UNIVERSITY MASTER PROGRAM IN ECOSYSTEM RESTORATION
http://www3.uah.es/master_rest_eco/

Syllabus - GEOMORPHIC RESTORATION

6 ECTS. Academic year 2022 – 2023 (January of 2022)

CONTENTS

Theory

1. Relationships between geology, geomorphology and ecological restoration.
2. Evaluation and diagnosis of geomorphic effects, and changes in runoff and erosion and sedimentation balance, caused by human activities implying earth movements (mining, civil works, urban developments…)
3. Understanding of the geomorphic restoration discipline, and how the designing and building of stable landforms and drainage networks, based on natural analogues, are the basis for successful ecological restoration of areas disturbed by human activities implying earth movements.
4. Knowing, at a very basic level, which are the most common hydrologic, erosion and landscape evolution models (used in restoration of degraded lands)
5. Basic concepts for soils and surficial deposits handling in geomorphic restoration.

Practical skills

1. Being able of using basic tools of CAD involved in engineering, mining and urban developments.
2. Make basic geomorphic restoration designs in the framework of ecological restoration projects that may need such approach. Specifically, by using the GeoFluv method - Natural Regrade *software*.
3. Introduction to the use of landscape evolution models (LEM), capable to forecast the erosive evolution of different restoration designs. Explicitly, by using the SIBERIA and EAMS tools.

LECTURERS

- José F. Martín Duque, Ignacio Zapico Alonso, Complutense University of Madrid, Spain.

TEACHING ORGANIZATION AND CLASSROOMS

Nine four-hour classroom sessions and one day of field work. All classroom sessions will include theory and practise (using of different software). All classes will be taught at the Computer Lab classroom (1st floor, by the elevators of the right wing of the building) of the Geological Sciences Faculty. For the first day, in case of doubt, ask at the Concierge *(Consejería)* of the Faculty of Geology.

GRADING SYSTEM

Attending to the face-to-face classes is compulsory, and it is indispensable to pass the subject. Since the teaching is concentrated in two weeks, just before the exams period, the grading will consist in: (a) a final exam, broad enough to reduce uncertainty for the student, consisting in: questions on benchmark papers (highlighted at the references section) on geomorphic restoration (20% of the final mark) and questions and short exercises on all the contents of the subject (70 % of the final mark); (b) a short report on the contents of the field work (10% of the final mark). Additional (optional) work can be carried out for improving the final grade, consisting of practicing at home with Natural Regrade. The details will be explained the first day of class.

The exam will be held on Friday, 4th of February, 2022, at the classrooms numbers 15 and 16, at the fifth floor of the Faculty of Geology of the Complutense University, from 15:30. The fieldwork report must be sent before or at the exam.

SCHEDULE AND CONTENTS

Session I. Monday, January 10th, 2022

1. 10:00 to 12:00. Course organization. *Theory*. Earth movement and global change **(ppt1)**. Introduction to Environmental Geomorphology **(ppt2).**
2. 12:20 to 14:00. *Practise*. (1) Introduction to AutoCAD and Carlson software. (2) Drainage basin analysis (ridgelines and talwegs).

Session II. Tuesday, January 11st 2022

1. 10:00 to 11:30. *Theory*. Geomorphology and ecosystem restoration (ppt3). Traditional landform design (in earth movement's construction and restoration). Geomorphology and erosion of areas disturbed by earth movements **(ppt4).**
2. 11:50 to 14:00. *Practise*. Basic exercises in CAD (II): (1) conventional topographic designs (pads); (2) basic morphometric analysis of drainage basins. (3) Quick overview to the Natural Regrade software (I)

Session III. Wednesday, January 12nd, 2022

1. 10:00 to 11:30. *Theory.* Geomorphic restoration of areas disturbed by earth movements **(ppt5)**. (4) Hydrologic, erosion and landscape evolution models **(ppt6).**
2. 11:50 to 14:00. *Practise*. Tutorial on the GeoFluv method and Natural Regrade software. General settings.

Session IV. Thursday, January 13rd, 2020

1. 10:00 to 11:30. *Theory*. The GeoFluv method **(ppt7)**.
2. 11:50 to 14:00. *Practise*. Tutorial on the GeoFluv method and on the Natural Regrade software. Channel settings.

Session V. Friday, January 14th, 2022

To be discussed on Monday January 10th, 2022

Session VI. Monday, January 17th, 2022

1. 10:00 to 11:30. *Theory*. How to build geomorphic restorations **(ppt8).** Methods for geomorphic restoration of hard-rock highalls and roadcuts **(ppt9)**. Worldwide examples of geomorphic restorations **(ppt10).**
2. 11:50 to 14:00. *Practise*. Tutorial on the GeoFluv method and on the Natural Regrade software. Cut and fill balances. Slope gradients. Runoff tracking.

Session VII. Tuesday, January 18th, 2022

1. 10:00 to 11:30. *Theory*. Monitoring of geomorphic restorations **(ppt11).**
2. 11:50 to 14:00. *Practise*. Stability of GeoFluv – Natural Regrade restoration designs **(ppt12).**

Session VIII. Wednesday, January 19th, 2022

1. 10:00 to 11:30. *Theory.* Landscape Evolution Models (LEM) **(ppt13).** Soil and surficial deposits handling in geomorphic restoration **(ppt14)**.
2. 11:50 to 14:00. *Practise*. Basic use of SIBERIA and EAMS software.

Session IX. Thursday, January 20th, 2022

1. 10:00 to 11:30. *Theory.* Linear infrastructures and urban developments **(ppt15).**
2. 11:50 to 14:00. *Practise*. Geomorphic landform design of a real case.

Session X. Friday, January 17th, 2020. FIELD WORK

Visit to the Santa Engracia and El Machorro mines (Peñalén and Poveda de la Sierra, respectively, Guadalajara province). The former is being ecologically restored, with geomorphic restoration basis, in the framework of a LIFE project of the European Union. The second shows several typologies of landform and soil restoration. Before of the field work, all the details about logistic and contents will be provided. The forecasted time for departing, from the Faculty of Biology of the UCM, will be 7:30 am. There will be an intermediate stop in Guadalajara, but not in Alcalá. The forecasted time of arrival is 19:00 to Madrid.

REFERENCES

The references listed below will be available for the student at the Virtual Campus (outside Rosgen 1996, obtainable at the library of the Faculty of Geology, UCM). Given the fact that Geomorphic Restoration is still a young discipline, there are no good and specific handbooks or books yet. We consider the following selection to be an updated synthesis. Reading all of them neither is needed to pass the subject nor is expected, mostly given the little time since the beginning of the subject. However, the papers highlighted (in bold) should be read, since there will be questions on them at the exam.

Bugosh, N., Epp, E. 2019. Evaluating sediment production from native and fluvial geomorphic reclamation watersheds at La Plata Mine. Catena, 174: 383-398.

Environment Australia. 1998. Landform Design for Rehabilitation. Department of the Environment, Canberra.

Gunn, J., Bailey, D. 1993. Limestone quarrying and quarry reclamation in Britain. Environmental Geology 21:167-172.

Hannan, J.C. 1984. Mine Rehabilitation. A Handbook for the Coal Mining Industry. New South Wales Coal Association, Sydney, 124 pages. (Second edition of 1995).

Hancock, G. 2004. The use of landscape evolution models in mining rehabilitation design. Environmental Geology 46:561–573.

Hancock GR, Willgoose GR. 2017 .Sustainable Mine Rehabilitation – 25 Years of the SIBERIA Landform Evolution and Long-term Erosion Model, Australian Institute of Mining and Metallurgy.

Hancock, G.R., Martín Duque, J.F., Willgoose, G.R. 2019. Geomorphic design and modelling at catchment scale for best mine rehabilitation – the Drayton mine example (New South Wales, Australia). Environmental Modelling and Software 114: 140 151.

Hancock, G.R., Martin Duque, J.F., Willgoose, G.R. 2020. Mining rehabilitation - using geomorphology to engineer ecologically sustainable landscapes for highly disturbed lands. Ecological Engineering 155, 105836.

Hooke R, Martín Duque JF, Pedraza J. 2012. Land transformation by humans. GSA Today 22 (12): 4–10.

Hooke and Martín Duque. 2020. Impact of the Great Acceleration on Our Life-Support Systems, Reference Module in Earth Systems and Environmental Sciences, Elsevier.

Martín Duque JF, Sanz MA, Bodoque JM, Lucía A, Martín C. 2010. Restoring earth surface processes through landform design. A 13-year monitoring of a geomorphic reclamation model for quarries on slopes. Earth Surf. Proc. Landforms, 35: 532-548.

Martín Duque, J.F., Tejedor, M., Martín Moreno, C., Nicolau, J.M., Sanz Santos, M.A., Sánchez Donoso, R., Gómez Díaz, J.M. 2020. Geomorphic landscape design integrated with progressive mine restoration in clay quarries of Catalonia. International Journal of Mining, Reclamation and Environment, 35(6), 399-420.

Martín Duque, J.F., Zapico, I., Bugosh, N., Tejedor, M., Delgado, F., Martín-Moreno, C., Nicolau, J.M. 2021. A Somolinos quarry land stewardship history: From ancient and recent land degradation to sensitive geomorphic-ecological restoration and its monitoring. Ecological Engineering, 170, 106359, 1-18.

Martín-Moreno C, Martín Duque JF, Nicolau JM, Muñoz A, Zapico I. 2018. Waste dump erosional landform stability – a critical issue for mountain mining. Earth Surf. Process. Landf. 43: 1431–1450.

Nicolau JM 2003. Trends in relief design and construction in opencast mining reclamation. Land Degradation and Development 14: 215-226.

Rosgen DL. 1994. A classification of natural rivers. Catena, 22:169-199.

Rosgen DL 1996. *Applied River Morphology*. Wildland Hydrology, Pagosa Springs, Colorado.

Sawatsky L, Beckstead G. 1996. Geomorphic approach for design of sustainable drainage systems for mineland reclamation. International Journal of Mining, Reclamation and Environment 10(3): 127-129.

Sawatsky, L.F., Beersing, A., Ade, F. 2008. Configuration of Mine Closure Landforms — Geomorphic Approach. A.B. Fourie, M. Tibbett, I.M. Weiersbye, P.J. Dye (eds), Mine Closure 2008, Australian Centre for Geomechanics, Perth.

Sawatsky, L. and Beersing, A. 2014. Configuring mine disturbed landforms for long-term sustainability. Proceedings of Mine Closure Solutions, 2014, April 26-30, 2014, Ouro Preto, Minas Gerais, Brazil.

SMCRA 1977. Surface Mining Control and Reclamation Act. Public law, 95–87, Statutes at Large, 91 Stat. 445. Federal Law. United States.

Stiller, D.M., Zimpfer, G.L., and Bishop, M. 1980. Application of geomorphic principles to surface mine reclamation in the semiarid West. Journal of Soil and Water Conservation, 274-277.

Toy TJ, Hadley RF. 1987. *Geomorphology and Reclamation of Disturbed Lands*. Academic Press, London.

Toy TJ, Black JP. 2000. Topographic reconstruction: the theory and practice. In Reclamation of Drastically Disturbed Lands, Barnishel R et al. (eds). American Society of Agronomy: Madison; 41–75.

Toy TJ, Chuse WR. 2005. Topographic reconstruction: a geomorphic approach. Ecological Engineering 24: 29-35.

Williams GP. 1986. River meanders and channel size. Journal of Hydrology, 88: 147-164.

Zapico I, Martín Duque JF, Bugosh N, Laronne JB, Ortega A, Molina A, Martín-Moreno C, Nicolau N, Sánchez L. 2018. Geomorphic Reclamation for reestablishment of landform stability at a watershed scale in mined sites: the Alto Tajo Natural Park, Spain. Ecological Engineering, 111: 100-116.

Zapico, I., Molina, A., Laronne, J., Sánchez, L., Martín Duque, J.F. 2020. Stabilization by geomorphic reclamation of a rotational landslide in an abandoned mine next to the Alto Tajo Natural Park. Engineering Geology, 264: 105321 https://doi.org/10.1016/j.enggeo.2019.105321.

Zapico, I., Laronne, J.B., Sánchez Castillo, L., Martín Duque, J.F. 2021. Drainage network evolution and reconstruction in an open pit kaolin mine at the edge of the Alto Tajo Natural Park. Catena, 204, 105392, pp. 1-12.

WEBSITES

Carlson software manuals - http://www.carlsonsw.com/support/manuals/.

Génie Géologique - http://www.2g.fr/.

GeoFluv - https://www.geofluv.com/

Landform Design Institute - https://landformdesign.com/

Landforma - https://www.landforma.com/

Mining Resource Consultancy - https://mresource.co.za/

Restauración Geomorfológica - http://www.restauraciongeomorfologica.es

RIVERMorph – http://www.rivermorph.com/

SIBERIA – http://www.telluricresearch.com/siberia-homepage.html

Vast - https://vast-la.com/

VIDEO RESOURCES

Geomorphic restoration at El Machorro mine - https://www.youtube.com/watch?v=Set5shHFYS8

Geomorphic restoration at the Nuria mine - https://www.youtube.com/watch?v=rYDQoGGd4l0

Geomorphic restoration at the Somolinos mine - https://www.youtube.com/watch?v=cLXiXzVvoXc

Geomorphic restoration at the Santa Engracia mine - https://youtu.be/kexLyhSTG40