Economics 382 – A01: Natural Resource Economics 1: Course Outline

Spring term 2012: MR 1:00 – 2:20 in Clearihue A212; Course number **21440**

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Recommended text: Barry C. Field, *Natural Resource Economics: An Introduction,* second edition, Waveland Press Inc., 2008. ISBN: 1-57766-531-7.

Chapters 1 through 9 of this book are relevant to Part One of Economics 382, Chapters 10 and 11 are relevant to Part Two, Chapters 12, 13, 15 and 18 are relevant to Part Three, and Chapters 14, 17 and 20 are relevant to Part Four. Time limitations are likely to preclude discussion of Chapters 16, 19 and 21.

Course description: This course introduces students to economic issues specific to the use and management of natural resources. It explores the economic principles for the efficient allocation of resources over time. Topics covered typically include the economic classification of natural resources; scarcity, growth and sustainability; ownership, access systems and rent dissipation; and principles of optimal depletion and use. Policies and mechanisms to foster greater economic efficiency in economic systems dependent on natural resources are examined.

Course outline:

Part One: Natural resource economics: a conceptual framework

Jan. 5: Natural resource economics: conservation and exploitation
Jan. 9: Environmental valuation: property rights, market failures and externalities
Jan. 12: Measuring social costs and benefits: net present values
Jan. 16: Resources as capital: the standard paradigm
Jan. 19: Cost-effectiveness, allocative efficiency, inter-generational equity and sustainability

Part Two: Non-renewable resources: models and management

Jan. 23: Non-renewable resources: minerals and mines
Jan. 26: Exploration and development activity
Jan. 30: Petroleum and natural gas resources
Feb. 2: Modelling the energy sector
Feb. 6: Instruments of public sector rent capture

Feb. 9: ***First midterm examination (25 marks)***

Feb. 13 to 17: *Midterm Break: no classes*

Feb. 20: The behaviour of primary commodity markets

Part Three: Renewable resources: models and management

Feb. 23: Forest resources: timber values and non-timber values
Feb. 27: The management of forest resources
Mar. 1: The softwood lumber dispute
Mar. 5: Open access resources: the fishery
Mar. 8: The management of renewable fish stocks
Mar. 12: Carrying capacity and the limits of acceptable change
Mar. 15: Water resource management

Mar. 19: ***Second midterm examination (25 marks)***
Mar. 22: *Class cancelled due to prior commitment*

Part Four: Resource use conflicts and sustainability objectives

Mar. 26: Resource use conflicts: land and resource management planning
Mar. 29: Recreational resources and amenity values
Apr. 2: Adventure tourism and recreation: the contribution of nature
Apr. 5: Eco-system service function values and sustainability

Apr. xx: ***Final examination (50 marks)***

Workshop Assignments, Examinations, and Grading Equivalencies:

Students are urged to work, either individually or in groups, on the assigned problems outlined below. These problems are designed to induce students to review the key ideas developed in class in relationship to four resource industries: fisheries, forestry, minerals and energy. The assignments do not need to be handed in to the instructor, and do not carry a grade weight. Course grades will be based upon three examinations, as follows:

Midterm exam one: 25% Midterm exam two: 25% Final examination: 50%

A+ = 90-100%	A = 85-89%	A- = 80-84%	B+ = 75-79%
B = 70-74%	B- = 65-69%	C+ = 60-64%	C = 55-59%
D = 50-54%	F = 0-49%		

Plagiarism and cheating: Students are expected to observe the same standards of scholarly integrity as their academic and professional counterparts. Students who are found to have engaged in unethical academic behaviour, including the practices described in the Calendar, are subject to penalty by the University.

Inclusivity and diversity: The University of Victoria is committed to providing an environment that affirms and promotes the dignity of human beings of diverse backgrounds and needs.

Travel plans: Students are advised to study the final examination timetable before making any end-of-term travel plans.

Economics 382: Assignment Problems: Review of Key Ideas

Problem One: Modelling the Mine: A Review

The fundamental proposition in the theory of the mine is that the mineral resource should be allocated to production/extraction over time so as to equalise marginal profit (or the marginal resource rental value), in present value terms, across all time periods in which the mine operates. This proposition involves a fundamental dynamic efficiency condition.

Demonstrate that the following propositions are true:
(a) in the simple Hotelling Rule case, the present value of marginal mineral rents remains constant over time, so that undiscounted mineral rents rise at the rate of interest; thus,

$$p(T) - MC(x) = [p(0) - MC(x)] \exp(rT),$$

where p(0) and p(T) represent the mineral resource price at time 0 and time T, respectively, MC(x) is marginal extraction cost, and r is the rate of interest;

(b) for a competitive minerals industry operating under constant extraction costs, and without new resource discoveries through exploration activity, mineral resource prices will rise at less than the rate of interest, and (given the industry demand function) extraction volumes will decline gradually over time until stock exhaustion occurs; moreover, efficient resource allocation implies stock exhaustion at the same time (T) as the resource price coincides with the 'backstop price', p(B), of a substitute resource; thus, p(T) = p(B), allowing one to solve the price equation backward for p(0), given p(B) and r.

Now consider the more general case of a mining firm which operates in a competitive industry. The firm has two choice variables, first to decide how much extractive effort is optimal and, secondly, to decide how much exploration and development effort is optimal. Its extraction process follows a standard production function which depends upon both extraction effort and its existing reserves of ore in the ground; positive but diminishing returns apply to both productive inputs. Its exploration and development process determines and delineates new reserve additions as a positive function of exploration and development effort but, since the firm moves on to less productive geological horizons as time passes, this production technology also involves diminishing returns to effort.

Demonstrate that the following propositions are true:
(c) where there are stock effects in the extraction process leading to rising marginal extraction costs, marginal resource rental values will increase at less than the rate of interest, and could fall through time; in this case, mine abandonment may occur when it is no longer profitable to operate the mine, and before exhaustion of the resource stock occurs;

(d) when exploration for new resources takes place, the search will be for mineral deposits for which, at the extensive margin (in which prospects should one invest?), the net present value of the resource rental stream exceeds the finding costs, while at the intensive margin (how much should one invest in each of the chosen prospects?) the level of exploration activity will be determined by the equation of marginal finding costs to marginal resource rental values. (See also below.)

Problem Two: Modelling Petroleum and Natural Gas Activity: A Review

In the case of petroleum and natural gas, the volume of production from a given resource pool ordinarily declines over time due to pressure effects. If this decline process is exponential, then one may write

$$A = V [1 – \exp(-bT)] / b,$$

where A is the (initial, or newly discovered) recoverable reserve volume, V is the initial production rate, b is the exponential decay rate that results from declining pressure, and T is the operational life of the pool. Both A and V refer to raw gas volumes.

Now let q represent the *in situ* unit value of the resource, or the reserve price, so that qA is the overall value of the resource pool. But qA must also be equal to the net present value of the extraction stream to the representative firm after deducting operating costs, production royalties and applicable taxes, and allowing for the shrinkage factor (or the ratio of sales gas volume to raw gas volume).

Demonstrate that the following propositions are true:

(a) the net present value of the extraction stream to the representative firm may be written as nVsg, where n is the netback value of the extracted resource after unit operating costs, royalties and taxes have been deducted from unit production revenues, V is the initial production rate, s is the ratio of sales gas volume to raw gas volume (or the shrinkage factor), and g is the 'double discount factor' which combines the decline rate with the discount rate;

(b) $g = [1 – \exp\{-(r+b)T\}] / (r + b)$;

(c) $qA = nVsg$;

(d) $q = ns [1 – \exp\{-(r+b)T\}] b / (r + b) [1 – \exp(-bT)]$, using the V to A relationship; and

(e) if the netback value, n, happens to rise at the rate of interest (as under the Hotelling Rule), rather than remaining constant (as assumed above), then all of the discount terms cancel out making $q = ns$, where n is the initial term in the netback time series, and s is the shrinkage factor; however, when the netback value is constant, the reserve price (q) will be smaller than the netback value adjusted for the shrinkage factor (or ns) due to time discounting; and

(f) the expected net present value (ENPV) of the resource prospect to the representative firm may be written as $ENPV = - K + qA$, where K represents the overall costs of finding the resource pool. These costs may include geological and geophysical (seismic) costs, exploratory drilling costs, well completion costs, and land acquisition costs, as represented by the bonus bids which provide the exclusive right to explore specific geological horizons that lie beneath the land in question. At the extensive margin, the representative firm will search for resource pools for which $ENPV = - K + qA > 0$, while at the intensive margin the maximisation of ENPV requires dK/dA to be set equal to q, where dK/dA measures marginal finding costs, and q is the reserve price. Notice that the calculation of ENPV involves the deduction of 'full cycle' costs, whereas the calculation of q only involves the

deduction of 'half cycle' or operating costs. It follows that q may be referred to as the developed reserve price, while ENPV/A may be referred to as the undeveloped reserve price. The undeveloped reserve price is a key measure of the profitability of new exploration and development activity.

Finally, consider how resource taxation and rent capture schemes might fit into these relationships. In particular, consider how royalties that are paid at the time of extraction, and bonus bids that are paid upfront at the time of land assembly, can be brought into the analysis. In this context, if p represents the natural gas price received by the producer, h represents the value of natural gas liquid bi-products per unit of natural gas sold, c represents the total operating costs per unit of natural gas sold, and R is the royalty rate that is payable, then the netback value, n, may be written as: $n = (p + h)(1 - R) - c$. All elements within this formula are expressed per unit of sales gas volume.

Problem Three: Modelling the Forest: A Review

Consider an even-aged growing forest in which the value of the stock of trees is equal to qS(t), where S(t) represents timber volume, and $q = p - c$ is the net unit value of the timber harvest, or the difference between delivered wood price (p) and harvesting cost (c). The site value of the land on which the trees are growing is equal to V, and the initial cost of forest regeneration is equal to K. Clear-cutting occurs at rotation age, T, and yields harvest volume S(T).

The site (or bare land) value, V, may be represented by the net present value of an infinite sequence of harvest rotations, each of length T. This bare land value, or land expectation value, is given by

$$V + K = [qS(T) + V] \exp(-rT), \text{ or } V = [qS(T) \exp(-rT) - K] / [1 - \exp(-rT)],$$

where r is the rate of interest. The initial investment in land and regeneration is equal to the net present value of the timber harvest plus the release of bare land for regeneration that together occur at rotation age, T.

Demonstrate that the following propositions are true:

(a) the rotation age that maximises the land value (and, thus, economic rent) occurs when $dV(T)/dT = 0$, or when

$$q\, dS(T)/dT = r\,[qS(T) + V], \text{ or } q\, dS(T)/dT = r\,[\, qS(T) - K\,] / [1 - \exp(-rT)],$$

and provide a verbal interpretation of this Faustmann formula;

(b) an increase in the rate of interest, r, will ordinarily shorten the optimal rotation period, and explain;

(c) an increase in regeneration costs, K, will ordinarily increase the optimal rotation period, and explain;

(d) a reduction in net harvest value, $q = p - c$, will ordinarily increase the optimal rotation period, and explain;

(e) the optimal (or Faustmann) rotation period is shorter than the rotation period which would be obtained by following a maximum sustained yield harvesting rule, that is by setting $dS(T)/dT = S(T)/T$; and

(f) when the growing forest also provides non-timber values, N(T), that depend positively on stand age, T, the optimal rotation period will ordinarily be longer than the Faustmann rotation period.

Problem Four: Modelling the Fishery: A Review

Assume that the harvesting function in a simple fishery takes the form: $X = AES$, where X is the catch size, A is the 'catch-ability coefficient', E is harvesting effort, and S is the size of the fish stock in biomass units. Assume also that the biomass growth function takes the logistic form: $G(S) = BS(S^* - S)$, where B measures 'stock productivity', and S^* represents the carrying capacity of the aquatic environment. The ratio of the cost of harvesting effort to the landed price of fish is w/p, and the rate of interest is r.

Demonstrate that the following propositions are true:

(a) the maximum sustained yield (MSY) of the fishery is associated with stock size, $S = S^*/2$, and harvesting effort, $E = BS^*/2A$;

(b) when harvesting is costly ($w/p > 0$), and the rate of interest is zero ($r = 0$), it pays to 'thicken' the stock so that, in an optimum steady-state fishery, S will exceed $S^*/2$ by the factor $w/2pA$; correspondingly, AE/B will fall short of $S^*/2$ by $w/2pA$;

(c) when harvesting is inexpensive ($w/p = 0$), and the rate of interest is positive ($r > 0$), society's implied impatience will generate an optimum steady-state stock size which is smaller than $S^*/2$ by a factor of $r/2B$; correspondingly, AE/B will exceed $S^*/2$ by $r/2B$;

(d) both of these steady-state equilibria are associated with a positive net rental value of the fishery, with the shadow price of 'fish in the sea' being equal to $q = p - w/AS$ in case (b) and $q = p$ in case (c);

(e) in steady-state equilibrium, an open access (non-optimal) fishery is associated with harvesting effort that is twice the effort in (b) above, with a stock size, $S = w/pA$, which is smaller than in (b) above, and with complete dissipation of resource rents ($q = 0$); and

(f) the dynamic time-path traced out by an open access fishery may lead to the extirpation of the fish species.

Thus, in the open access fishery, resource rents are dissipated because too much harvesting effort is applied, driving the size of the fish stock to a level that is smaller than optimal. In addition, the survival of the fish stock may be placed in jeopardy.

In two or three paragraphs, summarise the likely consequences for the rental value of the fishery from the use of harvest regulations (a fishery that is open until an overall quota is caught, and then closed), effort regulations (boat size and gear restrictions), landings taxes, and individual transferable quotas (ITQs), as possible tools for managing the open access problem.

DEPARTMENT OF ECONOMICS

UNDERGRADUATE COURSE POLICIES

Academic Integrity:
Academic integrity requires commitment to the values of honesty, trust, fairness, respect, and responsibility. Students are expected to observe the same standards of scholarly integrity as their academic and professional counterparts. A student who is found to have engaged in unethical academic behaviour, including the practices described in the Policy on Academic Integrity (http://web.uvic.ca/calendar/FACS/UnIn/UARe/PoAcI.html) in the University Calendar, is subject to penalty by the University.

Attendance:
Students are expected to attend all classes in which they are enrolled (Attendance Policy - http://web.uvic.ca/calendar/FACS/UnIn/UARe/index.html). Students who do not attend classes must not assume that they have been dropped from a course by a department or an instructor. Courses that are not formally dropped will be given a failing grade, students may be required to withdraw, and will be required to pay the tuition fee for the course.

An instructor may refuse a student admission to a lecture or laboratory because of lateness, misconduct, inattention or failure to meet the responsibilities of the course. Students who neglect their academic work, including assignments, may be refused permission to write the final examination in a course. Instructors must inform students at the beginning of term, in writing, of the minimum attendance required at lectures and in laboratories in order to qualify to write examinations.

Students who are absent because of illness, an accident or family affliction should report to their instructors upon their return to classes.

Term Assignments and Debarment from Examinations:
In some courses students may be assigned a final grade of N or debarred from writing final examinations if the required term work has not been completed to the satisfaction of the department. Instructors in such courses must advise students of the standard required in term assignments and the circumstances under which they will be assigned a final grade of N or debarred from examinations.

Grading:

Passing Grades	Description
A+ **A** **A-**	**Exceptional**, **outstanding** and **excellent** performance. These grades indicate a student who is self-initiating, exceeds expectation and has an insightful grasp of the subject matter.
B+ **B** **B-**	**Very good**, **good** and **solid** performance. These grades indicate a good grasp of the subject matter or excellent grasp in one area balanced with satisfactory grasp in the other area.
C+ **C**	**Satisfactory**, or **minimally satisfactory**. These grades indicate a satisfactory performance and knowledge of the subject matter.
D	**Marginal** Performance. A student receiving this grade demonstrated a superficial grasp of the subject matter.
Failing Grades	**Description**
F	**Unsatisfactory** performance. Wrote final examination and completed course requirements.
N	**Did not** write examination or complete course requirements by the end of the term.

Course letter grade - numerical score (%) equivalencies used in the Department are as follows:

A+	A	A-	B+	B	B-	C+	C	D	F
90-100	85-89	80-84	75-79	70-74	65-69	60-64	55-59	50-54	0-49

Late assignments:

Late assignments will not be accepted unless prior arrangement has been made with the course instructor.

Academic Concession for work that will be completed before course grades are submitted by the instructor.
A student whose academic performance is affected by injury, family or personal affliction, or illness should immediately consult with University Counselling Services, University Health Services, or another health professional, and may request, directly from the course instructor, deferral or substitution of a mid-term test or examination, or of other work which is due during the term. This request must be accompanied by supporting documentation from the health professional and must specifically cover the date of the missed examination or assignment deadline. It should normally be dated on or before the exam/deadline date and be submitted to the instructor within 10 days of this date.

All work for which a Concession is approved must be completed before course grades are submitted by the instructor.

If the request for deferral or substitution of term work is denied, a student may appeal as described under **Appeals** (http://web.uvic.ca/calendar/FACS/UnIn/UARe/Appe.html).

If make-up tests are assigned, they will be scheduled by the Department on Friday afternoons at 2:30 p.m. Students must be registered for these tests by their instructors in order to be permitted to take them.

Academic Concession for work that will be completed after course grades are submitted by the instructor.
In the event of a missed final examination, or submission of an assignment after grades are submitted by the instructor, students must submit a Request for Academic Concession (RAC) to Undergraduate Records with the required official documentation from a health professional within 10 working days of the end of the examination period. The RAC form is available on the Undergraduate Records website (http://registrar.uvic.ca/undergrad/records/forms/forms.html).

Travel Plans
Students are advised not to make work or travel plans until after the examination timetable has been finalized. Students who wish to finalize their travel plans at an earlier date should book flights that depart after the end of the examination period. There will be no special accommodation if travel plans conflict with the examination.

Students with a Disability
The University aims to provide equal opportunities and access for all students to enjoy the benefits and privileges of its classes and curriculum and to meet the syllabus requirements. Reasonable and appropriate accommodation will be made available to students with documented disabilities (physical, mental, learning) in order to give them the opportunity to successfully meet the essential requirements of a course. The accommodation will not alter academic standards or learning outcomes, although the student may be allowed to demonstrate knowledge and skills in a different way.

Students with disabilities seeking academic accommodation are expected to contact the Resource Centre for Students with a Disability (http://rcsd.uvic.ca/) as early as possible to avoid a delay in service, to initiate the process of determining and arranging appropriate academic accommodation in individual situations.

In order to receive course-based and exam-based accommodations, instructors must be notified of student needs. For example, if a student requires additional time on exams, assistance with note-taking or a substitute assignment, the instructor needs to be informed.

At the start of each academic term, students fill in a Memo to Professors Form and hand it in to the RCSD. Only instructors listed on the request form will receive a copy of this memo. The memo confirms that the student is registered with the RCSD and lists the accommodations to which the student is entitled and has requested. It is the student's responsibility to introduce themselves to their instructors to discuss the contents of the memo and make any necessary arrangements to receive accommodations.

The memo's collection, protection, retention and disclosure is governed by provisions of the B.C. Freedom of Information and Protection of Privacy Act.

Policy on Inclusivity and Diversity
The University of Victoria is committed to promoting, providing and protecting a positive, supportive and safe learning and working environment for all its members.

Last revised: August 2011