

Evidence for Regional Stream Aggradation in the Central Oregon Coast Range during the Pleistocene–Holocene Transition

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Low, nearly continuous terraces of similar age are present along streams in drainage basins that range in size from Drift Creek (190 km²) to the Umpqua River (11,800 km²) in the Oregon Coast Range. Radiocarbon ages from near the base of fluvial sediments underlying these terraces are clustered at about 9000–11,000 ¹⁴C yr B.P. Beveled bedrock surfaces (straths) that underlie the fluvial sediments are 1–8 m above summer stream levels and are present along most of the nontidal reaches of the rivers that we studied. Where exposed, the bedrock straths are overlain by 2–11 m of fluvial sediment that consists of a bottom-stratum (channel) facies of sandy pebble–cobble gravel and a top-stratum (overbank) facies of sandy silt or silt. Eight radiocarbon ages from the fluvial sediments allow correlation of the lowest continuous terrace over a wide area and thus indicate that a regional aggradation episode occurred in Coast Range drainage basins during the Pleistocene–Holocene transition. The cause of such widespread aggradation is unknown but may be related to climate-induced changes in the frequency of evacuation of colluvium from hollows, which are common in all drainage basins in the region.

INTRODUCTION

Fluvial terraces are poorly preserved in the central Oregon Coast Range, a rugged, deeply dissected mountain range of moderate elevation (highest elevations <1250 m) in western Oregon. The streams that we examined (Umpqua River, Siletz River, Smith River, Siuslaw River, and Drift Creek; Fig. 1) are mostly entrenched in deep, V-shaped valleys. Valley morphology and a lack of characteristic glacial landforms in the highest parts of the range indicate that the Coast Range probably was not glaciated in the late Pleistocene (e.g., Porter *et al.*, 1983). Most of the region examined in this study is underlain by a thick sequence of arkosic sandstone and siltstone of the Eocene Tyee Formation, and minor mafic volcanic and

intrusive rocks of Eocene and Oligocene age (Walker and Duncan, 1989; Walker and MacLeod, 1991).

In most nontidal reaches, Coast Range streams are flowing on bedrock channels or thin alluvial beds bordered by narrow beveled bedrock surfaces (modern straths) that lie within ± 20 cm of low water (summer) stream levels. The modern flood plains of these streams are usually confined to the active channel and associated bedrock straths by steep-walled terrace risers which are only occasionally reoccupied during large floods.

Small terrace remnants are preserved from less than a meter to over 200 m above modern stream levels in this region, but only a single widespread, nearly continuous, 6- to 15-m-high terrace is present in the basins that we examined. The presence of this low-elevation, regionally extensive terrace is the incentive for this study. Prior to our investigations, no age data existed for the 2- to 11-m-thick sediments that underlie this terrace. Because the terrace appears to be present along most Coast Range rivers, one of our primary objectives was to determine whether the underlying sediments were of the same age. Furthermore, we wanted to evaluate the possibility that deposition of these alluvial sediments overlapped in time with the age of evacuation of sediment from hillslope hollows in the region. Several workers (Reneau *et al.*, 1986, 1990) have discussed evidence of episodic evacuation of sediment from hollows, but we have found very few reported examples (e.g., Rypins *et al.*, 1989) where fluvial deposits have been temporally linked to periods of hollow evacuation. Such a temporal linkage over a large geographic area would be revealing because it implicates climatic forcing as a mechanism for regional episodes of hillslope erosion coupled with channel aggradation.

The purpose of this paper is to describe the stratigraphy, distribution, and age of the fluvial sediments that underlie the youngest regionally extensive terrace along

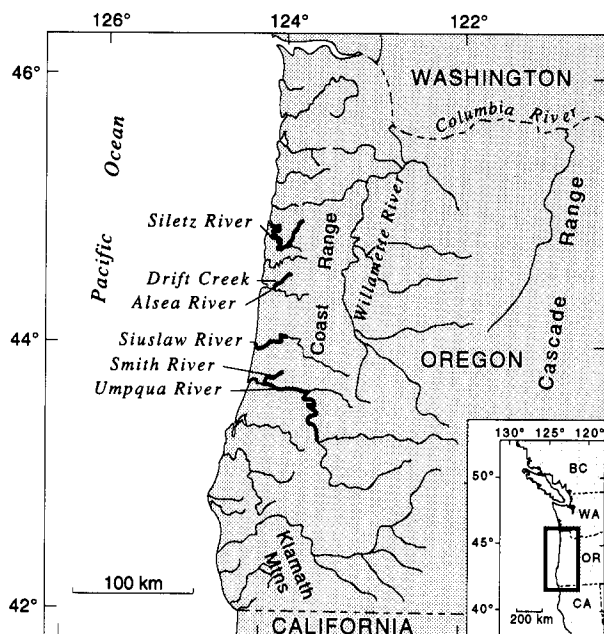


FIG. 1. Map showing the location of major rivers in the central Oregon Coast Range. Heavier lines mark reaches of rivers examined in this study.

several rivers in the central Oregon Coast Range. Our ^{14}C age determinations from the bottom stratum and lower to middle top stratum sediments indicate that an aggradation episode of regional extent began during the Pleistocene-Holocene transition and that the main part of this aggradation event was of relatively short duration. Although documentation of this episode is the main theme of the paper, we also speculate about possible causes of stream aggradation in the region.

RADIOCARBON DATING

Small quantities of detrital charcoal are present in the sediments underlying the lowest Coast Range terraces, and radiocarbon dating of such materials is our primary means of correlating fluvial sediments between basins. Most of our samples are collections of small (2–10 mm) fragments of detrital charcoal of unknown species (Table 1). We recognize that small samples of fluvial detrital charcoal can include older reworked carbon (e.g., Blong and Gillespie, 1978; Nelson *et al.*, 1988), but Personius (1993) reported that inclusion of younger carbon such as burned or decayed roots, rather than the reworking of older charcoal, is a much more common problem with radiocarbon samples from fluvial sediments in the Oregon Coast Range. Thus, we assume that the ages in Table 1 closely approximate the age of tree death, although some unknown but probably insignificant amount of time elapsed between death and deposition of the samples with fluvial sediment.

Most of the radiocarbon ages listed in Table 1 have been dendrochronologically corrected to calibrated years, using the calibration curves of Stuiver and Reimer (1986) or Becker *et al.* (1991, Fig. 1); two ages from Drift Creek were too old for these curves, therefore data from Stuiver *et al.* (1991, Table 1) were used to calibrate these ages. We used an error multiplier (Stuiver and Pearson, 1986; Long, 1990) of 2, because the results of recent interlaboratory comparisons (e.g., Scott *et al.*, 1990) of internal (systematic) and external (interlaboratory reproducibility) errors show that the quoted errors from most radiocarbon laboratories do not adequately describe the true errors associated with radiocarbon ages. The laboratories we used did not provide such multipliers, thus our choice is based on interlaboratory results that indicate that a value of 2 will account for the internal errors of most laboratories, although the external errors may be somewhat higher. In Table 1 we report our calibrated ages as ranges defined by two standard deviations (Stuiver and Pearson, 1986) and also list the midpoints for comparison. If our assumptions about dating errors are correct, then there is a 95% probability that the true ages of our samples lie within the calibrated age ranges listed in Table 1. In the following discussions, we report the uncalibrated ^{14}C ages with the laboratory-reported 1σ errors.

LOW TERRACES IN THE CENTRAL OREGON COAST RANGE

Setting

Upstream from tidal influence, a single widespread, nearly continuous terrace is present 6–15 m above stream level and is underlain by a beveled bedrock (strath) surface that is 1–8 m above the modern strath that flanks the present channel. The terrace is usually unpaired and is more commonly preserved on the insides of meander bends. Where exposed, the sediments underlying the terrace and overlying the bedrock strath are 2–11 m thick and consist of a bottom-stratum (channel) facies of clast-supported cobble-pebble gravel and a top-stratum (overbank) facies of sandy silt or silt (nomenclature of Brakenridge, 1984). The beveled bedrock strath underlying the lowest continuous terrace is the only fluvially cut bedrock surface that is extensively preserved in the Oregon Coast Range, and thus it is the only such strath surface that can be readily correlated among basins in this region.

Downstream from the head of tidewater, the terrace surface is lower (<6 m above summer stream level) and is underlain by sequences of sand, silt, and peat that may be tens of meters thick. Terrace characteristics in the zone of tidal influence may be related to post-18,000 yr B.P. eustatic sea-level rise, therefore we concentrated our investigations on upstream reaches where base level con-

TABLE 1
Radiocarbon Ages of Samples from Fluvial Sediments, Oregon Coast Range

Field site	Laboratory sample number ^a	Latitude and longitude	Geologic material and sample weight (g)	Age and 1 σ lab error (¹⁴ C yr B.P.)	Calibrated age range, midpoint, and source (cal. yr B.P. at 2 σ and error multiplier of 2) ^b	Remarks
Umpqua River						
McGee Creek 1	BETA-27962	43° 31.45'N 123° 32.54'W	Charcoal 5.0	9120 \pm 150	9370–10,570 9970 (B)	Collection of many small fragments from silty interbed in bottom-stratum facies.
McGee Creek 2	BETA-22662	43° 31.44'N 123° 32.21'W	Charcoal 3.0	9800 \pm 410	9280–12,560 10,920 (B)	Single fragment from middle of top-stratum facies.
Elkton	AA-2752	43° 38.00'N 123° 34.11'W	Charcoal 0.24	8630 \pm 100	9100–9900 9500 (B)	AMS age on several small fragments from middle of top-stratum facies.
Elkton	USGS 2643	43° 38.00'N 123° 34.11'W	Charcoal 1.0	730 \pm 80	—	Collection of many small fragments from upper part of top-stratum facies.
Siletz River						
Logsdan	BETA-27966 (ETH-4488)	44° 44.63'N 123° 47.76'W	Charcoal 0.3	9030 \pm 110	9480–10,360 9920 (B)	AMS age on several small fragments from base of top-stratum facies.
Siletz	GX-15311	44° 43.79'N 123° 55.42'W	Charcoal 3.0	9695 \pm 440	9100–12,620 10,860 (B)	Collection of many small fragments from base of top-stratum facies.
Drift Creek						
Lower Drift Creek	GX-18330	44° 27.96'N 123° 57.65'W	Charcoal 0.4	10,620 \pm 140	11,360–12,480 11,920 (S)	AMS age on several small fragments from base of top-stratum facies and top of bottom-stratum facies.
DC Meadows 1	BETA-34396	44° 30.73'N 123° 50.01'W	Wood	260 \pm 70	—	Fragment of 20-cm diameter log from organic layer in channel cut in top-stratum facies.
DC Meadows 2	BETA-34397	44° 30.75'N 123° 50.00'W	Charcoal	9580 \pm 120	10,030–10,990 10,510 (B)	Collection of many small fragments from sandy bottom-stratum facies.
DC Meadows 3	BETA-34398	44° 30.66'N 123° 49.99'W	Charcoal	10,710 \pm 330	10,690–13,300 12,010 (S)	Collection of many small fragments from bottom-stratum facies.
Siuslaw River						
Firo	BETA-27967 (ETH-4489)	44° 03.72'N 123° 52.98'W	Charcoal 0.2	7010 \pm 90	7490–8130 7810 (SR)	AMS age on several small fragments from base of top-stratum facies; site is 2 km above head of tide.

^a Radiocarbon laboratory abbreviations: AA, University of Arizona/NSF Accelerator Facility; BETA, Beta Analytic, Inc., Coral Gables, Florida; ETH, Eidgenossische Technische Hochschule, Zurich (through Beta Analytic); GX, Geochron Laboratories, Cambridge, Massachusetts; USGS, U.S. Geological Survey, Menlo Park, California Radiocarbon Laboratory.

^b Sources of calibration: B, Becker *et al.* (1991, Fig. 1); S, Stuiver *et al.* (1991, Table 1); SR, Stuiver and Reimer (1986).

trol probably did not have a major impact on stream aggradation (McDowell, 1987; Personius, 1993).

In the following discussions, we have termed the youngest and lowest regionally extensive terrace along Oregon Coast Range rivers the "lowest terrace" ("PHT" terrace of Personius, 1993), even though a few younger, discontinuous terrace remnants are inset within the low-

est terrace fill along parts of most Coast Range rivers. The beveled bedrock surface that underlies the bottom stratum sediments is a fluvially cut strath. We do not know if the cutting of this strath and the deposition of the bottom-stratum sediments was contemporaneous because our radiocarbon ages are from the overlying sediments and do not directly date the strath-cutting event.

Thus, our primary focus in this paper is on the timing and regional extent of the depositional episode that left the bottom stratum and lower top stratum deposits, but we recognize that the age of cutting of the underlying bedrock strath may or may not be of the same age.

Umpqua River

The Umpqua River drains the largest basin we examined (11,800 km²; Oregon State Water Resources Board, 1958) and is the only river whose headwaters extend east of the Coast Range into the Cascade Range of west-central Oregon (Fig. 1). Although older fluvial terraces are relatively poorly preserved along the Umpqua River, remnants of the lowest terrace are almost continuously present along the lower 200 km of the river (Fig. 2). Above tidal influence (head of tide), the lowest terrace is 8–15 m above river level and the underlying bedrock strath lies 1–4 m above the modern strath that is adjacent to the present channel. The terrace is commonly unpaired and is usually narrow (<600 m wide), and discontinuous younger terraces are inset into it (Fig. 2).

Numerous examples of the lowest terrace are present on the upper reach of the Umpqua River. Near McGee Creek at river km 120, the lowest terrace is expressed as an unpaired, 200-m-wide surface on the south side of the river that lies 13–15 m above river level. The sediments underlying this terrace are visible in one of the longest continuous exposures of fluvial terrace sediments on the lower 200 km of the Umpqua River (Fig. 3). The morphology of the 100-m-wide, 1-km-long exhumed section of the underlying bedrock strath visible in the center of Figure 3 is quite variable; the surface is flat where the strath is cut on massive sandstone, but shallow channels and numerous other irregularities are present where the strath is developed on bedded siltstone and sandstone.

We examined two exposures of the lowest terrace at two sites about 500 m apart near McGee Creek. These

exposures revealed a consistent fluvial stratigraphy consisting of a bottom-stratum facies of sandy pebble and cobble gravel overlain by a top-stratum facies of fine sandy silt (Fig. 4). Charcoal samples from these two sites yielded conventional radiocarbon ages of 9800 ± 410 yr B.P. (BETA-22662) and 9120 ± 150 yr B.P. (BETA-27962). The older radiocarbon age was obtained for a single charcoal fragment from the upper half of the silty top-stratum deposits, and the younger radiocarbon age was obtained for a collection of small pieces of charcoal from a silty interbed in the bottom-stratum gravel. The ca. 700-yr age difference between these two samples may be an indication of the accuracy of radiocarbon dating detrital charcoal samples from such settings, but the difference may not have much significance because the calibrated ages do not differ at the 2σ level (Table 1).

A less-well-exposed section of the sediments underlying the lowest terrace was examined near Elkton at river km 77.5, about 200 m downstream from the highway bridge across the Umpqua River. Here the lowest terrace is paired, about 500 m wide, and lies 11–13 m above river level. The stratigraphy of the upper 8 m of sediment visible in the Elkton exposure is similar to that in exposures at McGee Creek (Fig. 4): 5–7 m of silty top-stratum sediment, with thin stringers of sandy pebble gravel, overlies more than 2 m of bottom-stratum sediment consisting of sandy pebble and minor cobble gravel. Two radiocarbon ages were obtained for charcoal from the top-stratum facies in the Elkton exposures. Small fragments of charcoal from the middle of the top-stratum facies yielded an AMS radiocarbon age of 8630 ± 100 yr B.P. (AA-2752). A second, conventional radiocarbon age of 730 ± 80 yr B.P. (USGS 2643) was obtained for charcoal fragments from the upper part of the top-stratum facies.

Our radiocarbon results at McGee Creek and Elkton (Fig. 4) appear to indicate that little (if any) time elapsed between deposition of the bottom-stratum and most of

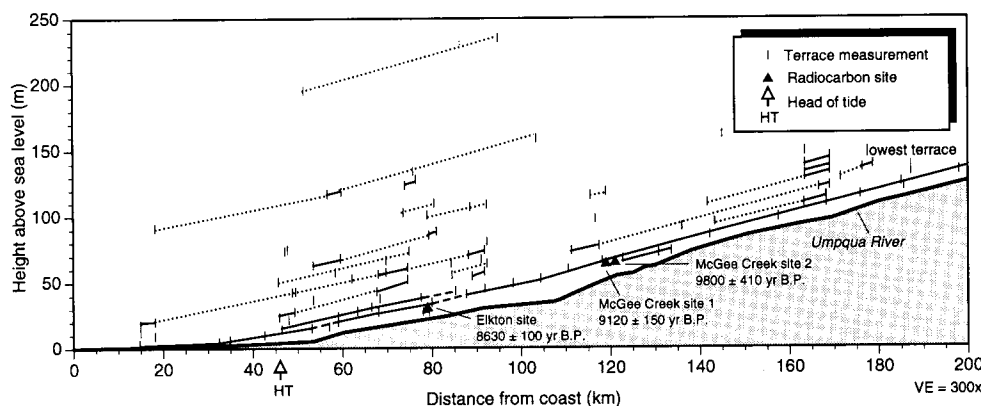


FIG. 2. Longitudinal profile of terraces along the lower reach of the Umpqua River. Heavier solid line is elevation of the Umpqua River, and lighter solid lines connect terraces that can be physically correlated; dashed lines connect terraces that are probably correlative, and dotted lines are speculative correlations. Terrace heights may have vertical errors of ± 5 m for the higher terraces and ± 2 m for the lower terraces.

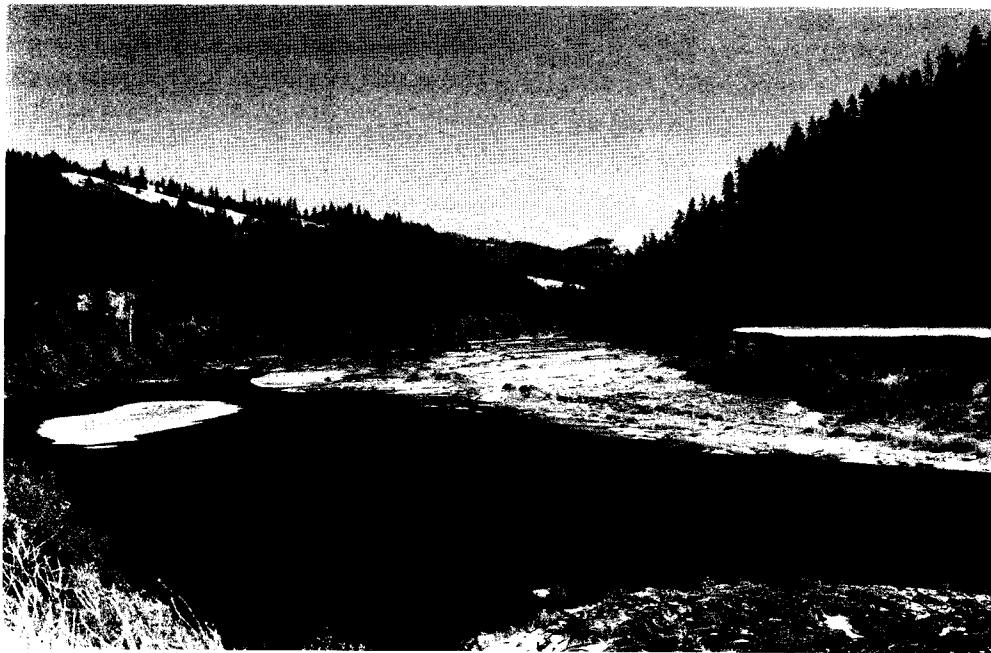


FIG. 3. Photograph of lowest continuous terrace at about river km 120 on the Umpqua River near McGee Creek; McGee Creek site 2 is located at right edge of photograph. Note extensive exhumed bedrock strath to the left of the terrace and in the foreground.

the top-stratum facies underlying the lowest terrace at these sites. Following calibration, the three early Holocene radiocarbon ages are nearly indistinguishable at 95% confidence intervals (Table 1). These similar ages and the fact that we found very few buried soils or other indications of unconformities in the exposures we examined support the conclusion that most of the sediment underlying the lowest terrace is about the same age. The late Holocene age from near the top of the section at the Elkton site indicates that, in most places, perhaps only the upper meter or so of the top-stratum facies may have been deposited during flooding events that briefly reoccupied the lowest terrace in late Holocene and historic time.

Siletz River

The Siletz River drains a basin of about 800 km² (Oregon State Water Resources Board, 1965), and is located about 100 km north of the Umpqua River (Fig. 1). As with other Coast Range rivers, terraces generally are poorly preserved along the Siletz River, but the lowest nearly continuous terrace, about 2–15 m above river level, is well preserved from about river km 86 downstream to the coast (Fig. 5). Upstream from river km 86, the Siletz River flows on volcanic rocks, rather than on sandstone and siltstone of the Tye Formation (Snively *et al.*, 1976), through a narrow canyon called Lower Gorge. Terraces are rare in the gorge because the more resistant bedrock may have prevented the lateral incision necessary to form extensive bedrock straths (Personius, 1993).

Downstream from Lower Gorge, accordant radiocarbon ages at two sites were obtained from fluvial sediments underlying the lowest terrace. These ages and the nearly continuous presence of the lowest terrace along the Siletz River indicate that this terrace may correlate with the lowest terrace on the Umpqua River.

Several good exposures of fluvial sediments are present in an abandoned quarry near Logsdon at river km 78.5. The lowest terrace at this site is about 15 m above river level. In a quarry-wall exposure, several meters of top-stratum silt overlies more than 2 m of bottom-stratum sandy gravel (Fig. 6). Several small fragments of charcoal from near the base of the sandy silt in this exposure yielded an AMS ¹⁴C age of 9030 ± 110 yr B.P. (BETA-27966, ETH-4488). Bedrock was not exposed at the sample site, but exposures of the bedrock strath are present near the northern edge of the gravel pit at a height of 7–8 m above river level.

A similar exposure of fluvial sediment underlying the lowest terrace is present near river km 60, 1 km northwest of the town of Siletz (Fig. 6). The town of Siletz lies in a broad, 1- to 2-km-wide meander belt in which the river has incised into the lowest terrace, which here lies about 13 m above river level. Here a 4-m-thick top-stratum facies of fine to medium sand and thin sandy silt interbeds overlies about 1.5 m of bottom-stratum facies sandy pebble and cobble gravel. A collection of small fragments of charcoal from near the base of the top-stratum sand yielded a conventional radiocarbon age of 9695 ± 440 yr B.P. (GX-15311).

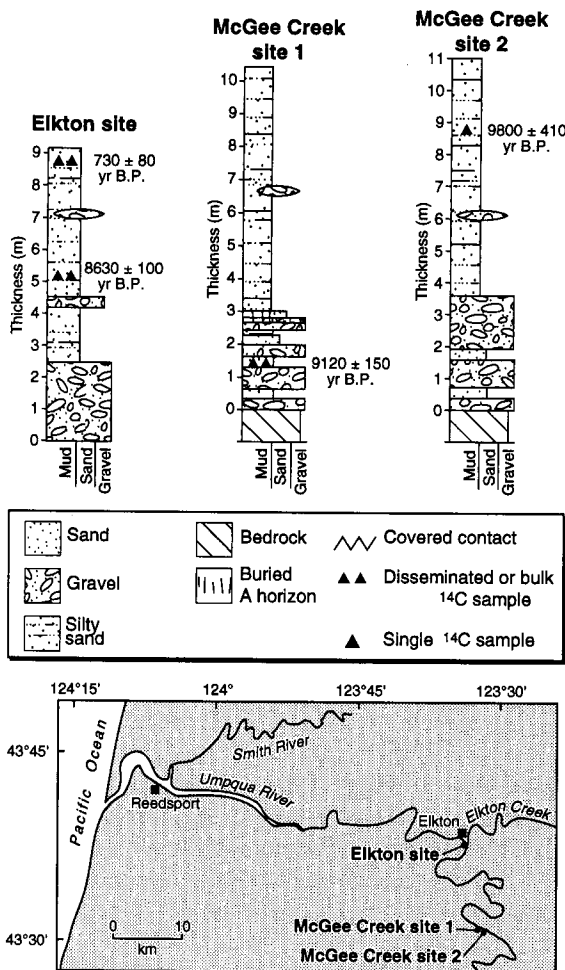


FIG. 4. Stratigraphic columns of fluvial sediments underlying the lowest continuous terrace along the Umpqua River at the McGee Creek and Elkton sites (locations on map). Legend shows patterns and labels for all stratigraphic columns in this report. Columns show complete exposures of terrace sediments, from the bedrock strath to the terrace surface, except where bedrock is not shown at the base of the column.

Drift Creek

An extensively preserved low terrace also is present in the 190 km² Drift Creek basin (Fig. 1). We examined the terrace and the nature of the underlying fluvial sediments in detail at Drift Creek Meadows and Swinford Meadows (Grabau, 1990), and in less detail at a third site on lower Drift Creek. These sites are 36.5, 33.5, and 14 km, respectively, above the confluence of Drift Creek with Alsea River (Fig. 7A). The Lower Drift Creek site is located on the lowest of a well-preserved flight of terraces near the confluence of Trout Creek. Both of the upper Drift Creek sites, Drift Creek Meadows and Swinford Meadows, are single terrace remnants preserved on the insides of meander bends. As with most Coast Range terraces, these terraces slope gently toward the channel and in the downstream direction. At the Drift Creek and Swinford Meadows sites, Drift Creek is incised about 1 m

below the beveled bedrock surface on which the fluvial sediments are deposited; at the Lower Drift Creek site, Drift Creek is incised about 3 m below the bedrock strath.

We conducted extensive hand-auger surveys at Swinford Meadows and excavated six trenches along auger core lines at Drift Creek Meadows (Figs. 7B and 7C) in order to assess lateral and longitudinal stratigraphic variations in the top- and bottom-stratum facies. These stratigraphic studies provide a better picture of the three-dimensional architecture of the fluvial sediments underlying the lowest terrace than at most of our sites on other Coast Range rivers.

The stratigraphy of fluvial sediments on Drift Creek (Figs. 7 and 8) is similar to that at other sites we examined in the Oregon Coast Range. The top-stratum facies consists of massive silt, clay, sandy silt, and silty, fine to medium sand. The top-stratum thickness is 0.4–1.3 m and averages about 0.8 m at the two meadows sites on upper Drift Creek, but increases to about 3 m at the Lower Drift Creek site. Although the top-stratum thickness is variable over distances of a few meters, we found no evidence of increasing or decreasing trends in thickness across the terraces. The bottom-stratum facies lies directly on the beveled bedrock surface and consists of grain- to matrix-supported, subrounded to rounded flat pebbles and cobbles, and massive, fine to coarse sands. In all cases, a basal pebble or cobble layer fines upward to sand. The upper surface of the bottom-stratum gravels is irregular (Fig. 8), and the contact with the top-stratum facies is generally sharp. In the six trench excavations, the bottom-stratum thickness is 0.9–1.9 m and averages about 1.6 m; where discernible, individual beds within the bottom-stratum facies are 0.2–0.4 m thick. At the Lower Drift Creek site, the bottom-stratum thickness decreases to about 0.5 m. At all sites, bedding was only observed in the gravelly sediment in the lower facies. If bedding was once present in the finer sediments of both facies, then it has subsequently been obscured by mottling or bioturbation.

We obtained three radiocarbon ages from trench excavations at the Drift Creek Meadows site and one age from the Lower Drift Creek site. Small fragments of detrital charcoal from a stream bank exposure at the Lower Drift Creek site yielded an AMS ¹⁴C age of 10,620 ± 140 yr B.P. (GX-18330). Two of the three radiocarbon samples from Drift Creek Meadows yielded similar ages. Detrital charcoal fragments in coarse sands 5–10 cm above the bedrock strath in trench T2 yielded an age of 9580 ± 120 yr B.P. (BETA-34397), and we obtained an age of 10,710 ± 330 yr B.P. (BETA-34398) for charcoal from the basal gravel 0.4 m above the strath in trench T3. A third age of 260 ± 70 yr B.P. (BETA-34396) was obtained for a 20-cm-diameter log deposited within an organic-rich layer in trench T1, only 10 m from the active channel at Drift Creek Meadows. The organic layer, which lies uncon-

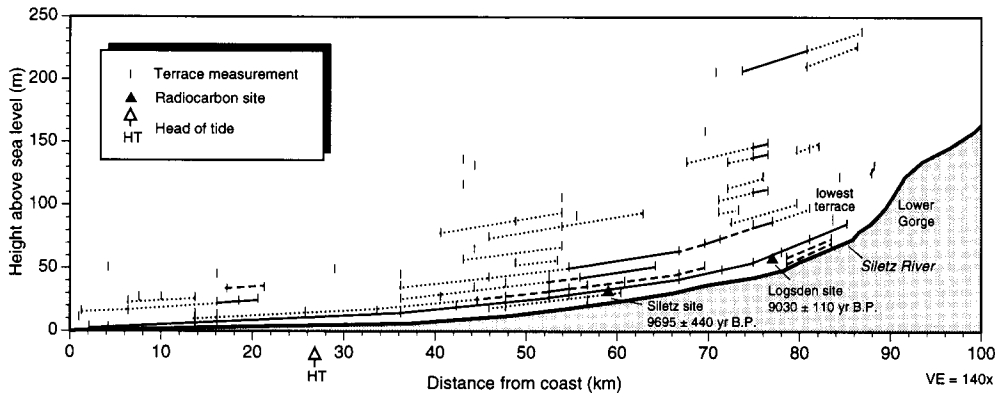


FIG. 5. Longitudinal profile of terraces along the lower reach of the Siletz River. Line conventions are the same as in Figure 2.

formably over truncated, bedded sands (Fig. 8), was traced for 40 m with auger holes from the terrace edge toward the interior, where it pinched out at the surface. This organic layer apparently accumulated in a shallow, recently filled channel inset below the surface of the lowest terrace, adjacent to the active channel of Drift Creek.

Drift Creek Meadows is the only site where trench excavations allowed us to examine exposures of the fluvial sediments across the entire width of the terrace. Such exposures aided in determining whether the bottom-stratum sediments were progressively deposited as the channel slowly migrated to the outside of the meander. We observed no sedimentologic evidence, such as cross-stratification in the bottom-stratum facies or systematic cross-valley changes in degree of oxidation, that would indicate incremental channel widening and progressive deposition toward the meander bend. The locations of the two basal ¹⁴C ages from the bottom-stratum facies at Drift Creek Meadows are on opposite sides of

the strath surface (Fig. 7C), but after calibration, these ages are indistinguishable at 95% confidence intervals (Table 1). Thus, our data do not support the hypothesis of slow outward migration and subsequent deposition but rather support the alternative interpretation that Drift Creek was capable of mobilizing sediment over the entire width of the cut strath; deposition subsequently occurred over the whole strath at about the same time.

Smith River

The Smith River, one of the largest tributaries of the Umpqua River, has a drainage area of about 900 km² (Oregon State Water Resources Board, 1958), and enters the Umpqua River about 18.5 river km from the coast (Fig. 1). Fluvial terraces on the Smith River are less well preserved than terraces along the Umpqua River; most terrace remnants are small and localized on the insides of meander bends, but several flights of terraces are better

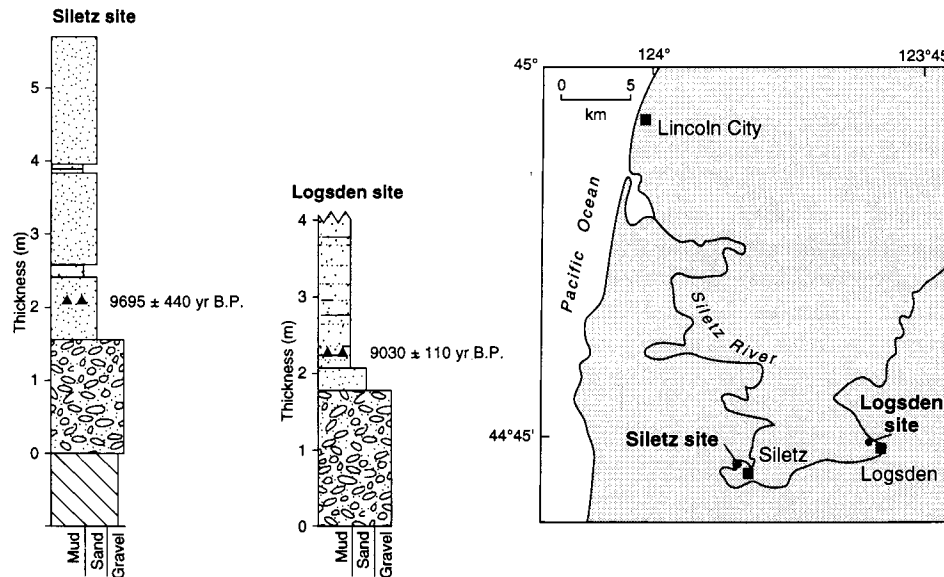


FIG. 6. Stratigraphic columns of fluvial sediments underlying the lowest continuous terrace along the Siletz River at the Logsdan and Siletz sites (locations on map). See legend in Figure 4 for explanation of symbols and patterns.

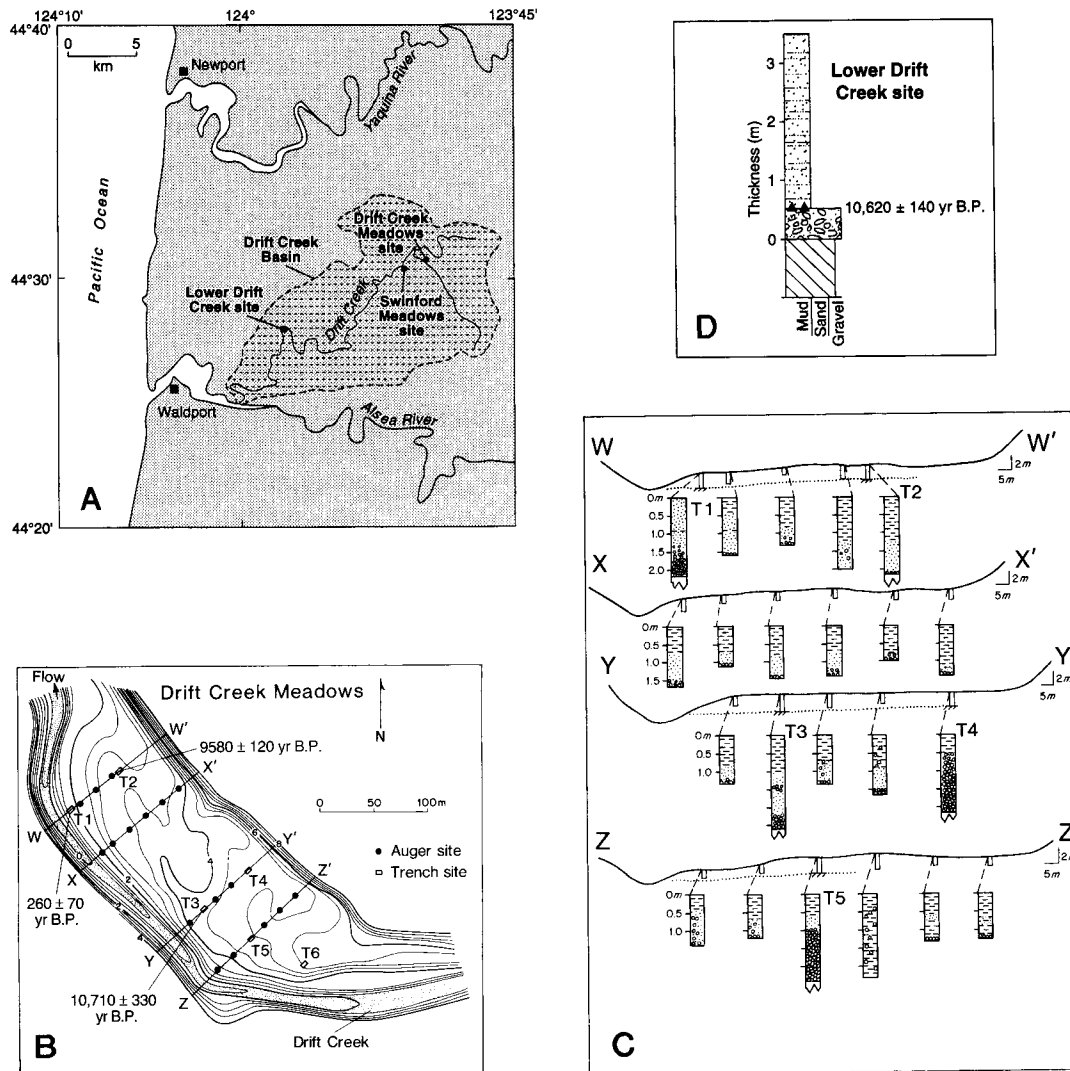


FIG. 7. Maps and stratigraphic columns from the Lower Drift Creek and Drift Creek Meadows sites on Drift Creek. (A) Location map. (B) Topographic map of the Drift Creek Meadows site; contour interval is 0.5 m above an arbitrary datum. (C) Cross sections of the Drift Creek Meadows terrace. Stratigraphy in cross sections is from auger investigations (short columns) and trench investigations (longer columns labeled T1 through T5). Cross-section patterns: dashed pattern, silt; stippled pattern, sand; pebble pattern, pebbles and cobbles; diagonal line pattern, sandstone bedrock observed in stream and trench exposures; dotted line, contact between bedrock strath surface and overlying fluvial sediments, in places extrapolated from trench and stream exposures. Depth of auger holes was limited by inability of auger to penetrate gravel, thus for auger columns, only the thickness of the top-stratum facies was determined. (D) Stratigraphic column of fluvial sediments underlying the lowest terrace at the Lower Drift Creek site. See legend in Figure 4 for explanation of symbols and patterns.

preserved in abandoned meander bends on the lower 60 km of the river (Personius, 1993). A 2- to 10-m-high, mostly continuous terrace can be physically correlated along most of the lower Smith River. The height and continuity of this terrace and the nature of the underlying fluvial sediments are similar to those of the lowest terraces on the Umpqua and Siletz Rivers and Drift Creek, but no radiocarbon ages have been obtained from the Smith River terrace above the tidal limit.

Siuslaw River

The Siuslaw River has a drainage basin of about 2000 km² (Oregon State Water Resources Board, 1965) and is

located about 35 km north of the Umpqua River (Fig. 1). Extensive older fluvial terraces, 70–120 m above river level, were recognized by Baldwin (1956), Schlicker and Deacon (1974), and Personius (1993) along the lower (tidal) reach of the Siuslaw River. Below the higher terraces, a nearly continuous low terrace is present at about 2–10 m above river level along the lower 50 km of the river. This terrace, which is narrow (<200 m wide) and unpaired above the tidal limit, converges downstream and eventually merges with salt marshes near the coast. The height and continuity of this terrace and the nature of the underlying fluvial sediments are similar to those of the lowest terraces on the Umpqua and Siletz Rivers and Drift Creek.

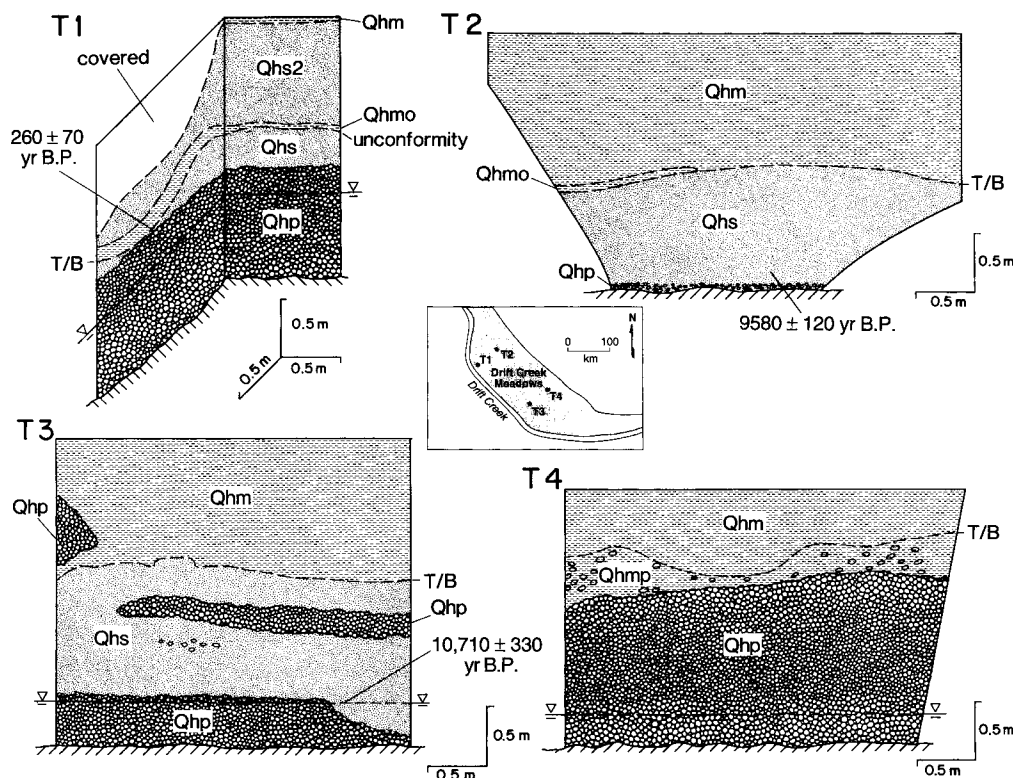


FIG. 8. Logs of trenches T1 through T4 excavated at the Drift Creek Meadows site. Units: Qhp—poorly sorted, well-rounded pebbles and cobbles, generally in a matrix of fine to coarse sand; Qhs—massive to laminated, light-brown to orange, mottled fine sand; Qhs2—massive, light-brown fine sand that coarsens downward to laminated, medium to coarse sand; Qhmp—massive light-brown and orange mottled silt and sandy silt with abundant rounded flat pebbles and cobbles; Qhmo—dark-brown silt, clay, and sandy silt with abundant wood and organic matter; Qhm—massive, medium- to dark-brown silt and sandy silt with sparse rounded flat pebbles. T/B denotes location of contact between top- and bottom-stratum deposits, diagonal line pattern denotes bedrock, and inverted triangles denote water table level.

A single radiocarbon age of 7010 ± 90 yr B.P. (BETA-27967, ETH-4489) was obtained for small fragments of charcoal from fluvial sediments underlying the low terrace about 38 km upstream from the mouth of the Siuslaw River near Firo (Personius, 1993). The charcoal was sampled near the base of sandy top-stratum sediment that overlies about a meter of bottom-stratum sandy gravel at this site. This age is slightly younger than other ages from sediments underlying the lowest terraces in the Coast Range (Table 1), but these ages may not be directly comparable because the Siuslaw River sample site is located only 2 km above the head of tide. This apparently anomalous age may indicate a eustatic sea-level control on fluvial sediment aggradation in locations near the present tidal limit of Coast Range streams.

DISCUSSION

An extensive, nearly continuous fluvial terrace that lies 6–15 m above river level (the “lowest terrace”) is present above the tidal limit in all drainage basins that we investigated in the central Oregon Coast Range. Radiocarbon ages of detrital charcoal from the sediments underlying this terrace support regional correlation of these sediments in at least three drainage basins. Eight latest

Pleistocene–earliest Holocene ages from the Umpqua, Siletz, and Drift Creek basins are nearly indistinguishable at 95% confidence intervals (Table 1, Fig. 9). Most of the sediment underlying these terraces appears to have been deposited during a few thousand years spanning the Pleistocene–Holocene transition. The regional occurrence of sediments of this age range is significant because such widespread distribution makes it less likely that local perturbations in sediment supply or discharge, such as forest fires, localized flooding, and temporary damming by landslides or large accumulations of organic debris, could have caused aggradation on a regional scale.

The consistent ages and widespread distribution of fluvial sediments underlying the lowest terrace indicate that an aggradation episode of regional extent was initiated in latest Pleistocene time, but the large error intervals for our limited radiocarbon ages (Table 1, Fig. 9) prevent us from determining the precise duration of this episode. Our oldest radiocarbon ages, from sediments underlying the lowest terrace on Drift Creek (Figs. 7 and 8), yielded calibrated ages of about 12,000 yr B.P. This age may be a reasonable estimate for the time of initial aggradation. The termination of the episode is also poorly constrained, but radiocarbon ages at two sites on the Umpqua River (Fig. 4) indicate that all of the bottom-stratum and at least

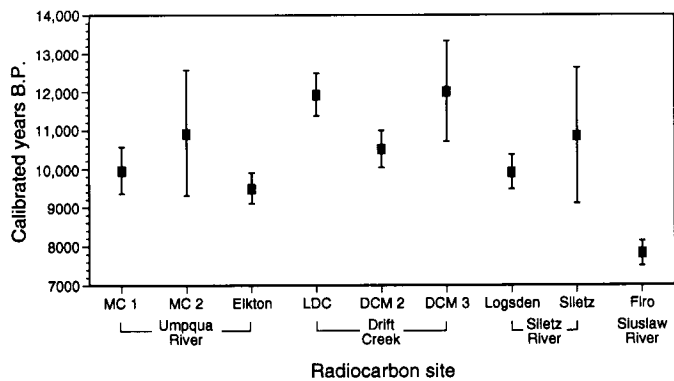


FIG. 9. Radiocarbon ages in calibrated years B.P. from basal fluvial sediments underlying the lowest continuous terrace along several Coast Range streams. Calibrated age midpoints are shown as filled squares; error bars are 2σ (95%) confidence intervals, calculated with a lab error multiplier of 2. See Table 1 and text for calibration sources.

half of the top-stratum sediments were deposited by about 9000 yr ago. Only a few middle and late Holocene radiocarbon ages have been obtained from upper parts of the top-stratum facies in discontinuous terraces inset into the lowest terrace (Personius, 1993). Thus, we infer that accretion of the top-stratum facies continued by over-bank deposition during infrequent flooding events throughout the Holocene, but probably at a much reduced rate since about 9000 yr ago.

The most likely controls on the onset of regional aggradation are climate-induced changes in sediment supply or stream discharge, and aggradation induced by eustatic rise in sea level. Tidal reaches of Coast Range streams were certainly affected by the late Pleistocene and early Holocene eustatic rise in sea level, but this rise probably did not affect streams very far inland from the coast (McDowell, 1987). This conclusion is supported by studies of river behavior upstream from recently flooded reservoirs (e.g., Leopold *et al.*, 1964; Leopold and Bull, 1979), and by the lack of radiocarbon-dated fluvial sediments in the Coast Range that might correlate with the onset of the rapid rise in sea level that accompanied the last deglaciation (Personius, 1993).

Other controls on regional aggradation could include a regional decrease in mean annual discharge, with no concurrent decrease in sediment supply. Although this possibility cannot be ruled out, we favor a third alternative, namely that the regional aggradation episode was related to climatically induced increases in sediment input into Coast Range streams in latest Pleistocene time. By analogy to modern stream-process studies in the Coast Ranges of Oregon and northern California, the trigger for regional aggradation was probably storm-induced landsliding from hillslopes. Historic aggradation events, although on a much smaller scale than the one we interpret from the stratigraphic record, show a temporal and spatial association between increased delivery of sediment

from hillslopes and subsequent channel and flood plain deposition. Regional aggradation occurred as a consequence of landsliding associated with the high-magnitude, regionally extensive storm of December 1964 in the western United States (Waananen *et al.*, 1971). This extensive storm-initiated landsliding was followed immediately by widespread channel aggradation in northern California (Harden *et al.*, 1978; Kelsey, 1980; Lisle, 1982) and may be responsible for accretion of fluvial sediment underlying a young terrace on the Umpqua River near Elkton (Personius, 1993). In the Oregon Coast Range, landslides generated from hillslope hollows during historic storms have been the primary source of sediment delivered to stream channels (Pierson, 1977; Dietrich and Dunne, 1978; Benda and Dunne, 1987; Benda, 1990).

The geologic record of hillslope colluvial deposits in the Coast Ranges of the western United States shows periods of increased sediment mobility on hillslopes. The ages of basal colluvial deposits from hollows in Washington indicate an early Holocene period of accelerated discharge of colluvium from hillslopes (Reneau *et al.*, 1989; Reneau and Dietrich, 1990), and basal radiocarbon ages from central and northern California indicate a similar period of increased erosion during the latest Pleistocene (Reneau *et al.*, 1986, 1990; Rypins *et al.*, 1989). We suggest that the occurrence of accelerated discharge of colluvium in other parts of the Pacific Northwest during the Pleistocene–Holocene transition provides circumstantial evidence that the aggradation episode we document may have been caused by an increase in debris flow activity. A similar situation has been suggested for the temporal coincidence of stream aggradation and accelerated mass movements in central California at the Pleistocene–Holocene transition (Rypins *et al.*, 1989; Reneau *et al.*, 1990). Because colluvial deposits in hollows are widespread in Oregon Coast Range drainages, an accelerated period of landsliding from these hollows could have provided the regionally distributed sediment supply necessary for regional aggradation.

The results of a recent study of colluvial deposits in part of the Oregon Coast Range (Reneau and Dietrich, 1990), however, suggest a middle Holocene rather than a late Pleistocene episode of landsliding. Radiocarbon ages from basal colluvium appeared to cluster about 7500–4000 yr ago (Reneau and Dietrich, 1990). However, one of the samples yielded a latest Pleistocene age, and an additional colluvial deposit in the Siuslaw River drainage has yielded an early Holocene age (Benda and Dunne, 1987), thus some ages from Coast Range hollows do indicate evacuation of colluvium during the Pleistocene–Holocene transition. The lack of a well-documented period of accelerated discharge of colluvium during the latest Pleistocene and early Holocene may be due to several factors, including the relatively small number of radiocarbon ages for basal colluvial deposits in the Oregon

Coast Range (Reneau and Dietrich, 1990) and the removal of evidence of older episodes of hollow evacuation during subsequent landslides.

A related problem with our preferred interpretation is the apparent lack of extensive fluvial deposits in the Coast Range that might correlate with Reneau and Dietrich's (1990) middle Holocene landsliding episode. Perhaps their middle Holocene episode was a relatively minor hillslope event that did not deliver large volumes of sediment to stream channels. To test this idea, more age data are clearly needed, both from sediments underlying the lowest terraces and from colluvium in hillslope hollows. However, our terrace data appear to indicate that the episode of regional aggradation that occurred during the Pleistocene-Holocene transition involved significantly greater volumes of sediment than any subsequent period of aggradation.

The nature of the climate change that may have triggered increased landsliding is speculative and beyond the scope of this paper. Studies of accelerated evacuation of colluvium in California and Washington (Reneau *et al.*, 1986, 1989, 1990; Rypins *et al.*, 1989; Reneau and Dietrich, 1990) have suggested several possible climatic causes for increased hillslope erosion. Increased landsliding at the Pleistocene-Holocene transition in these regions may have been induced by increased storm intensities in latest Pleistocene time. Other possible causes include the loss of vegetative cover, related either to changing vegetation patterns or to increased frequency of forest fires associated with warmer, drier early Holocene climatic conditions. Although no detailed palynological or other paleoclimatic studies in the Oregon Coast Range have been published, such studies in northern California (Adam, 1988) and southern Washington (Barnosky, 1985) indicate a period of climatic instability during the Pleistocene-Holocene transition. The closest palynological data, from Battle Ground Lake in southern Washington (Barnosky, 1985), show evidence of cooler, moister conditions in the very latest Pleistocene and warmer drier conditions accompanied by more severe summer drought in the early Holocene.

In summary, we have presented lithostratigraphic and chronostratigraphic data from fluvial sediments underlying a regionally extensive, low terrace present along several rivers in the central Oregon Coast Range. We infer from our data that a regional aggradation episode was initiated during the Pleistocene-Holocene transition. The bulk of this aggradation occurred between about 12,000 and 9000 yr ago, although minor vertical overbank accretion apparently has continued on top of these deposits through the rest of the Holocene. The cause of the aggradation cannot be resolved from our data, but we suggest that the aggradation episode was caused by a regional increase in landslide activity induced by climatic changes during the Pleistocene-Holocene transition.

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