The Long Tom, a Former Tributary of the Siuslaw River

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A STUDY of the topographic maps covering the Long Tom drainage system of western Oregon shows that many of its tributaries, including former tributaries now diverted, trend westward. Certain of the smaller tributaries constitute "barbed drainage" typical of streams in which direction of drainage has been reversed. Much of Long Tom drainage lies within an area drained by the Siuslaw River system. This evidence pointed to a former westward course to the ocean. It was with this in mind that the writers sought corroboratory evidence such as remnant stream gravels, windgaps, etc., in the field. A thick section of alluvial material, filling a valley far too large for the present streams, was recently discovered at the divide between Elk and Fish creeks (located 4 miles west of Noti) and substantiates the hypothesis of former westward drainage. The presence of this broad, filled valley together with the westward trending tributaries of the Long Tom River, is considered proof of its former westward course before capture diverted it to its present northward course paralleling the Willamette River to its junction with that stream a few miles north of Monroe.

DRAINAGE TRENDS

FOR CONVENIENCE OF DESCRIPTION, drainage of the Long Tom River may be regarded as divided into the northern branch, called ancient Bear Creek, the central branch, which is the reversal of the present Noti to Veneta drainage and which can be called the ancient Long Tom, and the southern

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or Coyote Creek branch, which flowed to Noti by way of Noti Creek. Spencer Creek may have been a tributary of the former Coyote Creek drainage or it may have joined the ancient Long Tom at Veneta and thus have been a tributary of the central branch.

Ancient Bear Creek headed where it heads today, but instead of turning westward near Goldson it flowed southwestward around the Poodle Creek bend, joining the other major streams just west of Noti and then trending westward. A stretch of this valley formerly occupied by Bear Creek is now swampy and practically undrained. This stretch of valley remains almost unmodified since capture caused its abandonment. A prominent tributary from the north, the present headwaters of Long Tom River, joined ancient Bear Creek just south of Alderwood State Park and now remains as the principal stream of this area.

The middle drainage, that of the ancient Long Tom, may have been the smallest of the three branches. Unless Spencer Creek drained into this valley, ancient Long Tom drained little more than the north slope of the hills to the east, perhaps as far as Bailey Hill and Spencer Butte. It may have received the water of Amazon Creek in pre-alluvial time.

Ancient Coyote Creek had, as at present, a pattern very similar to that of the Siuslaw near Lorane a few miles to the south. It has two forks, Fox Hollow and another apparently unnamed branch, which join near the Cottage Grove-Crow quadrangle boundary and then trend northwestward. Although it now turns northward, it formerly drained by way of Sturtevant Creek and Noti Creek to Noti.

POINTS OF CAPTURE

IF THE ANCIENT Long Tom drainage is visualized as three main branches converging near Noti and thence trending westward, then there have been several points of capture to produce the present drainage pattern. Probably the most important was piracy of the central branch, the ancient Long Tom, which caused reversal of this tributary. Then during the ensuing stage of erosion and down-cutting, a tributary worked headward capturing Spencer Creek. In case Spencer Creek was a tributary of Coyote Creek, reversal of lower Spencer drainage brought Coyote Creek with it; if not a tributary then further headward erosion by the previously mentioned branch continued south until it had captured Coyote Creek also.

A tributary of the ancient Long Tom near Noti, working headward in the relatively soft Eocene sandstone, intercepted ancient Bear Creek near the mouth of Hayes Creek at a point about 4 miles north of Noti, cutting off the Poodle Creek bend. There may have been a large meander of the ancient Long Tom which reached nearly to the Bear Creek channel. Perhaps the last point of capture was just west of Goldson, where a stream tributary to the newly integrated Long Tom River pirated the headwaters of ancient Bear Creek.

Causes of Stream Capture

THERE ARE SEVERAL FACTORS which may have caused the capture of the westward draining Long Tom tributary of the Siuslaw and diverted it to the Willamette River; it is possible that no one cause is the sole reason. Eastward tilting of this slope of the Coast Range is undoubtedly involved. Piracy by headwaters of a stream flowing to the Willamette on the thick alluvial fill is probably the chief reason for capture. Minor changes in the drainage pattern may have been caused by superimposition from the alluvial fill upon the Tertiary strata. Landslide blocks in the vicinity of the present drainage-divide may have contributed a death blow to an already sluggish stream. Although piracy is believed to be the major cause for stream capture by the Willamette tributary, the above mentioned factors are believed to have been operative.

Eastward tilting due to diastrophism.—Several facts point to eastward tilting of the eastern flank of the Coast Range. The Tertiary beds between Veneta and Richardson Butte generally dip eastward 5°–10°. The erosion surface on the bedrock slopes eastward 264 feet to the mile as disclosed by drill holes at Fern Ridge Dam. The ever-broadening pattern of alluvial fill in the valley between Noti and Veneta is indicative of eastward tilting. Tilting is substantiated by plotting the elevation of the base of the alluvial fill. The elevation is about 500 feet at the drainage-divide at the head of Elk Creek, about 135 feet at the east end of Fern Ridge Dam, and presumably even less a short distance to the east. This slope is much steeper than many of the present Cascade stream gradients. Besides the dip of the strata there is a concordant lowering of summit levels toward the east which, together with the broadening and thickening of alluvium toward the east, points to eastward tilting.

Piracy by a Willamette tributary.—As the Long Tom River now joins the Willamette River, there is much reason to suppose that it was pirated by a tributary of the Willamette River cutting headward along the west side of the valley on the thick alluvial fill. Since it is much farther to base level by way of the Willamette River than by way of the Siuslaw River, it is difficult to see how the Willamette River unaided could attain an advantage in gradient and thus capture the stream. However, regional alluviation would have filled the southern Willamette Valley and the Siuslaw Valley to a nearly equal level, thus covering up topography in the valley and existing low drainage-divides and putting the two streams on nearly the same level, where other factors could enter into re-alignment of drainage.

Superimposition.—In some instances present stream alignment may be due to superimposition of the streams from the old alluvial fill upon weak Tertiary strata. Streams are subject to channel shifts during alluviation, and, if the old fill covered the low-lying hills, it might have been at this time that some of the minor stream changes took place. This should have been restricted to the eastern edge of the Coast Range foothills where summit levels were low enough to have been inundated. It may have been from this cause that Spencer Creek was turned northward across the low hills toward the present Fern Ridge Reservoir.

Landslide blocking of the westward channel.—Large landslide blocks of gabbro, a relatively resistant rock, are found in and on top of the alluvial fill in the Elk Creek-Fish Creek divide. The same rock caps the hill on the south sides of the valley at the divide. It is suggested that, if arching was slowly taking place, the headwaters of ancient Long Tom River probably became sluggish. The occurrence of one or more landslides, even though not unusually large, may have been a contributing factor in diversion of the waters to the Willamette River, for the sluggish stream may have lacked the power to cut the material away. Since the Willamette River drainage was separated from that of the Long Tom River by a very low divide, such a landslide may have been the deciding factor.

Age of Long Tom Alluviation and Capture

ALTHOUGH THE PRESENCE of deep fill in the Long Tom system is well established, the time of alluviation and capture is not fully known. The following sequence of events during the late Cenozoic, contributing to defeat of the west-

ward draining Long Tom River, is suggested by the writers with the full knowledge that the history of the river is integrated with that of the whole Coast Range and Willamette Valley. Evidence uncovered in other parts of western Oregon will no doubt throw further light on the solution of this problem.

The summary of events is as follows: (*a*) Deep erosion of the Coast Range during uplift in late Tertiary time, during which time down-cutting by the river kept pace with uplift; (*b*) Alluviation of both the Long Tom and the Willamette valleys during a stage of regional subsidence and alluviation; (*c*) Piracy of the Long Tom River with some later uplift of the Coast Range; (*d*) Erosion and integration of a new river system.

Late Tertiary uplift and erosion.—There has been much erosion of the Coast Range in post Miocene time. A thick cover of sediments has been stripped from the Upper Oligocene sills, which in turn have been intrenched by still later erosion. Remnants of the sills have been uplifted to form the highest peaks in the Coast range (*1*). The Long Tom River, like the Siuslaw and Umpqua rivers to the south, evidently maintained a course to the sea throughout uplift. In this respect the Long Tom River was an antecedent stream. Had there not been an alternate route open, the river would probably still be flowing westward like the main Siuslaw River, for uplift since capture has been but a small fraction of that which took place previously.

The original valley dates from the time of post-intrusive uplift and stripping, but the end of down-cutting and start of alluviation occurred at a later, as yet undetermined, time.

Correlation of Long Tom and Willamette Valley alluviation.—The Long Tom river system, as well as the neighboring Willamette River Valley, shows abundant evidence of a relatively old alluvial filling. This fill is considerably older than the present widespread gravels and is maturely dissected. The base of this fill near the Willamette River may be near or in some cases below sea level, while its known top elevation is about 750 feet at the Elk Creek-Fish Creek divide. It is altogether likely that the fill exceeded even this elevation.

At Alvadore, near the east end of the Fern Ridge Dam, drilling by the Corps of Engineers during the construction of the dam penetrated 188 feet of gravel, sand, and mudstone, the upper part of which was thoroughly decomposed gravels. Although this hole did not reach bedrock, data from nearby

drill holes indicated that bedrock should be encountered about 30 feet deeper. As the hole was started at 357 feet in elevation, the top of bedrock at this point would be about 139 feet above sea level. Drill holes indicated that the surface of the bedrock was dipping valleyward, hence a deeper fill should be encountered to the east.

Similar fill was encountered by the Army Engineers in drill holes at the Thurston Dam site along the lower McKenzie River a few miles to the east, where drilling penetrated alluvial deposits to a point 160 feet below the present river level; although this fill material is in part younger, its existence points to deeply submerged bedrock throughout this general area.

Other exposures of the older valley fill are present in cuts along the Coos Bay branch of the Southern Pacific Railroad and in highway cuts in the vicinity of Veneta and Elmira. Here it is mottled soft pale brownish-yellow claystone with some streaks of gray and occasional tuffaceous pebbles. Nearly continuous outcrops of this series may be seen along the road leading westward from Elmira to Noti and also along the Long Tom River in this same area. When traced westward there is evidence showing that the base is not far below valley level and in the Elk Creek-Fish Creek divide the base of the alluvium is approximately 500 feet in elevation. Exposures of this fill are found near Vaughn in Noti Creek Valley, just north of the junction of the Vaughn spur with the main Coos Bay branch of the Southern Pacific Railroad. At this point the top of the fill is about 100 feet above the creek. However, erosion has probably removed the upper part of the fill.

The most significant fill is found in the old drainage-divide between Elk Creek and Fish Creek, the small tributary of Wildcat Creek, which flows westward to the Siuslaw River. At present, Elk Creek Valley proper, without considering the small tributaries, is little more than 3 miles in length, yet it is very wide when compared with nearby streams, and the creek appears to be underfit in relation to its valley. Dissected alluvial terraces are present along Elk Creek to its head in the present drainage-divide, where the fill thickens to approximately 250 feet. At this point the rock is a soft yellow weathered sandy mudstone with small well-rounded pebbles of sandstone and silt stone and a few tuffaceous pebbles similar in lithology to the Fisher formation. Blocks of gabbro, native to the region, are also included.

On the west side of the divide, a structureless yellow mudstone with some small blocks of sandstone are present. Landslide blocks of gabbro, similar to

that capping the adjoining hills, are more prominent in the upper part of the section. In most cases these blocks and boulders are quite well decomposed and exhibit spheroidal weathering. A particularly large block of gabbro is cut by the headwaters of Fish Creek. Yet the abundance of alluvium a short distance below indicates that the gabbro is on the fill and is not bedrock in place.

The uppermost part of the fill in the divide area has been removed and the fill is partially dissected. Lateritic soil, no doubt the product of a long stage of weathering, is present. Shot soil, caused by limonite-cemented silt particles, is also common, and seams of limonite an inch in thickness were found interbedded with the sediments.

The fine-grained aspect of the alluvial fill points to deposition by relatively sluggish streams. The scarcity of pebbles indicates that fine-grained sediments comprised most of the stream's load. An examination of the alluvial fill shows that its constituents are entirely derived from local rock plus perhaps some consolidated tuff similar to that found in the Fisher formation, the country rock of Coyote and Spencer Creek drainage. Such tuffs are not indigenous to Elk Creek drainage. No pebbles of extrusive or intrusive rocks from the Cascade Mountains were recognized, and, although the writers have considered the possibility that the upper Willamette River drainage as well as the Long Tom may have flowed in this channel, there is nothing in the composition of the fill to support such an idea. Even though no great barrier was known to divide Long Tom drainage from the Willamette then or today, the Willamette River probably tended to pursue a course independent of streams in the western part of the valley as it does today. Any divide that did exist may have been composed of the valley fill described above and similar to that of Fern Ridge, the present low divide, which trends from the Tertiary rock hills on the south to a point north of Alvadore.

Alluviation was undoubtedly a regional event, for weathered terrace deposits comparable to those along the Long Tom River are common in other present day Willamette tributaries. Weathered limonite-streaked claystone and pebble lenses are exposed along the relocated channel of the Long Tom north of the Fern Ridge Reservoir. Similar sediments have been viewed by Howell in the northern part of the Monroe quadrangle about 5 miles due south of Philomath, and sediments very similar in lithology and stratigraphic position were shown to the senior writer by I. S. Allison in railroad cuts on the east edge of Camp Adair.

Such a stage of alluviation was apparently caused by rise in base level, which in turn affected the entire drainage systems of western Oregon. In the Portland region the Troutdale sediments occupy valleys cut in the older Tertiary sediments. The floors of these pre-Troutdale valleys are likewise warped, in some places below sea level. 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. Chaney (*2*) has assigned the Troutdale formation to the Lower Pliocene on the basis of fossil leaves. However, alluviation may have continued for a considerable time and certain deposits may be somewhat younger. Marine Pliocene deposits along the Oregon and Washington coast are generally assigned to the Middle or Upper Pliocene (*3*) and continental sedimentation may have been taking place during the same rise of the sea.

Gravels correlated with glacial stages have been recognized in parts of the Willamette Valley by Allison (*4*). The gravels assigned by him to both the Illinoian and Kansan stages, although weathered on top, are apparently less deformed and perhaps less dissected.

It is conceivable that the sediments of the Long Tom are younger than some of the Troutdale sediments, yet pre-Troutdale valleys with fills equivalent to that of the Troutdale are recognized in many of the valleys of the Cascade Range between the Columbia River and the McKenzie River, and the same prominent stage of erosion and later alluviation may be expected to be present in the Coast Range stream valleys. Thus the older deposits in the Long Tom and adjacent southern Willamette Valley are tentatively correlated with the Troutdale formation and with similar deposits in the Clackamas, Molalla, and North Santiam River valleys which have been correlated with the Troutdale by Lowry and Baldwin (*5*).

Capture of the Long Tom River and later uplift.—The piracy of the Long Tom River probably took place after the stage of maximum alluviation, during which time down-cutting was taking place. Just how much of the original fill in the center of the Coast Range is missing is unknown, but it is likely that during the initial stage of erosion that followed recession of base level, the Long Tom River continued its westward course. Although it is admitted that at that time there was probably an insignificant barrier between the headwaters of the Long Tom and the Willamette-McKenzie river system, it should be noted that that is also the case today. The more rapidly alluviating Wil-

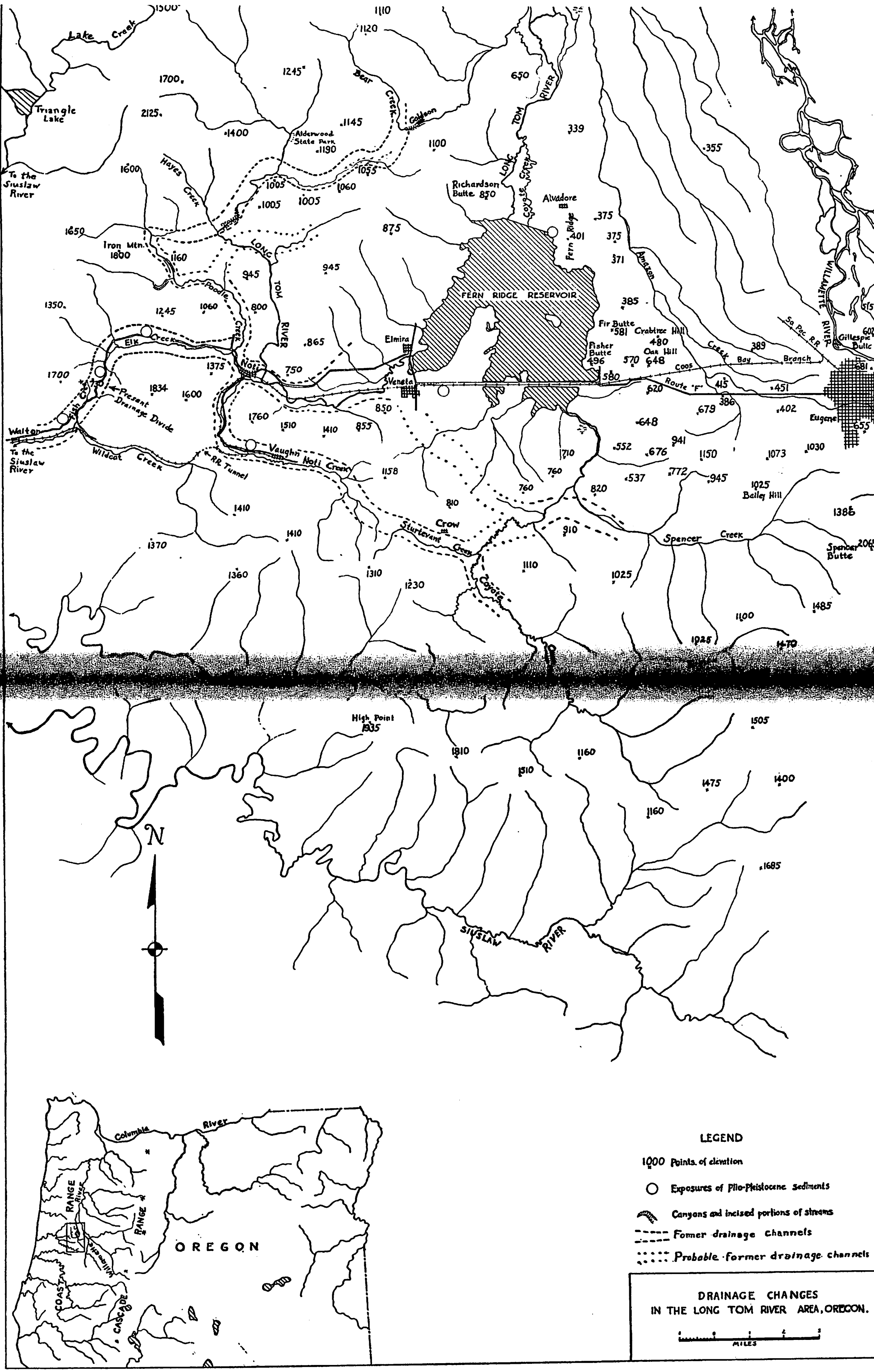
LEGEND
1000 Points of elevation
Exposures of Plio-Pleistocene sediments
Canyons and incised portions of streams
Former drainage channels
Probable former drainage channels
DRAINAGE CHANGES
IN THE LONG TOM RIVER AREA, OREGON.
MILES
Lake Creek
Triangle Lake
To the Siuslaw River
Bear Creek
Alderwood State Park
Hayes Creek
Iron Mtn.
LONG TOM RIVER
Poodle Creek
Elk Creek
Noti
Present Drainage Divide
Walton
Wildcat Creek
RR Tunnel
Vaughn
Noti Creek
Elmira
Veneta
FERN RIDGE RESERVOIR
Richardson Butte
Alvadore
Fern Ridge
Coyote Creek
Amazon
Fir Butte
Crabtree Hill
Fisher Butte
Oak Hill
Coos Bay Branch
Route "F"
So. Pac. R.R.
WILLAMETTE RIVER
Gillespie Butte
Eugene
Bailey Hill
Spencer Creek
Spencer Butte
Crow
Sturtevant Creek
Coyote
High Point
SIUSLAW RIVER
N
Columbia River
COAST RANGE
CASCADE RANGE
OREGON

Figure 1

lamette system tends to repel tributaries in the vicinity of Eugene. It should be noted that Amazon Creek, as well as adjacent minor tributaries, drain slightly away from the Willamette, and no doubt during extreme flood stages Willamette overflow is contributed to the Long Tom. Zimmerman (6) stated that "It is easy to conceive that the Willamette River once ran west from Eugene, followed the channel of the present Amazon slough and flowed down the channel now occupied by the Long Tom River."

Relatively fresh gravels of undoubted Cascade origin are found east and north of Fern Ridge in the valley of Amazon Creek and the Long Tom River, but it will take further work to prove that the Willamette River or former tributaries contributed to the older alluvial fill in the present Long Tom drainage south or west of the Fern Ridge Dam.

The elevation of the base of the alluvial fill in the center of the Coast Range as well as the incision of meanders along the Siuslaw River, no doubt let down from a broad fill of the same stage as that of the Long Tom, points to further uplift of the Coast Range after the stage of maximum alluviation. Uplift of the Coast Range in itself is not enough to explain defeat, for even though not a large stream, the Long Tom should have been able to excavate the relatively soft alluvial fill, in the heart of the Coast Range.

The main Siuslaw has kept pace with the uplift under similar conditions and probably similar volume. Despite the fact that uplift is not the primary cause of capture, it may have been a factor aiding the tributary of the Willamette to capture Long Tom drainage.

Thus it may be that headwaters of the Long Tom and Willamette were separated by a low divide or marshy area and the occurrence of even a small landslide in the narrows in the heart of the Coast Range might have been enough to tip the balance in favor of the Willamette. In case landslides were not involved, the eastward tilting, during uplift, which would tend to produce a sluggish stream may have favored capture by a more vigorous tributary of the Willamette. Overflow of the Long Tom during flood stage may have hastened diversion.

Erosion and integration of a new river system.—In case the Long Tom river system east of the Coast Range divide was reduced in gradient because of eastward tilting, reversal of its drainage by piracy upon a soft alluvial fill would be easily accomplished and the flow from Noti would be eastward along the old Long Tom Valley. Down-cutting would be, and apparently was, much

greater in the heart of the range. Much of the fill was excavated from the Ell Creek portion of the old valley and the gradient of the tributaries from th heart of the Coast Range increased. Thus that part of ancient Bear Creek tha followed the Poodle Creek Channel would not only have its greatest uplif but would also need to cut the deepest in order to keep up. It happened, how ever, to cut beneath its old fill into Coast Range intrusives, the hardest roc in the vicinity. Thus it is not surprising that a tributary from the central chan nel (that of the ancient Long Tom River) cut headward in the softer Tertiar sediments intercepting ancient Bear Creek about 4 miles north of Noti nea the mouth of Hayes Creek before it made the Poodle Creek bend. This too place after ancient Bear Creek had largely stripped its valley of fill and wa cutting on bed rock; only enough time has elapsed to allow the stream to cu slightly more than 50 feet into the Tertiary sediments at the point of piracy

One part of the drainage picture is not clear and that is the former cours of Spencer Creek. If it were a prominent tributary of Coyote Creek, then head ward erosion of a northward flowing stream may have intercepted Spence Creek, reversed the drainage in the lower part of Spencer Creek bringin Coyote Creek with it, and thus diverted the flow northward as it is today. Th greater uplift in the western part of the old Coyote Creek Valley, as well a the presence of gabbroid intrusives between Vaughn and Noti, no doul favored the capture from the north where a low divide of softer Eocene roc could be more easily eroded.

It is also possible that Spencer Creek pursued an independent course nortl westward to join the old Long Tom River at Veneta (Fig. 1). Such a valle is indicated by topography. If this were true, the aluvial fill may have bee deep enough to nearly submerge the divides, allowing drainage patterns forme on the fill to be superimposed, and thus allow a northward flowing stream t capture both the Spencer and Coyote Creek valleys. If this is the case, fill i these valleys has since been largely removed. Of the two hypotheses, the form perhaps would be the simplest interpretation.

Another probable drainage change took place south of the ancient Be Creek capture at the mouth of Hayes Creek (Fig. 1). At this point a broa valley is bisected by the Long Tom River. Through this valley a strea apparently flowed at one time, probably a tributary of ancient Bear Cree which joined it just south of the present Poodle Creek narrows. If so, the Lon Tom tributary, or perhaps a large meander of the main stream, captured th stream previous to its capture of ancient Bear Creek.

Another capture is that of the head of ancient Bear Creek near Goldson by a tributary of the present Long Tom. The stream which is now called Bear Creek drops rapidly to the Willamette Valley by way of Goldson. The creek drops 150 feet in a half mile at Goldson, which distinctly shows that headward erosion has only recently intercepted ancient Bear Creek. The streamless continuation of the former Bear Creek Valley likewise points to recent desertion by the creek.

Down-cutting by the newly integrated Long Tom River is more apparent near the center of the Coast Range where it flows on bedrock, for the broad and still deeply filled portion of the system east of Noti a high base level has prevented its incision and stripping of the soft sediments to bedrock. In this portion of its course it meanders across the old fill which its lateral erosion has kept planed down to near stream level. The present gradient of the Long Tom River east of Noti is not steep enough to cause rapid down-cutting, as is shown by its readiness to overflow the valley during winter floods. Although accurate means of dating the time of diversion is not at hand, the amount of uplift in the center of the range, and down-cutting in the fill and underlying bedrock in Elk and Wildcat creeks, indicates that it could have occurred during the late Pleistocene. Some of the adjustments within the present Long Tom drainage system could be uppermost Pleistocene or Recent.

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Factors in Social Mobility

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For the purpose of this paper, the term "mobility" has been limited in its meaning to the movement of households from one address to another. This includes "migration," which places emphasis upon the general movement of large numbers of people over considerable distances, but it excludes the vertical mobility up and down the social ladder, as employed by Sorokin and others.

The free movement of people over this continent has ever been a characteristic of American life. Migration helped create the frontier, populate territories, and bring new states into the Union. It has been connected with most of the great historical events in our country for more than three centuries and it still plays an important role on the national stage. The motives for migration have changed; the movement has taken different forms; and the total volume has fluctuated with conditions; but millions of Americans are perennially on the move, and there is no indication that they will soon settle down.

Access Across State Lines a Vital Freedom

Historians like Frederick Jackson Turner have given migration prominent place in the American scene. It was a prerequisite to national expansion. It called for the building of homes, communities, industries, states, all of which built a nation. The westward movement, characterized as it was by prairie schooners, Indian wars, cowboys, and pioneers, has contributed enough