OUTLINE 1 LATE -2 2/4

Nick Barrera

ES 202

PAPER TITLE?

3/4/18

Term Paper Outline

STILL NEED EXPANDED OUTLINE

1. Introduction

   i) The effects of plate tectonics and convection in the mantle keeps the continents moving.

   ii) When the oceanic crust moves under the continental, the magma moves up and forms volcanic mountains along the coastline.

   iii) These mountains and volcanoes are continuously active and major risks to people.

2. Overview of Plate Tectonics/Neotectonics

   i) Mantle is in a motion of convection.

   ii) Oceanic crust is more dense and slides under the less dense continental crust

   iii) Convergent zones are the cause of Mountain building

3. EVIDENCE OF Mountain building along the coast

   i) ~~Subduction zone~~ RE-LEVELING SURVEYS

   ii) ~~Volcanoes and mountains~~ RIVER TERRACES

   iii) ~~Internal processes~~ MARINE TERRACES

4. CONCLUSION

~~4.~~ 5. References

Adams, J. (1984), Active deformation of the Pacific Northwest Continental Margin, Tectonics, 3(4), 449–472, doi:10.1029/TC003i004p00449.

NEED TO BEEF UP DETAILS – MORE PAPERS

Kelsey, H. M., D. C. Engebretson, C. E. Mitchell, and R. L. Ticknor (1994), Topographic form of the Coast Ranges of the Cascadia Margin in relation to coastal uplift rates and plate subduction, J. Geophys. Res., 99(B6), 12245–12255, doi:10.1029/93JB03236.

Kelsey, H. M. (1990), Late Quaternary deformation of marine terraces on the Cascadia Subduction Zone near Cape Blanco, Oregon, Tectonics, 9(5), 983–1014, doi:10.1029/TC009i005p00983.

Personius, S., Kelsey, H., & Grabau, P. (1993). Evidence for Regional Stream Aggradation in the Central Oregon Coast Range during the Pleistocene-Holocene Transition. Quaternary Research, 40(3), 297-308. doi:10.1006/qres.1993.1083

Cassie Borcher

ES 202

Dr. Taylor

2/25/2018

✓ 6/6

Effects of Forestry Practice on Watershed Processes in Western Oregon

- Introduction
- ~~Geologic Overview~~ Hydrogeomorphic Processes
  - Water transport
    - Soil infiltration
      - Infiltration capacity of forest soils is usually high. Surface erosion and transport of soil are eliminated when and where infiltration capacity equals or exceeds rainfall, snowmelt, and lateral overland flow additions (Anderson, 1976)
      - However, Ellison showed how a bare, very permeable soil having a high infiltration capacity can be practically waterproofed by the splash erosion from 20 minutes of rainfall. (Anderson, 1976)
      - But high infiltration capacities can have an undesirable effect. In some localities, high infiltration builds up soil water which locally destroys cohesion of the soil mass, augments soil creep into channels, or causes mass slope movement into them; or it may cause local soil saturation and growth of channels by solifluction (mudflows). However, a recent intensive study of slope stability in coastal Oregon (Harr and Yee 1975) showed that saturated soil was rarely found, and further that natural infiltrated and percolating water did not affect the soil aggregation that was essential to slope stability. (Anderson, 1976)
    - Erosion
      - The three hydrologic processes principally initiating erosion and sedimentation are raindrop splash, overland flow, and streamflow scour. (Anderson, 1976)
      - For raindrops intercepted by a high canopy and dripping from it have greater mass and kinetic energy than ordinary rainfall (Tsukamoto 19660) and therefore greater potential for causing splash erosion. (Anderson, 1976)
  - Hydrology
- Influence of Forestry on Watershed Processes
  - Forestry Practices

    - Debris in rivers is normal but the extent can be greatly increased due to forestry practices such as clear cutting and road building on steep, shallow, unstable soils (Bescheta, 1979).
    - Surface erosion of forest sites usually follows intense rainstorms that follow baring of the soil by logging, fire, overgrazing, mass movement, or other causes (Anderson, 1976)
    - Where areas of the forest floor have been disturbed by logging, grazing, or burning, infiltration is reduced by the compactive effect of moving equipment, trampling animals, or beating raindrops, and overland flow; soil erosion can result (Anderson, 1976)
- Stream Morphology
    - Stream flow
        - Organic debris carried in river can have significant influence on streamflow in PNW in riparian habitat (Bescheta, 1979).
        - Figure 4 shows how much erosion occurred along the bottom of the stream bed after the debris was removed. Further downcutting would not occur this rapidly in the future because the majority of what was removed was the built up sediment. Now the stream bed is cobbles and boulders (Bescheta, 1979).
    - Riparian habitat
        - Debris can create unique habitat for fish or plants but also prevent migration necessary for the completetion of life cycles (Bescheta, 1979).
        - Logging/contstruction occurred near Alsea in 60's, flooding in 1964-1965 and several debris accumulations in Mill Creek, logging/roads continued adjacent to creek up until 1974 and by 1975 there were enough large debris accumulations to block the migration of anadromous fish. Timber was removed by hand and machine (Bescheta, 1979).
    - Sedimentation
        - Debris accumulation reduces stream velocity and affects sediment transportation (Bescheta, 1979).
        - 15 years of debris accumulation allowed for large amount of sediment to collect above the accumulation sites. Removing the debris triggered localized scouring of sediment deposits. Several downstream pools began to fill with sand and silt. This sedimentation change increased downstream turgidity from 30 to 100 ntu due to the scouring of stored sediment (Bescheta, 1979).
    - Landslides
        - Surface erosion of forest sites usually follows intense rainstorms that follow baring of the soil by logging, fire, overgrazing, mass movement, or other causes. Landslides and mudflows may be started or accelerated by land use, but usually they too are

associated with heavy rains and slide-prone conditions either in the soil mass or at the contact of the soil with the underlying rock. However, mass movements by soil creep and ocassionally by mudflows or landslides are pervasive natural processes that occur even in the undisturbed forest. (Anderson, 1976)

    - Storage
        - Surface
        - Watershed
    - Water quality
        - Pollution
        - Temperature
            - The forest influences the temperatures of soil water and streamwater by affecting the paths that water takes, by shading the ground and the stream, and by using energy for evaporative cooling. Management that changes any of these influences can change water temperature (Anderson, 1976)
            - Raising water temperature may have both good and bad results; the balance depends on the particular stream situation. Warmer temperatures favor food production, which is all too small in many trout streams. If temperature of the stream is already near the upper threshold favorable for trout, opening the forest along the stream channel may be detrimental. (Anderson, 1976)
            - At elevated temperatures decomposition of organic debris in streams may deplete oxygen below critical levels for fish (Anderson, 1976)
- Summary and Conclusions

References Cited

Anderson, H.W., Hoover, M.D., Reinhart, K.G., 1976, Forests and water: effects of forest management on floods, sedimentation, and water supply: General Technical Report PSW-018. Berkeley, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Forest and Range Experiment Station.

Brown, G.W., Krygier, J.T., 1971, Clear-Cut Logging and Sediment Production in the Oregon Coast Range: Water Resources Research, pages 1189–1198.

Bescheta, R.L., 1979, Debris Removal and Its Effects on Sedimentation in an Oregon Coast Range Stream: Department of Forestry Engineering, pages 71-77.

5/6 -1

Does not follow template

The Missoula Floods

By Jenny Calderon
ES 202

See example outline model on class web site.

What is a flood

Definition: An overflowing of a large amount water beyond its normal confines, especially over what is normally dry land

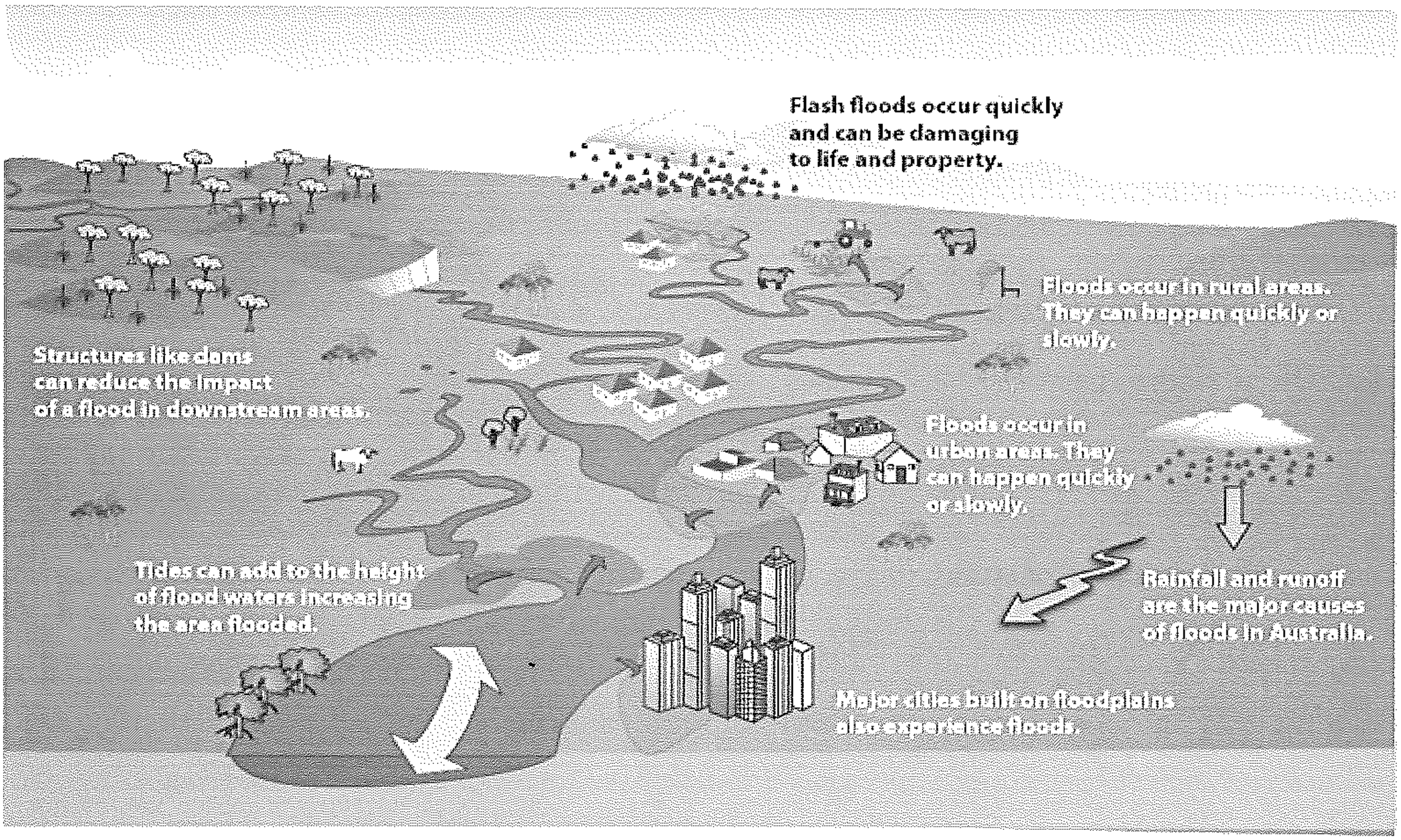


Figure 1 : It shows where floods can occur

I. Introduction
II. Late Pleistocene Glaciation
III. Missoula Flood History
A. Landform Record
i Scablands
B. Sediment Record
ii Willamette Silt
iii Erratics
IV Summary & Conclusion
V References Cited

How the Missoula Floods Happened

1. The 2000 ft tall ice dam ruptured letting the 500 cubic miles of water race across Idaho, Oregon and washington towards the pacific ocean.
    a. **" Glacial Lake Missoula formed as the Cordilleran Ice Sheet dammed the Clark Fork River just as it entered Idaho, The rising water behind the gacial dam weakened it until water burst through in a catastrophic flood that raced across idaho, Oregon, and Washington toward the Pacific ocean"(Montana Natural History Center).**

2. Lake Missoula formed where Cordilleran Ice Sheet blocked the clark Fork River Valley near the border of Idaho-Montana.

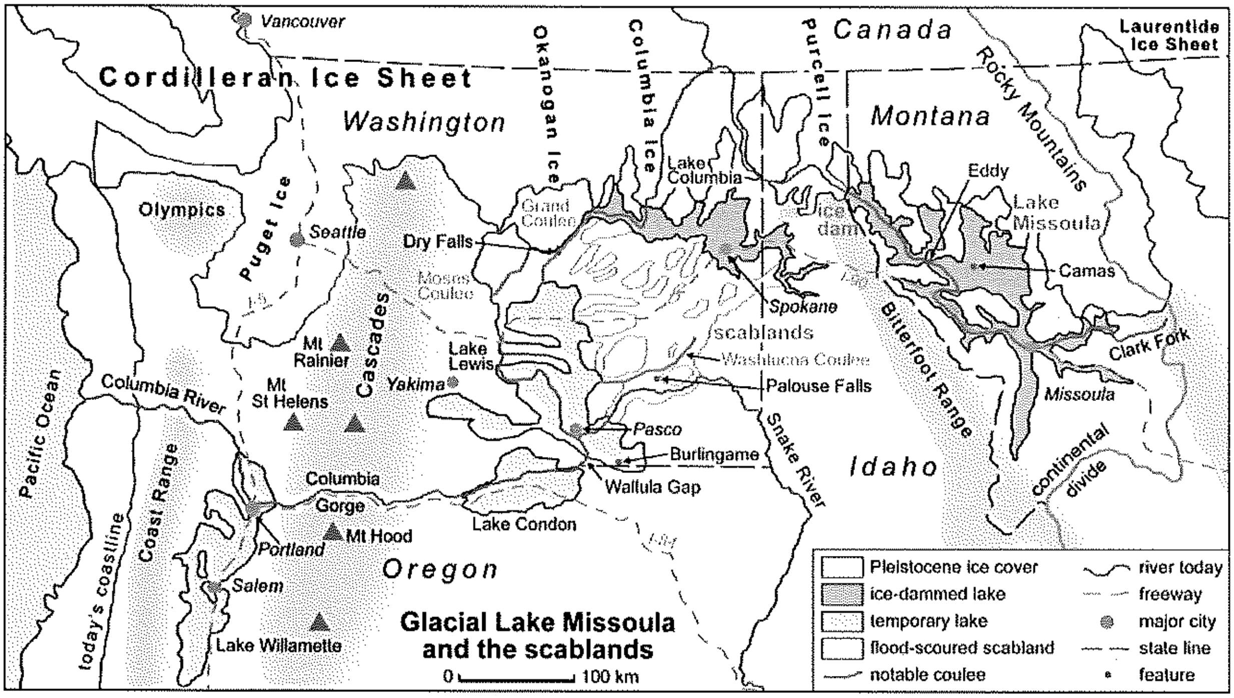
a. The floods reached up to 50 mph stripping away the soil revealing the bare basalt bedrock below.
b. There was boulders the size of cars

When did they happen

1. They happened approximately 12000~15000 years ago.
    a. They were first observed by J Harlen Bretz in 1923
    b. They created the

What they affect or create

Figure 2 : A topographic map of the Missoula Floods



1. The Portland,Oregon region owes a massive thank you to the Missoula Floods that happened about 15,000 years ago for the rich agriculture it now posses.
    a. They created huge ripped in the bed of the giant flood, 30m high and 100m apart. They can be still be seen today in Camas Prairie

Camas Prairie ripples

Work Cited

"What Is a Flood?" *What Is a Flood? | Office of the Queensland Chief Scientist*, www.chiefscientist.qld.gov.au/publications/understanding-floods/what-is-a-flood#.

http://www.wou.edu/las/physci/taylor/gs407rivers/Bjornstad_2008_Ice_Age_Floods_Scablands.pdf

"» The Great Missoula Floods." *Museum of the City*, www.museumofthecity.org/project/the-great-missoula-floods/.

Neal Cranston

March. 6th 2018

Geology 202 paper Extended Outline

Dr. Taylor

6/6

Geology of the Columbia River Gorge

I. Introduction

II. PHYSIOGRAPHIC SETTING

A. Quick overview of the columbia gorge modern features and what makes them unique.

B. Introduce the Columbia river and briefly discuss the rivers qualities (discharge, length)

a. Length - 1243 miles

b. Discharge- 264,862 ft^3/s

c. Basin extends across Pacific Northwest and through Idaho all the way to yellowstone. (257,916 sq miles)

C. Climate of the gorge and how it transitions as you drive from Hood river to the The Dalles.

a. Rainfall per year in Hood River

i. 31.26 in annual avg.

b. Rainfall per year in The Dalles

i. 14.52 in annual avg.

II. Geologic Overview

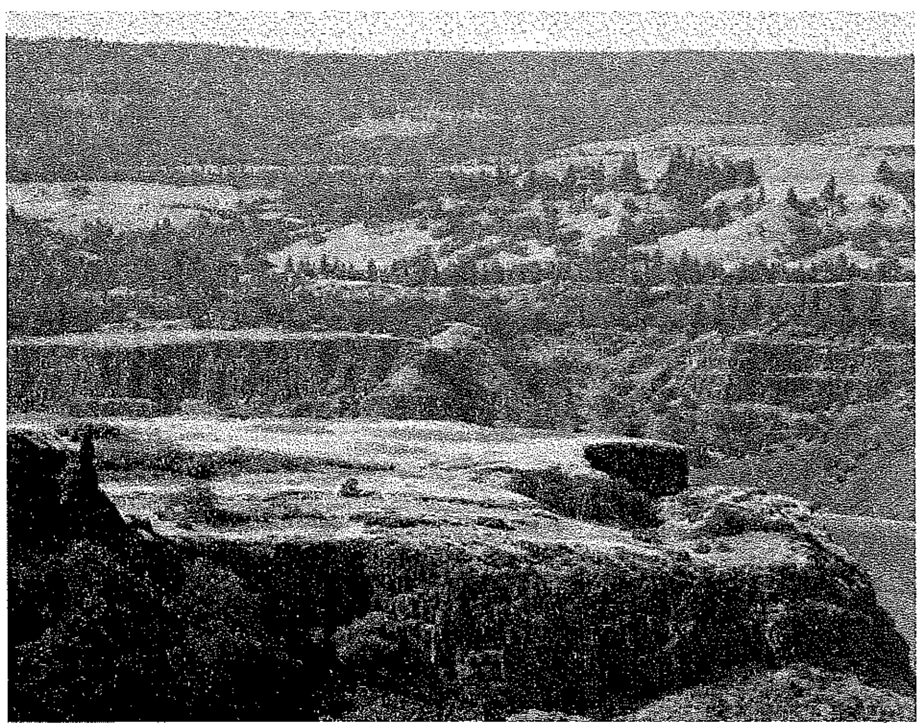
A. Tectonic Setting

1. Cascadia subduction zone

a. Volcanic activity

i. Volcanic eruptions

b. Basalt flows



c. **(Figure 1: Example of Columbia River Basalt Layers)**

d. Columbia river Basalt Group

   i. Flowed over a massive region extending from eastern oregon to parts of idaho, nevada and northern california.

   ii. Volcanic layers in the gorge are now readily exposed do to the erosional processes of the Columbia river.

e. Tectonic uplift (causing some of the sideways land features throughout the gorge.

B. Geologic History

   a. 40-20 million years ago (Eocene to Miocene)

      1. Lava flows

      2. Mudflows

   b. 17-12 million years ago (Miocene)

1. Basalt floods erupted in eastern oregon and washington during this period

C. 2 million to 700,000 years ago (Pleistocene)

1. Birth of the columbia gorge
2. Mountains began to uplift
3. As mountains rose the columbia river carved its way through the george
4. The river is actually older than the mountains

D. 16,000-14,000 years ago (Pleistocene)

1. Missoula floods
    a. Ice Dam in western montana
    b. Massive floods through eastern washington into the gorge and willamette valley
    c. Recurrence history
2. Influence on the gorge geology
    a. At the end of the last ice age, the missoula floods helped carve the extensive walls that exist today.

E. Bridge of the Gods (500 years ago)

1. Natives stories

2. Columbia river naturally damned

IV Summary and conclusion

~~IV~~ V. References

1. Layman, A. "The Geologic History of the Columbia River George." *Historic Columbia River High Way*, 17 Sept. 2012, columbiariverhighway.com/columbia-gorge-geologic-history/.

2. Gilfilin, Jule. "Columbia River George Geology Tour." *OPB*, 3 Mar. 2015, www.opb.org/television/programs/ofg/segment/columbia-river-gorge-geology-tour/.

3. Murry, John. "Waterfalls." *Columbia River Gorge*, 16 Feb. 2017, www.columbiarivergorge.info/waterfalls.html.

4. "Climate Hood River/The Dalles." *U.S. Climate Data* , 1 Jan. 2018, www.usclimatedata.com/climate/hood-river/oregon/united-states/usor0162.

See me for 1 or 2 critical research papers

Lawrence Dannen

TITLE OF PAPER?

ES 202

6/6

Extended Outline

I. Introduction
   A. General statistics of Mt. Hood
      1. Height, area covered, location; part of the Cascade Mountain Range

II. ~~Expanded Mt. Hood Information~~ Geologic Setting
   A. Quantity of water/ice, stream/river systems, drainage, etc.
   B. Formation of Mt. Hood, along with specifics in formation of upper dome area
   C. Composition of Mt. Hood (basaltic, continental crust, andesitic, etc.), Composite Volcano; recent geological activity/history, timeline of when certain features appeared
   D. Brief mention/description of different glaciers currently present
   E. Climate and its effect on Mt. Hood's Glaciers
      1. Inclusion of data about the "mini" ice-age some 150 years ago
      2. Current trends and how it has affected the movement of glaciers and total ice present
      3. Freezing and Thaw cycles

III. Glacial Features
   A. Glacial Deposits
      1. The different Moraines present; what can be concluded from their locations
      2. Glacial Valleys, Cirques, and their recorded advancements/recessions
      3. Other Glacial features; the Till within the glaciers
   B. Other Despostional/Erosional occurrences
      1. Lahars, rockslides, avalanches, expansion on the general landscape of Mt. Hood - interaction of different variables
      2. Fluvial processes tied to glacial processes precipitation run-off

IV. Specific case study of Eliot Glacier
   A. Zone of Accumulation/Ablation
      1. Unique properties of Eliot Glacier concerning the Till within - insulating properties
   B. Record of glacial changes from early 1900's in comparison to more current times
      1. How and why the measurements are taken and the conclusions that can be drawn from them

V. Conclusion
   A. Glacial Trends
   B. What is seen and what is expected - the features left behind

Lawrence Dannen

References Cited

A. Lilliquist, K., 2006, Historical Glacier and Climate Fluctuations at Mount Hood, Oregon: Arctic, Antarctic, and Alpine Research, v. 38, p. 399-412.

B. Jackson, K., 2005, Glaciers of Oregon: Glaciers of the American West. Academic & Research Computing, URL: glaciers.research.pdx.edu/Glaciers-Oregon.

C. Scott, W.E., 1996, Geologic History of Mount Hood Volcano, Oregon- A Field-Trip Guidebook, U.S. Department of the Interior U.S. Geological Survey. p. 1-40.

D. Driedger, C., and Kennard, P., 1986, Ice Volumes on Cascade Volcanoes: Mount Rainier, Mount Hood, Three Sisters, and Mount Shasta, U.S. Geological Survey Professional Paper 1365. p. 1-38.

E. Jackson, K., and Fountain, A., 2007, Spatial and morphological change on Eliot Glacier, Mount Hood, Oregon, USA, Department of Geography, PSU. p. 222-226

Good Refs.

Jessica Donahue

ES 202W

Term Paper Outline

✓ Good 6/6

The Geomorphic and Ecologic Effects of Dam Building and Removal on the Rogue River

I. Introduction
  a. Introduce the Rogue River, where it is, and other statistics about the river.
    i. The Rogue River exists in southwestern Oregon.
    ii. Over 8,500 km of mapped stream channels make up the Rogue River network (Jones, 2012).
    iii. The Rogue River starts in the Cascade Range near Crater Lake and flows toward the Pacific Ocean (Blumm, 2012).
    iv. The main stem of the Rogue contains sediment of volcanic rock fragments based on the flow direction of the river (Elliot, 2014).
    v. The river is well known for the large number of wild salmon (Blumm, 2012).
    vi. Congress protected 84 miles of the lower Rogue River from development to preserve the habitat of the wild salmon (Blumm, 2012).
  b. This paper will discuss three well-known dams on the Rogue River and how they have affected the geomorphology and ecosystems in the area.

II. Savage Rapids Dam
  a. Information and Location
    i. Savage Rapids Dam was built in 1921 and removed in 2009 (Jones, 2012).
    ii. The dam is located about 5 miles east of Grants Pass, Oregon (Blumm, 2012).
  b. Geomorphic Effects
    i. The was a reduction in residual depth and impacts to locations farther downstream were delayed by two years following the removal of Savage Rapids Dam (Tullos, 2014).
    ii. The release of sand to downstream areas of the river resulted in a reduction of grain size and overall bed stability (Tullos, 2014).
    iii. The sand released reduced bed material size and mobility, but did not impact the channel slope (Tullos, 2014).
  c. Ecological Effects
    i. Even though the dam had a fish bypass system, it was never successful in preventing the fish from entering the irrigation systems (Blumm, 2012).
    ii. The rate of fish mortality is what led to the dam's removal (Blumm, 2012).
    iii. The recovery from the disturbance that occurred from removing the dam happened within a year of removal (Tullos, 2014).

iv. Upstream and downstream sites were distinct prior to the removal of the dam, but no additional evidence was found that the removal of the dam affected more than the short period of disturbance found in taxonomically-defined assemblages (Tullos, 2014).

III. Gold Ray Dam
   a. Information and Location
      i. The Gold Ray Dam stood 35 feet tall located at mile 125.7 on the Rogue River (Elliot, 2014).
      ii. Constructed in 1904 and removed in 2010 (Blumm, 2012).
   b. Geomorphic Effects
      i. Sediment in the reservoir consisted of 63.4% sand, 9.2% gravel, and 19.4% silt and clay (Jones, 2012).
      ii. The amount of sediment in the Gold Ray Reservoir was approximately 306,000 cubic meters. (Elliot, 2014). These values are considered low.
      iii. The low values of sediment in the reservoir could be explained by the low gradient in the area. Prior to the dam being removed, the gradient was 4.9 feet per mile. After removal, the gradient increased to 11.1 feet per mile just upstream of the reservoir, which can be compared to the gradient of 11.8 feet per mile several miles upstream from the reservoir. Downstream of the reservoir, the gradient was calculated at 14.2 feet per mile. (Elliot, 2014).
   c. Ecological Effects
      i. This dam presented a problem for migrating salmon upstream from the Savage Rapids Dam.
      ii. More cost effective to remove the dam than to replace and upkeep the fish ladders and refurbish the dam to bring it up to standards (Blumm, 2012).
      iii. After the removal of this dam as well as two other main stem Rogue river dams, the salmon population showed signs of recovery (Blumm, 2012).

IV. William L. Jess Dam
   a. Information and Location
      i. 327 feet tall and located 28 miles northeast of Medford, Oregon (US Army, 2018).
      ii. Was constructed by the U.S. Army Corps of Engineers in 1977 (Jones, 2012).
      iii. As of 2011, the Jess Dam is the last dam on the main stem of the Rogue River (Jones, 2012).
   b. Geomorphic Effects
      i. The Lost Creek reservoir behind this dam store over 584,000 cubic meters of coarse sediment and accumulates it on an average of 17,700 cubic meters per year (Jones, 2012).
      ii. Lost Creek Lake, created by this dam, allows for 3,430 acres of water storage when at full capacity (US Army, 2018).

iii. The powerhouse has a generating capacity of 49,200 kilowatts produced by two 24.6 megawatt generators (US Army, 2018).

c. Ecological Effects

  i. The temperature of the water is regulated by combining the river water with lake water from several different depths to cool the water (US Army, 2018). This cools the overall water temperature to make it more suitable for the salmon and other fish in the area.

  ii. The Cole M. Rivers fish hatchery was built downstream of the Jess Dam to collect the fish returning on migration for spawning and they release the juvenile fish into the Applegate River to maintain the runs (US Army, 2018).

V. Summary and Conclusion

a. Show some before and after pictures of the Dams before and after removal

b. Explain that the distubances that occurred after removing the dams were small in relation to the negative effects that came from building them in the first place.

c. Explain how the building of fish hatcheries near the last remaining dam on the Rogue River has helped maintain the Salmon and other fish populations in the area.

VI. References

a. Blumm, M., and Erickson, A., 2012, Dam Removal in the Pacific Northwest: Lessons for the Nation: SSRN Electronic Journal, doi: 10.2139/ssrn.2101448.

b. Elliott, W., Dittmer, E., and Lane, C., 2014, Sediment study and removal of Gold Ray Dam on the Rogue River, Jackson County, Oregon: Environmental Geosciences, v. 21, p. 1–15, doi: 10.1306/eg.07311313006.

c. Jones, K.L., O'Connor, J.E., Keith, M.K., Mangano, J.F., and Wallick, J.R., 2012, Preliminary assessment of channel stability and bed-material transport in the Rogue River basin, southwestern Oregon: U.S. Geological Survey OpenFile Report 2011–1280.

d. Tullos, D., Finn, D., and Walter, C., 2014, Geomorphic and Ecological Disturbance and Recovery from Two Small Dams and Their Removal: PLoS ONE, v. 9, doi: 10.1371/journal.pone.0108091.

e. US Army Corps of Engineers, Jess Dam and Lost Creek Reservoir, http://www.nwp.usace.army.mil/Locations/Rogue-River/Lost-Creek/ (accessed March 2018).

http://www.dfw.state.or.us/fish/local_fisheries/rogue_river/index.asp

Formal format

Need some published references

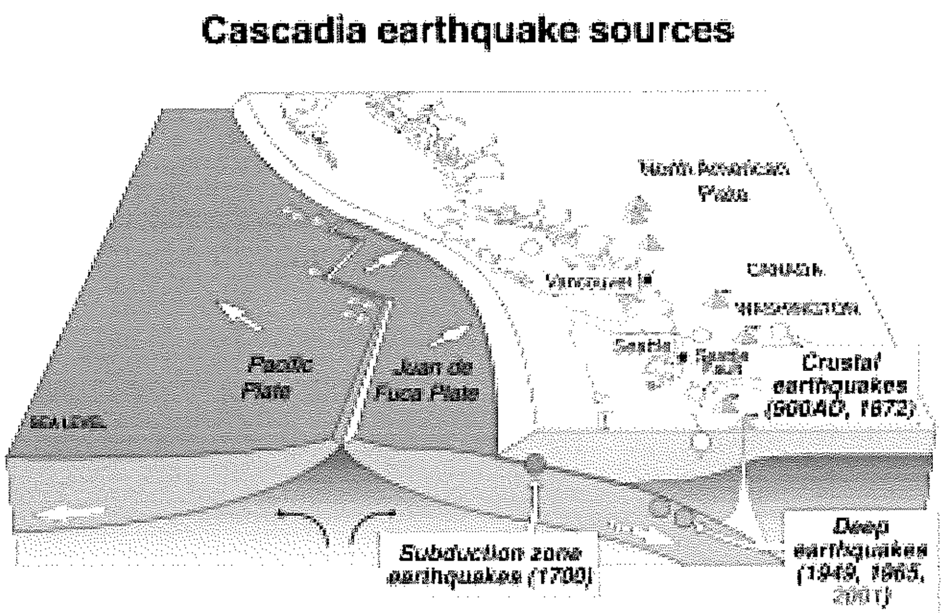
5/6

I. Introduction
II. Tectonic Setting
A. Cascadia Subduction Zone
III. Earthquake History
IV. Tsunami Hazards
A. Defined
B. At-Risk Areas
V. Hazards Mitigation
VI. Summary & Conclusion
VII. References Cited

Allura Eldridge
Dr. Taylor
ES 202W
16 February 2018

Potential Tsunami Hazards of the Pacific Northwest

- Introduction
  - What is a tsunami
    - Underwater waves caused by disturbances under water. Earthquakes, Meteorites, landslides, volcanic activity
  - The PNW ranges from Northern California to British Columbia
    - Aka Cascadia



  -

Factors that can increase chance of Tsunamis

  - Juan de fuca plate
  - Earthquakes : brief intro
    - "The big one"
    - How they relates to tsunamis
  - Subduction zone and its relation
  - Submarine landslides
    - Def: underwater landslides that transport sediment across the continental shelves
    - Sea floor sediment

        - Measured by seismometers (university of washington)

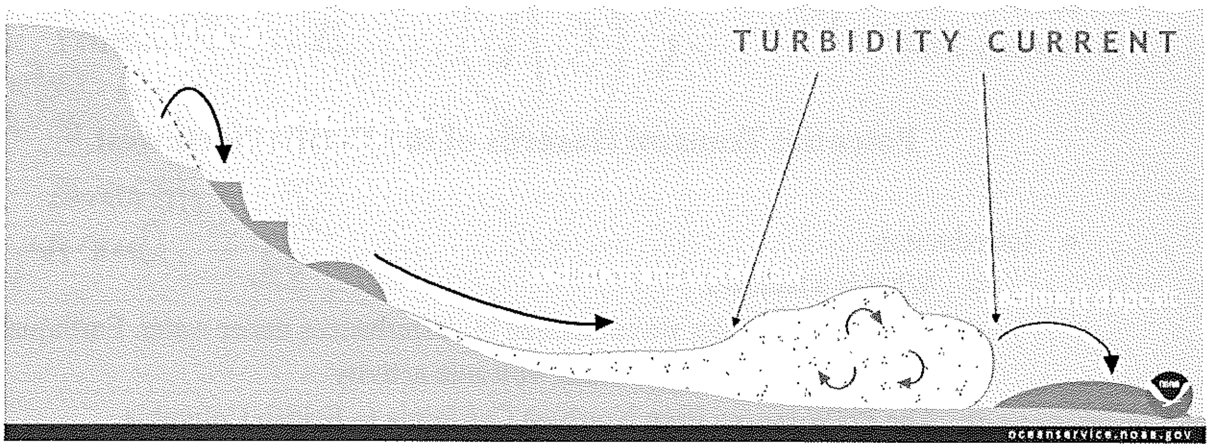


Figure 1. Submarine landslide; loose sediment and unstable slopes pushes sediment and water flow downwards causing landslides underneath the water

- **Amount of people living in the pacific northwest**
    - Over 2.8 Million
    - Previous Tsunamis have been known to cause the most destruction to California, Oregon, Washington and Hawaii (ITIC 2018)
- **Hazards**
    - Flooding
    - Contamination of water
    - Drowning
    - Loss of resources

- **How to prepare for a tsunami**
    - Awareness of the dangers
        - Tsunamis can reach heights greater than 100 feet, and are hazardous to many people
    - Evacuation routes

(A)

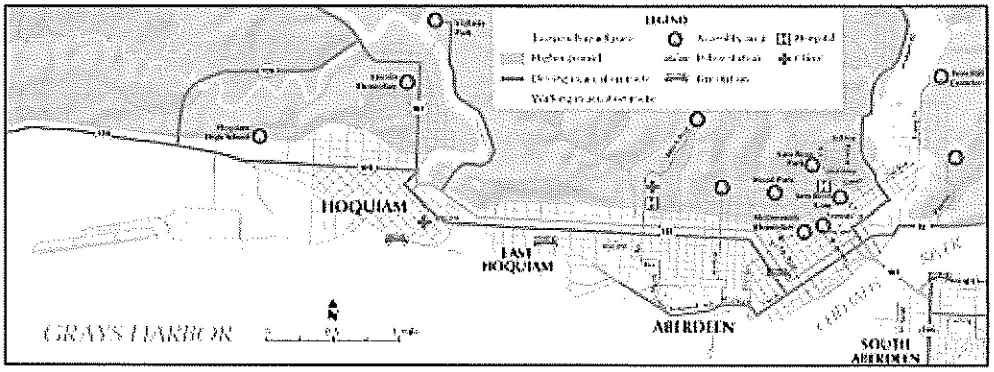


Figure 2. Hoquiam, Washington. Tsunami evacuation route. Highlighted yellow shows hazard zone.

- Tsunami ready-International

- Technology
- Regional Planning Tool
    -

Reduce tsunami hazards
https://www.researchgate.net/profile/Russell_Jackson2/publication/228946396_Reducing_Earthquake_and_Tsunami_Hazards_in_Pacific_Northwest_Ports_and_Harbors-Protecting_Our_Ports_and_Harbors_Project/links/558aa18108aeae8413bd6af6/Reducing-Earthquake-and-Tsunami-Hazards-in-Pacific-Northwest-Ports-and-Harbors-Protecting-Our-Ports-and-Harbors-Project.pdf

Sea floor sediment
https://phys.org/news/2017-11-seafloor-sediments-earthquake-tsunami-danger.html
http://www.washington.edu/news/2017/06/27/distant-earthquakes-can-cause-underwater-landslides/

Tsunami information center
http://itic.ioc-unesco.org/index.php?option=com_content&view=article&id=1017:what-are-tsunamis-and-what-causes-them&catid=1004&Itemid=1004

Email/See me for Additional References

Ali Faruqbey

Dr. Taylor

Geology

3 March 2018

Email me for a key reference

6/6

Extended Outline
Coastal Erosion and Processes/Hazards in Oregon

I. Introduction

   a. Waves, They can be destructive or constructive. For low energy or constructive waves, there is a stronger swash. With a destructive wave or high energy waves, there is a stronger backwash.

   b. Power of Waves influenced by Length of wind blowing, strength of wind and how far the wave has travelled.

II. Erosion

   a. Different types of erosion. Hydrolic action. Abrasion. Attrition. Solution.

   b. Hydraulic Action is when Air becomes trapped in cracks in cliff and compresses which weakens the cliff.

   c. Abrasion is when rocks and sand grind down the cliff surfaces with waves.

   d. Attrition. Waves smash rocks and pebbles onto shore causing them to break.

   e. Solution is when acid in sea water dissolves certain type of rock after splashing into them continuously.

III. Erosional Feautures

a. Rock Type - A more resistant rock erodes slowly. Less resistant rocks, erodes faster.

b. Jointing / Faulting - More faults and joints in a rock = more susceptible to erosion, both from coastal and sub-aerial processes.

c. Coastal Rock Arrangement - A coastline with rocks that run parallel to the coast is called Pacific coastline. One that has rocks running at right angles to the coast is called an Atlantic coastline.

IV. Human Causes of Coastal Erosion w/Effects

a. Deforestion

b. Removing Vegetation

c. Sand Mining

d. Construction

e. Building Houses

V. Hazards Associated

a. Sea Level Rise

b. Flooding

c. Harmful Algal Bloom

d. Tsunamis

e. Landslides

f. Contamination

VI Summary & Conclusion

VI. Refernces

http://greatlakesresilience.org/climate-environment/coastal-hazards-risks

https://oceanservice.noaa.gov/hazards/natural-hazards/

https://www.hiltonheadislandsc.gov/publicsafety/flood/erosionhazard.cfm

http://www.marbef.org/wiki/human_causes_of_coastal_erosion

Email me for Key Reference Koman et al., 1993

Salvador Garcia Lopez

Earth Science 202

Dr. Taylor

6 March 2018

TITLE?

6/6

Extended Outline

I. Introduction:

Smith Rock is in central Oregon and was formed from volcanic eruptions (Serres). For this research, I will be finding out: the type of magma, type of volcano, last time there was an eruption, rock type, and how it got named. Besides finding the answers to those questions I will also try to find some information about a feature at Smith Rock called Monkey Face. Like, how was it formed? Monkey Face is a pillar-like stone where on top it looks like the head of a monkey.

(Most of the information below was collected from the Mcclaughry, Jason D., Mark L. Ferns, Caroline L. Gordon, and Karyn A. Patridge. "Field Trip Guide to the Oligocene Crooked River Caldera: Central Oregon's Supervolcano, Crook, Deschutes, and Jefferson Counties, Oregon." source)

A. Location of Smith Rock State Park
   1) Terrebonne, OR
   2) Northwest side of Crooked River caldera

2) Geologic History

a) Oligocene to early Miocene (5 to 23 Ma)

i) Studies say that two additional calderas formed during this time, but it has not been mapped yet

b) Paleogene (23 to 66 Ma)

i) Newberry Volcano erupted (date here)

(1) Formed Newberry basalt at the base of Smith Rock State Park

ii) Three calderas were identified to have existed during this time period in the area

(1) The biggest being in Prineville called the Crooked River caldera

(2) The smallest one called the Wildcat Mountain Caldera

(3) Another one was the Tower Mountain caldera

c) Pliocene to Miocene (1.6 to 5 Ma)

i) Basalt lava erupted during this time from vents in the lower Crooked Basin

d) Crooked River Caldera

i) Volcanic tuff was erupted

ii) Diameter of caldera was about 41x 27 km

iii) Occurred approximately 29.5 million years ago

iv) Bigger than Crater Lake eruption

v) One of the biggest eruptions ever

e) John Day Formation

i) Defined as ash-flow tuff

3) Physical features of Smith Rock

a) The shape it has today

i) Eruptions

(1) Crooked River caldera

(2) Newberry Volcano

ii) Erosion

(1) Crooked river carved Smith Rock State Park into the way it looks like today

III ~~4)~~ Human activity at Smith Rock

a) Rock climbing

i) Monkey Face

ii) Rope-de-Dope

iii) The Dihedrals

b) Hiking

IV Summary and Conclusion:

Smith Rock State Park would not be the geological masterpiece it is today if had not gone through the eruptions from the Crooked River caldera and the Newberry Volcano.

Reference Cited:

Bruce discoveries. "Oregon's Supervolcano." *The Barneyville Blog*, 04 Feb. 2014. Web. 25 February 2018.

Jensen, Robert A., Donnelly-Nolan, Julie M., Mckay, Daniele. et al. "A Field Guide to Newberry Volcano, Oregon." Field Guide, vol. 15, 18 June 2009, pp. 53–79.

Mcclaughry, Jason D., Mark L. Ferns, Caroline L. Gordon, and Karyn A. Patridge. "Field Trip Guide to the Oligocene Crooked River Caldera: Central Oregon's Supervolcano, Crook, Deschutes, and Jefferson Counties, Oregon." *Ore Bin / Oregon Geology Magazine / Journal* 69.1 (2009): 25-44. Print. 25 February 2018.

Oregon State Parks Staff. "Smith Rock State Park Master Plan.". *Smith Rock State Park Masterplan*. 1990. Web. 24 February 2018.

Serres, Chris De. "How Did Smith Rock Get There?" *Rock Never Melts*. Rocks Never Melts, 18 July 2010. Web. 25 February 2018.

Shari. "Smith Rock: Dynamic Geology, Beautiful Place." *Apres Rain Arroyo RSS*. Arroyo Rain, 24 July 2011. Web. 25 February 2018.

"Smith Rock Climbing Escape." *Rare Earth Adventures*. 2015. Web. 26 February 2018.

"Smith Rock State Park Map." Smith Rock Climbing Guides Inc. Web. 26 February 2018.

Staats, Scott. "Meet the Crooked River Caldera." *Portland Tribune*. Pamplin Media Group, 03 Mar. 2008. Web. 25 February 2018.

"USGS: Volcano Hazards Program CVO Newberry." *USGS: Volcano Hazards Program CVO Newberry*. USGS, 02 Feb.2015. Web. 25 February 2018.

Nick Griffith
ES 202
3/7/18

Glacier History

Glaciation Periods of Oregon

- Introduction
  - Glacial placement today in contrast to Pleistocene Epoch
  - Degree in which glaciers can affect the planet
- Overview of Glaciation Periods
  - Glacial expanse-Pleistocene Ice Age
    - Causes, effects and processes which causes glaciers to advance and spread.
  - Glacial setting
    - Cascade range
      - Pleistocene ice cap
      - Period of glacial decline & mountain erosion
    - Wallowas
      - Glacial extent
      - Creation of glacier lake
    - Mt. Hood
      - Pleistocene ice cap
      - Cirque glaciers
      - Extent of glaciers during last glaciation period
      - Rivers fed by Mt. Hood glaciers
  - Geologic impact of Pleistocene Ice Age
    - Erosional features
    - Depositional features
      - erratics
    - Lithospheric subsidence
      - Average rate of subsidence
      - Cascade range

✓ 6/6

    - Glacial impact on the environment
        - Sedimentary rock patterns
        - Glacial structures in the environment
        - Impact and alteration on plant and wildlife
            - Introduction of new species
            - Extinction events
- Post-Pleistocene Oregon Glaciation
    - "Little Ice Age" (1300 to 1900 CE)
        - Description and extent of glaciated area
        - Impact on environment, both in terms of geology and ecosystem
        - Impact on humans, if applicable
    - 1950's to Present
        - Glacial activity of Cascades, Mt. Hood, Three Sisters, Wallowas, etc.
        - Study of glacial activity
        - Modern glacial trends in Oregon
- Summary/Conclusion
    - Importance of glacial study
        - Agriculture
        - Water sources
        - Geologic history
    - Future of Oregon Glaciation
- References cited

    - Fountain, Andrew, 2017, Oregon Encyclopedia: Glaciers of Oregon, URL: https://oregonencyclopedia.org/articles/glaciers_in_oregon/#.Wp81UOjwaUk
    - Jackson, Keith, 6/6/05 (modified 22 June 2011), Glaciers of the American West: Glaciers of Oregon; URL: http://glaciers.research.pdx.edu/Glaciers-Oregon

- Kargel, Jeffery & Leonard, Gregory, 2014, Global Land Ice Measurements from Space, Intergovernmental Panel on Climate Change

OUTLINE #1

Excused Lateness

2/4

Genevieve Hardin

Dr. Taylor

Rough Outline

3/6/18

The Story of the Missoula Floods

Thesis: The history of the Missoula Floods is a long and interesting one.

a. How they formed

b. How they broke free

c. Why they stopped

d. How we know

e. How it affects us today

Genevieve Hardin

Dr. Taylor

Expanded Outline

3/6/18

The Story of the Missoula Floods

Thesis: The history of the Missoula Floods is a long and interesting one.

a. How they formed

b. How they broke free

c. Why they stopped

I. The formation of the Missoula lakes.

a. Cold temperatures

b. Effect of the lakes on the landscape

c. Effect of the lakes leaving the landscape

II. The effect of the floods on the landscape.

a. Building pressure

b. Landforms created by floods

c. Volume of floodwater

d. Why they stopped.

III. How we know.

a. Visual evidence.

b. Radiocarbon age dating.

c. experiments

Conclusion: How the Missoula floods affect our lives today.

Needs same note

6/6

Details needed

I. Introduction

II. Late Pleistocene Glacial History

III. Missoula Floods

A. Evidence

i. Landforms Scablands

ii. Deposits

a) Willamette Silt

b) Erratics

B. Flood Chronology

IV Summary & Conclusion

V. References Cited

Works Cited

benito03_fairbanks_divide_Missoula_flood

Bjornstad_2008_ice_age_floods_Missoula

oconner_baker_1992_Missoula

Crystal Harvel
ES 202
Outline for Term Paper

TITLE

I. Introduction
   A. Potential settlement of the area by Paleo-Indians during the flooding
   B. Number of glacial lakes in the area
   C. Climate of the area
      1. Amount of precipitation
      2. Temperature increase

II. Geologic Overview
   A. Location
      1. Glacial Missoula Lake
      2. Clark Fork River
         a. 68 mi NW of Missoula Montana and N. end of Camas Valley
      3.Idaho, Oregon, Washington
         b. Columbia River, Snake River, Scablands, Dry Falls, Willamette Valley

II. Geologic History
   A. Last Glacial Maximum (LGM) 26.5kBP Pleistocene Epoc
         a. Deglaciation 20kBP causing melt to erode and create strong rivers and lakes
         b. 15,000-12,000kya part of ice sheet broke off damming Clark Fork River ~ 2,500 ft tall
         c. Glacial Missoula Lake became the size of Lake Erie and Lake Ontario combined, overfilled by meltwater 2,000 ft tall causing breach
         d. Glacial meltwater and sediment eroded tunnels in the dam which gave way
   B. Force of Glacial Dam Breach
         a. Water flowed with force 60 times that of the Amazon river
         b. Flood water speeds of 30-50 mph 9.46 cubic mph
   C. Depth of Flood
         ~ 1,250 feet estimated at <u>Pasco, Washington</u>, located over 200 miles from the Lake Missoula Dam,
         ~1,000 feet estimated at <u>The Dalles, Oregon</u>
         ~400 feet at <u>Portland, Oregon</u>, nearly 400 miles away
         ~375 feet estimated at <u>Longview and Kelso, Washington,</u>
   D. Amount of Time to Drain the Glacial Lake
         a. Took a few days to a week to drain

III. Effect on the Land
   A. Lakes created by the Glacial Missoula Flood
         a. Lake Condon, Lake Lewis, Lake Allison
         b. Scablands of Eastern Washington

✓ Good 6/6

c. Coulees

d. Rich farm soil in the Willamette Valley

e. Glacial erratic rocks - Glacier Rock, Mcminnville, OR, Yeager Rock, Mansfield, Wa.

IV. Summary and Conclusion

A. Created rich soil for agriculture
B. New lakes formed
C. Landforms and erratics

V. References

"*Glacial Lake Missoula*," Internet web resource
URL:
http://www.hugefloods.com/Ice-Age-Floods-Links.html

Oregon State Parks
URL:
https://oregonstateparks.org/index.cfm?do=parkPage.dsp_parkPage&parkId=96

"*Glacial Lake Missoula and The Ice Aged Floods*," Internet web resource
URL:
http://www.glaciallakemissoula.org/story.html

Cappious, S.L. 1939. A history of the Bitter Root Valley to 1914 [master's thesis]. Seattle, WA: University of Washington. [Pages unknown]. Internet web resource
URL:
https://www.fws.gov/refuge/lee_metcalf/about/people_of_the_Bitterroot_Valley.html

Bianca Hernandez
Dr. Taylor
ES 202 11:00 PM
March 2, 2018

Volcanic Hazards in Oregon

66

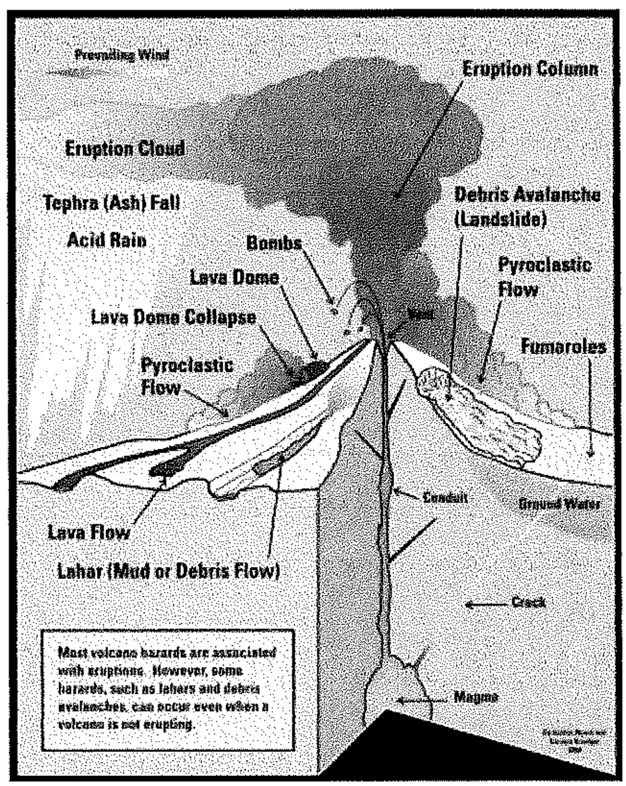
I. Introduction:

a. Definition:

- Volcanic Hazard- a volcanic eruption or related geophysical event will occur in a given geographic area and within a specified window of time.

b. Volcanic Hazards in Oregon:

- Crater Lake
- Mt. Hood
- Mt. Jefferson
- Newberry Volcano
- Three Sisters



c. Other Regions:

- Glacier Peak
- Lassen Volcanic Center
- Mt. Adams
- Mt. Baker
- Mt. Rainier
- Mt. St. Helens

II. Geologic Overview

a. List of Volcanic Hazards:

- Pyroclastic density currents
- Lahars
- Structural Collapse: Debris flow- Avalanches
- Dome Collapse and the formation pyroclastic flows and surges
- Lava flows
- Tephra fall and ballistic projectiles
- Volcanic gas
- Tsunamis
- Volcanic lightning

b. What causes Volcanic Hazards?

- Lava flows
- Seismic activity
- Minor eruptions of Steam and Ash

III. Major Eruptions and Impacts on Oregon:

a. History of Oregon Volcanic Hazards- Mt. Lassen 1919, and Mt. St. Helens 1980

b. Impacts on Oregon

- Killed 57 people
- Major ashfall
- Lahars
- Physical
- Chemical

- Biological characteristics of surface water, groundwater, and precipitation

IV. Summary and Conclusion

V. References Cited

- Program, Volcano Hazards. "Cascade Volcano Observatory." *Cascades Volcano Observatory*, USGS, volcanoes.usgs.gov/observatories/cvo/hazards.html.
- "Hazardous Volcanic Events." *Volcano Information Center (VIC)*, Richard V. Fisher, volcanology.geol.ucsb.edu/hazards.htm https://pubs.usgs.gov/fs/fs002-97/.
- "Volcanic Hazards." *Google Books*, R.J Blong, books.google.com/books?hl=en&lr=&id=6kjgBAAAQBAJ&oi=fnd&pg=PP1&dq=what%2Bcauses%2Bvolcanic%2Bhazards%3F&ots=ebbyaxEX3W&sig=h8UVtwtCFiOyrL03VrE5N282ra8#v=onepage&q=what%20causes%20volcanic%20hazards%3F&f=false.
- "GCSE Bitesize: Key Facts." *BBC*, BBC, www.bbc.co.uk/schools/gcsebitesize/geography/natural_hazards/volcanoes_rev1.shtml.
- "Volcanic Hazards." *Volcanic Hazards*, Oregon Department of Geology and Mineral Industries, www.oregongeology.org/sub/earthquakes/volcanoes.htm.
- "Volcano World." *What Were the Effects on People When Mt St Helens Erupted? | Volcano World | Oregon State University*, Oregon State University, volcano.oregonstate.edu/what-were-effects-people-when-mt-st-helens-erupted.

- *Mount Hood--History and Hazards of Oregon's Most Recently Active Volcano, Volcano | USGS Fact Sheet 060-00*, pubs.usgs.gov/fs/2000/fs060-00/.
- *Effects of the Eruption Of Mount St. Helens*. Douglas B. Lee, books.google.com/books?id=AlysQS0xwjEC&pg=PA122&dq=mount%2Bst%2Bhelens%2Beruption%2Bimpact%2Bon%2Boregon&hl=en&sa=X&ved=0ahUKEwjC7saQ9djZAhUmqlQKHUGRDmwQ6AEIKTAA#v=onepage&q=mount%20st%20helens%20eruption%20impact%20on%20oregon&f=false.

Oregon, why are you so hazardous? Chanel Karbonski

-2 4/6

Introduction

Overview

1. Tectonic boundary (current)
   Subduction zone – Juan de Fuca plate (ex. Movement that caused eruptions)

   More in depth of the current tectonic boundary and where we reside on it. How it affects our day to day life in Portland. Recent tectonic plate movements (earthquakes).

2. Volcanic process
   -EX. St Helens & Mt Hood
   How have the past eruptions have influenced the population and people residing here in the PNW.
   Talk about each eruption and describe what we did to benefit from the eruptions (https://volcanoes.usgs.gov/observatories/cvo/cvo_volcano_updates.html)

3. Current hazards
   Things we have done to improve awareness
   Insurance that is offered to people in the 'hot' zone

Summary & conclusion

References cited

email me / see me for References

I. Introduction
II. Physiographic Setting
A. Plate Tectonics
B. Climate
III. Geologic Hazards
A. Seismic – Shaking – Tsunami
B. Volcanic
C. Surface Processes – Landslides
IV. Hazards Mitigation flooding
V. Conclusion
VI. References Cited

"Department of Geology and Mineral Industries Volcanic Hazards." Www.Oregon.gov, www.oregon.gov/dogami/pages/earthquakes/volcanoes.aspx.

Prehistoric and Historic Volcanic Eruptions in Oregon, www.oregongeology.org/sub/earthquakes/volcanoeshist.htm.

DOGAMI - Oregon Department of Geology and Mineral Industries. "Oregon HazVu: Statewide Geohazards Viewer." DOGAMI | Statewide Hazards Viewer - Hazards and Assets, www.oregongeology.org/sub/hazvu/hazards-assets.htm.

Geologic History of the Columbia Gorge

Hannah Moshinsky, ES 202

+1 7/6

Introduction

I. General Facts about the Gorge

a. The Columbia Gorge is an awe-inspiring construction of nature. It had tremendous influence on the cultures who established themselves around it, and it continues to affect the societies flourishing around it today. Reaching a length of 75 miles and an average valley width of 3 miles, the Columbia Gorge is home to about 70,000 residents and 13 unique species of wildflower (Facts).

b. Rome was not built in a day, and neither was the Columbia Gorge. Formed over 12,000 years ago, the Columbia Gorge was fashioned through thousands of years of tectonic uplift and erosion (Facts).

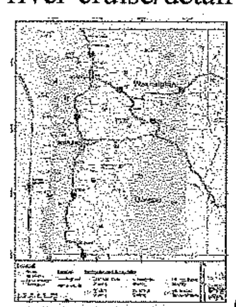
Geology

II. Tectonic Setting

a. Looking on a map, the Columbia can be found in the Pacific Northwest along Washington and Oregon states. Taking a closer look at the map will show the Columbia Gorge is located along the North American Plate. Not only that, but it's on the Cascadia Subduction Zone where the Juan de Fuca Plate is submerging beneath the North American Plate. The Gorge itself is where the river cuts through the Cascade Range, and it serves as the state line between Washington and Oregon (Columbia River Gorge, 2015).

The pictures won't be this small on the draft. I just shrunk it to save paper and ink. ✓ o.k.

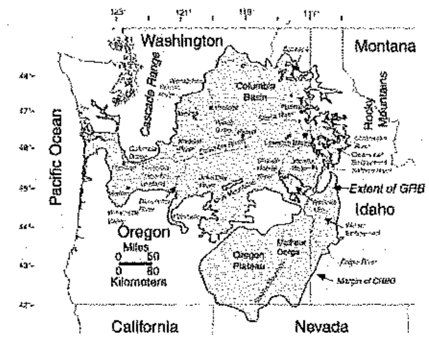
b. (Columbia and Snake Rivers Voyage) Retrieved from: http://www.nationalgeographicexpeditions.com/expeditions/columbia-snake-river-cruise/detail



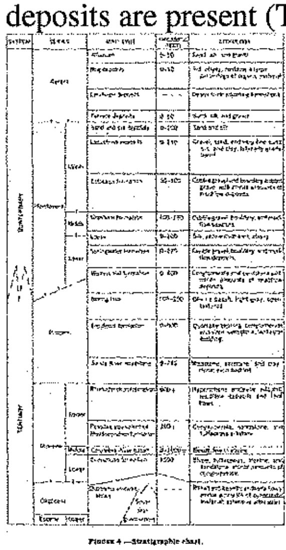
c. (Marzeles, 2015) Retrieved from: http://www.goldendalesentinel.com/story/2015/07/22/news/northwest-set-to-train-for-monster-quake/6184.html?m=true

III. Types of rocks found there

a. Basalt Flows and the Columbia River Flood Basalts

i. Mostly tholeiitic basalt (Columbia River Flood Basalts).
ii. Over 350 volcanic flows occurred between 16.7 mya and 5.5 mya, but most of the volume came from eruptions between 16.7 mya and 15.6 mya (Columbia River Basalt Group Stretches from Oregon to Idaho).
iii. Tie it back to the formation of the Gorge.
iv. 

(Columbia River Basalt Group Stretches from Oregon to Idaho) Retrieved from: https://volcanoes.usgs.gov/observatories/cvo/cvo_columbia_river_basalt.html

b. Sedimentary Rocks
   i. Fluvial and lacustrine origin and are evidence to a period of massive flooding. Some sand and silt layers come from terrace deposits. Bog deposits contain organic material. Mudstone deposits and floodplain deposits are present (Trimble, 1963).
   ii. 
   (Trimble, 1863) Retrieved from: https://pubs.usgs.gov/bul/1119/report.pdf

<u>History</u>

IV. What it looked like long ago
   a. Before there was the Gorge, there was a valley similar to the Willamette Valley of today that was 60 miles wide. The cascades were low, and the valley itself was almost flat. Evidence from the ancient basalt flows show where in the valley the Columbia River flowed (Columbia River Gorge).

V. How the rocks and landforms formed and changed over time

i. More information on the Columbia River Basalt Group and the basalt flows. The Basalt flows starting approximately 17 mya came from up to 200 miles east of where the Gorge is today, and because the Gorge was just a valley at the time the basalt flows followed the valley to the Pacific Ocean. Pillow lavas can be seen today from when the lava interacted with the water from the river (Columbia River Gorge, 2015).
ii. Tectonic uplift formed the Cascade Range from the basalt flows that came millions of years before. It is responsible for rising 3000 feet in the last 3 million years (Columbia River Gorge, 2015).
iii. Yakima fold-and-thrust belt created the tilted beds seen in the Columbia Gorge. The anticlines and synclines are a result of crustal compression by a group of faults from central Washington that cross the Gorge (Columbia River Gorge, 2015).

VI. Geologic structures, landforms, and how they formed
   a. Eagle creek formation is exposed rock that is older than the basalt flows. It is composed of volcanic mud, lahars, petrified wood, and volcanic rocks of eruptions that were 20 mya to 30 mya (Columbia River Gorge, 2015).
   b. Landslides from the basalt and clay bedrocks. Example: Bonneville Slide (Columbia River Gorge, 2015).

VII. What came first: the river or the gorge?
   a. The river was there before the Gorge had formed. The Columbia Hills Anticline proves evidence that the ridges came second because the river cuts right through the anticline (Columbia River Gorge, 2015).

VIII. Impact from the River
   a. The ice age floods did not form the Columbia River Gorge, but every flood passed through the Gorge and left its mark. Flood deposits as well as erosion marks, such as giant potholes, can be observed as being left behind (Columbia River Gorge, 2015).
   b. How the gorge was changed by and influenced the river. The Columbia River cut through the tectonic uplift that's was forming the Cascade Range, and that's why the rock around the river is so high (Columbia River Gorge).

Summary and Conclusion

I. The Columbia Gorge has an extensive geologic history with many forces of nature being involved in the process. The rock composing the Gorge formed long before the Gorge took its shape, but the Gorge itself is a product of tectonic uplift and erosion. It not only serves as a place to study geologic processes, but also as a great place to hike and have a picnic.

References Cited

Camp, V.E., Reidel, S.P., Ross, M.E., Brown, R.J., and Self, S., 2017, Field-trip guide to the vents, dikes, stratigraphy, and structure of the Columbia River Basalt Group, eastern Oregon and southeastern Washington: U.S. Geological Survey Scientific Investigations Report 2017–5022–N, 88 p., https://doi.org/10.3133/sir20175022N.

Columbia and Snake Rivers Voyage, n/a, National Geographic Expeditions: Internet Web Resource, URL: http://www.nationalgeographicexpeditions.com/expeditions/columbia-snake-river-cruise/detail (last updated n/a).

Columbia River Basalt Group Stretches from Oregon to Idaho, n/a, US Geological Survey: Internet Web Resource, URL: https://volcanoes.usgs.gov/observatories/cvo/cvo_columbia_river_basalt.html (last updated Jun 27, 2017).

Columbia River Gorge, 2015,. [video] Available at: https://www.youtube.com/watch?v=w7eqBtc2tv0 [Accessed 23 Feb. 2018].

Columbia River Flood Basalts, n/a, Volcano World: Internet Web Resource, URL: http://volcano.oregonstate.edu/book/export/html/486 (last updated n/a).

Facts, n/a. Columbia River Gorge: Internet Web Resource, URL: http://www.columbiarivergorge.info/facts.html (last updated n/a).

Marzeles, L., 2015, Northwest set to train for monster quake: The Goldendale Sentinel: Internet Web Resource, URL: http://www.goldendalesentinel.com/story/2015/07/22/news/northwest-set-to-train-for-monster-quake/6184.html?m=true (last updated n/a).

O'Connor, J. The Evolving Landscape of the Columbia River Gorge: Oregon Historical Society. URL: http://columbiariverhighway.com/wp-content/uploads/2014/02/The-Evolving-Landscape-of-the-Columbia-River-Gorge.pdf.

O'Connor, J., and Burns, S., 2009, Cataclysms and controversy -- Aspects of the geomorphology of the Columbia River Gorge: The Geological Society of America.

The Columbia River Highway, n/a, The Geologic History of the Columbia River Gorge: Internet Web Resource, URL: http://columbiariverhighway.com/columbia-gorge-geologic-history/ (last updated n/a).

Tolan, T., Martin, B., Reidel, S., Anderson, J., Lindsey, K., and Burt, W., 2009, An introduction to the stratigraphy, structural geology, and hydrogeology of the Columbia River Flood-Basalt Province: A primer for the GSA Columbia River Basalt Group field trips: The Geological Society of America.

Trimble, D., 1963, Geology of Portland, Oregon and Adjacent Areas: US Geological Survey. Retrieved from: https://pubs.usgs.gov/bul/1119/report.pdf.

Maddie Peterson
ES 202
Taylor
7 March 2018

6/6

The Geologic History and Evolution of the Columbia River Gorge

I. Introduction

1) Overview of tectonics and location (1,200 m deep, 130 km long, bounds Oregon and Washington through the west Cascades. Extends from junction of Columbia and Deschutes rivers, down east past the greater Portland area.)
2) Anatomy of the canyon, area and key features
3) Brief history of the gorge in human time scale
4) Importance for transportation (riverways, highways), energy generation (wind, hydroelectric) and cultural significance

II. Geologic Setting

A. Overview of Geology

- Tectonic Setting
- Geography

III. ~~B.~~ Geologic History

1. Eocene to Miocene

- Columbia River Basalt Group (evolution, impact), geography of CRBG flows, impact on existing topography

2. Pleistocene

- Missoula Floods (2,500 year period)
- Volcanic sediments and deposits (Cascade Range)
- Tectonic uplift of mountains and downcutting of Columbia river
- Bonneville flood

3. Holocene to Present Day

- Ice Age flooding (13-15 tya)
- Major landslide event (500 years ago)

C. Formation of present day major geologic features and structures

- Multnomah Falls
- Beacon Rock
- Bonneville dam

IV. Summary and Conclusions

- Significance of the gorge for populations living near it
- Geologic future

References

- Oregon State University, 2009, Columbia River Flood Basalts: http://volcano.oregonstate.edu/book/export/html/486 (accessed February 2018).

- Jim E. O'Connor, 2004, The Evolving Landscape of the Columbia River Gorge: Lewis and Clark and Cataclysms on the Columbia: *Oregon Historical Quarterly* 105:3 [2004]: 390–421

- Donald E. Trimble, 1963, Geology of Portland, Oregon and Adjacent Areas: Geologic Survey Bulletin, USGS, U.S Department of the Interior

- United States Geological Survey (USGS), 2017, Cascades Volcano Observatory: Columbia River Basalt Group: https://volcanoes.usgs.gov/observatories/cvo/cvo_columbia_river_basalt.html (accessed February 2018).

- Ron Suchanek, 1974, The Columbia River Gorge the Story of the River and Rocks: The Ore Bin, Oregon Department of Geology, Vol. 36 No. 12

Adam Panichello
2/16/18
Geology 202

6/6

Effects of Forestry Practice on Watershed Processes in Western Oregon

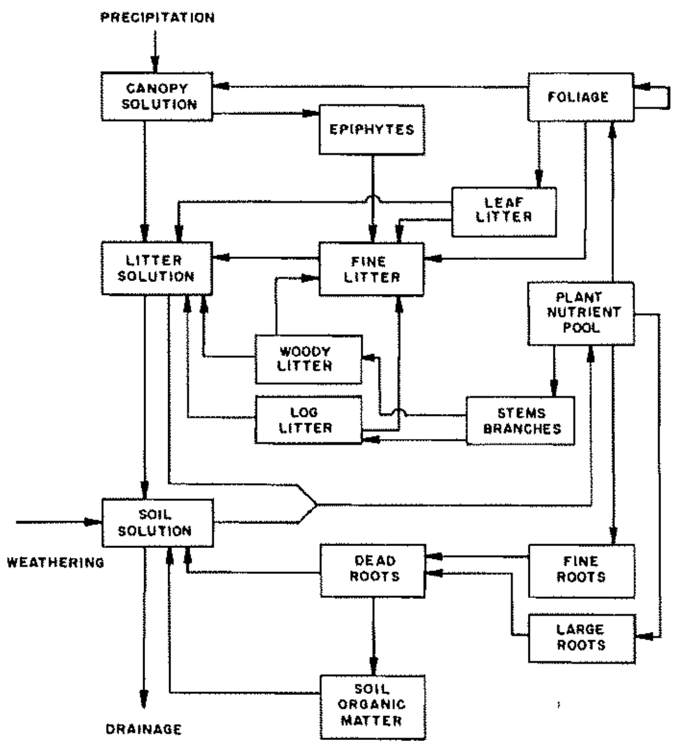
Outline 2

Introduction

Definition of Forestry/logging industraily: The mass removal of an large group of trees using one of three common logging methods to speed up the process versus standard chainsaw tree falling

Three main types of logging: Clear cutting: The use of heavy machines to cut a massive area of land bare of the useful timber. This method is very disruptive to the local environment as the heavy machine rip up the land. Cable Logging: The use of a Skyline to transport the logs to a loading site to be taken to the mill this method does minimal damage to the surrounding environment because it only takes a few men to fall the trees instead of heavy machines. Selection tree logging: this is where only certain trees are logged from one area leaving the rest behind. Such as logging only the oak out of a area and leaving behind all the pine or fir that are still mixed in.

Define Watershed: a basin or low lying area that drains into the same basin as the flat lands of western oregon do because of the surrounding highlands.



Characteristic of the Western Oregon Watershed

Location: West of Salem, Rickreall Watershed

Climate Characteristic: Wet/Rainy with periods of dry warm days. Mostly in the 40s to 50 throughout the year but can drop below freezing for long periods during the winter Heavy winds from the west and the coast.

Soil Compositions: Silty clay mix that drains very poorly.

Forestry Types and locations:

Forestry use and possible climate changes

Effects on Soil after logging: Nitrogen levels changing in the soil after large areas of trees are removed from the forest.

<u>Effects on local Rivers:</u> Changes in sedimentary deposits after clearcutting and air line logging.

Sorry about this huge blank space here. I am planning on fixing this for the final term paper but I was unable to format the outline so that the diagram and the text would fit into this space.

Streamflow changes: Obstructions causing backups and the effects on the river structure after the dam has been removed.

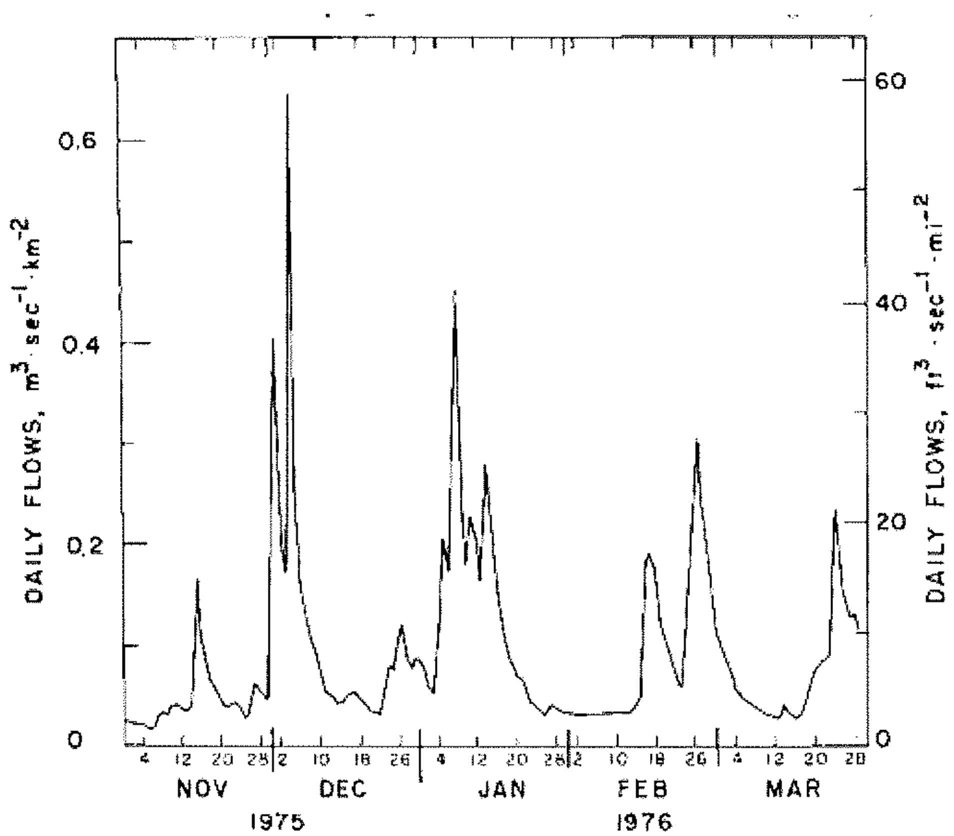


Figure 2. Streamflow for the North Fork of the Alsea River near Alsea, Oregon.

Fish Pop/Spawning Changes After logging: Back ups caused from logging causing local fish populations to be able to continue upstream and on to possible spawning locations.

TABLE 2. ORGANIC DEBRIS LOADING DATA FOR FOREST AND CLEARCUT STREAM REACHES (STREAM WIDTH 1 TO 8.5 m) IN WESTERN OREGON AND SOUTHEAST ALASKA. BULK DENSITY OF WOOD IN THE OREGON STREAMS WAS ASSUMED TO BE 0.58 AND FOR ALASKA 0.50 g/cm³

Location	Sample size	Before logging		After logging	
		Coarse*	Fine	Coarse*	Fine
		kg/m²			
Western Oregon+					
Old-growth forest	10	39.1	3.0		
Clearcut					
Free-falling	3	24.9	2.6	56.6	11.5
Cable-assist directional falling	4	50.1	3.8	46.0	12.0
Free-falling, buffer strip	3	38.5	2.5	35.8	3.2
Prince of Wales Island, Alaska∆					
Old-growth forest	3	5.3	1.0		
Clearcut, free-falling	3			15.6	7.1

* Diameter of coarse debris > 10 cm.

\+ From Froehlich (1973b).

∆ From Swanson & Lienkaemper (unpub. data).

Air Quality effects after clear cutting:

Impacts of forest changes on water at a forest ground level

Effects on soil after root structure of the forests are removed:

(I am hoping to expand on this part and on the implications for trying to manage this problem within the paper more. I am just looking for a slightly more up to date source that can provide better possible changes to make within the logging industry to better preserve the Western Oregon watershed.)

Implications for management and adaptation strategies

Possible Management strategies: Replanting as you clear cut

Only allow certain amounts of clear cutting to take place

Selective tree cutting: Looking into research about what trees are need to maintain the soil nitrogen and other nuritant levels while also preserving the structural integrity of the soil.

Conclusion

Less trees equals more water in the watershed and more trees means less water going into the watershed.

The less logging the goes on in a area the less dramatic changes happen to the hydrologic cycle and the watershed is effected at the smallest amounts.

TABLE 2. Change in Timing of Peak Flows After Logging in Watershed 10

	Prelogging		Postlogging		
Type of Peak Flow	No. of Peaks	Time Difference,* hr	No. of Peaks	Time Difference,* hr	t
All peaks of >2.2 l/s/ha	90	1.1	13	9.7	7.34†
Rain of >1.6 l/s/ha	49	0.7	7	1.3	0.97
Snow of >2.2 l/s/ha	45	1.3	9	12.8	7.25†

*Watershed 10 peaked later than watershed 9.
†The change is significant at the 0.01 level of probability.

References

Cromack, K, et al. "a Comparison of Harvesting Methods and Their Impact on Soils and Environments in the Pacific Northwest." ***a Comparison of Harvesting Methods and Their Impact on Soils and Environments in the Pacific Northwest*****, 1979, pp. 439–479., doi:02/25/18.**

"Debris Removal and Its Effects on Sedimentation in an Oregon Coast Range Stream." ***Debris Removal and Its Effects on Sedimentation in an Oregon Coast Range Stream*****, vol. 55, 1979, pp. 71–77., doi:02/25/18.**

Harr, Dennis F, and Micheal F McCorrison. "Water Resources Research." ***Intail Effects of Clearcut Logging on Size and Timing of Peak Slows in a Small Watershed in Western Oregon*****, vol. 15, 1979, pp. 90–94., doi:02/25/18.**

US Department of Agriculture. "Soil Survey of Polk County Oregon." ***Soil Survey*****, 1972, pp. 4–263., doi:02/02/18.**

Sergey Sharpe
Geology 202
Taylor
2/26/18

Geologic History of the Oregon Columbia River Gorge
Outline two

(6/6)

i. Introduction

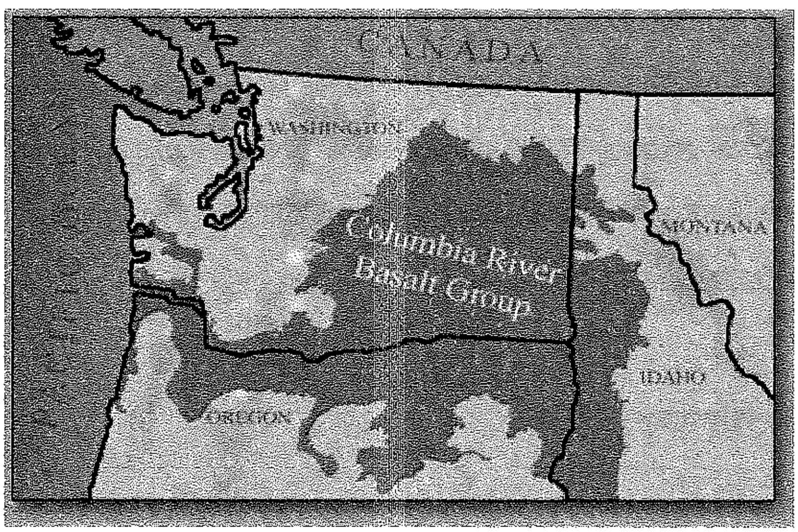
a. Founded by Louis and Clark. On April 9, 1806, Lewis describes the area: " we passed several beautiful cascades which fell from a great height over the stupendous rocks" ... " The hills have now become mountains high on each side are rocky steep covered generally with fir and white cedar".

b. **Facts**: 1,243 miles long (7th longest river in the U.S). Average width of river: 1 mile. Length of gorge: 75 miles. Area drained by Columbia river: 259,000 square miles. 75 Gorge waterfalls. 4 million annual visitors of Multnomah falls. Time in which it took to carve Columbia river gorge: ~ 12,000 years. Number of State Parks & Recreation Areas: 21. Approximate Number of Residents in The Gorge: 70,000. All provided by www.columbiarivergorge.com.

ii. Geologic History

a. **Missoula Floods:** Largest floods on the planet occurred on the planet near Oregon. Last ice age, ice sheets covered most of Canada. 2,000 feet high ice sheets moved towards Idaho. Over time the ice began to melt and flooded Western Washington. The floods cause many rivers and canyons to form. Waterfalls also formed thanks to the floods.

b. **Basaltic rocks:** The Columbia Basin of eastern Washington is plastered with deep layers of a fine grained black rock known as basalt. The basalt is lava that cooled and hardened after it flooded over the landscape. These astounding lava floods occurred on a scale unequalled anywhere else on the entire planet. Lava began flowing in the Columbia Basin about 17 million years ago and continued until about 6 million years ago. In all, there may have been 300 individual outbreaks. Each lava flood was separated by thousands of years in which nothing happened. The coverage area for Columbia River flood basalts exceeds 60,000 square miles. At least 50,000 cubic miles of basalt can be found within that area, and some estimates go as high as 90,000 cubic miles. The immense weight of this rock caused the Earth's outer crust to depress and form the shallow basin that dominates the topography of eastern Washington. Provided by http://hugefloods.com/Basalt.html

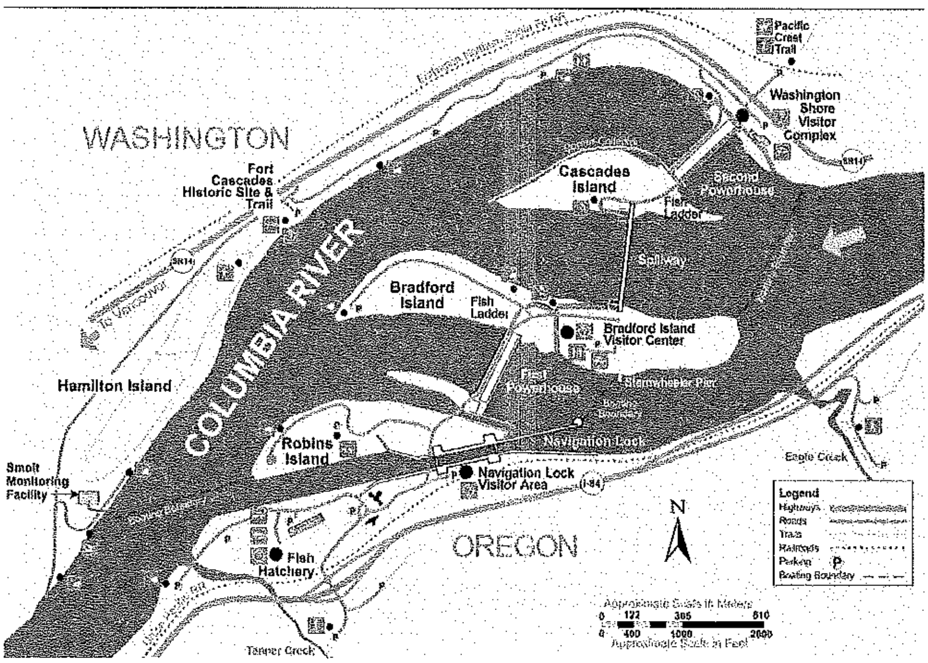


http://hugefloods.com/Basalt.html

c. **Landslides:** Landslides are very common at the Columbia River Gorge. Near Bonneville, lava layers started to build up and the lava layers ended up sliding into the gorge. There was a series of four landslides. These landslides ended up damming parts of the Columbia River Gorge. The gorge is constantly changing, and landslides are still very common. In the winter of 1996 there was a landslide located near the

Bridge of the Gods and destroyed homes. You can see this damage at milepost 35 on I-84

d. Bonneville Lock & Dam: First dam on the Columbia River, construction ended in 1937. It was built by Roosevelt administration. The dam was built to allow big vessels to travel to the ocean. There is now a fish hatchery also located in the dam and is a small tourist attraction.

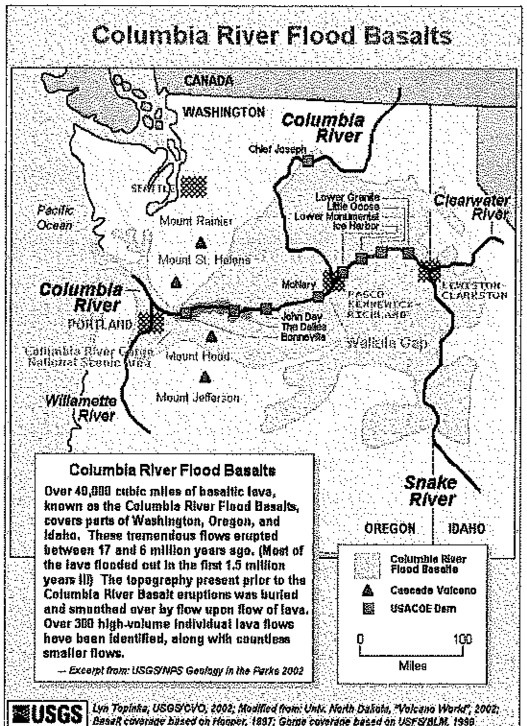


e. Winds: Columbia River Gorge has a history of high winds. These winds contribute to things such as landslides.

f. River Basin: Need more research

g. Tectonic Uplift: Need more Research

Sergey Sharpe
Geology 202
Taylor
2/26/18



https://volcanoes.usgs.gov/observatories/cvo/Historical/LewisClark/Maps/map_columbia_river_flood_basalts.shtml

iii. Multiple Waterfalls

a. **Multnomah Falls:** Plummeting 620 feet from its origins on Larch Mountain, Multnomah Falls is the second highest year-round waterfall in the United States. Formed roughly 15,000 years ago and fed by underground springs from Larch Mountain.

b. **Horsetail Falls:** 176 feet tall.

c. **Punchbowl Falls:** 35 feet tall.

d. Talk about a few of the falls and how they are all different, some are alluvial fans, segments, plunging, tiers, blocks, etc.

iv. Further History of Columbia River Gorge

Sergey Sharpe
Geology 202
Taylor
2/26/18

e. "Geologic History of the Columbia River Gorge." *Historic Columbia River Highway*, columbiariverhighway.com/columbia-gorge-geologic-history/.

f. "OregonColumbia River Gorge." *Columbia River Gorge - Go Northwest! A Travel Guide*, www.gonorthwest.com/oregon/columbia/columbia_river.htm.

g. Plattenberg, Rachel H. *Environmental Pollution: New Research*. Nova Science Publishers, 2007.

h. Ríos, A. "The Carbonic System Distribution and Fluxes in the NE Atlantic during Spring 1991." *Progress In Oceanography*, vol. 35, no. 4, 1995, pp. 295–314., doi:10.1016/0079-6611(95)00010-e.

i. Wells, Ray E., et al. "The Columbia River Basalt Group—From the Gorge to the Sea." *Volcanoes to Vineyards: Geologic Field Trips through the Dynamic Landscape of the Pacific Northwest*, 2009, pp. 737–774., doi:10.1130/2009.fld015(32).

Sergey Sharpe
Geology 202
Taylor
2/26/18

A. **The founding of the name:** On May 11, 1792, Gray became the first newcomer to "discover" the Columbia River, naming it after his vessel, the Columbia Redditive.

B. **Trade of Goods on River:** River was used on late 1800's to trade goods. The main export was furs. The river is currently still used for trade, but also for fishing salmon.

C. **Fishing:** There are many fish ladders on the dams located on the Columbia River Gorge for the salmon to migrate and lay their eggs.

D. **Interstates:** Two key events came for the Columbia Gorge came in the latter half of the 20th century: development of Interstate 84 (originally known as Interstate 80-N), replacing Highway 30 in the late 1950s and allowing the large-scale movement of truck traffic, and the 1986 passage by Congress of the Columbia River Gorge National Scenic Area.

V. Summary and Conclusion

Wrap everything up and talk about why the river gorge is so important to Oregon. Where would Oregon be without it?

VI. Works Cited

a. *The Columbia River Basalt Group - Exposed by the Ice Age Floods*, hugefloods.com/Basalt.html.

b. Coates, Donald R. *Landslides.* Geological Society of America, 1977.

c. "Columbia River Gorge." *Columbia River Gorge*, www.columbiarivergorge.info/.

d. "Correction." *Nature*, Sept. 2017, doi:10.1038/548141a.

Tiffany Sullivan

ES 202

Term Paper Outline

26 February 2018

I. INTRODUCTION

Effects of Forestry Practice on Watershed Processes in Western Oregon

I. Normal forestry practices along with recent rules and guidelines.

a. Harvesting trees for human purposes- causes: "temporary disturbance to the forest environment." -- what exactly does that mean? (https://secure.sos.state.or.us/oard/displayDivisionRules.action?selectedDivision=286

b. Maintenance of road systems and why it is necessary to have these processes-- to reduce contamination by debris to streams and other wildlife.

c. Water Protection: Restricted processes near water sources such as, lakes and rivers prohibit chemical usage, road maintenance and construction, and the harvesting of trees by nearby waterways. (http://www.oregon.gov/ODF/Working/Pages/FPA.aspx#Harvesting)

d. The standardized forestry practice rules are to preserve the viability of forest quality, reduce debris and soil runoff along with other disturbances into nearby streams and ecosystems. ((https://secure.sos.state.or.us/oard/displayDivisionRules.action?selectedDivision=286)

e. Even with all of these protective measurments in place, there are still harmful impacts on, wildlife habitats, waterways even humans life in the event of landslides .

(http://www.oregon.gov/ODF/Working/Pages/FPA.aspx#Harvesting)

II. B. Maintenance of road systems:

a. Asphalt laying and construction of the road systems itself – chemicals used– and asphalt has no permeability/ porosity qualities needed in order to absorb excess moisture on roadways.

b. Clearing of debris after storms, accidents, oil spills?

Clearing debris after oil spills on roadways—replacing soils and redoing asphalt (corvaillis hwy—find article) –

c. if not cleaned up the correct way—can be harmful to water sources and humans.

IV. C. Water Quality

a. water quality can be impacted by silt and clay sized materials, these materials increase along with the amount of tree harvesting, without the tree root systems the natural filtration of water is nonexistent and these materials "find their way into drinking water" "Water treatment system" (https://www.gao.gov/assets/160/156263.pdf)

b. contamination of drinking water- Ex Oregon coast drinking water: The streams without fish receive no buffer zones when it comes to harvesting timber or the spraying of chemicals. keep in mind that these oregon streams can make up about 80 percent of a watershed.

c. While compared to Washington these same types of streams receive a 50 foot buffer of protection against clear cutting and chemical usage.

(http://www.oregonlive.com/environment/index.ssf/2013/08/oregons_rules_for_logging_priv.html)

d. contaminated drinking water is detrimental to all living things, why do we do this to ourselves?

III. FORESTRY AND LANDSLIDE HAZARDS

~~IV.~~ Forest practices: Landslide trouble: impact on humans

a. too many forestry practices along with too much watershed- "Over saturation of soil and a decrease in healthy tree root systems (due to forestry practices) cause mass wasting occurrences such as landslides."
b. Landslide will occur in the same areas they have happened in the past, but forestry practices increase the risk of devastation caused by mass wasting, landslides. http://www.oregon.gov/ODF/Documents/WorkingForests/landslidespublicsafety.pdf
c. Landslides impact human functions:
d. Landslides disturb clear roadways and the safety of roadways.
e. They have the capability of destroying the homes of citizens and endangering the lives of humans.

IV ~~VI.~~ SUMMARY & CONCLUSION--How increased standardized forestry practices are beneficial to everyone involved.

b. Roadways and continuous problems—accidents.

c. Protect waterways by increasing buffers.

d. Reduce the occurrences of landslides cause by harvesting timber

e. why these would be Great things to do.

(http://www.oregon.gov/deq/wq/tmdls/Pages/TMDLs-LID.aspx)

REFERENCES CITED (Will add more as needed)

Gao.gov, 1998, Oregon Watersheds: Internet Web Resource, URL:

https://www.gao.gov/assets/160/156263.pdf

Oregon.gov, 2017, Department of Environmental Quality: Internet Web Resource, URL:

http://www.oregon.gov/deq/wq/tmdls/Pages/TMDLs-LID.aspx

Oregon.gov, 2001, Forestry, Landslides and Public Safety: Internet Web Resource, URL:

http://www.oregon.gov/ODF/Documents/WorkingForests/landslidespublicsafety.pdf

Oregon.gov, 2017, Oregon Department of Forestry: Internet Web Resource, URL:

http://www.oregon.gov/ODF/ForestBenefits/Pages/default.aspx

Email me, I'll send some papers, as needed http://www.oregon.gov/deq/wq/tmdls/Pages/TMDLs-LID.aspx "In undeveloped areas, very little rainwater or snowmelt runs off the land like it does in cities. Trees, plants and soil capture much of the precipitation, and some of it evaporates back into the air. Most of the precipitation that doesn't evaporate or get captured by vegetation soaks into the ground where soil and microbes remove pollutants naturally. The water slowly recharges streams, wetlands and groundwater. Very little runs off, except in very large storms."

https://www.uidaho.edu/extension/idahoforestrybmps/topic-areas/working-forests pg 39-

http://www.oregon.gov/ODF/Board/Pages/default.aspx

http://www.oregon.gov/ODF/Working/Pages/FPA.aspx#Harvesting

http://www.oregon.gov/ODF/Working/Pages/FPA.aspx#Water

Forest harvesting can cause erosion to occur faster (The relatively small landslides that occur on steep slopes are often referred to as "shallow-rapid landslides." Inventories have shown that forest management affects the occurrence of shallow-rapid landslides. These are the landslides that typically pose the greatest off-site public safety threat. They have also been called debris flows, debris avalanches, debris torrents, or rapidly moving landslides pg. 16)

"Increasing landslide susceptibility Many processes can make slopes more vulnerable to landslides. The processes that make slopes less stable include: steepening the slope, loading the slope, reducing the strength of the materials within the slope, and altering drainage to allow more water into the slope. Over time, tectonic uplift and subsequent channel downcutting by streams make slopes steeper. Engineered cuts and fills (for roads and building pads, etc.) can result in greatly steepened slopes in the short term. Soil and rock weathering usually reduces slope strength and smoothes topography over time. Placement of loose fill, or loss of soil reinforcement by roots, may affect slope strength in a relatively short time period (1-10 years). Any activity or process that causes more water to flow into a slope usually increases the likelihood of a landslide. As slopes become steeper, more of the earth's gravitational force effectively acts in the direction of the slopes or potential failure plane (instead of perpendicular to the slope). Other things being equal, steeper slopes are less stable. Robison and others (1999) found that 84 percent of landslides surveyed that entered stream channels initiated on slopes steeper than 70 percent (35 degrees). Other studies have made similar findings. For example, Millard (1999) found that, depending on landform, minimum debris flow initiation slope steepness varies between 26 degrees (49 percent) and 39 degrees (81 percent). Slope steepness is an important factor to use in evaluating slope stability because there is strong scientific evidence that it theoretically 17 FORESTRY, LANDSLIDES AND PUBLIC SAFETY June 2001 explains landslide susceptibility. It has been found to explain observed landslide survey results and it is among the easiest site characteristics to measure." Pg 17

http://www.oregon.gov/ODF/Documents/WorkingForests/landslidespublicsafety.pdf

Anthony Visuano Jr

ES 202

2018 03 07

6/6

Effects of Forestry Practices on the Western Oregon Landscape

INTRODUCTION

- Mankind has been depending on forest and forest products since time immemorial
- ~~The Dover Bronze Age Boat is one of the oldest boats, made from planks of oak sewn together with yew lashings. The boat dates to 1575-1520 BCE~~ Old wood is old
- There have been many ways harvest wood over the years

TIMBER HARVESTING PRACTICES

1. **Past Practices**

- In days long past, almost all mills and felling of trees was on or near rivers
- Most areas were harvested in winter, during the spring the full rivers would make it easier to transport the lumber via the various water ways (streams, rivers, lakes)
- Even up until the 1960's a million feet of lumber a season was reasonable

2. **Current Practices**

- Oregon current practices the "silvicultural method" which has two cases: regeneration methods or intermediate methods

- Regeneration has the goal of initiating a new forest crop. The harvest trees to open the forest canopy enough to allow grow of adolescent trees. This method has four main categories: 1) even-aged; 2) two-aged; 3) uneven-aged; and 4) coppice
- Intermediate methods also known as "thinning," is a periodic cutting of a stand. Usually the intent to allow for stand development
- In western Oregon, clear cutting usually only applies to certain tree species, such as Douglas-fir because the seedlings need direct sunlight to grow
- The other common method of cut is known as selective-harvest. This method is generally used where protected wildlife or plants are located
- All harvest methods must leave buffer zones around water sources, must make every effort to protect the soil and

INFLUENCE ON THE LANDSCAPE

1. **Rivers**

- Streamflow increases after a clear cut, in some places as much as 35% of an increase.
- 20% or less of a stand cut, will not increase streamflow
- Increase of sediment in rivers and stream can lead to problems
- High sediment levels can also mean pathogens, dissolved oxygen other elements in the water system

2. **Water Tables**

- While small floods in cleared areas did increase in the fall, most likely due to soil compaction, large floods however, did not increase

- These floods mostly occur during the fall because the water table is higher, and no transpiration could occur all pull moisture from the soil

3. Soil & Sediment

- Soil compaction because of skid trails can change the flow of running water and start channels if left uncontrolled
- Poorly drained roads can form cut banks and fills
- Quickly built roads on steep hills can trigger land slides or mass soil movement
- Mass soil movement can cause damage to rivers, streams directly and down stream

INFLUENCE ON WILDLIFE

1. Fish

- Higher sediment levels in rivers, can lead to deposition of sediment on spawning beds
- Large amounts of oxidation and pathogens can large affects on fish in streams and rivers

2. Mammals

- Mammals often have a negative impact on forests and reforestations
- Gophers will prune the roots of seedlings or clip their stems
- Beavers have cause an estimated $40 billion in damages over a 40-year period (southeast US)
- Mice, Hares can also devastate reforestation efforts

ECONOMIC IMPACTS (might cut this one)

- Many grumpy loggers and sawyers and their families
- Millions of dollars lost

SUMMARY & CONCLUSION

- Need to clean up and fix some things

REFERENCES

*** Need to clean up and add a couple ***

Elliot, W.J., Page-Dumroese, D., and Robichaud, P.R., 1999, The effects of forest management on erosion and soil productivity, 16p.

Brown, G.W., 1971, The Impact of Timber Harvest on Soil and Water Resources, 19p.

Vorderstrasse, R., 2006, The Timber Industry and its Effects on the Pacific Northwest, 27p.

Beschta, R.L., Pyles, M.R., Skaugset, A.E., and Surfleet, C.G., 2000, Peakflow responses to forest practices in the western cascades of Oregon, USA, p. 102-120

Flora, D.F., 2003 Forest Economics Research at the Pacific Northwest Research State, to 2000, 213p.

*http://www.oregonloggers.org/Forest_About_Methods.aspx

*https://secure.sos.state.or.us/oard/displayDivisionRules.action?selectedDivision=2869

Scott Warren
ES202: Term Paper
Volcanic Hazards of the 3 Sisters Volcanic Complex
Outline

I. **Introduction**

- Topic: Volcanic Hazards of the 3 Sisters Volcanic Complex

~~**Overview**~~
~~**Geology**~~ II. Physiographic Setting 6/6

a. General information
    a. The Three Sisters volcanic complex likes in the Three Sisters Wilderness in central Oregon. It is the ultimate marker of the transition between wet and arid environments. Since Broken Top is often associated and is right next to the three sisters, it shall be included.
        i. Bend is approx. 30 minutes to Bend, 15 minutes to Sisters
    b. These strato-cones are a result of the offshore subduction zone where the Juan De Fuca plate is descending below the North American plate. This encourages the generation of magma via bringing down of water subduction lowering the melting temperature of the parent rocks. The magma than rises towards the surface. Initially basalt, the interaction with more felsic continental materials altered the lava over time changing from basalt to almost a rhyolite composition.
        i. "Devils Hill"
    c. Alternate names (Faith, Charity, Hope)
    d. Elevation, Last Eruptions/Brief History

III. ~~**4. Hazards**~~ Volcanic Hazards

Proximal and Distal Hazards

- Hazards to persons in immediate surrounding areas of the volcanoes and any localities could suffer consequences.
- Large enough debris/mudflow could reach sisters in approx. 30 minutes. The sisters view point sits on glacial material. Sisters sits in the hazard zone for this. Distal areas (Bend) may see some changes.
    - Earth Flows
        - People in "distal" zones or along rivers should be wary of possible effects of an earth flow into a body of water.

    1. Lahar
    2. Landslides

    - Oct 7, 1966 Mudflow from Broken Top into Soda Creek and out into sparks lake, likely result of moraine dam failure from falling ice.
- Lava Flows
    - Most studied lava flows average about 8-12 km from vent, and one larger scales (more rare), flows as far out as 20 km as has been possible. Sisters is the biggest municipality at risk. It sits just 14 miles from the North Sister, which is home to the Collier cone and near the sub feature of the Yapoah cone. Flows from this cone flowed south than flowed 8 km eastward towards Sisters. Sisters should be an area of concern.
    - Lava flows at these vents are unique in composition. North and Middle Sister a primarily basalt/basaltic andesite and the South Sister has erupted everything, but popular for the Rhyolite flows. This shows a dramatic change in composition from "one side" of the complex to the "other".
- Tephra/Fallout/Ballistics
    - Pyroclastic flows are not considered to be a major harm to municipalities, unless extreme events (really extreme). The major hazard posed would be to anyone in the heavily used recreational sites in and around this area.
    - Ballistic projectiles will be primarily limited to 3-6 km from the volcano assuming is not a significant event.
    - Tephra/Ashfall can reach further.
        - Shevlin park tuffs are a likely result of volcanism from the three sisters/broken top area. This park is on the west outskirts of Bend

5. Recent Events

South Sister (Last 50 years)
Deformation from 1996 to 2010
Increased Seismicity
1970 Debris Flow down Squaw Creek
1966 Debris/Mudflow from Broken Top into Sparks Lake Wilderness

7. Conclusions
a. Summary
b. Opinion

Bibliography

Deligne, Natalia I., McKay, Daniel, Conrey, Richard M., Grant, Gordon E., Johnson, Emily J., O'Connor, Jim, and Sweeny, Kristin, 2017, *Field-Trip Guide to Mafic Volcanism of the Cascade Rnage in Central Oregon-A Volcanic, Tectonic, Hydrologic, and Geomorphic Journey:* United States Geological Survey, p. xx
Scott, W.E., Iverson, R.M., Schilling, S.P., and Fisher, B.J., 2000, *Volcano Hazards in the Three Sisters Region, Oregon:* United States Geological Survery, p. 1-13
Moran, Seth C., 2004, *Seismic Monitoring at Cascaade Volcanic Centers, 2004- Status and Recommendations:* United States Geological Survey, p. 1-22
Volcano World, 2013, Three Sisters (322070) in Volcanoes of the World Smithsonian Institudtion National Museum of Natural History, URL: *https://vo/cano.si.edu/gvp_votw.cfm?vn=322070*