this was the original pattern of flow. However, gaps S 154 and S 133a & b support an integration of the southern Coyote Creek with the southern Siuslaw drainage basin.

Detailed Analysis of Gaps

The main link between the Long Tom and the Siuslaw systems is Cougar Pass (gap S 81). The gap is between Fish Creek, which flows into Wildcat Creek (a tributary of the Siuslaw River) and Elk Creek, which is a tributary of the Long Tom River. This point marks the divide between the Siuslaw and the Willamette drainage. Morphologically S 81 appears to be a very low saddle. On the air photo the lack of relief is obvious, but the overall shape does not resemble a convincing gap. However, the geologic map (Baldwin 1955a) shows large deposits of old alluvium, definitely indicating a former stream valley at this spot. The eastern extension of the fill could not be examined, because the adjacent geologic map (Vokes et al. 1951) does not map this type of deposit. Patching (1987, 72) shows extensive Honeygrove silty clay loam on 3 to 25 % slopes for the area. According to the surveyor this soil is not associated with alluvium. However, Honeygrove silty clay loam was already found in gaps S 108b and 108c (see Figure 18, p. 75), where it

occurred on alluvial fills documented on geologic maps. One small section within the gap consists of Cumley silty clay loam. It is formed in colluvium and glacial till material in the uplands of the Cascade Range (Patching 1987, 53). In the unglaciated Coast Range old alluvium might produce a similar soil.

Baldwin and Howell (1949, 117-118) also comment on the thick alluvial fill (up to 250 ft. at the head of Elk Creek) and dissected terraces along Elk Creek. On the western side of the gap they suspect landslide material on top of the alluvium. The fills are fine-grained, a fact they attribute to a sluggish stream. S 81 probably fell dry immediately after the capture of the drainage northeast of the gap by the Willamette system. This capture reversed the drainage direction of the ancient Long Tom. At 780 ft. S 81 is the highest in a series of gaps.

Following the present Elk Creek downstream (upstream in the previous stream system), further gaps can be found.

Gap S 158 constitutes a former connection between Poodle Creek and the Long Tom. The Long Tom River shows a significant bend in its course here, away from the original southward direction to the east (Figure 33). The gap is very low, wide, broad and flat at 500 ft. The southern valley side of the Long Tom is very steep here, as it was observed on map, air photo and in the field. During field

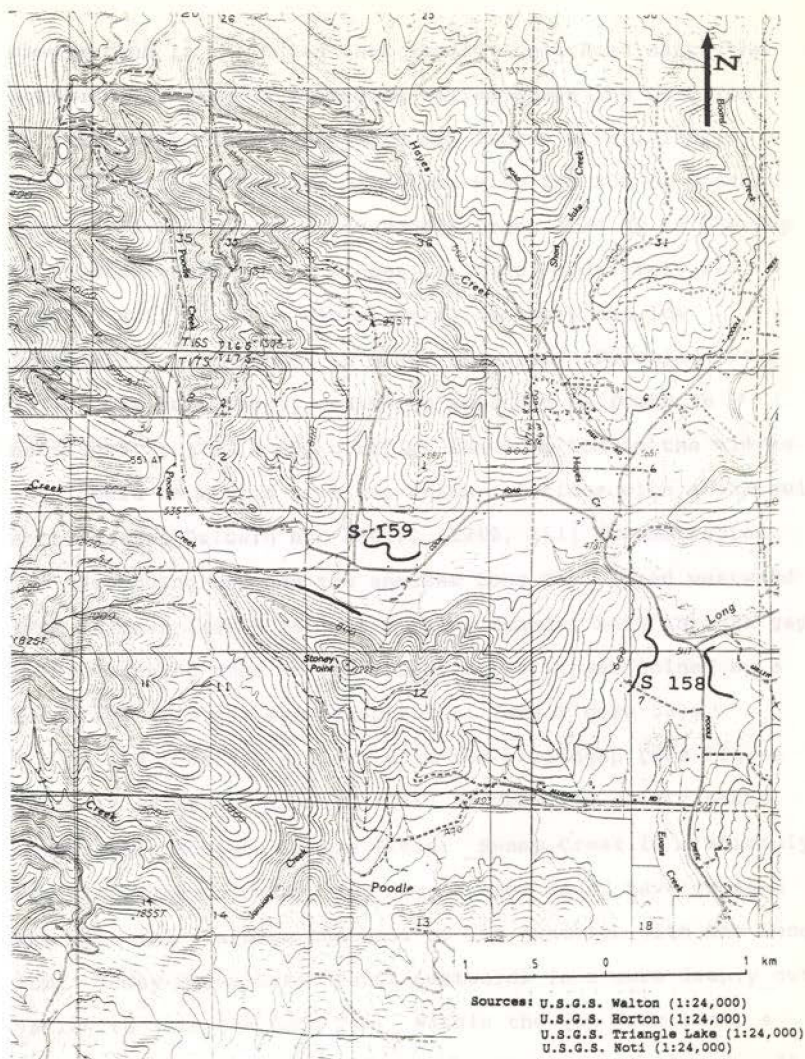


Figure 33. Location of capture points S 158 and S 159.

observation it was noted that Poodle Creek Road marks the northern boundary of a hanging valley above the Long Tom.

According to the geologic map (Vokes et al. 1951) alluvial fill of the gap coincides with the 800 ft contour line. The soil found along Poodle Creek Road up to the gap is Veneta loam 0 to 7 % slopes, a "deep, moderately well drained soil . . . on old alluvial terraces and low foothills, . . . formed in mixed alluvium" (Patching 1987, 139). The same deeply weathered soil can be found in section 5, T 17S, R 6W, north of the Long Tom on the slopes. This could be an old terrace, which coincides with a channel section that Baldwin and Howell (1949, 111) reconstructed.

According to them the ancient Long Tom flowed westward from Goldson (gap S 160) in a large meander belt through gap S 159, turning then to the south, where it was joined by a tributary from the east (gap S 158) (see Figure 32).

S 159 fulfills all criteria for a windgap (see Figure 33). It is broad, low and flat, as observed on air photo, topographic map and in the field. Swamp Creek is a strongly west trending tributary and Hayes Creek could have crossed the alluvial plain to the west of its junction with the Long Tom. Today Hayes Creek bends eastwards in a more deeply cut valley to join the Long Tom. Within the gap Meda loam, a deep, well drained soil on fans and terraces, is found. It is typically very gravelly and commonly stratified. The C-

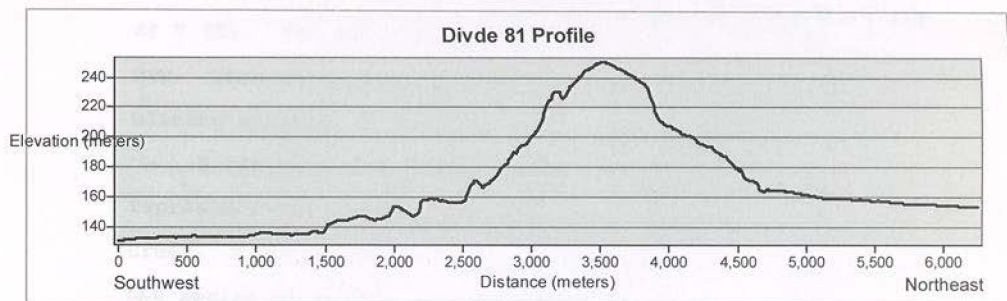
horizon contains 30 to 50 % coarse fragments (Patching 1987, 58). This soil type marks the previous stream course all the way to a southward bend in the creek close to Poodle Creek Road.

The western side of the meander loop west of S 159 is cut through intrusives and does not show any alluvial fill (Vokes et al. 1951). Baldwin and Howell (1949, 123) assume that ancient Bear Creek cut through its old fill into the underlying bedrock. Stronger uplift closer to the center of the Coast Range is their explanation for the downcutting in this particular case. This seems plausible, but there may be an alternative reconstruction. Maybe the headwater tributaries of Poodle Creek flowed to the east through gap S 159, joining the northern Long Tom in its southward course through gap S 158. The present day loop of Poodle Creek would have been divided by Eocene intrusives into two opposite tributaries, one flowing north toward Hayes Creek, the other one flowing to the southeast along the present course of Poodle Creek. A divide seems possible along the narrow stretch in the SW1/4 of section 12, T 17S, R 7W. The western tributary of Poodle Creek within this incised reach seems barbed, as if it once flowed northward. Another supporting factor for this theory is the difference in elevation between S 158 and S 159. The northern gap (S 159) is about 80 ft. higher than the southern one (590 ft.

compared to 510 ft.). The main valley should have been lower than the valley of the side tributary, unless it was captured first. If Poodle Creek had always followed its present course, it should have eroded more deeply within the valley of gap S 159 than that of S 158, which was just a tributary.

On the other hand, had the headwaters of Poodle Creek been a tributary and not a meander, it would have continued flowing eastward through S 159 into the Long Tom after the capture that led 158 to fall dry. It is also possible that the southern tributary cut through the intrusive body first and captured the northern tributary, thus causing the divide at S 159. The main valley was via S 158, which then fell dry. This would explain the difference in elevation and the missing alluvial fill within the Poodle Creek bend.

S 160 is the farthest upstream capture point and represents the connection between Bear Creek and Swamp Creek. With an elevation of 597 ft. this gap is highest in the series of gaps along the northern branch of the former Long Tom system, thus supporting the assumption of a former southwestern course. S 160 shows the same morphological features as the previous ones. It also contains alluvial fill and was easily distinguished on air photos and in the field. Bear Creek has cut down below the original surface and there appears to be a hanging valley. In the gap



Divide 81: Fish Creek/Elk Creek

- Coastal Drainage
- Willamette Valley Drainage
- Lakes



Winslow loam has developed, which is found along drainage ways dissecting old terraces and colluvial fans. It is a deep gravelly soil on old mixed alluvium. Similar soils of the Waldo series are mapped for this gap as well (Patching 1987, 43).

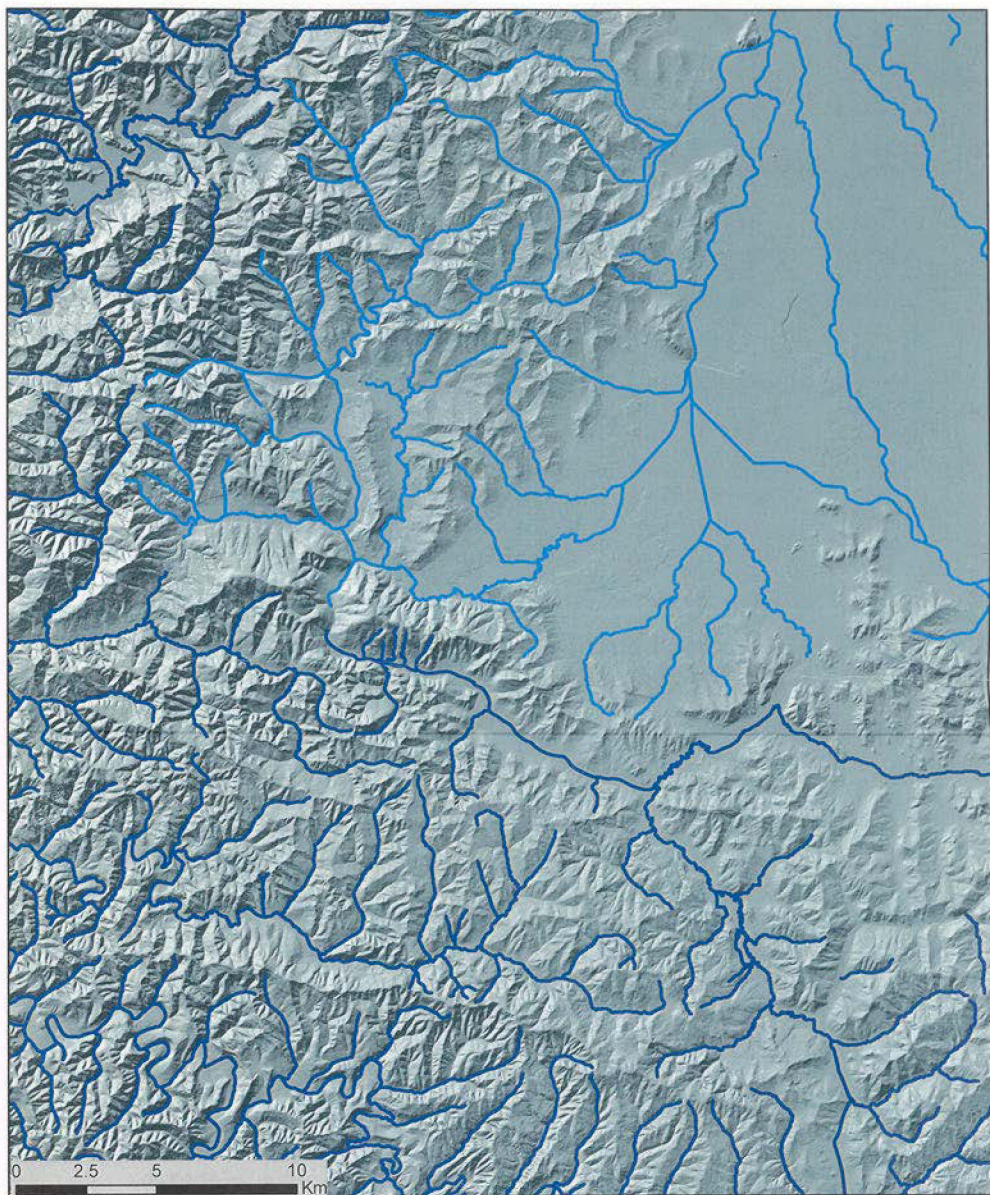
Baldwin and Howell (1949) assume that S 160 was the last gap to fall dry, after Bear Creek was captured by a tributary of the newly established Long Tom. They take the rapid drop of Bear Creek to the Willamette Valley as an indicator for recent capture. However, it seems logical to assume that the Willamette River had tributaries reaching out to the west, before the whole Long Tom was reversed.

S 161 is the connecting gap between Coyote Creek and Noti Creek. Morphological and geological evidence, air photo interpretation and soil survey indicate a wind gap. The same soil type as in gap S 160 (Linslaw series) is found here (Patching 1987, 89). With 540 ft. the gap is slightly higher than the next gap to the north (S 158). This supports the idea that there was a northern branch (involving Swamp and Poodle Creek) and a southern branch (involving Noti and Sturtevant Creek) that joined and drained westward through S 81. Several tributaries of Sturtevant Creek are barbed or could have flowed westward instead of eastward within their present valleys. On the air photo several terrace-like features can be identified.

The soil type at S 161 is commonly found on terraces (Patching 1987, 101).

The alternative outlet for Spencer Creek is S 162 (see Figure 32). Instead of joining Coyote Creek and flowing northwest through S 161, Spencer Creek may have been connected with the ancient Long Tom via S 162 as suggested by Baldwin and Howell (1949, 111). This gap is not as wide but lower than 161. The alluvial fill on the geologic map appears to be much more narrow than that of 161. It leads into areas of huge alluvial fill around Fern Ridge Reservoir, which makes it difficult to find abandoned valleys. This gap might as well be an abandoned meander of Coyote Creek. On the air photo it looks very convincing, because it is low and slightly moulded like a channel. The distribution of soils of the Dupee series, which forms on floodplains, confirms fluvial deposits, but does not indicate any former course beyond the gap.

Baldwin and Howell (1949, 123) discuss two possible scenarios. One is that Spencer Creek has always been a tributary of Coyote Creek. The capture of Spencer Creek resulted in the diversion of Coyote Creek. In this case one of the Fern Ridge creeks must have been connected with Coyote Creek. Another model would connect Spencer Creek directly with the Long Tom through S 162, before it was captured by Coyote Creek and a Willamette tributary. I



1.05-2 Million Years Ago



— Willamette Drainage

— Coastal Drainage

agree with Baldwin and Howell that the first model is the simpler one.

An important question is how far south this southern branch of the ancient west flowing Long Tom (Coyote Creek) extended. Baldwin and Howell (1949, 111) seem to think that the headwaters of the ancient Coyote Creek were the same as today. In the course of this study, however, four wind gaps were found beyond their proposed divide.

Two of them lie very close together on the divide between Coyote Creek and Wolf Creek (see Figure 32). Gap S 133a is very low and flat. The gap trends east-west and may represent the former junction of Wolf Creek and Jordan Creek. Jordan Creek would have flowed westward through the gap into Wolf Creek. On the map and on the air photo Wolf Creek valley appears to be rather wide and fairly high and seems to originate in a hanging valley above the more deeply incised Jordan Creek. This is supported by evidence from the geologic map, which shows alluvial fill up to the very edge of the hanging valley. The headwaters of Wolf Creek flow westward in a sharp bend right at the gap, which is another indicator for a wind gap. One soil type (Cumley) covers the Wolf Creek valley as well as most of the gap and extends southward to gap S 133b (Patching 1987, 123). It is the same soil type as found on Cougar Pass (S 81). Another

soil type in this gap (Minniece) is associated with drainage ways.

Directly south of S 133a is the NNW-SSE trending gap S 133b. This gap is slightly higher than S 133a (1060 ft. compared to 980 ft.) and therefore may have fallen dry earlier. It could have connected Bear Creek with Wolf Creek.

If these two points are indeed wind gaps, the southern reach of Coyote Creek, or at least part of it, may have flowed out through these gaps. It seems simplest to reconstruct Jordan Creek and Bear Creek as separate tributaries of Wolf Creek (see Figure 32).

The remaining headwaters of Coyote Creek originate in a very interesting wind gap. S 154 lines up Coyote Creek with the North Fork Siuslaw to one north-south trending valley. The gap is wide but very short in cross section (Figure 34). The alluvial fill is here interrupted by a very narrow ridge caused by a dike (Vokes et al. 1951), which forms the divide between the Siuslaw River and Coyote Creek. It is possible that this spot fell dry through capture in combination with the greater resistance of the intrusive material. It is very unlikely that this spot fell dry randomly. On the air photo this feature appears to be too minimal to be a real divide. More likely a stream used to flow over the 730 ft. high gap, which is only about 50 ft. above the present

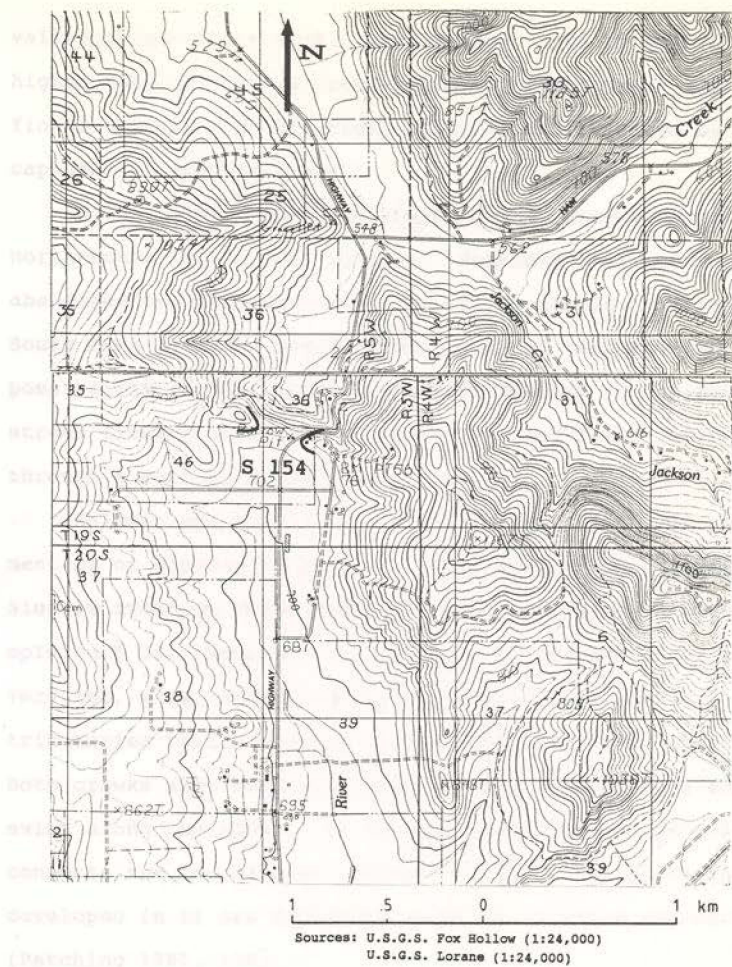


Figure 34. Location of capture point S 154 between the Siuslaw River and Coyote Creek.

valley of the North Fork. This valley is 80 to 100 ft. higher than the Coyote Creek valley. Coyote Creek may have flowed southward at one time, until it was reversed by capture (by Spencer Creek?).

S 151 lines up perfectly with S 154, extending the north-south valley even farther. Possibly this gap is an abandoned meander, which was cut off by the South Fork. The South Fork shows a westward bend south of the gap. Another possibility is that both forks were combined to one common stream flowing northward through S 151 and S 154 reversed through a capture of the North Fork. Baldwin and Howell (1949) and Baldwin (1987) do not mention or discuss these gaps. They apparently consider the Siuslaw drainage south of Coyote Creek unchanged. In my opinion S 151 shows all qualities of a good wind gap. It is very low, wide, smooth and flat. Both of the tiny tributaries that originate from it are definitely underfit. Both creeks also bend away from the gap and terraces seem to exist along the sides. It is underlain by alluvium which connects the two valleys through the gap. The soils that developed in it are typically found on alluvium and terraces (Patching 1987, 139).

Capture Points of Uncertain Origin

Two other capture points are worth discussing, because they are very untypical.

On the divide between Coyote Creek and Wolf Creek is a gap fairly close to S 161. S 131 is morphologically broad and flat with apparant stream alignment (Figure 35). The gap is relatively high (1100 ft.) and high relative to the next valley floor. On the air photo Panther Creek appears to be in a broad hanging valley at a fairly high elevation above the deeply incised Sturtevant Creek. The headwaters of Battle Creek are similarly incised. No speculation can be made on what caused this flat area between the creeks, because there is no evidence from soil survey or geologic map for a wind gap.

One wind gap was found close to the Pacific Coast. Gap S 2a connects the South Inlet of the Siuslaw with Gibbs Creek at 173 ft. (see Figure 17, p. 72). Even though the gap is distinctively lower than the surrounding ridges, air photo observation was not quite convincing. The valley of the South Inlet is much lower than the valley of Gibbs Creek. There is no indication of headwater capture. Alluvial fill can be found on both sides of the gap (Baldwin 1955a). The soil survey shows Lint silt loam 7-12% slopes for the gap, "a deep, well drained soil on dissected marine

Figure 15. Location of capture point S 131.

terraces, formed in mixed alluvium and volcanic ash" (Patching 1987, 95). As Gibbs Creek is very short and drains directly into Woahink Lake, the two tributaries may never have been connected. The flat area may be simply an expression of the old marine terrace. Another possibility is that the South Inlet, which would be more actively downcutting, captured a little stream that used to drain into the lake as well. This is indicated by one barbed tributary just north of the capture point.

Summary

All significant capture points in the Siuslaw area are related to the Long Tom - Siuslaw drainage system. The former Long Tom flowed west, eventually draining out through gap S 81 at Cougar Pass. This gap may have fallen dry as the first one, right after the Long Tom was reversed, because it has the highest elevation. If we assume that the Willamette tributaries captured the west-flowing system one by one, it may have been the last point to be affected. A chronological study of the fluvial deposits in the different gaps would help to determine this. According to Baldwin and Howell (1949, 119) the "degree of weathering, distribution of the sediments, and degree of deformation suggest that the sediments of the Long Tom and southern Willamette Valley may

be equivalent to the Troutdale formation in age". They conclude that the sediments of the Long Tom are probably from the Lower Pliocene or younger.

The Willamette watershed is not only extending to the west, but also to the south. It is very likely that Coyote Creek used to be connected with the southern branch of the Siuslaw River, before it was captured by a stream from the expanding Willamette Valley.

Interpretation and Discussion

The analysis of the capture points found in the study area supported the assumptions made at the beginning. The most significant wind gaps occur within the north-south band that was already apparent in Figure 11 (p. 58). Through headward erosion of the Willamette River and its tributaries, coast-draining streams lost tributaries along their eastern flanks. Larger stream segments were completely reversed, so that they are still occupying the same valleys. Division gaps along the modern divide and barbed tributaries, however, clearly indicate capture and reversal of stream flow. In the Yaquina area this process has had its greatest extent. The Willamette River and its tributaries occupy a much greater basin than they do farther to the south in the Alsea and Siuslaw areas. The former

patterns of the Yaquina and Siuslaw areas are easy to reconstruct. In the Alsea area evidence is more obscure.

CHAPTER V

SUMMARY AND CONCLUSION

Based on the analysis of capture points in the study area the following conclusions can be drawn:

Changes in the stream pattern are most extensive along the eastern margin of the Coast Range. Derangement of Coast Range streams is commonly not a result of capture among the coast-draining streams (Yaquina, Alsea and Siuslaw Rivers) and their tributaries. Interaction of these streams with the Willamette Valley drainage system is the main cause of changes in the stream pattern.

Significant captures and remnants of previous channels lie in a north-south corridor east of the major divide between the Willamette River and the coast-draining rivers. Points, where reconstruction of previous patterns is possible (Figure 36) lie about 6 to 10 miles east of the divide and within the Willamette River watershed. Points which mark the connection of present Willamette tributaries with coast-draining streams (i.e. Cougar Pass (S 81), the Summit wind gap (A 48b) and Y 16a) are directly situated on the divide.

Figure 36. Distribution of Willamette River captures of previously stream channels and divide east of divide.

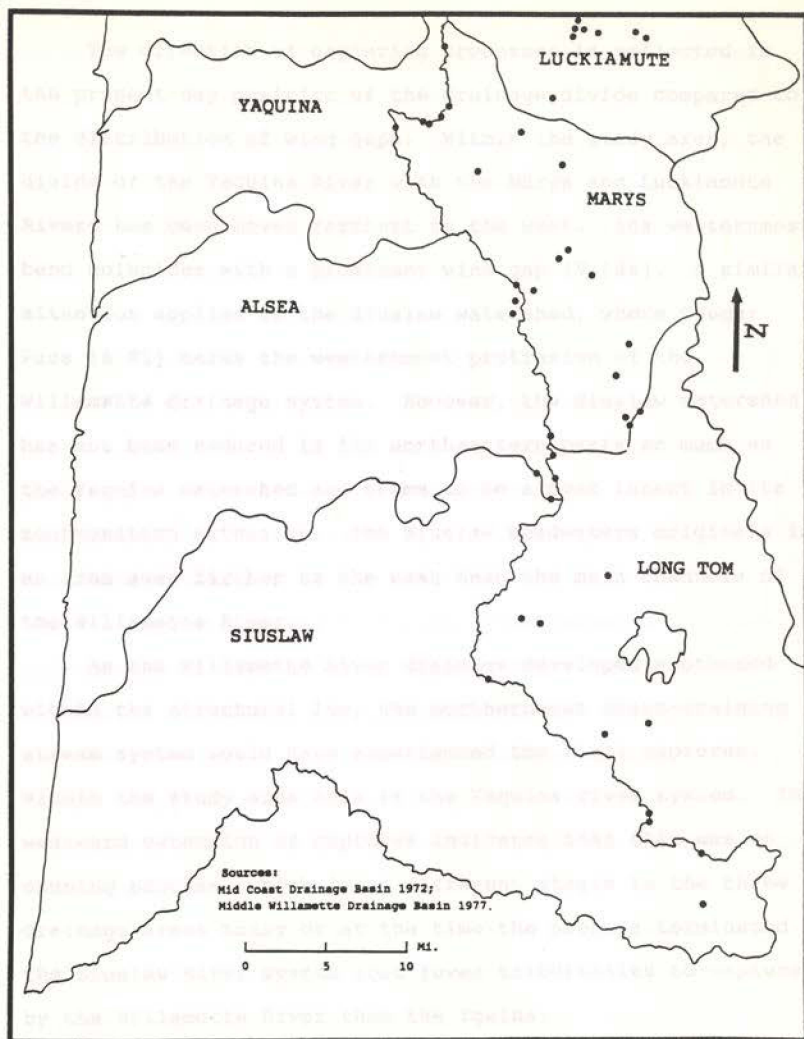


Figure 36. Distribution of possible remnants of previous stream channels from data set 3.

The direction of capturing processes is reflected in the present-day position of the drainage divide compared to the distribution of wind gaps. Within the study area, the divide of the Yaquina River with the Marys and Luckiamute Rivers has been moved farthest to the west. Its westernmost bend coincides with a prominent wind gap (Y 16a). A similar situation applies to the Siuslaw watershed, where Cougar Pass (S 81) marks the westernmost protrusion of the Willamette drainage system. However, the Siuslaw watershed has not been reduced in its northeastern parts as much as the Yaquina watershed and seems to be almost intact in its southeastern extension. The Siuslaw headwaters originate in an area even farther to the east than the main channels of the Willamette River.

As the Willamette River drainage developed southward within the structural low, the northernmost coast-draining stream system would have experienced the first captures. Within the study area this is the Yaquina river system. The westward extension of captures indicates that this was an ongoing process, which is at different stages in the three drainage areas today or at the time the process terminated. The Siuslaw River system lost fewer tributaries to capture by the Willamette River than the Yaquina.

For the Alsea River area reconstruction of the former stream network was more difficult than for the two other

systems. The divide bulges eastward and definite capture gaps lie within the Willamette Valley. The low topography in the valley obscures morphological evidence and geological and pedogenic evidence is inconclusive. Fluvial deposits may have been removed since the captures occurred. The proximity of the gaps to the Willamette River suggests that they were caused by channel changes on an alluviated or partly inundated valley floor. These changes ultimately turned the lower reaches of the Long Tom River and Muddy Creek into Yazoo streams of the Willamette River. The new pattern was probably established after the draining of the second Missoula flood phase, around 13,000 yr BP. (McDowell and Roberts 1987).

The capture points along the divide between the Alsea and Willamette basins are relatively high. This is due to the high elevations of Marys Peak and Grass Mountain, which are formed of erosion resistant intrusive rocks. Due to the higher elevation of the eastern part of the Alsea area, capture has been slow and has mostly affected the headwaters of tributaries.

Despite the occurrence of possible small headwater captures throughout much of the study area, external controls must have influenced the capturing process.

The impact of processes like uplift, rotation, tilting, local deformation, base level fluctuation and sediment input

on the Coast Range and the Willamette Valley led to the capture and diversion of coast-draining streams to the east. The fact that uplift was lower in the northern part of the study area may have created favorable conditions for local channel changes. Down-to-the-east tilting of the Coast Range and structural breaks between the Coast Range and the Willamette Valley also favored capture by the Willamette River system.

Baldwin and Howell do not accept uplift as the only reason for piracy, because a river like the ancient Long Tom/Siuslaw should have been able to keep up with the uplift. The fact that the Yaquina - Marys River obviously has not been able to maintain its course speaks against their theory. On the other hand, other geologic features, such as intrusives and the major fault lines in the Yaquina area, may have had considerable influence on the stream system. The Alsea River has been able to keep up with the uplift better than the other two streams.

Two areas within the study region may be indicators of the future development of the fluvial system. The wind gaps along the South Fork Alsea may actually be imminent capture points instead of valley remnants. In the northern part of the study area the Yaquina River has been extending its headwaters by capturing from the Marys River. Niem (1976) must have noticed this as well, because she predicted an

eastward extension of the Yaquina watershed. On the other hand she predicted the Luckiamute River expanding further westwards by capture from the Siletz River system.

If the outside factors still have the same impact, generally capture should progress westwards. If the situation has become more stable, small scale differences can be assumed to have had greater impact on the river systems in the recent past. As a result there is a general distribution pattern of old capture points from past movements, while the most recent ones are more closely related to local differences.

A11 SW1/4 of NW1/4 of section 31, T 43N, R 7W
 A12 SW1/4 of NW1/4 of section 32, T 43N, R 7W
 A13 SW1/4 of NW1/4 of section 33, T 43N, R 7W
 S14 NW1/4 of SW1/4 of section 34, T 43N, R 7W
 S1 SW1/4 of SW1/4 of section 1, T 43N, R 7W
 S2 SW1/4 of SW1/4 of section 8, T 43N, R 7W
 S08 SW1/4 of SW1/4 of section 9, T 43N, R 7W
 S108E SW1/4 of NW1/4 of section 25, T 43N, R 7W
 S105E SW1/4 of NW1/4 of section 30, T 43N, R 7W
 S130 SW1/4 of NW1/4 of section 14, T 43N, R 7W
 S147 SW1/4 of NW1/4 of section 23, T 43N, R 7W

EXHIBIT FORTY-ONE

Y1 SW1/4 of NW1/4 of section 17, T 43N, R 7W
 Y2 SW1/4 of NW1/4 of section 27, T 43N, R 7W
 Y14 SW1/4 of NW1/4 of section 8, T 43N, R 7W
 Y24 SW1/4 of NW1/4 of section 18, T 43N, R 7W
 Y37 SW1/4 of NW1/4 of section 8, T 43N, R 7W
 A32b NW1/4 of SW1/4 of section 15, T 43N, R 7W
 A33 SW1/4 of NW1/4 of section 7, T 43N, R 7W
 A38b NW1/4 of NW1/4 of section 8, T 43N, R 7W
 A70 SW1/4 of NW1/4 of section 8, T 43N, R 7W
 S131 SW1/4 of NW1/4 of section 12, T 43N, R 7W

APPENDIX

LIST OF ALL CAPTURE POINT COORDINATES IN DATA SET 3

Headwater Captures

Y54a	NE1/4 of SE1/4 of section 21, T 10S, R 7W
A11	NW1/4 of SE1/4 of section 2, T 14S, R 10W
A42	NE1/4 of SE1/4 of section 31, T 14S, R 7W
A51	SE1/4 of NW1/4 of section 12, T 13S, R 7W
A60	SE1/4 of NE1/4 of section 23, T 13S, R 7W
S1a	NE1/4 of NW1/4 of section 35, T 16S, R 12W
S1	NW1/4 of NW1/4 of section 7, T 17S, R 11W
S2	SW1/4 of SW1/4 of section 8, T 19S, R 11W
S88	NW1/4 of NW1/4 of section 9, T 19S, R 7W
S108b	NE1/4 of NE1/4 of section 25, T 19S, R 7W
S108c	NE1/4 of NE1/4 of section 30, T 19S, R 6W
S130	NE1/4 of SE1/4 of section 13, T 15S, R 7W
S147	SW1/4 of SE1/4 of section 25, T 21S, R 5W

Geologic Features

Y1	SW1/4 of NW1/4 of section 17, T 10S, R 10W
Y2	SE1/4 of NE1/4 of section 27, T 10S, R 10W
Y14	NW1/4 of SE1/4 of section 6, T 12S, R 8W
Y24	SE1/4 of NE1/4 of section 12, T 12S, R 8W
Y57	SE1/4 of NE1/4 of section 8, T 10S, R 7W
A52b	NE1/4 of SW1/4 of section 13, T 13S, R 7W
A53	SW1/4 of SE1/4 of section 7, T 13S, R 6W
A68b	NE1/4 of SW1/4 of section 5, T 15S, R 6W
A70	SE1/4 of NE1/4 of section 8, T 15S, R 6W
S122	SW1/4 of SE1/4 of section 12, T 16S, R 7W

Former Stream Patterns and Gaps of Uncertain Origin

Yaquina

Y34	SE1/4 of NE1/4 of section 33, T 11S, R 7W
Y42	NE1/4 of NW1/4 of section 13, T 11S, R 8W
Y43	SW1/4 of SW1/4 of section 12, T 11S, R 8W
Y44	NE1/4 of NW1/4 of section 7, T 11S, R 7W
Y48b	SE1/4 of SE1/4 of section 6, T 11S, R 7W
Y56	NE1/4 of SE1/4 of section 18, T 10S, R 7W
Y61	NE1/4 of SW1/4 of section 32, T 9S, R 6W
Y66a	SE1/4 of SW1/4 of section 2, T 10S, R 6W
Y67a	SE1/4 of NE1/4 of section 11, T 10S, R 6W
Y67	NW1/4 of NW1/4 of section 14, T 10S, R 6W
Y71	NWE/4 of SW1/4 of section 1, T 11S, R 7W
Y73	NE1/4 of NW1/4 of section 4, T 11S, R 6W
Y78	NW1/4 of SW1/4 of section 18, T 11S, R 6W
Y79	NW1/4 of NE1/4 of section 33, T 11S, R 6W
Y100	NE1/4 of NW1/4 of section 15, T 10S, R 5W
Y100a	NW1/4 of SE1/4 of section 9, T 10S, R 5W
Y101	center of section 12, T 10S, R 6W
Y102	NE1/4 of NE1/4 of section 23, T 10S, R 8W

Alsea

A1	NW1/4 of SE1/4 of section 10, T 13S, R 11W
A3	NE1/4 of SW1/4 of section 9, T 12S, R 10W
A68b	NE1/4 of SW1/4 of section 5, T 15S, R 6W
A70	SE1/4 of NE1/4 of section 8, T 15S, R 6W
A71	SW1/4 of SW1/4 of section 8, T 15S, R 6W
A72	NE1/4 of SW1/4 of section 18, T 15S, R 6W
A73	SE1/4 of SE1/4 of section 17, T 15S, R 6W
A77	NE1/4 of SE1/4 of section 6, T 15S, R 5W
A80	NW1/4 of NE1/4 of section 32, T 14S, R 5W
A82	SE1/4 of SW1/4 of section 33, T 12S, R 6W
A83	NW1/4 of NW1/4 of section 34, T 12S, R 6W
A79/N1	SE1/4 of SE1/4 of section 30, T 14S, R 5W
N2	NW1/4 of NW1/4 of section 28, T 14S, R 5W
N3	SW1/4 of SE1/4 of section 7, T 14S, R 5W
N4	NE1/4 of SE1/4 of section 2, T 13S, R 6W
N5	NW1/4 of SE1/4 of section 32, T 13S, R 5W

WORKS CITED

- Allen, J. E. 1990. The case of the counterclockwise river. In Oregon Geology 52:67-69.
- Ando, M., and E. J. Balazs. 1979. Geodetic evidence for aseismic subduction of the Juan de Fuca Plate. In Journal of Geophysical Research 84: 3023-3027.
- Baldwin, E. M. 1955a. Geology of the lower Siuslaw River area, Oregon. U. S. Geological Survey Oil and Gas Investigations Map OM-186, 1:62,500.
- _____. 1955b. Geology of the Marys Peak and Alsea Quadrangles, Oregon. U. S. Geological Survey Oil and Gas Investigations Map OM-162, 1:62,500.
- _____. 1981. Geology of Oregon. 3d ed. Dubuque: Kendall/Hunt.
- Baldwin, E. M., and P. W. Howell. 1949. The Long Tom, a former tributary of the Siuslaw River. In Northwest Science 23: 112-124.
- Basher, L. R., P. J. Tomkin, and M. J. McSaveney. 1988. Geomorphic history of a rapidly uplifting area on a compressional plate boundary: Cropp River, New Zealand. In Zeitschrift für Geomorphologie 60: 117-131.
- Bates, R. L., and J. A. Jackson, ed. 1984. Dictionary of Geological Terms. 3d ed. Garden City, New York: Anchor Press/Double Day.
- Bela, J. A. 1979. Geology and Geological Hazards of Eastern Benton County. In Geological Hazards of Eastern Benton County. Oregon Department of Geology and Mineral Industries, Bulletin 98, 1:62,500.
- Bloom, A. L. 1978. Geomorphology. Englewood Cliffs, New Jersey: Prentice-Hall.

- Bostwick, D. A. 1959. Field Trip No. 1: Corvallis to Depoe Bay via Newport. In Field Guidebook. College Teachers Conference in Geology, Oregon State University, Corvallis, Oregon, June 15-27, 1959, edited by Wilkinson, W. D., Department of Geology and Mineral Industries Bulletin 50.
- Bull, William L., and P. L. Knuepfer. 1987. Adjustments by the Charwell River, New Zealand, to uplift and climatic changes. In Geomorphology 1: 15-32.
- Cole, M. R., and J. M. Armentrout. 1979. Neogene Paleogeography of the Western United States. In Cenozoic Paleogeography of the Western United States. Pacific Coast Paleogeography Symposium 3, March 14, 1979, 297-323.
- Corliss, J. F. 1973. Soil survey: Alsea area, Oregon. Washington, D.C.: U.S. Government Printing Office.
- Cowell, J. C. 1986. Active tectonics along the western continental margin of the conterminous United States. In Active Tectonics, by Geophysics Study Committee, Geophysics Research Forum, Commission on Physical Sciences, Mathematics and Resources, National Research Council. Washington, D.C.: National Academy Press.
- Drake, E. T. 1982. Tectonic evolution of the Oregon continental margin. In Geology 44: 15-21.
- Feiereisen, J. J. 1981. Geomorphology, alluvial stratigraphy and sediments: lower Siuslaw and Alsea River valleys. PH.D. diss., University of Oregon. 68545.07F4
- Hare, Paul W., and T. W. Gardner. 1985. Geomorphic indicators of vertical neotectonism along converging plate margins, Nicoya Peninsula, Costa Rica. In Tectonic Geomorphology, edited by M. Morisawa, and J. T. Hack, 75-104. Boston: Allan & Unwin.
- Harvey, A.M., and S. G. Wells. 1987. Response of Quaternary fluvial systems to differential epeirogenic uplift: Aguas and Feos river systems, southeast Spain. In Geology 15 (August): 689-693.
- Heaton, T. H., and S. H. Hartzell. 1987. Earthquake hazards on the Cascadia Subduction Zone. In Science 236: 162-168.

- Heaton, T. H., and H. Kanamori. 1984. Seismic potential associated with subduction in the northwestern United States. In Seismological Society of America Bulletin 74: 933-941.
- Heller, P. L. 1983. Sedimentary response to Eocene tectonic rotation. Ph.D. diss., University of Arizona.
- Heller, P. L., and P. T. Ryberg. 1983. Sedimentary record of subduction to forearc transition in the rotated Eocene basin of western Oregon. In Geology 11: 380-383.
- Howard, A.D. 1967. Drainage basin analysis in geologic interpretation. In American Association of Petroleum Geologists Bulletin 51: 2246-2259.
- Keller, E. A. 1986. Investigation of active tectonics: Use of surficial earth processes. In Studies in Geophysics: Active Tectonics, Geophysical Research Forum (U.S.) by the Geophysics Study Committee. Washington D.C.: National Academy Press, 136-147.
- Knezevich, C. A. 1975. Soil Survey of Benton County, Oregon. Washington, D.C.: U.S. Government Printing Office.
- _____. 1982. Soil Survey of Polk County, Oregon. Washington, D.C.: U.S. Government Printing Office.
- Magill, J., and A. Cox. 1981. Post-Oligocene tectonic rotation of the Oregon western Cascade Range and the Klamath Mountains. In Geology 9:127-131.
- Maroukian, H., and E. Lagios. 1987. Neotectonic movements in the Sperkhios River basin, Central Greece. In Zeitschrift für Geomorphologie Suppl.-Bd. 63 (März): 133-140.
- McDowell, P. F. 1989. Quaternary stratigraphy and geomorphic surfaces of the Willamette Valley, Oregon. In Quaternary non-glacial geology of North America, edited by R. B. Morrison, in print.
- McDowell, P. F., and Roberts, M. C. 1987. Field guidebook to the Quaternary stratigraphy, geomorphology and soils of the Willamette Valley, Oregon. Field Trip No. 3, Association of American Geographers 1987 Annual Meeting, Portland, Oregon, U.S.A..
- McKee, B. 1972. Cascadia, the geological evolution of the Pacific Northwest. New York: McGraw-Hill.

- Mid-Coast Drainage Basin, Oregon. [1:218,750] 1972. Map 18.6. Salem, Oregon: Oregon Water Resources Department.
- Middle Willamette Drainage Basin, Oregon. [1:250,000] 1977. Map 2B.6. Salem, Oregon: Oregon Water Resources Department.
- Mills, H. H. , and J. R. Wagner. 1985. Long-term change in regime of the New River indicated by vertical variation in extent and weathering intensity of alluvium. In Journal of Geology 93: 131-142.
- Neef, E. 1966. Geomorphologische Möglichkeiten zur Feststellung junger Erdkrustenbewegungen. In Geologie 15: 79-101.
- Niem, W. 1976. Drainage basin morphology in the central Coast Range of Oregon. M.A. thesis. Oregon State University, Corvallis.
- Ouchi, S. 1983. Response of alluvial rivers to active tectonic movement. PH.D. diss., Colorado State University, Fort Collins.
- Ouchi, S. 1985. Response of alluvial rivers to slow active tectonic movements. In Geological Society of America Bulletin 96: 504-515.
- Panizza, M., and D. Castaldini. 1987. Neotectonic research in applied geomorphological studies. In Zeitschrift für Geomorphologie 63: 173-211.
- Patching, W. R. 1987. Soil Survey of Lane County Area, Oregon. Washington, D.C.: U.S. Government Printing Office.
- Phillips, L. F., and S. A. Schumm. 1987. Effect of regional slope on drainage networks. In Geology 15: 813-816.
- Reed, J. C. Jr. 1981. Disequilibrium profile of the Potomac River near Washington, D.C. - A result of lowered base level or Quaternary tectonics along the Fall Line? In Geology 9: 445-450.
- Reheis, M. C. 1985. Evidence for quaternary tectonism in the northern Bighorn Basin, Wyoming and Montana. In Geology 13: 364-367.
- Reilinger, R. E., and J. Adams. 1982. Geodetic evidence for landward tilting of the Oregon and Washington coastal ranges. In Geophysical Research Letters 9:401-403.

- Rhea, S. 1988. How can river valley morphology help to identify areas of differential uplift in the western Oregon Coast Range? In Geological Society of America Abstract with Programs 20: A307-308.
- Rhea, S. 1989. Evidence of uplift near Charleston South Carolina. In Geology 17: 311-315.
- Riddihough, R. P., C. Finn, and R. Couch. 1986. Klamath-Blue Mountain Lineament, Oregon. In Geology 14: 528-531.
- Ritter, D. F. 1972. The significance of stream capture in the evolution of a piedmont region. In Zeitschrift für Geomorphologie 16: 83-92.
- _____. 1974. The origin of unpaired stream terraces by envalley piracy: a hypothetical model. In The Canadian Geographer 18, no. 2: 125-138.
- Schumm, S. A. 1973. Geomorphic thresholds and complex response of drainage systems. In Drainage Basin Morphology, edited by S. A. Schumm, 335-346. Stroudsburg Pa.
- _____. 1986. Alluvial River Response to Active Tectonics. In Studies in Geophysics: Active Tectonics Geophysical Research Forum (U.S.) by the Geophysics Study Committee. Washington D.C.: National Academy Press, 80-93.
- Seely, D. R., P. R. Vail, and G. G. Walton. 1974. Trench slope model. in The geology of continental margins. New York: Springer Verlag.
- Selby, M. J. 1985. The Earth's Changing Surface: an introduction to Geomorphology. New York: Oxford University Press.
- Shaw, P. A., and D. S. Thomas. 1988. Lake Caprivi: A late Quaternary link between the Zambezi and middle Kalahari drainage systems. In Zeitschrift für Geomorphologie 32: 329-337.
- Simpson, R. W., and A. Cox. 1977. Paleomagnetic evidence for tectonic rotation of the Oregon Coast Range. In Geology 5: 585-589.
- Snively, P. D. 1964. Geologic sketch of northwestern Oregon. Geological Survey Bulletin 1181-M, N. Washington: U. S. Government Printing Office.

- Snively, P. D., N. S. MacLeod, H. C. Wagner, H. G. Schlicker, R. J. Deacon, G. W. Olcott, and J. D. Beaulieu. 1973a. Geologic Map of the Alsea River Section, Lincoln County, Oregon. In Environmental Geology of Lincoln County, Oregon. Oregon Department of Geology and Mineral Industries, Bulletin 81, 1:62,500.
- _____. 1973b. Geologic Map of the Yaquina River Section of Lincoln County, Oregon. In Environmental Geology of Lincoln County, Oregon. Oregon Department of Geology and Mineral Industries, Bulletin 81.
- Snively, P. D. Jr., N. S. MacLeod, H. C. Wagner and W. W. Rau. 1976. Geologic Map of the Yaquina and Toledo Quadrangles, Lincoln County, Oregon. U. S. Geological Survey Miscellaneous Investigation Series Map I-867, 1:62,500.
- Snively, P. D. Jr., N. S. MacLeod, H. C. Wagner, and W. W. Rau. 1976. Geologic Map of the Waldport and Tidewater Quadrangles, Lincoln, Lane and Benton County, Oregon. U. S. Geological Survey Miscellaneous Investigation Series Map I-867, 1:62,500. Washington, D.C..
- Snively, P. D., H. C. Wagner, and D. L. Lander. 1980. Interpretation of the Cenozoic geologic history, central Oregon continental margin: Cross-section summary. In Geological Society of America Bulletin 91: 143-146.
- Soil Survey of Lincoln County (in preparation). USDA Soil Conservation Service, Newport, Oregon.
- Summerfield, M. A. 1987. Neotectonics and landform genesis. In Geography 11: 384-397.
- Taber, J. J., and S. W. Smith. 1985. Seismicity and focal mechanism associated with the subduction of the Juan de fuca Plate beneath the Olympia Peninsula, Washington. In Seismological Society of America Bulletin 75: 237-249.
- Thomas, D. S., and P. A. Shaw. 1988. Late Cainozoic drainage evolution in the Zambezi basin. Geomorphological evidence from the Kalahari rim. In Journal of African Earth Sciences 7: 611-618.
- Upper Willamette Drainage Basin. [1:218,750] 1976. Map 2 .6. Salem, Oregon: Oregon Water Resources Department.

- Vincent, P. 1989. Geodetic Deformation of the Oregon Cascadia Margin. M.A. thesis, University of Oregon.
- Vokes, H. E., D. A. Myers, and L. Hoover. 1954. Geology of the West-Central border area of the Willamette Valley, Oregon. U. S. Geological Survey Oil and Gas Investigations Map OM-150, 1:62,500.
- Vokes, H. E., P. D. Snavely Jr., D. A. Myers. 1951. Geology of the southern and southwestern border area of the Willamette Valley, Oregon. U. S. Geological Survey Oil and Gas Investigations Map OM-110, 1:62,500.
- Whittow, J. B. 1984. Dictionary of Physical Geography. New York: Penguin Books.
- Zernitz, E. R. 1932. Drainage patterns and their significance. In Journal of Geology 40: 498-521.

sufficient to change the stream course. The latest channel changes of the Long Tom are assigned to Pleistocene or Holocene time. Absolute dating of the fluvial deposits was not done.

A recent study by Allen (1990) focussed on the effects of tectonic movement and stream capture in the northern Oregon Coast Range. He explains the almost circular streamcourse of the Nehalem River by updoming and exposure of volcanic rocks. Either the Nehalem River captured other streams in clockwise direction or a formerly east-flowing tributary of the river was diverted to the north to join the Nehalem headwaters. Evidence for the study came from topographic maps (stream gradients, barbed tributaries) and geologic surveys. The findings of this thesis made clear that not only processes in the Coast Range, but also developments along the borders of the Willamette Valley are of importance for stream capture in the study area.

Two studies are available on the Quaternary geomorphology of the Willamette Valley (McDowell and Roberts 1987; McDowell 1989). They help to understand the relationship between the Coast Range and the Willamette Valley.

During the late Miocene, after uplift of the Coast Range, the Willamette Valley became a depositional center of lacustrine and fluvial sediments (McDowell and Roberts

continent changed (Cole and Armentrout 1979). This may have caused uplift during this fourth episode.

Marine terraces indicate uplift and emergence during the Pleistocene (Armentrout and Cole 1979). Today Pleistocene marine terraces can be found up to an elevation of 1,600 ft. (McKee 1972). Eustatic sea level change accounts for only 400 ft. of this difference. Therefore, additional tectonic uplift during this fifth episode must be responsible for their modern elevation.

Tilting

There is evidence of tilting of the Oregon and Washington Coast Ranges in the recent past. A rate for landward tilting of 3×10^{-8} rad/yr was calculated for the past 10 to 50 years through observations along levelling lines (Reilinger and Adams 1982). The results are in agreement with those derived from gauge analysis, tilted marine strata and deformed sedimentary strata. Reilinger and Adams (1982) concluded from the tilting rates that subduction is still occurring, but aseismically. The rate of tilting is also lower than at other subduction zones. A more recent study on tilting rates revealed additional tilting directions (Vincent 1989). Down-to-the-north tilting from Coquille to Newport and down-to-the-south

WORKS CITED

- Allen, J. E. 1990. The case of the counterclockwise river. In Oregon Geology 52:67-69.
- Ando, M., and E. J. Balazs. 1979. Geodetic evidence for aseismic subduction of the Juan de Fuca Plate. In Journal of Geophysical Research 84: 3023-3027.
- Baldwin, E. M. 1955a. Geology of the lower Siuslaw River area, Oregon. U. S. Geological Survey Oil and Gas Investigations Map OM-186, 1:62,500.
- _____. 1955b. Geology of the Marys Peak and Alsea Quadrangles, Oregon. U. S. Geological Survey Oil and Gas Investigations Map OM-162, 1:62,500.
- _____. 1981. Geology of Oregon. 3d ed. Dubuque: Kendall/Hunt.
- Baldwin, E. M., and P. W. Howell. 1949. The Long Tom, a former tributary of the Siuslaw River. In Northwest Science 23: 112-124.
- Basher, L. R., P. J. Tomkin, and M. J. McSaveney. 1988. Geomorphic history of a rapidly uplifting area on a compressional plate boundary: Cropp River, New Zealand. In Zeitschrift für Geomorphologie 60: 117-131.
- Bates, R. L., and J. A. Jackson, ed. 1984. Dictionary of Geological Terms. 3d ed. Garden City, New York: Anchor Press/Double Day.
- Bela, J. A. 1979. Geology and Geological Hazards of Eastern Benton County. In Geological Hazards of Eastern Benton County. Oregon Department of Geology and Mineral Industries, Bulletin 98, 1:62,500.
- Bloom, A. L. 1978. Geomorphology. Englewood Cliffs, New Jersey: Prentice-Hall.