An Integrative Summer Field Course in Geology and Biology for K-12 Instructors and College and Continuing Education Students at Eastern Washington University and Beyond

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ABSTRACT

For the last fifteen years, a small group of faculty members in the departments of geology and biology at Eastern Washington University in Cheney, WA have offered a seven to ten day interdisciplinary summer field course. The course is designed for college students, K-12 instructors, and for those seeking continuing education experiences. We have been successful in attracting students who take the course repeatedly and continue to draw a pool of new students by providing a different route each year within a 1280 km (800 mi) radius of our institution. Our academic expectations are rigorous and include reading assignments, pre-trip questions, field notebooks and journal entries as well as a research paper and follow-up post-trip questions all of which are designed to capitalize on the integration of the two disciplines. This field course is one way in which we get our students out in the field for a trip longer than a day trip or weekend trip to learn about the interaction of geology and biology on both small and large scales in the scenic Pacific Northwest. We suggest that this technique of integration may be applied to field courses at a variety of academic institutions and in any physiographic province provided that three critical aspects in the successful implementation of our approach are met: (1) Two (or more) faculty in different fields that are willing to work together during preparation and execution of the course; (2) A clear primary objective or overarching theme for the course that is well-defined and that lends itself to an integrative approach; and (3) A prominent National Park or significant geographic feature to enhance the interest in the course and to draw enrollments.

INTRODUCTION

Eastern Washington University (EWU) is part of the Washington State university system located in Cheney, WA, just 26 km (16 mi) from the Spokane metropolitan area (population 417,000) (Figure 1). EWU is a comprehensive university providing services to over 9,500 students, primarily from the Inland Northwest but also serving students from nearly every state and more than 20 different countries. The university's location in the Pacific Northwest provides an excellent opportunity to explore vastly different physiographic provinces within a day's drive from the campus. As such, for the last fifteen years, we have offered a seven to ten day interdisciplinary summer field course for college students (both undergraduate and graduate) majoring in geology or biology, K-12 instructors, and for those seeking continuing education experiences. At EWU, the course meets a degree requirement for a five-credit elective field-oriented study for our majors. The interdisciplinary (geology, botany, ecology, history) approach to our field course has allowed us to offer neither a typical geology field camp course nor a traditional plant identification or plant ecology course for majors in geology or biology and may be used by other institutions wishing to do the same. In the early years we incorporated a few simple geological and ecological measurement techniques that could be reproduced in a high school classroom into the course. Now most of the field experience focuses on recognition and interpretation of geological features and the dominant flora, and especially on how geological forces and plant and animal ecology interact.

Most of our students are from EWU, but we also draw from other institutions throughout the country as well as from the local Spokane Community Colleges. In the first five or so years of the program, teachers seeking continuing education credits were a major constituent and, in fact, were the initial impetus for the development of a field course that would offer an interdisciplinary perspective. However, the type of student served has evolved since the course's inception. Participation in the course by K-12 teachers has dropped off from comprising over half of the enrollment to generally including only two or three out of twenty students. The decrease in this population is attributed to the fact that, in the mid-1990's, the Washington legislature had abandoned its requirement of a Masters Degree in their discipline for secondary school teachers. Presently, the course is about equally divided between students enrolling for geology or biology credit, and is about half comprised of students majoring in geology, biology, or environmental science (Table 1). The remaining half consists of a mix of post-graduate students from a variety of professions taking the course either as personal enrichment, or as science credits needed for professional advancement. About 25 to 30% of our course enrollments have been students who have been on prior field trips. Although the nature of the student population taking the course has evolved, students consistently cite the opportunity to directly observe in the field abstractions that they've so far only read about, and the opportunity to integrate biologic and geologic processes as the primary attractions of the course.

This paper provides the reader with a discussion of field course planning, cost, goals and expectations, academic challenges, assessment, and summarizes, using specific examples, how we have capitalized on this unique opportunity to integrate geology and biology in the field. We suggest that this technique of integration may be used as a model for field courses at a variety of academic institutions and in any physiographic province.

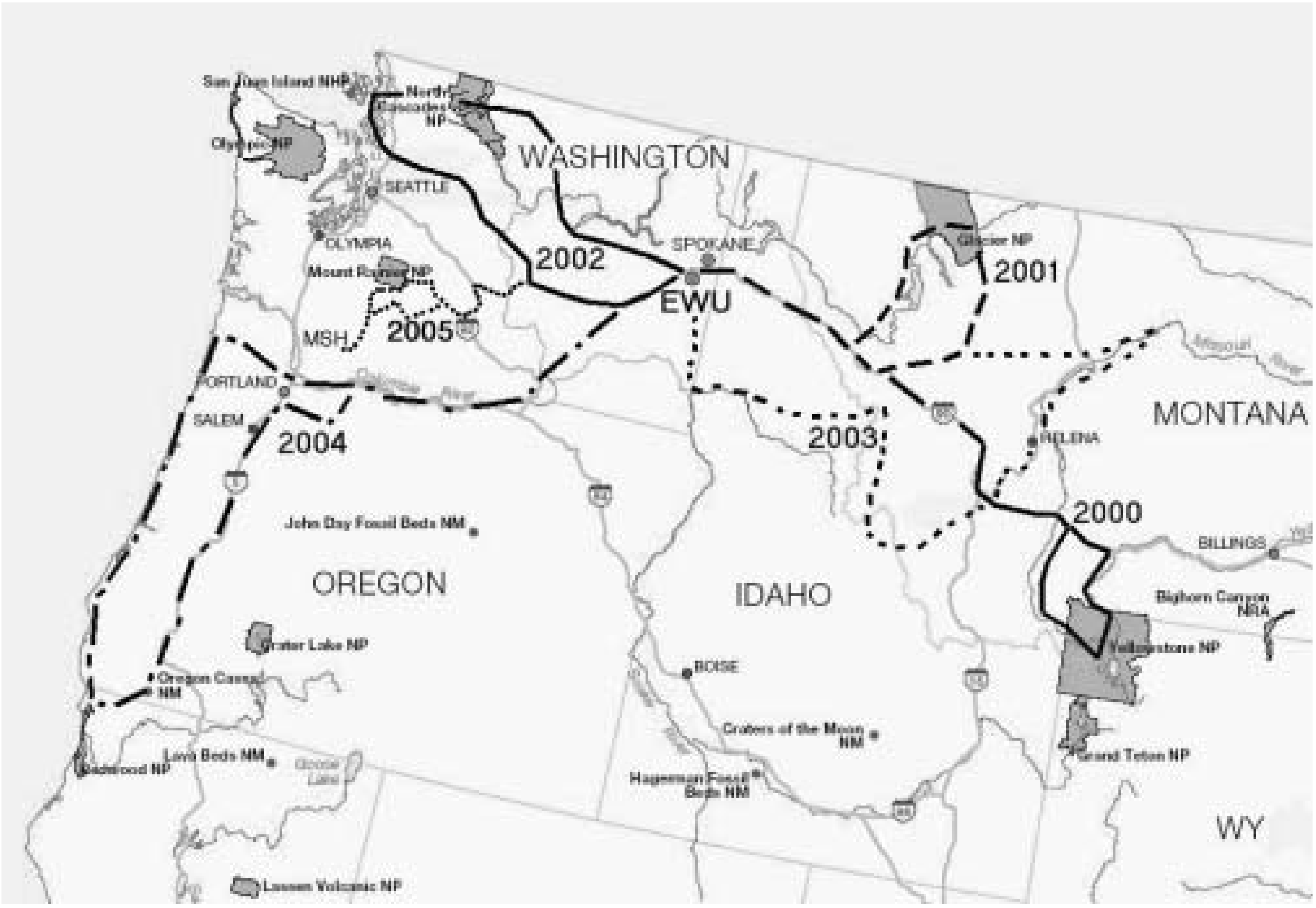

Figure 1. Map illustrating trip routes centered about EWU, Cheney, WA: (A) 2000 – Discovering Yellowstone; (B) 2001 – Glaciers and Grizzlies; (C) 2002 – Sage to Sea – The North Cascades; (D) 2003 – Natural History of the Lewis and Clark Trail; 2004 – Gorge to Shore; 2005 – Living with Volcanoes.

PLANNING, LOGISTICS AND COST

We have taken classes to various portions of the Colorado Plateau, through Yellowstone and Glacier National Parks and along portions of the Lewis and Clark route in the Rocky Mountains, across the northern Cascades, along the east slope of the southern Cascades, along the coast of the Olympic Peninsula, and along the Oregon Coast into Northern California (Figure 1). We (instructors, with student input) choose the destination for the following year's field trip by early September giving us ample time to prepare the logistics of the trip and to obtain internal approval. This includes mapping out a trip route and selected stops along the way, as well as camping locations. Reservations for group sites at state-run and National Park campgrounds are made in advance, although some National Forest Service campgrounds do not allow reservations. Total distance traveled is typically less than 2560 km (1600 mi) (Table 1). Twenty students and three instructors travel comfortably in 15 passenger vans with one U-Haul trailer to carry camping gear and food containers. Students carry their daypacks in the vehicles. We do not allow the use of coolers; instead, we typically stop at a grocery store en route approximately every two to three days. These stops allow students to replenish their supplies of much appreciated fresh produce and meat to supplement the dried and canned food eaten between stops. Hikes incorporated into the field experience range from relatively short (less than 1 mile) jaunts to more extended day-long hikes (to 10 miles round-trip) with variable vertical elevation changes 60 - 1130 m (200 to 3700 ft) and it is expected that students will be in very good physical condition. Students must be able to carry out physical activity at high elevation (occasionally to as high as 2290 - 2590 m (7500 - 8500 ft)). Students with personal medical concerns must notify an instructor before participating in the field trip.

The cost to students is for tuition (on a per credit basis for 5 summer quarter credits) and an additional course fee is used to cover transportation and camping costs. Despite fluctuations in gas prices over the years, our course fee has averaged about $135.00 (Table 1). Students are responsible for providing their own camping gear and food, and are encouraged to share tents and stoves. We provide our students with a list of recommended equipment.

GOALS AND ACADEMIC EXPECTATIONS OF THE COURSE

Clearly, field trips allow for a more enriching experience than a typical classroom or laboratory setting. But,

Year	Course Title	Fee	Miles*	Total Enrollment	GEOL	BIOL
1990	Mount St. Helens Geology and Biology	$125	1050	25	25**	24
1991	Natural History of Cascade Volcanoes	$130	860	16	10	6
1992	Canyons, Slickrock and Cactus	$170	1040	15	8	7
1993	Canyons, Bristlecone and Desert	$180	2910	16	7	9
1994	Beaches, Jungles and Glaciers	$140	1375	20	9	11
1995	Geysers and Grizzlies	$155	1650	29	13	16
1996	Craters, Calderas and Botany	$122	1320	19	14	5
1997	Kicking Ash at St. Helens	$113	1050	21	13	8
1998	Red Rock and Rattlesnakes	$160	2530	19	8	11
1999	Lava and Life	$142	1840	18	9	9
2000	Discovering Yellowstone	$105	1420	20	12	8
2001	Glaciers and Grizzlies	$100	1120	20	10	10
2002	Sage to Sea - Across the North Cascades	$127	970	18	10	8
2003	Natural History of the Lewis and Clark Trail	$136	1585	9	5	4
2004	Gorge to Shore	$149	1600	17	7	10
2005	Living with Volcanoes - Mount Rainier and Mount St. Helens	$119	850	13	9	4

Table 1. Summer field courses offered 1990 - 2005, Eastern Washington University. The cost to students is for tuition (per credit for 5 credits) and an additional course fee is used to cover transportation and camping costs as well as entry fees to National Parks. *Multiply milage by 1.6 to get kilometers. ** All students registered for one geology section and one biology section, with the exception of one student.

beyond having a good time in the field, the primary learning goals for our students taking this class are: (1) to familiarize students with basic, introductory-level concepts and processes in the fields of geology and botany, (2) for students to use their knowledge to integrate the complex relationships between these two fields, and (3) for students to learn to make and record observations in the field and to understand the connectivity between geology, botany and human impact, if any.

Students are required to attend an evening pre-trip meeting approximately one week before departure. At this meeting, instructors review the goals and academic requirements, physical rigor of the course, equipment list and packing tips, and have them sign a waiver to provide us with contact information and any health issues that we should know about that might impact their participation in the course (e.g., diabetes, epilepsy, asthma). An excellent resource for field trip safety is found at the Science Education Resource Center at: http://serc.carleton.edu/NAGTWorkshops/hydrogeo/field_trips.html. Students are provided with a trip packet at this preliminary meeting including a copy of the syllabus, campground locations, equipment list, text requirements and reading assignments, as well as a set of pre-trip questions (for both geology and botany) and a series of photocopied maps and handouts to which they will refer during the trip.

Students are expected to purchase any texts prior to departure and to use the reading assignments to answer the pre-trip questions. Typically, the questions are designed to familiarize the students with the physiography, geography, and ecology of the trip route. Examples of pre-trip questions from previous courses are presented in Table 2. The pre-trip assignment is due at the time of departure. Students are expected to keep a field notebook for the duration of the trip where they record notes from each locality along with sketches and a record of any photograph taken. It is in the field notebook where they will also take lecture notes from discussions and introductory lessons. A section in the field notebook is reserved for writing a journal each evening reflecting on the day's activities. Other field-based courses use journals for a means to recognize themes of student-learning (e.g., Hemler and Repine, 2006). Students taking the course for graduate credit are also expected to prepare two field presentations based on published papers on the geology and the biology of a particular locality. This provides and excellent vehicle for peer learning. The papers are selected by the instructors and are provided to the students one week prior to departure. We prepare a series of post-trip questions in the field and again on a web page upon our return. Examples of post-trip questions from our most recent course are presented in Table 3. Students are responsible for answering these questions and submitting them with their course materials for a grade.

ACADEMIC CHALLENGES OF THE COURSE

Like many field courses, this field experience presents a number of logistical challenges including inclement weather, accessibility, and transportation issues (e.g., Lathrop and Ebbett, 2006). However, these are challenges that can be overcome with flexibility and an understanding that things don't always go as they should. The main academic challenge that we face, however, is making sure our diverse student body successfully makes connections between two very different fields: geology and botany.

Our geology students have not necessarily had a course in plant identification and our biology students have not necessarily had a course in geology. So, first and foremost, we must provide a foundation upon which students can build their knowledge and from which they

Geology Pre-Trip Questions (2005)

First, read Chapters 1 - 4 (p. 1-45) and Chapters 16 and 17 (p. 201-255) in Harris' (1988) book "Fire Mountains of the West". Also, read the photocopy of U.S. Geol. Surv. Bull. 1292 on "The Geologic Story of Mount Rainier" and the U.S.G.S. fact sheet entitled "Mount St. Helens Erupts Again" provided to you in your packet. Then, provide answers to the following questions.

1. Describe the plate tectonic setting of the Pacific Northwest region. How does this relate to the "Ring of Fire"?
2. Briefly summarize the historic activity of Mount Rainier.
3. Describe the events of the 18 May 1980 eruption of Mt. St. Helens, commenting specifically on: the debris avalanche and directed blast, pyroclastic flows and mudflows.
4. Generally describe the nature of the recent volcanic behavior at Mt. St. Helens (since Fall 2004).
5. How do glaciers work? Describe the manner in which glaciers erode, transport and deposit sediment.
6. Define the following terms (clearly labeled sketches may be helpful here).

Breadcrust bombs	Glacial drift	Outwash	Subduction
Breccia	Glacier	Plug dome	Talus
Cinder cone	Laterial moraine	Pyroclastic	Terminal moraine
Cirque	Lava	Recessional	Till
Composite cone	Magma	Moraine	Volcanic Ash
End moraine	Mudflows	Snowline	Welded tuff

Biology Pre-Trip Questions (2005)

Read "The Forests of Mount Rainier National Park: A Natural History" by Moir (1989) and "Ecological Responses to the 1980 Eruption of Mount St. Helens" by Dale et al.(2005), both of which are provided in your packet.

1. Moir describes three broad vegetation zones on Mount Rainier - low elevation and along water courses, mid-elevation, and high elevation above 500 ft. For each of these broad zones, what species of tree and what species of understory shrub is most characteristic of that zone? What other species of trees and shrubs are commonly found in at least portions of these zones?
2. What soil feature contributes to the poor drainage and saturated soil conditions at higher elevations? How does this feature hinder soil drainage, and what effect does it have on the distribution of plants?
3. Briefly describe how Merriam's live zone concept was developed. What would one predict about the distribution of tree species around Mount Rainier based on the simplified version of this life zone concept? What are at least five features of Mount Rainier (and mountains in general) that complicate the life zone concept and contribute to more complex patterns of plant distribution over an elevation gradient.
4. Suppose that during a hike in some silver fir forests on Mount Rainier that you noticed that the understory shrub layer changed from consisting mostly of devil's club to consisting mostly of Oregon grape. What would you surmise about the relative climates of these two areas? Suppose you were hiking amongst a thicket of devil's club and you noticed that the overstory changed from mostly silver fir to mostly western hemlock. What would you surmise about the relative climates of these two areas?
5. In what way were the forests of Mount St. Helens prior to the 1980 eruption different than the forests of Mount Rainier and other nearby Cascade volcanic cones. What accounts for these differences?

Table 2. Examples of pre-trip questions in geology and biology for the summer field course offered in 2005.

can draw from both fields and instructor's expertise. This goal of familiarizing biology students with geology and geology students with botany such that communication is possible is met by the pre-trip question assignment (Table 2) as well as by incorporating introductory-level lectures into the course when the need arises. For example, common in-field lectures in geology that are typically given at some point during each course are: (1) an introduction to Earth structure and plate tectonics; (2) basic rock and mineral identification; (3) basic geologic structures; (4) glacial processes; (5) beach processes; (6) igneous processes and volcanism; (7) mass wasting processes; (8) river processes. Similarly, examples of common in-field lectures covering botanical considerations are: (1) basic plant anatomy and morphology; (2) basic conifer identification; (3) fungus ecology; (4) plant reproduction; (5) mineral nutrition and nitrogen metabolism; (6) uptake of water and minerals; (7) photosynthesis; (8) plant communities and succession.

Therefore, much of the course includes material covered in typical introductory level geology and botany courses but with the added benefit of lecturing while, for example, touching a glacier, standing on a debris flow, perched on a crater rim, or hiking through the under-story of an old growth forest. Overheads and white boards are not available so instructors improvise by sketching illustrations on the sides of the white university vans using dry erase markers, or drawing in the sand with a stick. Maps carried into the field are laminated so the blank side can be used as a "white board". The challenges of instruction in the field can thus be overcome with a little imagination.

Geology Post-trip Questions (2005)

1. Despite the recent volcanic activity at Mt. Saint Helens, the most dangerous volcano in the Cascades is still considered to be Mt. Rainier due to its large population centers. Therefore, list and describe in some detail three (3) characteristics of Mt. Rainier that make the mountain very prone to mass failures (e.g., lahars and landslides). Then, in a paragraph or two, describe the nature of a lahar and explain why they are so destructive. Also, explain how these events can be dated reasonably accurately. Finally, list and describe at least three (3) features on Mt. Rainier that we examined during the field trip that are past evidence of these hazardous geological processes.

2. We examined a number of localities both in and out of the blast-affected area around Mt. Saint Helens during this field trip. For the sites listed below, describe (in a paragraph each) the type of processes and deposits that occurred during the moments after the May 1980 eruption event.

Bear Meadow	Meta Lake	Sprague Rest stop
Harmony Falls	Norway Pass	Windy Ridge Viewpoint
Iron Creek campground	Ryan Lake	

Biology Post-trip Questions (2005)

1. List four different plants that you observed on this trip that form associations with N-fixing bacteria. Tell us where you observed these plants, and what the surrounding plant community was like (you do not have to list all the associated species, but give a general description of whether the community was forested, or a meadow, for example) and list a few of the other dominant plants in the community. Explain what N-fixing bacteria do that is of benefit to these other associated plants.

2. Compare the plant communities on Norway Pass and the lower elevation meadows near Paradise Lodge. Describe the physical disturbance that Norway Pass was subjected to due to the 1980 eruption of Mt. Saint Helens. Describe some ways that the early successional plants on Norway Pass will modify their own environment, so that other plants/animals may become established. Using your knowledge of plant communities at elevations similar to Norway Pass on nearby Mt. Rainier, speculate on what the plant community on Norway Pass might be like in a few hundred years if there is no further disturbance.

Table 3. Examples of post-trip questions in geology and biology for the summer field course offered in 2005.

The foundation provided by these introductory lessons allows students to more effectively examine the complex relationships between the two disciplines, this being the primary goal of the course. In the following section, we describe a few specific examples from some of our field trips to illustrate the integration of geology and botany. The intent is to provide our readers with ideas for their own field courses. In retrospect, it now seems impossible to lead a field trip without some element of integration.

TRIP DESCRIPTIONS AND EXAMPLES OF INTEGRATION OF GEOLOGY AND BIOLOGY

Descriptions of selected trips are included here to illustrate the geological and biological diversity that each trip offers to our students. More specific examples of integration of geology and botany are included within each description. Trip routes are illustrated in Figure 1 and Table 4 lists the texts used in each of these courses as well as examples of hikes done during the field trip.

2000 - Discovering Yellowstone - Yellowstone National Park offers the opportunity to observe the interaction of geologic processes and ecology on a variety of spatial and time scales. The overall landscape of the park is determined by its volcanic origins, and there are abundant opportunities for students to observe evidence of its eruptive history. The resulting topography in turn has shaped large-scale vegetation patterns. On shorter time scales students can observe the effects of fire on vegetation, and on smaller spatial scales, students see the effects of depositions from geysers on plant growth and survival, and the effects of soils derived from different parent rocks on the grass composition of meadows. Hot springs inhabited by extremophiles offer a living example of the sorts of geological conditions that shaped the evolution of some of the earliest life forms.

2001 - Glaciers and Grizzlies - Glacier National Park provides students with the opportunity to see some of the most ancient strata in North America carved by the effects of much more recent geologic processes. Precambrian algal structures (stromatolites) are abundant throughout the park, and offer the opportunity to demonstrate how biological processes and geology interacted to create these fossils of some of the oldest known life forms. A follow-up post-trip question addressed stromatolites and the specific strata (and their age) in which they were most abundant in the park and asked students to discuss the significance of stromatolites to the origin of complex life forms. Hikes to some of the more remote glaciers (e.g., Grinnell Glacier) and comparisons of the existing glaciers with photos from only a few decades ago allow students to see dramatic short term changes in land forms and vegetation, and then work back in recent geological time as they descend down valleys over more ancient glacial deposits. Students were asked to list four types of disturbance of vegetation observed within the park and to describe the sequence of vegetation change they would expect to occur after disturbance in an upland site at the elevation of Lake MacDonald. They were also required to explain how the earliest species to become

Course andTexts	Itinerary
2000 - Discovering Yellowstone Fritz, W.J., Roadside Guide to the Geology of the Yellowstone Country (1985) Eversman, S. and Carr, M., Yellowstone Ecology: A Road Guide (1992)	1 - Drive to Yellowstone National Park; visit Madison earthquake area. 2 - Explore the Firehole River, Lower and Middle Geyser Basins. 3 - Explore the Upper Geyser Basin, Old Faithful, Lone Star Geyser. 4 - Explore Norris Geyser Basin, Mammoth Hot Springs 5 - Explore West Thumb, Yellowstone Lake, Hayden Valley, and Canyon. 6 - Explore Lamar Valley and Beartooth Pass, Specimen Ridge. 7 - Hike Mt. Washburn and return to Cheney.
2001 - Glaciers and Grizzlies Rockwell, D., Glacier National Park - A Natural History Guide, (1995)	1 - Drive to Glacier National Park. 2 - Stratigraphic and botanical overview, Logan Pass and Visitor's Center, hike to Hidden Lake. 3 - Granite Park loop hike. 4 - Avalanche Creek hike. 5 - Iceberg Lake hike, Chief Mountain viewpoint. 6 - Grinnell Glacier hike. 7 - Return to EWU in Cheney.
2002 - Sage to Sea - Cascades Tabor, R.W. and Haugerud, R., Geology of the North Cascades: A Mountain Mosaic (1999) Whitney, S.R. and Sandelin, R., A Field Guide To the Cascades and Olympics (2003)	1 - Drive to Methow Valley, Hart's Pass - roadside geology/biology. 2 - Hiking the Pacific Crest Trail; exploration of the Slate Peak area. 3 - Roadside geology/biology at Washington Pass, short hikes. 4 - Hike to Cascade Pass and Sahale shoulder. 5 - Drive to Mt. Baker, Schreiber's Meadow, Easton glacier hike. 6 - Drive to Deception Pass, various hikes. 7 - Various hikes along coast of Whidbey Island. 8 - Return drive to Cheney via Stevens Pass.
2003 – Natural History of the Lewis and Clark Trail Alt, D. and Hyndman, D.W. Northwest Exposures: A Geologic Study of the Northwest (1995) DeVoto, B., editor, The Journals of Lewis and Clark (1997)	1 - Drive to Great Falls area, Montana - roadside geology/biology. 2 - Explore Sun River Canyon area and the Great Falls of the Missouri River. 3 - Gates of the Mountain, Three Forks area, and Butte mining district. 4 - Lewis & Clark Caverns, Dillon valley, Bannack Territorial Capital. 5 - Lemhi Pass, the Salmon River valley, Lost Trail Pass, Lolo Hot Springs. 6 - Bitterroot Range, Clearwater River, and Nez Perce region. 7 - Return drive to Cheney.
2004 - Gorge to Shore Alt, D. and Hyndman, D.W., Roadside Geology of Oregon (1978) Shultz, S., The Northwest Coast: A Natural History (1998)	1 - Drive through the Channeled Scablands, roadside geology/biology. 2 - Columbia Gorge, Bonneville landslide, short hikes, Cape Lookout 3 - Hike on Mt. Hood, drive to Oregon coast, Beachside S.P. 4 - Shoreline biology/geology, short hikes; drive south to Newport area, Sunset Bay S.P. 5 - Shoreline biology/geology, short hikes; drive south to Coos Bay area, Harris Beach S.P. 6 - Shoreline biology/geology; drive south to Brookings area, Crescent City, CA, Redwoods, Jedediah Smith S.P. 7 - Oregon Caves National Monument, drive north, Willamette Valley, Mt. Hood. 8 - Mt. Hood hiking. Return drive to Cheney.
2005 - Living with Volcanoes Mathews, D., Cascade Olympic Natural History (1999) Harris, S.L., Fire Mountains of the West (1988)	1 - Drive to Mt. Rainier National Park via Chinook Pass. 2 - Hike to Emmon's Glacier; White River Campground. 3 - Hike to Longmire; Cougar Rock Campground. 4 - Hike Skyline Trail at Paradise; Cougar Rock Campground. 5 - Meta Lake, Norway Pass Trail; Iron Creek Campground. 6 - Windy Ridge; Iron Creek Campground. 7 - Return to Cheney via White Pass.

Table 4. Texts used and day-by-day itinerary of trips taken in the last six years.

established after disturbance alter their environment in ways that make it possible for them to be replaced by other species.

2002 - Sage to Sea - Across the North Cascades - This transect across northern Washington State was one of our most geologically and biologically diverse field trips. This trip started with a drive a cross the relatively uniform basalt flows of the Columbia Plateau, and then traversed the extremely geologically complex North Cascades accessible from a scenic route through the small and relatively less-traveled North Cascades National Park. Steep gradients in elevation, annual precipitation, and winter temperatures revealed equally dramatic changes in vegetation, from cold desert shrub lands to temperate coastal rainforests. Like the previous trip, this one allowed students to observe glacial processes up close, and trace the history of plant succession as glaciers retreat. An example of an integrative post-trip question is to compare the diversity of organisms on Rosario Beach on North Whidbey Island with the diversity at Double Bluff on South Whidbey Island. What features of the physical environment at these two beaches might explain the biological differences? Students were also required to explain what is meant by the term succession and to describe three examples of plant succession observed on the trip. For each example students described the substrate and the pioneer plant species. They explored how these pioneer species alter their environment, making the environment more favorable for other species to replace them.

2004 - Gorge to Shore - This trip followed the Columbia River across the basalt flows of the Columbia Plateau through the Columbia Gorge that bisects the Cascade Range, and then turned south along Oregon's spectacular coastline. The opportunities to integrate biology and geologic processes were limited only by time as students explored the plant and animal life of rocky and sandy beaches, dune fields, and coastal forests. The southernmost portion of the trip extended from Crescent City, CA (site of the 1964 tsunami) through the Klamath Mountains on the Oregon/California boundary, one of the most geologically dynamic landscapes in North America. The tectonic history of the region, with its resulting shifts in climate patterns, and merging of previously isolated land forms, along with an unusual abundance of ultramafic rocks, have driven the evolution of one of the most diverse flora's in North America. Populations of carnivorous *Darlingtonia* (Pitcher) plants provide a dramatic example of the unusually large number of plant species endemic to the serpentine soils of this region. To capitalize on the integration of geology and biology, students were asked to compare the diversity of species of trees and shrubs in northwestern Oregon with tree and shrub diversity along the coastal boundary between southern Oregon and northern California. They listed species observed in one area that were not found in the other, and discussed past and present geologic conditions that contributed to the difference in plant diversity in these two areas.

2005 - Living with Volcanoes - Mt. Rainier and Mt. St. Helens - The purpose of this trip to Mt. Rainier National Park and Mt. St. Helens National Monument was to examine the geology and biology of the largest and most active volcanoes, respectively, in Washington State. We observed the short- and long-term effects of the interplay among volcanic activity, glaciation and recent human activity on the vegetation and wild life of these two prominent mountains in the Cascade landscape. We were also able to see geology in action by witnessing a small eruption at St. Helens, a rockslide and a snow avalanche at Mt. Rainier. Table 3 illustrates the integrative nature of the post-trip questions asked of our students for this, our most recent trip.

OUTCOMES AND ASSESSMENT

Assessment of course goals is acquired by examining a student's understanding of the material in the way in which they have answered the pre- and post-trip questions. The answers to the pre-trip questions are obtained by reading assignments and so force the students into the literature and the learning of concepts on their own, with or without previous formal education (Table 2). Further learning comes from their ability to take good field notes and to use those notes in answering the post-trip questions that are specifically designed to assess our goal of integration (Table 3). We have found that throughout the field trip, students become more comfortable with their surroundings such that they are better able to make good observations and ask and answer questions with confidence - this is reflected in the progression of their field notes. Student's field notebooks are often accompanied by sketches, botanical rubbings, pressed plants, photographs and post cards purchased at park visitor centers. Students also demonstrate learning by researching and writing a paper with a topic of their choice. We encourage students to discuss their research paper topic with one of us prior to the end of the field trip, although students wrote and submitted their research papers prior to departure during the summer of 2005. Either way, the paper guidelines that we provide are very specific (e.g., paper length and format, a clearly stated purpose in the introduction, citations of a minimum of three solid references, a clear summary of key points made in the paper). The research papers submitted (either before or after the trip) by our students are well-written, even by students who have had very little geology or biology in their formal education. The journal entries are insightful and reflective and often reveal their newfound understanding of the relationships between geology and botany. Each instructor carefully reads the answers to pre- and post-trip questions, field notebook and journal entries, and research paper. Final grades are decided at a faculty meeting and range from 2.0 - 4.0.

CAN THIS WORK AT OTHER INSTITUTIONS?

We are fortunate in the Pacific Northwest region in having a great diversity of terrains to explore with field students, but this type of course should work well elsewhere. We believe there are three critical aspects in the successful implementation of our approach to an integrative field course: (1) Two (or more) faculty in different fields that are willing to work together during preparation and execution of the course; (2) A clear primary objective or overarching theme for the course that is well-defined and that lends itself to an integrative approach; and (3) A prominent national park or significant geographic feature to enhance the interest in the course and to draw enrollments.

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