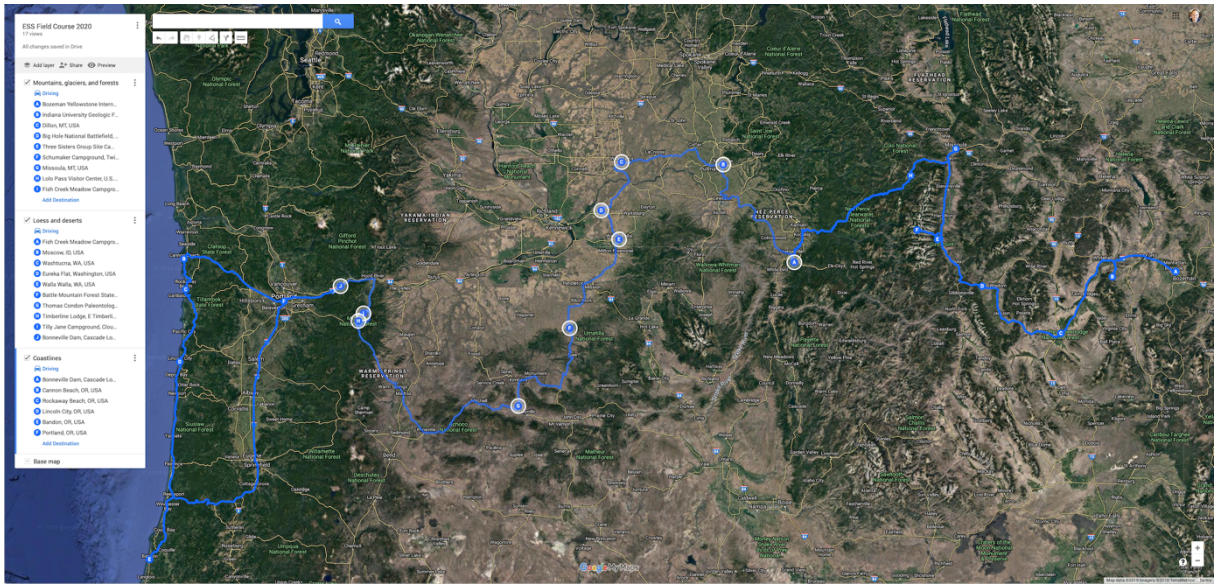
Detailed program for the Overseas Experiential Learning Activity *Integrated Field Studies in Earth System Science* (EASC3419)

Dates: 23 June – 17 July, 2020
Location: Northwestern United States
Start: Bozeman, Montana
End: Portland, Oregon



Day 0
Meeting at Bozeman-Yellowstone International airport, we'll be in the in the eastern Foothills of the Rocky Mountains. Once the group is assembled, we'll head west, across the easternmost reaches of the Great Plains, nearly to the Continental Divide. Along our way, we'll see the iconic grasslands of Montana, home to one of the largest ecological restoration projects in the world: the reintroduction of the Plains Bison. Leaving the plains and making our way into the Tobacco Root Mountains, we'll view the lower timberline and make our way through conifer forests to our evening stop at the Indiana University Geologic Field Station, nearly 1600 meters above sea level.

Day 1
Today will be spent traveling through the mountains and valleys of western Montana. Crossing three major mountain passes and the Continental Divide itself, we'll observe how the harsh climate of the northern Rockies influences the distribution of soils and vegetation, and discuss the farms, ranches, and working forests that are the economic engine of western Montana. We'll observe irrigation projects and have our first introduction to water resources and policy in the Western United States. Stopping at the Big Hole National Battlefield, we'll learn about the European conquest of the native peoples of the Western United States and bear witness to a shameful episode in American history. Descending from Lost Trail Pass in the afternoon, we'll enter the Bitterroot Valley that once an arm of an enormous lake dammed by glaciers during the last Ice Age. We spend the night at a campground in the Bitterroot Valley.

Day 2
The theme of today will be glacial landscapes. The Bitterroot Range was covered by a thick ice cap 15,000 years ago, and today's landscapes are a testament to the massive power of glaciers to sculpt landscapes. From the Lost Horse Observation Point, we'll have a spectacular view of the floor of Ice Age Lake Missoula, and the U-shaped glacial Lost Horse Canyon. We'll observe the Pleistocene landscape features, including moraines, kettle hole lakes, and. In the afternoon, driving up the Lost

Horse Valley, we will observe the vegetation gradient and the appearance of conifer species we haven't seen yet. Evening will be spent camping beneath the high peaks of the Bitterroot Range, where we will prepare for the following days' activities, studying maps and aerial photos and dividing into small teams for our Quaternary landscape mapping project.

Day 3
After an early start, we'll spend all of today in the field along the crest of the Bitterroot Range, mapping moraines, cirques, bergschrunds, and other glacial features. We'll work in teams of three, and spread out across the landscape. Our field mapping activities will be assisted by a drone-based topographical survey, which will enable us to gain a larger picture of the landscape. In the evening, we'll compare our results and make plans for a second day of mapping along the Bitterroot summits, weather permitting.

Day 4
We'll be up and out of camp early again today, completing our field mapping projects along the Bitterroot Crest. We'll also make observations of the treeline vegetation and understand the role of slope, aspect, and microclimate in influencing the spatial patterns of vegetation.

Day 5
After two intense days of work in the field, we'll leave the high crest of the Bitterroot Mountains and make our way to Missoula, the principal city of western Montana and home to the University of Montana. Along our way, we'll view traces of the ancient shorelines of Glacial Lake Missoula. In the afternoon we'll check in to university dorms and enjoy a well-earned shower. Our evening will be spent finalizing our Quaternary geology mapping projects.

Day 6
Today we'll have a chance to explore Missoula and visit the world famous Missoula Fire Sciences Laboratory run by the United States Forest Service. On our tour, we'll learn how so much of our understanding of wildfire behavior has been developed through tests in the lab's facilities, and discuss the importance of forest fire for the ecosystems of the Pacific Northwest.

Day 7
It's time for another mountain pass today, leaving Montana and crossing west into Idaho over the Lolo Pass, the route first used by the Lewis and Clark expedition as they explored North America in the early 19th century. We'll stop at the visitor's center in the pass to learn about the history of the exploration of the Western United States and the more recent legacy of industrial logging in the Rocky Mountains. Descending from the pass, we'll see a part of the Inland Temperate Rainforest of North America, the only temperate rainforest in the world not in a coastal region. In the afternoon, we'll leave the valley of the Clearwater River and climb on to the loess plateau of the Palouse. We'll camp in a lush forest at the edge of the Palouse, and discuss the formation of the Palouse plateau and it's link to glacial lake Missoula.

Day 8
Imagine an Ice Age landscape, freezing, dry, and windy with the sky obscured for days by clouds of blowing dust. The Palouse formed during periods of the last glacial epoch, when strong winds blew fine sediments of an ancient dry riverbed up against the western edge of the Clearwater Mountains. This dust settled into layers tens of meters thick, and today we'll be mapping those deposits and seeing how their thickness changed along a transect from east to west. Because of its rich loess-derived soils Palouse is also one of the most productive agricultural landscapes of the United States, and we'll discuss how more than a century of land use has led to erosion and efforts to promote sustainable agriculture. Returning to our forest camp in the evening, we'll discuss the results of our mapping projects.

Day 9
Heading northwest, we'll cross the heart of the Palouse loess plateau and observe the natural and anthropogenic landforms of the region. We'll supplement the loess thickness maps we prepared yesterday with new data from this perpendicular transect. In the afternoon we'll arrive in the university town of Moscow, Idaho, home to the University of Idaho and enjoy a hot shower and a real bed in the university dorms.

Day 10
A few kilometers to the west of Moscow, we'll leave Idaho and cross into Washington. As we reach the western edge of the Palouse, the landscape will change dramatically – we'll have our first glimpse of the Channeled Scablands – more than 5000 km2 of barren basalt, scoured by massive floods caused when the glacier dam holding back the waters of Lake Missoula burst in a catastrophic flood. At Washtucna Coulee, we'll measure the dimensions of the valley and estimate the volume and velocity of the water that carved a channel out of solid rock in a matter of days. At Eureka Flat, we'll observe active sand dunes and the source area for much of the Palouse loess. We'll follow the flow of the Lake Missoula floods across the Channeled Scablands south and west, stopping at our crossing of the Snake River to discuss the damming of the Columbia River and its tributaries and the importance of this for the agricultural and industrial development of the region. We'll end the day in the university town of Walla Walla, Washington where we'll stay in the dorms of Whitman College.

Day 11
Heading southwest out of Walla Walla, we'll soon cross the state line into Oregon and drive along the escarpment of the Blue Mountains that separates the Columbia Basin from the high plateau of northeastern Oregon. Guided by U.S.-based collaborators, we'll visit a field site where colleagues are working on reconstructing the fire history of the Blue Mountains forests using tree ring analyses. Moving through the Blue Mountains, we'll cross several mountain passes on our way into the heart of central Oregon, the John Day valley. One of the driest parts of the state, we'll observe the zonation in vegetation and climate, and the open ranchlands contrasting with the narrow strips of irrigated agriculture along the river valleys. By evening, we'll arrive at the John Day Fossil Beds National Monument, one of the most important locations in North America where Neogene plants and animals have been discovered. We will camp under the stars of the Oregon high desert.

Day 12
No region in the world shows a more complete sequence of Tertiary land populations, both plant and animal, than the John Day Basin (R. Chaney).

Today we will explore the desert canyons of the John Day Fossil Beds National Monument, and reflect on the deep-time climate changes implied by the fossils discovered there. The John Day Fossil Beds contain some of the best examples of Neogene mammalian life, and discoveries of nuts and traces of palm trees and avocados attest to the humid, tropical setting of the region more than 40 million years ago. We'll discuss how plate tectonics led to the gradual cooling of the planet, and the establishment of a more xerophytic flora and fauna in central Oregon over millions of years. We will be guided through the important fossil discoveries here by expert scientist-interpreters from the National Monument.

Day 13
Oregon is a land of contrasts. Mountain forests are sky islands surrounded by sagebrush shrublands and semideserts. As we leave the desert lowlands of the John Day River valley and climb into the forests of the Ochoco Mountains, we'll observe how quickly the complete ecological gradient is represented. Crossing the Deschutes River, we'll get our first glimpse of the high, snow-capped volcanoes of the Cascade range. Traveling up the east slope of the Cascades, we'll quickly transition from high desert to snow forests. Along the way, we'll stop to measure meteorological conditions

and note the changing forests. We'll discuss fire management and efforts to restore the fire-adapted Ponderosa Pine parklands of the eastern Cascades. Reaching the summit of the Cascades, we'll camp at the foot of Mount Hood, Oregon's highest mountain.

Day 14
After a short drive to the northeast side of Mount Hood, we'll make a short hike up on to the Holocene moraines of the Eliot Glacier. Here we'll spend the day mapping the moraines and measuring the size of lichens growing on the moraine rocks. Working as a team, we'll quickly build up a dataset that allows us to estimate deglaciation history of the region using lichenometry, which we'll develop into a report this evening. We'll camp just below the terminal moraine, close to the treeline.

Day 15
At nearly 2000 meters elevation on the shoulder of Mt. Hood, the sunrise will make a great start to another day of contrasts and transitions. After a visit to Hood River, we'll head west through the Columbia River Gorge, stopping at The Bonneville Dam and fish hatchery to learn about the influence of the hydroelectric development of the Columbia River on what was once one of the world's most important rivers for salmon. Passing through the busy city of Portland we'll continue west to the Pacific Ocean. At our motel in Cannon Beach, we'll have a wrap-up of the trip so far with an oral exam covering the glaciers, loess, and deserts segments.

Day 16
Today begins the coastlines segment of our course. After a short introduction, we'll head into the field. The Cannon Beach area hosts a wide range of coastal geomorphology and terrestrial and marine ecosystems, which make an ideal introduction to the landscapes of the Oregon Coast. Our first stop will be a ghost forest, the legacy of extreme, rapid subsidence from a subduction zone earthquake in this tectonically active region. Along the shore, we'll explore the ecological zonation from coastal upland forests to tidepools and kelp forests.

Day 17
We continue to explore the Cannon Beach area and view damage from 1964 Alaska tsunami, including the destroyed Elk Creek bridge and a house transported several hundred meters by the tsunami wave. We will discuss hazards associated with near-field (e.g., Cascadian subduction zone) vs. far-field (Alaskan subduction zone) tsunamis. In the afternoon, we move to Ecola State Park to observe and map coastal bluff erosion and landslides.

Day 18
We start a two-day investigation into the tsunami and coseismic subsidence events that are recorded in marsh sediments of the Oregon coast. We will collect sediment cores along shore perpendicular transects and observe sequences of peat-mud couplets, a salt marsh or freshwater peat formed in the upper intertidal or supratidal zone sharply overlain by tidal flat muds representing lower intertidal conditions. To quantify the amount of subsidence associated with each peat-mud couplet, we will survey the elevational range of contemporary lower intertidal to supratidal environments represented in the sites' stratigraphy. We will begin our investigations in marshes of Nehalem River and Rockaway Beach.

Day 19
We carry on with the coring and surveying project started on day 18, moving to marshes of Neskowin and Nestucca River. In the evening, we'll stay in the coastal town of Lincoln City as we continue our trip south down to the coast.

Day 20
Today we travel down the to the southern Oregon coast, making several stops to view the rocky and sandy portions of the coastline. We stop at the Oregon coast aquarium in Newport to learn about the ecology of different environments on the coastline and environmental issues threatening these ecological communities. We finish the day in Bandon, Oregon, where we spend the next several days.

Day 21
We hike through the Oregon Dunes to explore several different kinds of dunes environments and the range of plant and animal communities they foster. We will also discuss the processes of dune formation and their morphology. As the present shoreline stabilized 6,000 years ago, tides, wave action and strong coastal winds moved sand up to 5 km inland for thousands of years. In the afternoon, we will visit the Cape Arago-Sunset Bay area and consider the geologic and weathering processes that contributed to the stunning features along the coastline. Since the early Ice Age, sections of the Coos County coast have been elevated to form flat terraces that were originally formed at sea level as wave-cut benches. The seaward edges of these terraces expose steeply tilted layers of sedimentary rock. These layers have varying resistance to erosion, resulting in a complex coastline shaped in part by a pattern of faults that offset the brittle bedrock.

Day 22
In the morning, we visit the Ni-les'tun Marsh Restoration of the Bandong Marsh. Twelve times in the last 6,700 years, earthquakes shook this coastline and triggered tsunamis. The last event in 1700 scoured the shore and lowered the entire Coquille River delta a several decimeters. More than a century later, settlers drained vast stretches of the marsh, diking off the tidal influx to create pastureland. In 2011, the estuary was altered again by restoring tidal flow into the former marsh with the intent to sustain fish and wildlife by letting natural processes take precedence. This restoration project has allowed scientists to study the effects of a rapid inundation of a coastline in real time. We'll wrap up the coastal section of the course with a leisurely stroll along the scenic Bandon beach to take in the beautiful sea stacks that line the coast before finalizing assignments and the project report in the evening.

Day 23
On our final day of the course, we'll travel through the Oregon Coastal Ranges and into the fertile Willamette Valley. We'll consider the long human history of this region and the paleoecological evidence that suggests native peoples carefully managed the oak parklands of the valley through their use of fire. We'll have an opportunity to consider one of the centers of early European settlement of the west, here at the end of the Oregon Trail. We'll end the day in Portland, for departures to Hong Kong on the following day.