

UNDERGRADUATE MINOR AND GRADUATE CERTIFICATE PROGRAMS IN *RECLAMATION AND RESTORATION ECOLOGY*¹

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Abstract. *Reclamation and Restoration Ecology* undergraduate minor and graduate certificate programs are now available at the University of Wyoming, which is one of only a few institutions in the U.S. that provides training in these fields of study. Students completing a *Reclamation and Restoration Ecology* minor or certificate are more marketable for jobs requiring training in applications of ecosystem reclamation, rehabilitation, and/or restoration. Because mining, rehabilitation of disturbed lands, and restoration for production and wildland uses are major economic activities throughout the U.S., graduates with *Reclamation and Restoration Ecology* education are needed to meet the job market demands for these skills.

The *Reclamation and Restoration Ecology* undergraduate minor and graduate certificate at the University of Wyoming has broad appeal and considerable relevance to students, state and federal agencies, and private industry. These programs are available to students throughout the country that are interested in *Reclamation and Restoration Ecology* education. The *Reclamation and Restoration Ecology* programs were designed to build upon strengths that exist across the University of Wyoming campus; the Renewable Resources department has actually been offering education and training in *Reclamation and Restoration Ecology* for several decades. The *Reclamation and Restoration Ecology* undergraduate minor and graduate certificate reinforces the identity and enhances professional opportunities of students completing the programs

Additional Key Words: Soil, Revegetation, Disturbed Lands, Rehabilitation, Education, Course Work, Renewable Resources, University of Wyoming

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Introduction

On a local, regional, national, and international level, career opportunities abound for graduates with academic training in ***Reclamation and Restoration Ecology***. Many city, county, state, and federal employers aligned with natural resource management responsibilities on public and private lands are seeking future employees with scientific training in holistic ecosystem management. Private sector employers, such as environmental consulting companies, are increasingly contracted to complete environmental assessments of proposed land development projects, evaluate impacts to threatened/endangered plant and animal species, or complete ecosystem reclamation and restoration projects following land disturbances. These prospective employers are seeking employees with a broad, comprehensive understanding of ecosystem processes and function. They need trained professionals that understand the basic and applied ecological concepts embodied in the various components of an ecosystem such as soils, water, flora, and fauna. With expanding natural resource exploitation, all projections indicate accelerated future demand for professionally trained resource specialists who can properly manage these ecosystems and their natural resources.

Reclamation and Restoration Ecology involves using basic and applied ecological concepts to rehabilitate and restore processes and functions to disturbed ecosystems. Examples of ecosystems requiring reclamation and restoration practices include coal mined lands, bentonite mined lands, altered wetlands, degraded rivers and streams, lands infested with exotic plants or noxious weeds, eroding range and forest watersheds, fragile arid and semi-arid rangelands, lands contaminated by toxic chemicals (As, Cd, Hg, Pb, Zn, organic compounds, oils, tars, radioactive materials, etc.), and alkali/salt mudflats, to name a few. Rehabilitation and restoration of these disturbed ecosystems requires an understanding of the edaphic, biotic, hydrologic, geologic, and topographic factors comprising these ecosystems, including the complex interrelationships that support and perpetuate ecosystem function. A thorough understanding of the basic and applied ecological processes associated with each of these factors is essential to rehabilitate and restore ecosystem function.

Reclamation and Restoration Ecology programs are designed to educate students to better understand the concepts and principles involved in remediating and rehabilitating disturbed ecosystems. Students complete formal course work in a number of ***Reclamation and***

Restoration Ecology related courses established in the Department of Renewable Resources and in other natural resource oriented departments across campus (e.g., Botany, Zoology/Physiology, Geography, Geology, Engineering, Environment and Natural Resources, etc.). Students in the **Reclamation and Restoration Ecology** programs complete a broad array of natural resource related courses so they have a measurable level of understanding in edaphic, biotic, hydrologic, and geologic processes. Students who receive the minor or certificate in **Reclamation and Restoration Ecology** are able to evaluate impacts to disturbed ecosystems and make reclamation or restoration management recommendations to restore ecosystem function.

Employment opportunities

Undergraduate and graduate students completing a **Reclamation and Restoration Ecology** program can pursue careers in fields involving various basic and applied sciences, and can become prominent members of interdisciplinary groups that evaluate both natural resource management and environmental quality issues. Prospective employers include universities, research institutions, mining industries, state or federal resource management agencies, consulting firms, and regulatory agencies. In the next 5-10 years, many state and federal agencies will lose a significant proportion of their employees to retirement, thus increasing the opportunities for students completing one of the **Reclamation and Restoration Ecology** programs. Retirements and promotions in federal land management agencies such as Bureau of Land Management, U.S. Forest Service, Natural Resources Conservation Service, and Bureau of Indian Affairs will continue to create entry level positions. State agencies, such as the Department of Environmental Quality and Game and Fish Department, will need entry-level employees who have knowledge of whole ecosystem processes for regulatory and natural resource management responsibilities. Mining industries throughout the U.S. have been a steady source of employment for students trained in existing Soil Science, Range Management, Hydrology and Engineering academic programs. As public awareness of environmental impacts increases, employment opportunities with private consulting firms will grow to meet increasing company demands for environmental assessments.

Typical areas of employment opportunities for students with a **Reclamation and Restoration Ecology** undergraduate minor or graduate certificate include:

- ! Management of soils and vegetation for land improvement such as in landscape design, surface mined land reclamation and site restoration;
- ! Reclamation/restoration and creation of wetland, riparian, and aquatic habitats;
- ! Evaluation and investigation of ecosystems as they relate to natural resource management, including rangelands, forests, wetlands, streams and rivers, environmental endangerment assessments, ecological evaluations and archeological sites;
- ! Assessment and management of watershed soil erosion problems and stabilization of sand dune areas;
- ! Assessment and investigation of environmental hazards to soils and plants and evaluation of chemical fate and transport phenomena and suitable remediation alternatives;
- ! Evaluation and management of noxious and exotic plant, animal, and insect infestations, as well as threatened/endangered plant and animal species;
- ! Enhancement of edaphic, hydrologic, floral, and faunal resources on arid and semi-arid rangelands;
- ! Regulation of the use of land resources (soils, water, fauna, flora) by private and public interests (government agencies);
- ! Assessment and investigation of the suitability of disturbed lands for application of wastes (residue and sludge management) and site evaluations for on-site disposal of wastes;
- ! Management of ecosystem soils, vegetation, and water for agricultural purposes, forest products, and erosion control;
- ! Suitability studies for a variety of land development uses, including soil stability, moisture retention or drainage, sustainability and environmental impact; and
- ! Research support positions related to *Reclamation and Restoration Ecology* and management by public agencies and institutions, and private industry.

Description of the Reclamation and Restoration Ecology Programs

Reclamation and Restoration Ecology are disciplines that encompass natural resource management, biological studies, and environmental sciences. Educational components of the proposed minor and certificate include agriculture, botany, forestry, range management, hydrology, disturbed land rehabilitation, wildlife management, physical geography, surficial geology, geomorphology as well as others. Students, industry, and federal and state agencies have expressed interest in programs that emphasis *Reclamation and Restoration Ecology* to ensure that job opportunities and prospects can be met. The establishment of both the *Reclamation and Restoration Ecology* undergraduate minor and graduate certificate will strengthen our students ability to compete successfully in the job market, particularly because few opportunities for training in these fields of study are available throughout the U.S. The *Reclamation and Restoration Ecology* undergraduate minor and graduate certificate will

enhance our ability to educate and train students majoring in a number of degree programs and potentially industry and regulator agency personnel requiring certification.

Expanded educational opportunities are needed for students interested in areas such as reclamation, rehabilitation and/or restoration ecology. Change is occurring at universities across the nation as programs are being reorganized, department names are changing, and curricula are undergoing revitalization. For both undergraduate and graduate programs in ***Reclamation and Restoration Ecology***, the added knowledge and credentials provided by these programs will bestow immediate recognition to employers as to their training. Undergraduate and graduate students who pursue careers with federal land management or conservation agencies (i.e., Forest Service, Bureau of Land Management, Bureau of Reclamation, Army Corp of Engineers, Natural Resources Conservation Society), state and federal regulatory agencies (i.e., Wyoming Department of Environmental Quality, U.S. Environmental Protection Agency), mining and oil companies, environmental consulting companies, or scientific research organizations benefit from receiving the minor or certificate in ***Reclamation and Restoration Ecology***.

Requirements of ***Reclamation and Restoration Ecology*** are courses in Reclamation of Disturbed Lands and Restoration Ecology, which prepare students for other courses that complement the ***Reclamation and Restoration Ecology*** minor and certificate. In addition, new faculty in Spatial Processes Ecology/Hydrology and Plant Stable Isotope Ecology provide additional ecosystem level training for students in state-of-the-art GIS, computer applications and modeling, and stable isotope investigations.

Learning Goals

Learning goals for the ***Reclamation and Restoration Ecology*** programs are:

- ! Develop a broad-base understanding of disturbed land ecosystems in order to function as an effective resource management professional;
- ! Know how to analyze above and below ground processes of disturbed land environments in order to synthesize and apply reclamation/restoration techniques to enhance ecosystem dynamics, function, and sustainability;
- ! Be able to evaluate important soil biological, chemical and physical properties and plant community dynamics, structure and function in native and disturbed ecosystems;
- ! Utilize state and federal regulations and policy applications and interpretations regarding remediation of disturbed (including contaminated) lands;

- ! Develop the ability to synthesize information related to reclamation procedures appropriate for unique reclamation problems;
- ! Know how management practices are used to develop reclamation and restoration approaches to improve unstable ecosystems, for example lands that have been influenced by invasive exotic weeds and insects;
- ! Understand how soil-plant-microbe interrelationships, microbial-mediated processes, and chemical reactions influence different ecosystems (e.g., croplands, pastures, watersheds);
- ! Know how hydrologic and nutrient cycles influence plant growth and survivability;
- ! Develop an appreciation of how soil, vegetation and hydrology are integrated and respond to disturbed and natural processes based on soil quality/function and plant growth characteristics;
- ! Appropriately apply resources that are in the public domain (e.g., Soil Surveys, and OSM, NRCS, BLM, U.S. Forest Service websites) and know how GIS, GPS, remote sensing and different mapping techniques can be used for evaluating different landscapes.

Undergraduate Minor and Graduate Certificate

Students are required to complete the necessary courses and credit hours needed to understand and comprehend the learning goals listed above. The undergraduate minor curriculum is listed in Table 1. Those interested in the graduate certificate are required to complete from 10 to 17 credits (depending on previous course work) from the courses listed in Table 2. All students are required to have completed REWM 4200/5200 and REWM 4580/5580 either as an undergraduate or graduate student. For example, undergraduate students who have completed RNEW 4200 and RNEW 4580 will not be required to take the course again. The graduate certificate is granted to students who have completed a B.S. in an appropriate discipline or are currently enrolled in an M.S. or Ph.D. degree program (e.g., Botany, Entomology, Environmental Engineering, Geography and Recreation, Geology/Geophysics, Rangeland Ecology and Watershed Management, Soil Science, Zoology and Physiology, etc.). In addition, the graduate certificate are available to individuals (e.g., mine land reclamation specialists, WDEQ and OSM personnel and others seeking advanced knowledge) wishing to upgrade their training in *Reclamation and Restoration Ecology*.

Department of Renewable Resources Faculty

The Department of Renewable Resources administers the *Reclamation and Restoration Ecology* programs. There are currently 22 faculty specializing in basic sciences include: Insect

Table 1. Reclamation and Restoration Ecology Undergraduate Minor Course Work

		Credit Hours
i. Required Courses		
General Ecology	BIOL 2400	3
Introduction to Soil Science	SOIL 2010	4
Reclamation of Drastically Disturbed Lands	RNEW 4200	3
Rangeland Restoration Ecology	RNEW 4580	3
Reclamation and Restoration Ecology Seminar	RNEW 4900	<u>1</u>
Required Course Credits		14
ii. Select one course that emphasizes Below-Ground Processes		
Microbial Ecology	BIOL 4400	3
Hydrology	CE 4800	3
Groundwater and Drainage Engineering	CE 4820	3
Soil Physics	SOIL 4100	3
Genesis, Morphology and Classification of Soils	SOIL 4120	4
Soil Microbiology	SOIL 4140	4
Forest and Range Soils	SOIL 4150	4
Soil Fertility and Fertilizers	SOIL 4160	3
iii. Select one course that emphasizes Above-Ground Processes		
Remote Sensing and Natural Resource Management	BOT 4140	3
Vegetation Ecology	BOT 4700	4
Weed Science and Technology	CROP 5070	4
Aquatic Entomology	ENTO 4678	3
Geographic Information Sciences	G&R 4200	3
Wildland Hydrology	REWM 4280	3
Wildland Watershed Management	REWM 4700	3
Rangeland Vegetation Management Techniques	REWM 4850	3
Shrubland Ecology	RNEW 4540	3
Watershed Water Quality Management	REWM 4710	3
Wetland Ecology	ZOO 4550	4
Remote Sensing of the Environment and Remote Sensing Laboratory: Applications for Vegetation or Remote Sensing Laboratory: Applications for Geology	BOT/GEOL 4111	2
	BOT 4112	2
	GEOL 4112	2
iv. Select one course that emphasizes Planning and Policy		
Natural Resource Law and Policy	AGEC 4710	3
Approaches to Environment and Natural Resource Systems	ENR 3000	3
Conservation of Natural Resources	G&R 4040	3
Public Land Management	G&R 4750	3
Environmental Politics	POLS 4051	3
Federal Land Policy	POLS 4052	3
Rangeland Management Planning	REWM 4900	3
Selected Course Credits		<u>8-11</u>
TOTAL CREDITS NEEDED		22-25

Table 2. Reclamation and Restoration Ecology Graduate Certificate Course Work

		Credit Hours
i. Required Courses		
Reclamation of Drastically Disturbed Lands	REWM 5200	3
Rangeland Restoration Ecology	REWM 5580	3
<i>NOTE: Students who have already completed these course at the 4000 level have satisfied this requirement</i>		
Special Topics in Reclamation and Restoration Ecology	RNEW 5595	3
Reclamation and Restoration Ecology Seminar	RNEW 5900	1
<i>NOTE: In the Special Topics in Reclamation and Restoration Ecology course, students are required to complete a synopsis paper. Students will also give presentations on reclamation/restoration ecology topics in the Graduate Seminar (RNEW 5900) course.</i>		
ii. Select one of the following courses.		
Environmental Engineering Principles	ENVE 5010	4
Geological Environments of Coal-Bearing Deposits	GEOL 5070	3
Remote Sensing of the Environment	GEOL5111	4
Vegetation Ecology	BOT 5700	4
Primary Production/Cycling in Terrestrial Ecosystems	BOT 5740	3
Plant Physiological Ecology	BOT 5730	3
Biogeochemistry	BOT 5780	4
Weed Science and Technology	CROP 5070	4
Geohydrology	GEOL 5444	3
Advanced Geohydrology	GEOL 5570	3
Wildland Hydrology	REWM 5280	3
Watershed Water Quality Management	REWM 5710	3
Shrubland Ecology	RNEW 5540	3
Soil Physics	SOIL 5100	3
Modeling Flow Transport in Soil and Groundwater Systems	SOIL/MATH 5110	4
Genesis, Morphology and Classification of Soils	SOIL 5120	4
Chemistry of the Soil Environment	SOIL 5130	3
Soil Microbiology	SOIL 5140	4
Forest and Range Soils	SOIL 5150	4
Wetland Ecology	ZOO 5550	4
Remote Sensing of the Environment	BOT/GEOL 5111	2
and		
Remote Sensing Laboratory: Applications for Vegetation	BOT 5112	2
or		
Remote Sensing Laboratory: Applications for Geology	GEOL 5112	2
iii. Select one of the following Planning/Policy courses		
Environment and Natural Resource Policy Practices	ENR 4900	3
Solving Multidisciplinary Problems in Environment and Natural Resources	ENR 5900	3
Environmental Planning	G&R 5260	3
Environmental Law	LAW 6660	3
Environmental Politics and Administration	POLS 5050	3
MINIMUM TOTAL CREDITS NEEDED		10-17

Biodiversity and Population Dynamics, Insect Biology and Ecology, Rangeland Ecology, Rangeland Hydrology, Soil Biology and Ecology, Soil and Environmental Chemistry, Soil Classification and Genesis, and Soil and Water Physics. Focus areas in applied sciences and management include: Biological Control of Insects and Weeds, Disturbed Land Reclamation, Forest and Rangeland Soil Management, Insect Conservation Biology, Integrated Pest Management, Land Resource Management, Natural Resources and Environmental Quality Management, Rangeland Livestock Management, Rangeland Vegetation Management and Improvement, Watershed Management, and Restoration Ecology. Undergraduate students in the Department of Renewable Resources are required or encouraged to complete additional coursework in other campus natural resource related Departments such as Botany, Zoology/Physiology, Geology, Geography and Recreation, Engineering, and the School of Environment and Natural Resources. Small class size, personalized one-on-one faculty interactions with students, and commitment to student education by faculty (as evidenced by numerous faculty teaching awards) all ensure a quality educational experience for students enrolled in *Reclamation and Restoration Ecology* programs. In addition, active research programs by all teaching/research faculty in the *Reclamation and Restoration Ecology* area ensure that students are exposed to cutting edge ideas and technology.

Summary

The U.S. economy depends heavily upon the quantity and quality of its natural resources. Mining, oil and gas production, tourism and agriculture industries all have a vested interest in maintaining environmental quality and natural resources. Maintenance of traditional grazing systems, forestry practices, production agriculture, mining activities, oil and gas extraction, and water development will require a better understanding of natural resource management practices in the future to maintain environmental quality. These industries will need trained professionals who understand complex ecosystem processes and functions.

Groundwater protection/contamination is now at the forefront of environmental issues and is crucial to the needs of U.S. citizens and industry. Nationally, groundwater contaminants include nitrate, insecticides, herbicides, fertilizers, petroleum products, and industrial solvents. Threatened and endangered species such as the Wyoming toad, black-footed ferret, Kendall

warm springs dace, grizzly bear, gray wolf, prairie orchid, and others are the focus of environmental groups around the nation and world. Additional proposed listings of the sage grouse, mountain plover, and black-tailed prairie dog are further evidence of the need to properly manage fragile ecosystems in the future. Explosions of noxious weed infestations on public rangelands threaten ecosystem health. Catastrophic wildfires have become more evident in several areas throughout the U.S. with increased fuel loads from accumulated litter. Disappearing wetlands due to long-term drainage, drought, agricultural conversions, and land development activities threaten floral and faunal organisms dependent on these ecosystems. Alterations of aquatic (streams, rivers, lakes) and riparian habitat due to impacts from human disturbances and global climate changes threaten ecosystem health. All of these environmental issues will require trained professionals to protect and manage existing ecosystems for future generations. The ***Reclamation and Restoration Ecology*** programs prepare students for future employment opportunities to manage pressing environmental issues, and in a broad array of issues important to the U.S. economy and environmental health.

The ***Reclamation and Restoration Ecology*** programs are both attractive and have considerable application to the interest of students, state and federal agencies, and private industry. The programs are available to students in several disciplines that are relevant to ***Reclamation and Restoration Ecology*** interests. The ***Reclamation and Restoration Ecology*** programs include across campus courses at the University of Wyoming, with the Renewable Resources department leading the administration, education and training of the required course work in ***Reclamation and Restoration Ecology***. The ***Reclamation and Restoration Ecology*** undergraduate minor and graduate certificate have reinforced the identity and enhanced professional opportunities for students involved in these programs.