**HILLS AND VALLEYS LANDFORM ASSOCIATIONS**

**Fluvial Processes**

**Canyonlands** are an extensive landform north of the Wallowa Mountains. They are low linear concave features that at the base have a fluvial channel that may or may not be active. The active channel processes that is visible may not be the original process that formed this landscape. Conversely, the magnitude of the process at present may not be representative of its magnitude in the past. A central active channel is cutting a narrow slot that erodes or causes the collapse and mass movement of material to the channel where water flow removes it. Rock removal occurs because of slope mass collapse or movement. Recognition of the different processes occurring along the walls of the feature parallel to the current river or stream is what differentiates these features from one another.

In the Blue Mountains, Canyonlands have repeating elements from river to terraces to hill-slopes up to a ridge and then downslope in reverse in the next catchment. These repeating elements continue across the landscape for hundreds and sometimes thousands of acres. The thin-bedded Columbia River Basalts give a horizontal to sub-horizontal ridge swale going down a steep rocky slope. The benched landscape is cut by small drainages or gullies so that much of the Canyonlands are dominated by right angles in the drainages. Limited by the rate the resistant basalt bedrock is decomposed, very thin soil (if any) profiles build up, as a result, sediment supply is limited from this LfA. The horizontal strata intercepts what sediments and thin soils form in wedges on some of the benches. These accumulations and soils increase in thickness as you move downslope. Canyonlands have predominantly droughty conditions. However, the colluvial soil in lower landscape positions trap water and sediments. This can result in well-developed soils that hold moisture and facilitate better vegetation, timber and habitat. In this colluvial terrain positive landforms have developed overtime changing from concave to convex. This colluvial terrain is often neglected and is a source of excellent habitat. Soils found on hilltops are deep and those by depressions or ponds are thin, counter to expectation. On the project scale these are areas with great heterogeneity so planning and review needs to be site specific and site verified.

**Canyons** are long, deep, relatively narrow steep-sided valley confined between lofty and precipitous walls in a plateau or mountainous area, often with a stream at the bottom; similar to, but larger than, a gorge. It is characteristic of arid or semiarid areas where stream downcutting greatly exceeds weathering (BJ 1995, FS Geomorph). Canyons are often isolated low linear concave features that at the base have a fluvial channel that may or may not be active. The active channel processes that is visible may not be the original process that formed this landscape. The magnitude at present may not be representative of the magnitude in the past. A central active channel is cutting a narrow slot that erodes or causes the collapse and mass movement of material to the channel where water flow removes it. Rock removal occurs because of slope mass collapse or movement. Recognition of the different processes occurring along the walls of the feature parallel to the current river or stream is what differentiates these features from one another.

Canyons have predominantly droughty soil conditions. However, the colluvial soil in lower landscape positions trap water and sediments. This can result in well-developed soils that hold moisture and facilitate better vegetation, timber and habitat. In this colluvial terrain positive landforms have developed overtime changing from concave to convex. This colluvial terrain is often neglected and is a source of excellent habitat. Soils found on hilltops are deep and those by depressions or ponds are thin, counter to expectation.

**Coastal Fluvial Valleys** are located in a region of tidal influence; the tidewater area. Tides may influence or may affect the fluvial processes for many miles upstream depending on stream gradient in relation to sea level. Coastal Fluvial valleys within the diurnal tide cycles attenuate hyporheic flow and the daily ingress and egress of the tide intensifies the moisture effect in soils and soil development. Estuaries with wide low-lying channels and terraces within the tidal range develop a sinuous character and are richer in organic material from the twice-daily influx of nutrients from the ocean. Soil pores aerate and flood with each change in the tide. Flood events result in development of natural levee systems with coarser textured soils grading back into the hillslope to finer textured soils often with high or seasonal water tables. High flow events often engage these back water areas. The Coastal Fluvial Valleys fade or die as they merge with the bay or estuary. These areas provide highly productive fish and water fowl habitats. Soil orders include Entisols, Inceptisols, Mollisols and Histisols.

**Fluvial Terraces** are a step-like surface, bordering a valley floor that represents the former position of a flood plain. Fluvial Terraces characteristics are similar to Fluvial Valleys except this area is recognized as an ancient remnant of an earlier fluvial valley floor (flood plain) now preserved as an upland element. Soils are more mature than the lower, more recent Fluvial Valley andscapes and include Alfisos (and Ultisols in the west).

**Fluvial Valleys** are characterized by a broad valley floor, a plain related to a watercourse with broad terraces and parallel or sub-parallel boundaries. The valley is mostly ontiguoous with a direct relation between the flowing water and its surrounding floodplain. Soils will have redox features from numerous wet/dry cycles, high primary productivity is found due to low slope angles, sufficient moisture, and well-developed soil horizons with generous amounts of organic matter. In and near the channels, sandy to boulder, well-drained soil expedites hyporheic flow. The dynamic nature of the channel and water level fluctuation creates lakes and sloughs as well as seasonal and permanent wetlands adjacent to the stream and in currently abandoned streambeds. Mollisols, Inceptisols, and Alfisols are common depending on parent material and elevation above the valley floor.

**Fluviolacustrine Deltas** form where river systems deposit into a lake. Deltas are low, nearly flat, alluvial tract of land at our near the mouth of a river, commonly forming a triangular or fan-shaped plain of considerable area, crossed by many distributaries of the main river. Most deltas are party subaerial and partly below water (BJ 1995, FS Geomorph). Fluviolacustrine Deltas are complex landforms due to the varying lake levels into which they are deposited. The particle size deposited varies by what the river system is transporting. Once in the lake, sediments are sorted with the coarser particles in the channels and the finer particles in the levees. These sediments mix with the organic-rich diatomateous earth and fine paticles that form the lake substrates. Soils are dominantly Histisols and Mollisols, with Entisols and Inceptisols as minor components.

**Gorges** are deep, box-shaped valleys typically created by higher than normal discharges. These gorge-forming discharges are the result of a restriction or stoppage of normal flows upstream of this landform that upon release create a catastrophic flood. The gorge-forming flows have originated from a landslide formed lake, which was catastrophically breached, or a glacier-dammed lake breaching the restricting ice, as in the Missoula Floods. A gorge is identified by its vertical or overhanging walls, narrow slotted shape and higher relief slopes than the canyon or valley adjoining or bounding it. Gorges are spatially shorter along a channel reach than a canyon or valley. Soils are thin to not present on the scoured bedrock slopes. Local accumulations of colluvium and rock fall have immature soils.

**Meander Belts** are deep to very deeply incised meander plains; they contains similar landforms to a meandering river except most are greatly exaggerated in relief and are underlain by bedrock. Meander belts initially developed during previous geologic episodes when streams flowed in a sinuous pattern across a plain. Subsequent geologic uplift of the plain led the river to downcut at a rate similar to the uplift resulting in an incised meander belt. The current stream channel at the base of the Meander Belt is undersized in relation to the valley form. During the downcutting process, slopes were scoured, terraces and other stream geomorphic features, now elevated in the landscape, were deposited. The landscape within the Meander Belt is quite complex, resembling the elements of a current floodplain although they are found high on the valley walls above the current floodplain level. Soils vary from immature Entisols (in the west) near the present stream to mature Ultisols (in the west) on terraces at higher elevations.

**Megaflood Scours and Deposits** are areas along floodplains where soil and unconsolidated geologic sediments were removed/swept away by Missoula Floods floodwaters. Deposits are areas where the floodwaters slowed, spread out or backed up enough to deposit glacial and other floodwater entrenched sediments. These deposits are deep and generally stratified by successive flood events. The minerology of deposits will be entirely different than surrounding terrain.

**Megaflood Scoured Uplands** are low mountains areas adjacent to the Columbia River where soil and unconsolidated geologic sediments removed/swept away by Missoula Floods floodwaters. Much bedrock is exposed on this landform, where they exist, soils are generally shallow, some deeper pockets remain downstream of prominent topographic features that protected them from the flood waters or caused eddy deposits. Need More?

**Meltwater Valleys** were created during the melting, collapse and recession of alpine or continental glaciers. They are considered “water gaps”, gaps in the mountains created by water. They often break through ridge systems or topographic highs. The patterns are anastomosing, the valleys truncate downstream sometimes coming together then diverting again. The flow of water may be entirely opposite what it is today. Therefore sediments would be the opposite of what is expected and would coarsen in the lower portions of today’s channels. There are generally no rivers occupying these areas today, if streams or rivers do occupy these areas, they are undersized for the size of the valley and were not the source of fluvial erosion that created the valley. Current stream courses would be starved of sediment since the original erosional processes no longer exist; they capture sediment by eroding stream banks and widening the stream course. The valley bottom deposits are highly variable in thickness, they are not gradient developed stream course deposits. Meltwater Valleys are similar to Meltwater Canyons but they have more gently sloping valley walls and are more shallowly incised.

**Puget Fluvial Valleys** flow into the Puget Sound. They are similar to Coastal Fluvial Valleys but have undergone post glacial uplift due to crustal rebound. Tides may have no influence or may affect the fluvial processes for many miles upstream depending on stream gradient in relation to sea level. In areas of tidal influence Puget Fluvial valleys within the diurnal tide cycles have attenuated hypoheriec flow and the daily ingress and egress of the tide intensify the moisture effect in soils and soil development. The Puget Fluvial Valleys fade or die as they merge with the bay or estuary. Within the Puget Fluvial Valleys landform association, the streams have a distinctly different gradient than the terraces. There is a random mix of sediment sizes due to unsorted mix of continental glacial deposits. The streams are reworking the glacial sediments. The river surfaces develop an armored channel due to the current river power not being able to move the particles sizes available. Streams migrate to the margins to capture new sediments, constantly reworking the channel shape.

**Valley Bottom/Outwash** – Jay, on the images, these seem to be similar to meltwater valleys but also glaciofluvial mountainsides. Not sure how to describe this concept.

**Washboard Canyons** arean extensive landform north of the Wallowa Mountains. This is a subset of the Canyonlands Landform Associations. Washboard Canyons are long, linear concave features with a river or an intermittent stream along their central axis. The valley walls of these fluvial channels have a repeating pattern of ridges arrayed perpendicular to the streamcourse, giving the walls a washboard appearance. Rock removal out of this part of the landscape occurs because of mass collapse or creep down slope, that feeds the central active stream. Side channels and swales of the stream network locally have debris flow deposits that spread out along the stream channel, diverting its course. Erosion of the channel with the supplied rock leads to a rejuvenation of the cycle of slope instability and fresh rock supply for transport out of the canyons.

In the Blue Mountains, Washboard Canyons have repeating elements from river to “washboard” hill-slopes up to a ridge and then downslope in reverse in the next catchment. These repeating elements continue across the landscape for hundreds and locally thousands of acres. As with the nearby Canyonlands, hill slopes exhibit a layering pattern due to the underlying Columbia River Basalts. Deep, V-shaped channel erosion of the thin-bedded basalts yield a stepped morphology away from the stream and up the steep rocky slope. The benched landscape is cut by small drainages or gullies so that much of the Washboard Canyons are dominated by right angle (trellis) pattern of the streams.

Limited by the rate the resistant basalt bedrock is decomposed, soil development is limited to thin, rockly prfiles. Capture of loess in older hillslopes deposits of rock debris are common as ridge caps along canyon walls. In general, sediment supply is limited from this LfA. The horizontal strata intercept what sediments accumulate and thin soils form in wedges on some of the benches. These increase in thickness as you move downslope. Soils are typically droughty. Locally, however, northeast-facing slopes have accumulated volcanic ash that results in well-developed soils that hold moisture and facilitate better vegetation, timber and habitat.

**Glacial Processes**

***Glacial***

**Alpine Basins** are cirque basins in the Alpine Glacial Mountains of the eastern North Cascade Range and the Columbia Mountains of the Northern Rocky Mountain Ecoregion (Kettle River Range and Selkirk Mountains) that stood above the maximal extent of the Cordilleran Icesheet. These basins formed as a result of alpine glaciers on the high mountain slopes above the level of continental glaciation. The Alpine Basins are cirque features and include semi-circular bowl-like excavation in hanging valleys or at the head of a valley. An aerial view of a cirque or alpine basin shows a horseshoe like shape with the open end of the shoe pointing away from the steep headwall and surrounding side slopes. This open end of the shoe is a raised threshold often supplemented by a recessional moraine. The closed depression of the cirque frequently hosts a meadow, lake or tarn. A water filled series of interconnected depressions flowing down from a cirque basin is called paternoster lakes. These lake chains often have recessional moraines damming their basins. At higher these high elevations and latitudes cirque aspect can be to any point of the compass.

**Glacial Valley Bottoms** are those fluvial valleys that are found upstream of paleo-glacial moraines. Glacial Valley Bottoms are fluvial valleys with areas of glacially deposited sediments and scours mixed in with fluvial aggradation and erosion. This mélange makes discerning what is fluvial and what is glacial difficult. The glacial influence predates that fluvial in most locales. A meander plain that varies with watercourse sinuosity dominates the landform. Remnant moraines can detour or dam the stream channel creating valley lakes. In a Glacial Valley Bottoms where drainages meet, stream confluence is often downstream of what topography would indicate due to the presence of ancient medial moraines acting as a barrier. The confluence of waters is delayed for yards or sometimes miles. Heterogeneity of sedimentation is common rather than unusual with the glacial scouring and deposition intermingled with fluvial aggradation and degradation along the valley floor. These are droughty soils, quickly draining; in a climate with sufficient moisture they can be relatively productive.

**Glacial Valleys** are the U-shaped, ice-covered valley segments in glacial and glaciated areas. They include both the glacial valley bottom and sideslopes of the glacial valley wall. Often the landform is too narrow at this scale of mapping to differentiate the bottom as in Glacial Valley Bottoms from the wall sections themselves. The sideslopes accumulate the basal and lateral till of the valley glacier. The area experienced immediate post glacial redistribution of valley side till through colluvial deposition, debris flows, and sheet flow with deposition onto the valley floor. Many areas of the valley walls are exposed to bedrock as a result. There are pockets of lateral moraines with fluvial deposits between them. Seeps and springs emerge in the colluvial material and associated with till deposits.

**Glacial Valley Bottoms** are those fluvial valleys that are found upstream of paleo-glacial moraines. Glacial Valley Bottoms are fluvial valleys with areas of glacially deposited sediments and scours mixed in with fluvial aggradation and erosion. This mixing makes discerning what is fluvial and what is glacial difficult. The glacial influence predates fluvial. A meander plain that varies with watercourse sinuosity dominates the landform. Remnant moraines can detour or dam the stream channel creating valley lakes. In a Glacial Valley Bottoms where drainages meet, stream confluences are common downstream of what topography would indicate. This is due to the presence of ancient medial moraines acting as a barrier to the confluence of water. Heterogeneity of sedimentation is common rather than unusual with the glacial scouring and deposition intermingled with fluvial aggradation and degradation along the valley floor. These are droughty soils, quickly draining; in a climate with sufficient moisture they can be relatively productive.

**Glaciofluvial Fans** are fan deposits onto a plain or into a lake bed. The deposits spread out over a convex land surface with multiple flow paths during the depositional period. Glaciaofluvial fans contain a mixture of glacially deposited sediments and scours mixed in with fluvial aggradation and erosion. This mélange makes discerning what is fluvial and what is glacial difficult. The glacial influence predates that fluvial in most locales. Need More?

**Glaciofluvial Valleys** contain the full extent of glacial valley bottoms principally formed by meltwaters of Pleistocene glaciers. Some deposits formed in a flow direction counter to modern day drainages. As a result, sediment particle size classes are the reverse of expected. Coarse rounded cobbly and bouldery deposits are found. Glaciofluvial valleys experienced channelized flows that often deeply incised into the valley bottom. They result from both continental and alpine glaciation. Need More?

**Glaciolacustrine** deposition results from the meltwaters and runoff associated with alpine glaciation being backed up and slowed by coming in contact with the Puget Lobe of the Cordilleran Icesheet or other obstruction that backed up a glacial lake. The stratified fine glacial deposits settled out in a lake environment. These deposits now occupy a landscape position above current lacustrine or lowland landscapes. Is this correct? I thought it was all associated with the Puget lobe, until I saw the same feature over by Cle Elum. Need More?

**Glaciovolcanic Scours** occur on the upper slopes of glacial volcanoes. Theyare deposits and/or landforms derived from mixed sources of glacial and volcanic processes, including ash-on-ice sourced deposits and subglacial eruptive vents and flows that result in lahars.Scours are the powerful and concentrated clearing and digging action of flowing air, water, or ice, esp. the downward erosion by stream water in sweeping away mud and silt on the outside curve of a bend, or during time of flood. Need more?

**Meltwater Canyons** are sometimes called “Coulees”. They are landforms sculpted by glaciofluvial process in subglacial and epiglacial locations. Typically recognized as valleys with underfit streams or windgaps across watershed divides. Meltwater Canyons were created during the melting, collapse and recession of alpine or continental glaciers. They are considered “water gaps”, gaps in the mountains created by water. They often break through ridge systems or topographic highs. The patterns are anastomosing, the valleys truncate downstream sometimes coming together then diverting again. The flow of water may be entirely opposite what it is today. Therefore sediments would be the opposite of what is expected and would coarsen in the lower portions of today’s channels. There are generally no rivers occupying these areas today, if streams or rivers do occupy these areas, they are undersized for the size of the valley and were not the source of fluvial erosion that created the valley. Current stream courses would be starved of sediment since the original erosional processes no longer exist; they capture sediment by eroding stream banks and widening the stream course. The valley bottom deposits are highly variable in thickness, they are not gradient developed stream course deposits. Valley walls are generally bedrock with little soil development. Meltwater Canyons are similar to Meltwater Valleys but they are steeper sided and deeper.

**Outwash Scoured Valleys** occur on the west slopes of the North Cascade Mountains. They resulted from ice margin rivers or meltwater flowing out across the landscape. There is usually a strong stratigraphy break as sediments transported from alpine glaciation is deposited over continental glacial deposits. Could have flown in reverse of current day flows resulting in the reverse of anticipated sediment sorting with coarser particles at the lower positions of today’s stream flow. Deep sediments occupy these valley floors. Need More?

***Glaciated***

**Glaciated Gorges** are deep, box-shaped valleys created by higher than normal discharges. These gorge-forming discharges are the result of a restriction or stoppage of normal flows upstream of this landform that upon release create a catastrophic flood. The gorge-forming flows originate from a landslide formed lake, which was catastrophically breached, or a glacier dammed lake breaching the restricting ice, as in the Missoula Floods. A gorge is identified by its vertical or overhanging walls, narrow slotted shape and higher relief slopes than the canyon or valley adjoining or bounding it. Gorges are spatially shorter along a channel reach than a canyon or valley. Glaciated Gorges appear on the south side of the Columbia River Gorge where the gorge walls are sculpted by alpine glaciers leaving U-shaped hanging valleys above the gorge floor that house some of the most spectacular waterfalls in the Pacific Northwest. Glacial deposits may be found at the base of these valleys where they intersect the gorge. Most of the landform association has little soil cover. Bedrock features dominate. More??

**Lacustrine Processes**

**Lacustrine Terraced Uplands** occur adjacent to ancient lake beds and form a series of terraces on the hillsides or escarpments high above the current lakebed level. Wave cut terraces remain behind as the lake level lowered over time leaving a series of somewhat level benches to steeply sloping terrace risers. Fine textured soils deposited on the benches as a result of sediment sorting in the ancient lakes.

**Marine Processes**

**Estuaries** are fluvial valleys with wide low-lying channels and floodplains, they occur where the tide meets a large stream channel. The slowing of the stream and reduced stream gradient at the tidal influence zone results in development of a sinuous character to the stream channel as it runs through the estuary. Estuarine soils are richer in organic material from the twice-daily influx of nutrients from the ocean. Soil pores aerate and flood with each change in the tide.

**Mass Wasting Processes**

**Collapsed Gorges** consist of gorges whose sidewalls are dominated by landslides, with hummocky poorly-drained, chaotic fallen bedrock blocks that divert the main-axis river channel. Collapse of sidewalls lowers their overall slope from an original deep, box-shape. Gorges are deep, box-shaped valleys created by higher than normal discharges. These gorge-forming discharges are the result of a restriction or stoppage of normal flows upstream of this landform that upon release create a catastrophic flood. The gorge-forming flows originate from a landslide formed lake, which was catastrophically breached, or a glacier dammed lake breaching the restricting ice, as in the Missoula Floods. A gorge is Identified by its vertical or overhanging walls, narrow slotted shape and higher relief slopes than the canyon or valley adjoining or bounding it.

Collapsed Gorges have formed differently shaped hillslopes and contra shaped elements that trap water and sediments. This can result in well-developed soils that hold moisture and facilitate better vegetation, timber and habitat. This collapse terrain is often neglected and is a source of excellent habitat. In this collapsed terrain positive landforms have developed overtime changing from concave to convex. Soils found on hilltops are deep and those by depressions or pond are thin, counter to expectation.

**Hills and Valleys** - In a broad plain a prominence is most likely a hill. In some cases these hills may have been mountains that due to weathering, an adjacent uplift or surrounding deposition have a reduced prominence and are now hills. In glacial valley bottoms more resistant portions of the bedrock that the ice rose over will leave behind a hill or series of hills. Series of hills will have saddles joining them. Hills offer a vantage point for predators and shelter for prey. They can be islands of biodiversity in a landscape where areas of lower relief have been extensively modified.

**Coastal Hills** - the term Coastal refers to features and landforms adjacent to the modern coast, slopes, hills and mountains facing or having a general aspect toward the ocean. The ocean acts as a moderating factor on temperature and temperature fluctuations. These landforms are within the “fog belt” and the marine influence of moisture and moderate temperatures enhances soil development. These landforms drain to the ocean and are parallel or sub-parallel to the coast. The general aspect of coastal landforms faces prevailing winds, are moisture blocking and combined with a moderate temperature regime enhances weathering and creates an environment with high forest productivity and biodiversity. The weathering leads to landforms with steep relief, instability, and dense vegetation. The soils are isomesic in Oregon and isofrigid in Washington. Spodosols, Ultisols and Andisols dominate along the coastal terrain of the Pacific Northwest. Bioturbation, wind-throw churning and salt fluxes all contribute to the hastening of soil development in coastal landforms. Jay, we don’t have this LfA anymore,

**Tectonic Processes**

**Stratal Hills and Valleys** are hills with morphologies reflecting the underlying rock structure. Hills and their adjacent valleys are formed as a result of several processes including weathering of mountains, an adjacent uplift or surrounding deposition all of which have a reduced the prominence of this landscape feature and are now hills due to their low relief compared to the surrounding landscape. Hills are associated with valleys and a series of hills will have saddles joining them. Hills offer a vantage point for predators and shelter for prey. They can be islands of biodiversity in a landscape where areas of lower relief have been extensively modified. The obvious structural prominence (stratigraphy) arises as a consequence of degradation or denudation of an upland area by hillslope and fluvial processes. Stratigraphy is present and visible. Erosional exhumation reveals obvious layering of the underlying rock structure, including dip and anti-dip slopes. Synonymous terms used for these features are cuesta and cuestaform. Anti-dip slopes are benchy, rocky and relatively steep slopes. Following the colluvium downhill on an anti-dip slope you find a repeating pattern of bedrock outcrops with intervening areas of accumulated sediment. Habitat and vegetation distribution corresponds to this pattern. Dip slopes, on the other hand, are broad plains with shallow slopes underlain by relatively deep soils over rock. This is an almost featureless terrain with few features to orient by. Potential vegetation and habitat are largely invariable across these sloping plains.

**Volcanic Processes**

**Inverted Valleys** are basalt flows down an ancient river valley. The less resistant landscape eroded away from these flows, now they are an upland feature. Residual soils have developed on them, they are usually shallow and clayey argixerolls.