Watershed Assessment, River Restoration, and the Geoscience Profession in Oregon

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Introduction

Geologists have long been fascinated by the power, form, and function of river systems. Classical works in the U.S. include those by Powell (1882), exploration of the Colorado River; Davis (1889), drainage patterns and landscape evolution; Gilbert (1914), sediment transport by rivers; and Horton (1945), quantitative analysis of drainage networks. The historic importance of river environments in the geosciences is further emphasized by a key-word search in GeoRef, the bibliographic database sponsored by the American Geological Institute (American Geological Institute, 2007). The Boolean search string "river or fluvial" returns over 198,000 entries with publication dates ranging from 1801 to present. This paper discusses the role of professional geologists in the context of modern river restoration science, particularly as it pertains to watershed assessment and restoration in the state of Oregon.

Watersheds are composed of channel networks of varying spatial scales and represent one of the most fundamental landscape systems on the Earth's surface (Figure 1). Fluvial systems transport water, sediment, organic material, and chemical nutrients from the continents to the ocean basins. These systems have formed important habitat for freshwater aquatic and terrestrial life over a significant portion of geologic time. From an ecological perspective, watersheds provide services along riparian corridors that form critical habitat for flora and fauna. Humans in turn leverage these ecological goods and services to yield water resources, food, raw materials, and value-added economic infrastructure (e.g., transportation networks, industrial infrastructure, recreational facilities, agricultural land). Hence, watersheds serve as one of the fundamental regulatory units for allocating water, with the total estimated value of ecosystem services and natural capital approaching $12.3 billion (McCaffrey, 2001; Conca, 2005). The historic interplay between human occupation, intensive land management, and fluvial systems has resulted in significant impairment or pollution of waterways over the past century (U.S. Environmental Protection Agency, 2000; Gleick, 2003).

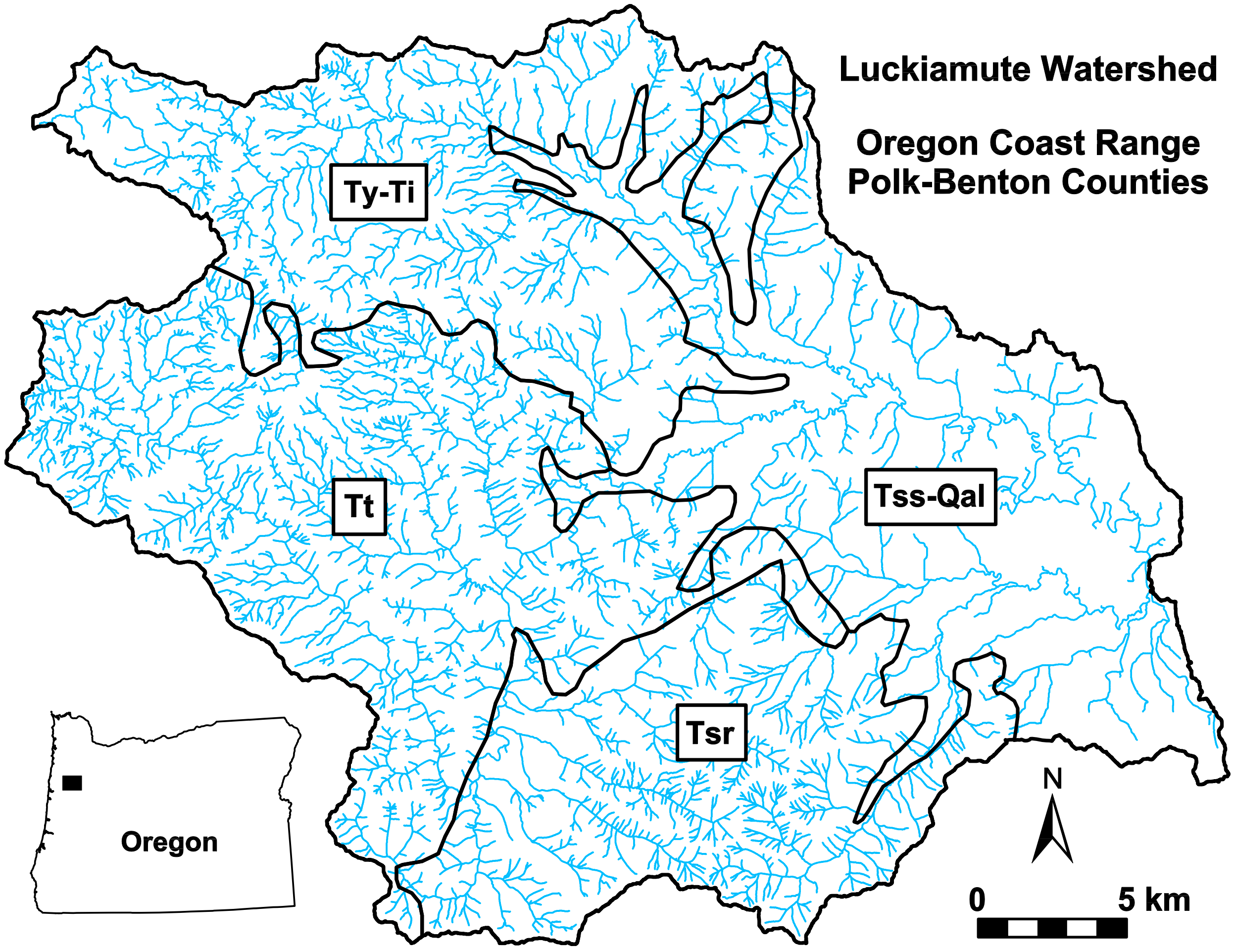
The Oregon Watershed Movement

Over the past 30 years, the state of Oregon has recognized the importance of watershed services to the economic vitality and environmental quality of the state. Oregon was a pioneer in the national environmental movement of the late 1970s, particularly with respect to land-use planning and water quality (Walth, 1994). The most recent manifestation of this priority recognition is exemplified by the Oregon Plan for Salmon and Watersheds (State of Oregon, 1997), a statewide initiative that was developed in response to proposed listings of native salmonids under the federal Endangered Species Act. The purpose of the Oregon Plan is to ensure watershed health and restore native salmonid fisheries to a sustainable level. To this end, the Oregon Watershed Enhancement Board (OWEB) was established by State Legislature in 1999 to monitor watershed conditions, coordinate programs, and administer lottery-derived restoration funds. With a current budget of $80 million, one of the primary functions of OWEB is to support protection, recovery, and restoration projects by community-based watershed councils across the state. The fundamental council philosophy is to engage citizens in understanding their local watershed conditions and to garner support for investment in the improved health therein.

The initial step in this process is completion of a basin-wide watershed assessment. As described by OWEB (1999, p. 3), "watershed assessment is a process for evaluating how well a watershed is working." The purpose is to determine locations that would most benefit by restoration of natural processes to improve fish habitat and water quality. Primary goals include:

1. Identifying features and processes important to fish habitat and water quality,
2. Determining how natural processes influence those resources,
3. Understanding the types of human activities that affect fish habitat and water quality, and
4. Evaluating cumulative effects of land management practices over time.

Thus, the philosophical premise of a watershed assessment "is that streams and their channels are the result not only of surrounding landform, geology, and climate, but of all upslope and in-stream influences as well. The assessment is directed at broad-scale patterns. It uses aspects of water quality and fish habitat as indicators of watershed health. To identify potential problems, the assessment relies on existing data, local knowledge of land managers, and field surveys." (OWEB, 1999, p. 4). Clearly, geological observation, data analysis, and interpretation are critical activities that lead to the understanding of landforms, processes, and ecological services in a given watershed (Figure 1). Once an initial assessment is completed, this baseline information is used to guide development, design, and implementation of river restoration projects to improve ecological function. River restoration is here de-



Bedrock Geology	No. Sixth-Field Subbasins	Avg. Drainage Density (km^{-1})	Avg. Basin Ruggedness	Avg. Shreve Magnitude	Avg. Basin Relief (m)	Avg. 1st Order Channel Gradient	Avg. Stream Power Index	Avg. No. Tributary Junctions Per Unit Area (km^{-2})
Tsr	6	2.2	1.2	49	530	0.23	0.20	2.9
Tt	5	2.4	1.6	55	660	0.22	0.19	2.9
Ty-Ti	5	2.0	1.1	32	540	0.21	0.41	1.9
Tss-Qal	6	1.4	0.2	14	150	0.06	0.03	0.7

Average Sixth-Field Subbasin Drainage Area = 10-20 km^2

Tsr Siletz River Volcanics (Paleocene to Eocene; basalt)
Tt Tyee Formation (middle Eocene; sandstone)
Ty-Ti Yamhill Formation-Tertiary Intrusives (Eocene-Oligocene; siltstone intruded by gabbro)
Tss-Qal Spencer Formation-Quaternary Alluvium (patchwork of Eocene siltstone-sandstone and alluvium)

Figure 1. Generalized geologic map and drainage network of the Luckiamute River basin, Polk and Benton counties, Oregon. The watershed is subdivided into four lithospatial domains: Siletz River Volcanics, Tyee Sandstone, Yamhill-Intrusive, and Spencer-Valley Fill (terminology after Taylor and others [2002]; map units from Walker and MacLeod [1991]). Tabulated morphometric data illustrate the controlling influence of site geology on fundamental watershed characteristics such as basin topography, drainage pattern, and channel configuration (from Taylor [2002, 2005]).

fined as the act of improving "hydrologic, geomorphic, and ecological processes in a degraded watershed system and replacing lost, damaged, or compromised elements of the natural system" (Wohl and others, 2005, p. 2).

The river restoration industry has experienced an exponential sixfold growth in the United States during the last decade (Figure 2). Over $1 billion is spent annually on small- to medium-scale restoration projects across the nation, with median costs of $45,000 per implementation (Bernhardt and others, 2005). Most restoration actions are performed on channel reaches less than 1 km in length. Through the work of community volunteers, government agencies, non-governmental organizations, and professional consultants, Oregon watershed councils have completed over 90 assessments, and OWEB has invested approximately $180,000,000 in restoration initiatives since 1999 (K. Bierly, OWEB, personal communication, 2007). Of the 37,099 restoration projects tallied in the National River Restoration Science Synthesis (NRRSS) database (survey years: 1990–2004; http://nrrss.nbii.gov), Oregon ranks second nationally behind Maryland in numbers of projects completed per 1000 km of river length (65.31/1000 km in Oregon) (Bernhardt and others, 2005). The most commonly cited restoration goals are (1) in-stream habitat improvement (pool development, woody debris augmentation), (2) riparian management (livestock containment, invasive removal), (3) fish passage (ladder installation, culvert modification), and (4) water quality management (riparian buffers, runoff control).

The Oregon Geoscience Profession

The laws governing the practice of geology in Oregon were established by the State Legislature in 1977 (Oregon Revised Statutes 672.505 to 672.991[1]; Oregon Administrative Rules 809[2]). Action was deemed necessary "to safeguard the health and welfare and property of the people of Oregon. These safeguards are in the fields of geology as related to engineering, ground water, land use planning, mineral exploration and development, geologic hazards, the further development of the science of geology, and other geologic matters of concern to the people of the state" (ORS 672.505). By statutory definition, "geology" refers to the science that involves the study of the Earth and its related processes and materials. Geologists utilize this knowledge for the benefit of the state and society at large. Engineering geology is a specialty area that refers to the application of geologic data, principles, and interpretations to naturally occurring materials so that geologic factors affecting planning, design, construction, and maintenance of civil engineering works are properly recognized and utilized.

As part of the 1977 legislation, the State Board of Geologist Examiners (OSBGE) was instituted as a five-member panel serving under the governor. Four members are appointed from the professional community and one as a public representative, each serving three-year terms. Board objectives include:

- Licensing professionals engaged in the public practice of geology
- Responding to complaints from the public and profession
- Educating the public and communicating with regulatory agencies
- Cooperating with related boards and commissions
- Promoting professional ethics and standards
- Providing systematic outreach to government agencies, non-governmental organizations, citizens, and registrants.

OSBGE currently administers licensing for over 1200 registered geologists (RG), certified engineering geologists (CEG), and geologists-in-training (GIT). The board is a member of the National Association of State Boards of Geology (ASBOG, 29 member states). Qualifications for professional registration include a college degree in geoscience or successful completion of 45 quarter hours (30 semester hours) of related course work, five years of post-baccalaureate work experience under the supervision of a registered geologist, and passing nationally standardized competency exams (ASBOG). The CEG requires licensing as an RG with additional experience and testing in that specialty area.

One of the primary duties of the board involves compliance actions related to the geologic profession. OSBGE reviews an average of 10 compliance cases per year with

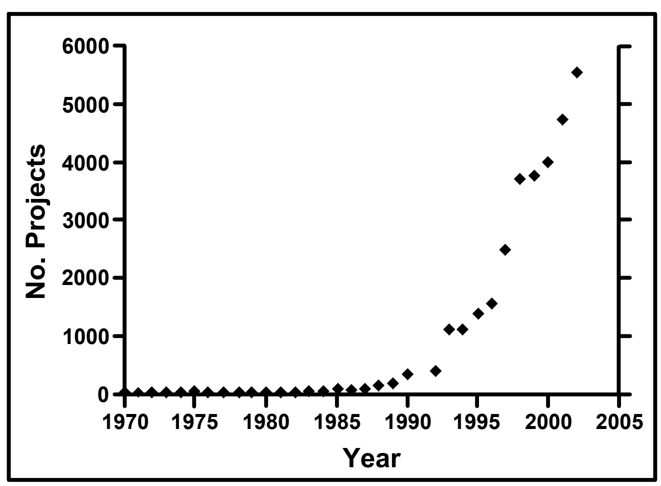


Figure 2. Time trend of the number of river restoration projects recorded in the National River Restoration Science Synthesis (NRRSS) database (http://nrrs.nbii.gov) and the years in which they were conducted (from Bernhardt and others [2005]).

1 Oregon Revised Statutes, Chapter 672 — Professional Engineers; Land Surveyors; Photogrammetrists; Geologists: Legislative Counsel Committee, Oregon Legislative Assembly, Salem, Oreg., Online document http://www.leg.state.or.us/ors/672.html.

2 Oregon Administrative Rules, OAR 809 Board of Geologist Examiners: Oregon State Archives, Salem, Oreg., Online document http://arcweb.sos.state.or.us/rules/OARS_800/ OAR_809/809_tofc.html.

the most commonly cited complaints consisting of poor-quality workmanship and public practice without a license. From a regulatory standpoint, OSBGE defines the *public practice of geology* as the "performance for another of geological service or work, such as consultation, investigation, surveys, evaluation, planning, mapping and inspection of geological work, that is related to public welfare or safeguarding of life, health, property and the environment" (ORS 672.505). The geoscience profession contributes significantly to sustainability and development of the natural resource base in the state. OSBGE and the state licensing laws provide a framework in which this work can be conducted safely, knowledgeably, and ethically for the greater good of Oregonians.

Watershed Projects and Geology Licensure

Given the long history of scientific contributions by geoscientists to the understanding of fluvial dynamics, and the stated importance of geomorphic and geologic analyses to watershed assessment, licensed professional geologists are well positioned to play a significant role in guiding river restoration practice in Oregon. Additionally, existing state licensing laws require that geologic components of watershed assessments and river restoration projects be performed under the supervision of a registered geologist (RG) or a certified engineering geologist (CEG). While only portions of watershed projects are geological in nature, it is recognized that properly designed river management plans require an interdisciplinary team with integrated contributions from geologists/geomorphologists[3], engineers, ecologists, fisheries biologists, botanists, foresters, hydrologists, landscape architects, social scientists, construction contractors, and community members. Because of the inherent overlap between Earth-resource professions (e.g., geology, engineering, hydrology), there is commonly confusion among regulators, project managers, and practitioners as to which state licensing board has legal primacy with respect to professional practice. The integrative nature of watershed assessment and restoration work renders these types of projects particularly vulnerable to practice outside of specialty disciplines and under-trained practitioners (Geological Society of America, 2004).

The OSBGE guiding policies for delineation of the public practice of geology are as follows. If the activity involves the simple review and reporting of previously published historical records, maps, and documents that explain the geology of a watershed (i.e., "the book report" approach), professional geology licensure is not required to write the summary report. However, if the professional activity involves re-analyzing published historical records, maps, and documents to conduct new analyses and to derive new or updated interpretations, the work must be conducted or stamped by a licensed geologist. Any work that involves direct observation, analysis, and interpretation of previously unpublished geologic data must be supervised or conducted by a registered professional geologist. Federal employees working on employment-related projects are exempt from Oregon geology licensing laws. However, federal employees working as independent consultants on geology-related projects at federal, state, or private locations, outside of their prescribed work duties, are required to hold professional licensure. State employees and private citizens, including retired federal workers, are required to abide by the state geology licensing laws and must have their work supervised and stamped by a registered professional. Exemptions include university professors conducting geologic analyses as part of their employment-related research and teaching duties. If watershed professionals are acting as private citizens to provide personal testimony at public hearings (e.g., planning commissions, city council meetings, etc.), free-speech laws allow those individuals to present geologic data, interpretations, and opinions without licensure. However, if such individuals are acting as third-party expert witnesses representing clients or other individuals, this constitutes the public practice of geology and professional registration is required.

The following is a summary of watershed assessment and restoration activities[4] that involve the practice of geology, require formalized training in the geosciences, and fall under the existing state licensing laws if professionally executed:

- ***Map and air photo interpretation of geologic features:*** any map and photo analyses used to delineate landforms, identify Earth materials (rock and/or sediment), and interpret Earth surface processes (including sediment sources); geologic analysis and interpretation of digital elevation models and LIDAR surveys.
- ***Geologic mapping:*** mapping and interpretation of bedrock type and lithostratigraphic units.
- ***Geomorphic mapping:*** mapping and interpretation of landforms including active channels, in-channel features (e.g., bars, cut banks, thalwegs), floodplains, terraces, alluvial fans, landslide terrain, and mine-land features.
- ***Fluvial geomorphology and geomorphic analysis:*** quantitative measures of channel dynamics including derivation of channel geometry; identification of sediment storage and transport sites; flood history and paleoflood analyses.

3 On the basis of alignment with the National Association of State Boards of Geology (ASBOG, www.asbog.org), OSBGE views geomorphology as a subdiscipline of geology that requires academic training in mathematics and physical sciences (geology, physics, chemistry). Geomorphology is documented as a qualifying geology subject area under OAR 809-030-0025.

4 This list was derived from extensive review of the Oregon Watershed Assessment Manual (OWEB, 1999). The numerous watershed activities that fall outside of geologic practice are not included in this discussion.

- ***Geologic interpretation:*** using landforms, Earth materials, and surface processes to render interpretations about the history of a watershed or stream reach on geologic or historic time scales.
- ***Hydrogeology:*** hyporheic conditions, groundwater-surface water interaction, and aquifer characterization; vadose zone (unsaturated soil) hydrology, porosity and permeability analyses; recharge studies, groundwater flow, spring hydrology, water quality and groundwater resource evaluation; contaminant migration; wetlands hydrology.
- ***Engineering geology:*** erosion and slope stability studies; channel-bank stability analysis; landslide hazard evaluation; erosion and sedimentation analyses; road drainage analyses; abandoned mine land assessment; seismic hazard analysis including floodplain liquefaction potential.
- ***Channel modification and enhancement:*** any restoration activity involving channel modification that may result in erosion, flooding, slope instability, or alteration of groundwater conditions as defined by the practice of Engineering Geology.

While portions of the above watershed assessment and restoration activities overlap in scope and content with allied professions, they are considered part of the geologic practice and, accordingly, may be regulated by the licensing laws administered by the Oregon State Board of Geologist Examiners.

Summary and Conclusion

The study of physical properties of river systems is historically rooted in the geoscience discipline. This paper examines the role of professional geologists in the burgeoning field of river restoration. The state of Oregon has long recognized the importance of fluvial systems to society, most recently exemplified by enactment of the Oregon Plan for Salmon and Watersheds. The plan utilizes an integrative process of watershed assessment and restoration to improve ecological function in degraded river systems. Oregon is a national leader in watershed restoration efforts with the majority of projects focusing on in-stream modification, riparian management, fish passage, and water quality improvement.

Given the long history of scientific contributions by geoscientists to the understanding of fluvial dynamics, and the importance of geomorphic and geologic analyses to watershed assessment, Oregon professional geologists are well positioned to play a lead role in guiding river restoration. The interdisciplinary nature of watershed management plans requires a team approach involving geologists and a suite of other natural resource professionals. Related geologic practice is in turn governed by well-established state licensing laws that have been in effect since 1977 to ensure public welfare and safeguard life, health, property, and the environment. These laws require that geologic components of watershed assessments and river restoration projects be performed under the supervision of a registered geologist (RG) or a certified engineering geologist (CEG). Project activities that involve the public practice of geology include map and air photo analysis of geologic features, geologic mapping, geomorphic mapping, geomorphic analysis, geologic interpretation, groundwater investigations, slope stability studies, and channel modification.

Water resources and ecological services are critical to the economic vitality and environmental quality of the state. To this end, the Board of Geologist Examiners stands ready to work with allied professional organizations to promote cost-effective and successful watershed enhancement projects in Oregon. For more information on the professional practice of geology in the state of Oregon, contact the OSBGE office administrator at (503) 566-2837 (email: osbge.info@state.or.us), or visit the web site at www.oregon.gov/OSBGE/index.shtml.

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