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Earth Resource Management, a New Graduate Degree at the University of Utah

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Abstract: Earth's resources can be considered in three categories: captured or reusable—sun, wind, rain, tides, etc.; nurtured or renewable—ecosystems, including soils, plants, animals, etc.; and extracted—mineral deposits, including oil and gas. All three types of resources are used by humans for sustenance and for improvement of the quality of life. Increasing human population and the continuing extraction of depletable resources may lead to shortages of key commodities, unbalanced markets with wide price swings, and economic depression in areas where those resources are depleted. In addition, some resources may be used or extracted without adequate consideration of the influence of that use on other resources. Until recently, all of the earth's resources were treated as infinite, and the use of those resources proceeded accordingly. In particular, mineral resources were often "high graded" with little thought of the resultant influences on other resources. For true sustainability, an integrated, holistic approach to resource usage must be developed and implemented. That approach will necessarily incorporate the knowledge and methods of the sciences, engineering, business, law, and humanities, and will include five important components: people, resources, innovation, cooperation, and leadership. At the University of Utah, the College of Mines and Earth Sciences is preparing to offer a master's degree in Earth Resource Management. This course of study will be one of the options in the accredited Professional Management of Science and Technology program, administered by the University's Graduate School. It is designed to prepare professionals competent in all of the aspects of sustainable resource management.

Keywords: natural resources, management, human factors, culture

1 Introduction—Earth Resources

Human society in all its forms depends on the use of the earth's resources. These resources are materials and sources of energy that can be used to improve conditions for human beings. The survival and success of human society depends on the sustainable use of those resources.

Resources can be considered in three categories. *Captured* or *reusable resources* include those resources whose occurrence persists with little or no management by humans, such as sunlight, wind, and ocean tides. *Nurtured* or *renewable resources*—including soils, plants, and even ecosystems—are also persistent, but human management may be required to ensure or enhance their persistence and usefulness. *Extracted* or *depletable* resources are subject to exhaustion with continued use, and primarily comprise of mineral deposits, including fossil fuels.

There is of course overlap among these categories. For example, a renewable resource such as soil may be depleted by misuse or changes in climate conditions. Furthermore, use of one resource may have unexpected influences on others, as appears to be the case with the effects of fossil fuel utilization on climate and ecosystem.

The history of resource utilization is not encouraging. Large areas of Europe were deforested to provide lumber and fuel (Williams 2000). The American bison was almost exterminated so that native Americans, deprived of a critical resource, could be subjugated (Stoll 2017). Hydraulic mining in California caused severe erosion in the mining areas and uncontrolled flooding and siltation downstream. This resulted finally in the first environmental lawsuit in the U.S., Woodruff v. North Bloomfield Gravel Mining Company, adjudicated in 1884 (Holliday 1999). Of course, many other historic examples can be cited, and unfortunately similar misuses continue.

2 Earth Resources and Sustainability

Continued growth of the earths' human population is expected, in spite of a decrease in the growth rate, as shown in Figure 1.

Increasing population will result in increased demand for resources. This is shown clearly in projections of demand for steel (Figure 2), energy (Figure 3), and battery cobalt (Figure 4). If population and demand for resources increase as expected, the sustainable management of all earth's resources will be critical.

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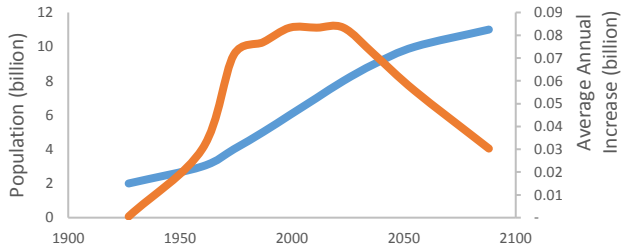

Figure 1 World population projected to 2100 (Source: United Nations 2017)

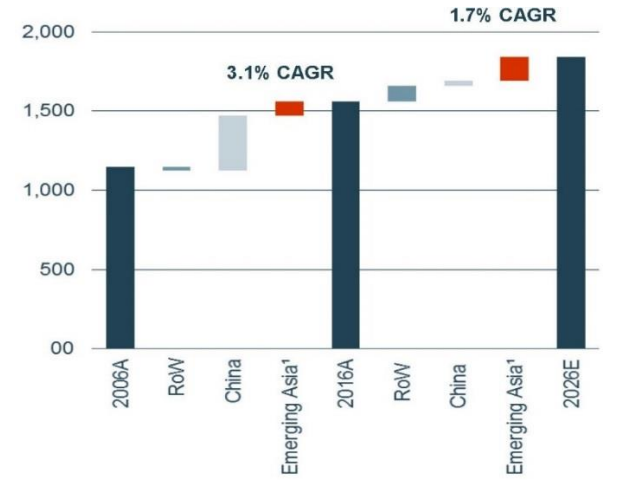

Figure 2 World finished steel demand projected to 2026. (Source: Basto 2018) [1]Emerging Asia includes India, ASEAN, and other South Asian countries, [2]New integrated steel projects commissioned or being built since 2017 (Sources: Platts, worldsteel; BHP analysis)

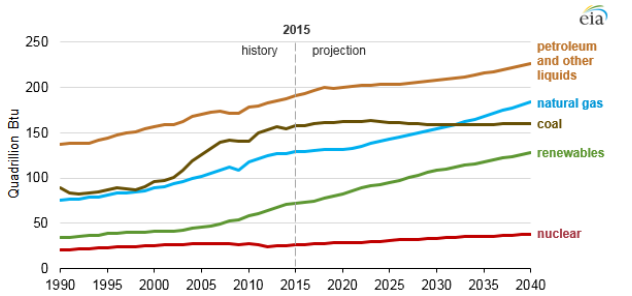

Figure 3 World energy consumption by energy source from 1990 projected to 2040. 1 quadrillion Btu ≈ 1.06E10[3] MJ (Source: U.S. Energy Information Agency 2018)

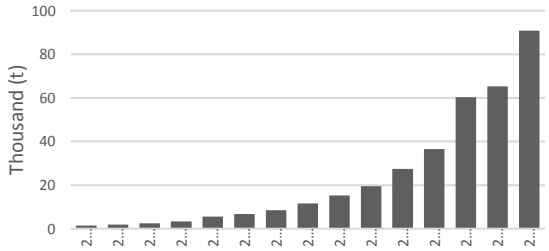

Figure 4 Battery cobalt demand projected to 2030. (After Burgess 2017)

3 A New Approach to Earth Resource Management

In 2015, considering changes in the mining industry, the Mining Engineering Department at the University of Utah undertook a revision of its strategic plan. Discussions with its Industry Advisory Committee (two of whom are co-authors of this paper), and other leading industry professionals clearly indicated the need for a new graduate degree for professionals working in or with the resource industries.

From these discussions it was concluded that executives and managers of resource production companies are often drawn from the companies' technical employees. The technology used in resource production is complex, and it is often thought that technically trained employees are best qualified to "run the company." The implicit assumption is that technically competent individuals can learn the additional skills (financial, social, political, and cultural) that are required in good management.

In some cases, resource production companies look for experienced engineers or scientists who also have advanced management training, often from a prestigious institution.

Both of these approaches rely on the individual to combine technical education and skills with business education, often with little guidance in how to do that successfully. In particular, the challenges unique to the resource production industries are often not fully addressed.

Two comments made during these discussions provide key insight. First, in a conversation regarding the public image of the mining industry, George Karpakis, retired CEO of BHP Specialty Metals, said, "I'm not sure what the mining industry will be like in 30 years. Mining will still be going on, but the industry will have to be completely different that it is now, or it won't be able to operate." Second, in a discussion of the skills needed by mining engineers, a Rio Tinto executive said, "I employ a lot of mining engineers. When I need to hire one, I can almost always find five or six good ones. On the other hand, if you could give me five mining engineers who can read a balance sheet, I'd hire all of them immediately."

The department concluded that there was a clear need for an advanced degree in earth resource management, and determined to propose such a degree as part of its strategic plan. In subsequent discussions with the Industry Advisory Committee, industry leaders, and University of Utah faculty from several colleges and departments, a draft curriculum was prepared.

4 Professional Master of Science and Technology

The University of Utah's Graduate School offers an accredited Master of Science and Technology (MST) degree for students who want to develop science, technical and business skills required for management careers in technology-based industries, government agencies or non-profit organizations. The degree has been reviewed and accredited by the National Professional Science Master's Association since 2001 (NPSMA 2018).

The degree was approved with five "tracks" or specializations, to be determined by the University. Four

tracks are presently functioning: Biotechnology, Computational and Data Science, Environmental Science, and Science Instrumentation. The Mining Engineering Department has proposed the addition of a fifth track, Earth Resource Management, and approval of that proposal is expected in the summer of 2018.

The MST degree requires 36 credit hours in three categories: 15 in Graduate Science, six in Advanced Quantitative Skills, 12 in Transferable Skills, and 3 in a Professional Experience Project (internship).

(1) The Graduate Science category comprises courses chosen by the department or entity that administers the specialty track in which the student is studying. Each track requires certain core courses and provides a list of approved elective courses.

(2) The Advanced Quantitative Skills category focuses on modeling and statistical tools for solving real-life problems. Students complete a 3-credit course in advanced statistical techniques and electives based on their programs of study.

(3) The Transferable Skills category includes courses in Effective Communication, Accounting and Finance, Leadership and Management, Strategic Planning and Marketing, Production and Operations Management, Entrepreneurship and New Product Development, and Scientific Reasoning and Inquiry. Students also take three credits of graduate coursework from the School of Business or an approved elective.

(4) The Professional Experience Project is an essential component of the PMST degree, in which the student works with a local company, government agency or non-profit organization. These activities engage students in realistic work situations involving technical problems, teamwork, communication skills, and decision making.

5 Professional MST in Earth Resource Management

The Mining Engineering Department at the University of Utah has proposed the addition of a fifth track, Earth Resource Management, to the University's PMST program. This track will provide education specifically for management and leadership in the resource industries. It will be designed for individuals with undergraduate degrees in engineering and the physical sciences, but also open to those in business or communications who have strong technical backgrounds.

The program will provide instruction in the science and technology of resource utilization, as well as in finance, economics, management, leadership, law, and innovation. In addition, students will be able to include important courses in sustainability, social responsibility, and cultural sensitivity in their courses of study. Students will have flexibility to align their individual programs of study with their professional interests. The degree track will be intentionally and inherently interdisciplinary. The course offerings appear in Tables 1 to 7 below. Descriptions of all these courses are available in the University of Utah's online General Catalog (UTAH 2018).

Table 1 Earth resource management graduate science courses

Course*	Title	Credits
Required		
MG EN 6010	Mineral Extraction & Processing	3
MG EN 6340	Resource Economics & Valuation	3
Elective—Three Required		
MG EN 6015	Mine Visits	3
MG EN 6080	Mine Permitting and Reclamation	3
MG EN 6350	Safety & Health Management	3
MG EN 6370	Data Management in Engineering & Heavy Industry	3

*MG EN is Mining Engineering.

Table 2 Earth resource management non-science electives

Course**	Title	Credits
LAW 7240	Environmental Law & Policy	3
LAW 7200	Natural Resources	3
LAW 7220	Oil and Gas	3
LAW 7230	Water	3
LAW 7796	Mining Law	3
EHUM 6101	Foundations of Env Humanities	3
EHUM 6103	Ecology of Residency	3

**EHUM is Environmental Humanities

Table 3 MST courses

Course	Title	Credits
MST 6010	Effective Communication	1
MST 6012	Accounting and Finance	1
MST 6020	Leadership and Management	1
MST 6021	Strategic Planning and Marketing	1
MST 6022	Production and Operations Management	1
MST 6023	Entrepreneurship and New Product Development	1
MST 6500	Scientific Reasoning and Inquiry	3
MST 6600	Advanced Statistical Analysis	3
MST 6963	Special Topics	1-3
MST 6974	Professional Experience Project Planning	1
MST 6975	Internship and Work Experience	3

Table 4 Transferable skills electives

Course	Title	Credits
MST 6010	Effective Communication	1
MST 6012	Accounting and Finance	1
MST 6020	Leadership and Management	1
MST 6021	Strategic Planning and Marketing	1
MST 6022	Production and Operations Management	1
MST 6023	Entrepreneurship and New Product Development	1
MST 6500	Scientific Reasoning and Inquiry	3
MST 6600	Advanced Statistical Analysis	3
MST 6963	Special Topics	1–3
MST 6974	Professional Experience Project Planning	1
MST 6975	Internship and Work Experience	3

Table 5 Transferable Skills electives in Communication (COMM)

Course	Title	Credits
COMM 6365	Communicating Climate Change	3
COMM 6370	Environmental Communication, Special Topics	1–3
COMM 6580	Public Relations Cases and Campaigns	4
COMM 6640	Communication Technology and Culture	3
COMM 6710	Quantitative Communication Research	4
COMM 7200	Environmental Communication	3

Table 6 Transferable skills electives in entrepreneurship (ENTP), geography (GEOG), information systems (IS), management, and operations and information systems (OIS)

Course	Title	Credits
ENTP 6810	Venture Foundations	1.5
ENTP 6820	Venture Trends	1.5
GEOG 6162	Project Management	3
IS 6420	Database Theory and Design	3
MGT 6154	Competitive Advantage Through Human Resources	1.5
MGT 6500	Managerial Negotiation	1.5
MGT 6510	Problem Solving	1.5
MGT 6545	Leading Responsibly	3
MGT 6570	Power and Politics within Organizations	1.5
MGT 6590	Managing the Global Workforce	1.5
MGT 6790	International Management	1.5
OIS 6040	Data Analysis and Decision Making I	1.5
OIS 6420	Quality Management I	1.5
OIS 6425	Six Sigma for Managers	3

Table 7 Transferable skills electives in strategy (STRAT) and writing (WRTG)

Course	Title	Credits
STRAT 6071	Competitive Strategy	1.5
STRAT 6154	Competitive Advantage Through Human Resources	1.5
STRAT 6156	Advanced Leadership: Problem Solving in Business Organizations	1
STRAT 6171	Managing in the Global Economy	1.5
STRAT 6175	Leading Innovation	1
STRAT 6310	Business Law	3
STRAT 6350	Intellectual Property-Copyright, Patent, and Trademark	3
STRAT 6530	Competitive Advantage Through People	1.5
STRAT 6710	Strategy & Technology	1.5
STRAT 6720	Applications of Business Strategy	1.5
STRAT 6740	Strategic Leadership	3
STRAT 6750	Business Turnarounds	1.5
STRAT 6760	Profiles of Leadership	1
STRAT 6791	Global Strategic Management	1.5
WRTG 6000	Writing for Publication	3
WRTG 6080	Writing for Environmental and Sustainability Studies	3
WRTG 7060	Scientific Writing	3

6 MST Earth Resource Management Degree Delivery

All of the PMST degree tracks at the University of Utah are designed for both full- and part-time students. The full-time curriculum can be completed in two years—four semesters with nine credits per semester. The part-time curriculum requires three years—six semesters with six credits per semester. The program is designed to be convenient for working professionals, with courses offered in the late afternoon or evening.

It is expected that many of those interested in the Earth Resource Management—particularly those working at mining operations—will be located some distance from the University campus. The Mining Engineering Department plans to offer its core and elective courses for remote access, using live video and on-line technology. The Graduate School also plans to transition its MST courses for availability by remote access.

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