Introduction to Watershed Analysis and Luckiamute Watershed System

I. Introduction

A. Luckiamute Watershed = Focus of NSSI Interdisciplinary Science Course
1. Forms portion of the upper Willamette River system
2. Luckiamute river drains from central Coast Range east to Willamette
3. Why the Luckiamute?
a. close to WOU Campus, our home
b. easy access
c. serves as a natural boundary for study
d. forms part of world-class landscape in western Oregon

B. Watershed Concept
1. Collection of inter-related:
a. Topographic elements
(1) shape of landscape (flat, mountainous, etc.)
(2) slopes under the influence of gravity
(a) drainage of water and sediment
b. geologic elements
(1) bedrock composition (igneous, sedimentary, metamorphic)
(2) plate tectonics
(a) plate boundary vs. no plate boundary
(b) active tectonic setting
i) convergent
ii) divergent
iii) transform
(3) surficial deposits
(a) loose, unconsolidated materials at Earth's surface
(b) in general: soil and sediment at surface
c. climate / meteorological elements
(1) cold / warm
(2) dry / wet
d. hydrologic elements
(1) types and numbers of rivers
(2) flood-disturbance patterns
(3) groundwater use / spring discharge to surface
e. biotic elements
(1) flora
(2) fauna
f. cultural elements
(1) social framework
(2) land use patterns
g. Environmental Quality
(1) soil / water quality
(2) anthropogenic contamination
(3) human care and interaction with landscape

II. Fundamental Concepts of Natural Science and Earth Science

A. Fundamental Elements of Earth Science

1. Time
   a. Time Frame
      (1) Age of Earth ~ 4.6 billion years and counting!
   b. Question: what is time and how is it measured?
2. Processes
   a. e.g. volcanic eruption, river erosion
3. Processes + Time = Rates of Processes
   a. how fast?
   b. e.g. rate of lava production from a volcano
4. Material / Products
   a. volcanic rocks
   b. What is the volume of rock associated with Mt. Hood?

B. Spatial Scales

1. What is the scale at which we examine the Earth and it's components?
   a. micrometers? mm? cm? m? km? 1000's of km?
2. microscopic to global

C. Temporal Scales

1. What is the time frame over which we examine the Earth and it's processes?
   a. microseconds? seconds? minutes? hours? days? years? millions of years?
2. Scaling of Rates
   a. how fast over how long?
   b. slow processes over long periods = big change!

III. Morphology of Drainage Systems

A. Watershed - a network of stream and/or river tributaries that merge into one, common channel outlet.

1. Stream - channelized flow of water at the Earth's surface, under the influence of gravity
   a. stream channel = "gutter of the continents"

2. Stream Tributaries - branches of channels that merge at confluences
   a. Essentially valley systems in which topography results from fluvial erosion of landscape

3. Dynamic Equilibrium
   a. Through Time: overall absolute elevation/relief diminishes through time via erosion and landscape degradation
      (1) However, the overall relative relief or "graded profile" of the drainage basin will be maintained over time via dynamic equilibrium
   b. I.e. The drainage basin systematically adjusts its morphology as landscape is denuded through time
   c. Landscape erosion / denudation is balanced by tectonic uplift / landscape contruction
      (1) e.g. volcanic eruptions build volcanoes, glacial erosion removes them

4. Morphometry: systematic quantitative description of a drainage basin
    a. Quantitatively describing and comparing geometric features of drainage basin

B. Morphologic Features of Drainage Systems

1. Drainage Basin: spatially restricted network of branching surface streams/rivers. aka a "watershed"- an area that contributes overland flow and groundwater to a specific stream network.

    a. Drainage Divide: upland flow separation between runoff that descends in the direction of the drainage basin in question and that which goes toward and adjacent basin.

    b. Drainage Net: the complex of streams within a drainage basin.

    c. Nested drainage basins based on scale

2. Topographic Considerations
    a. Valley- lowlying area that is totally or partially occupied by a stream channel

Includes: stream channel, adjacent floodplain, and valley sides. Valley bottoms may be narrow or extensively wide Valley sides may be gentle or very steep.

    b. Interfluve- the high land above valley sides that separates adjacent valleys ("between rivers"). May be sharp and well defined or broad and diffuse upland drainage divides.

3. Stream Order Hierarchy: organization of drainage basin tributaries according to relative size (Horton, 1945; Strahler, 1952)

    a. Stream Orders: hierarchical ranking of stream size within a drainage basin
        (1) First order- smallest unit in system, represents a single tributary in a net.
            (a) small scale tributaries in headland region of basin
        (2) Second order- a stream formed by two first order streams coming together
            (a) Medium scale tributary
        (3) Third order- a stream formed by confluence of two second order streams
        (4) Fourth Order: larger scale drainage basin

    b. Drainage Basin Classification: based on largest order trunk stream draining basin
        (1) e.g. 5th order Basin = drained by 5th order trunk stream, etc.

IV. Fundamental Quantitative Parameters

A. Slope or Gradient = rise / run
    1. S = change in elevation / change in horizontal distance

B. Discharge (associated with flowing liquids)
    1. Q = volume of displacement / time

C. Area = length * width

D. Volume = length * width * height
   1. Volume = Area x Depth

E. Elevation = height of point, vertically above or below sea level
   1. Relief = change in elevation between two points

F. Angular Measurement
   1. degrees
   2. 1 circle = 360 degrees

G. Map / Compass Bearings
   1. north, south, east, west
   2. North
      a. True North = geographic north pole (rotational axis)
      b. Magnetic North = magnetic north pole
   3. Azimuth Bearings (measured in clockwise angular direction from 0)
      a. Due North = 0 degrees
      b. East = 90
      c. South = 180
      d. West = 270
      e. Northwest = 315... etc.

H. Aspect = direction of landscape element relative to dominant orientation of incoming solar radiation
   1. e.g. south-facing slope vs. north-faciling
   2. measured as an azimuth
      a. e.g. if your house is built on a hillslope that has an aspect of 90 degrees, your house will face due east and you will have a great view of the Cascades.