Colgate University
ECON 383: Natural Resource Economics[†]
Fall 2021 (8/26 - 12/17)

Professor:	Pierce Donovan	pdonovan@colgate.edu
Lectures:	Lawrence 20	TR 8:30 - 9:45 am (A)
		TR 9:55 - 11:10 am (B)
Office Hours:	Spear 9	WF 10:30 am - 12:00 pm

Course Description and Objectives

When is the last time you went a day without hearing about climate change, pollution, overfishing, deforestation, or biodiversity loss? Today's most salient policy issues concern how we use natural resources, and it's clearly important to learn how to tackle these problems. But perhaps you're wondering, how does economics fit into all of this?

At its core, economics is a discipline focused on allocating scarce resources. And this extends to natural resources, naturally! In fact, we can't really understand how to properly manage the environment *without* economics. Why is this? Well, only by understanding the economic principles behind resource use—i.e. the incentives that motivate stakeholder behavior, like the decisions to plant water-intensive crops in arid lands, flare natural gas at the oil wellhead, or race to fish until our oceans are empty—can we prescribe the right policy intervention.

My plan for this course is to teach you some of the techniques in natural resource economics that are used to inform environmental policy. The level of analysis we'll take on will be more rigorous than a qualitative explanation. You'll study and solve mathematical models in order to understand how to facilitate the efficient use of natural resources. We'll encounter real-world examples in fisheries and forestry, oil and mineral extraction, pollution control, and elsewhere.

Each lesson is structured in the following way: (1) I'll introduce an environmental problem and we'll boil it down to its key components. (2) We'll go through the process of modeling the behavior that leads to that phenomena. (3) Using our model, we'll investigate what can be done to correct any behavior we aren't thrilled about. You'll walk away with a consistent strategy toward taking on new problems that you encounter well after this course.

At the end of this course, you should be able to explain how to address environmental policy issues in a detailed manner. You'll acquire the means of doing so—skills in mathematical modeling and computational methods—and thus be able to back up your explanations with the deeper intuition that natural resource economics is meant to provide.[††]

[†] As the semester goes on, I may change the contents of this syllabus regarding the schedule, grading, or other details.

[††] This course complements ECON 228: *Environmental Economics*, which is about using the principles of economics to create better environmental policy. The analysis in 228 is qualitative and emphasizes developing strong *written* arguments—in contrast to our modeling-based approach here. This course also provides a methodological complement to the econometric work you might pursue in ECON 483: *Seminar in Resource and Environmental Economics*.

Expectations

There are three prerequisites, ECON 251 and 252 (Intermediate Micro/Macro), and a solid background in calculus. Why? This is a class about developing and solving models in natural resource economics; 251/252 provide a good introduction to economic models, and calculus happens to be the ideal language for the modeling/optimization process. I might introduce some mathematical concepts that you haven't seen before (on dynamic optimization, differential equations, linear algebra, etc.), but I'll make sure they are sufficiently covered before applying them to our class.

This course will have a computational component that will complement your pen-and-paper abilities. This is a direct response to comments from students that feel as if they do not yet know how to *do* economics and that their classes are perhaps too theoretical. For those of you who have not done any programming before, fear not. I will be providing you with the tools you need to succeed.

Importantly, you're responsible for wanting to learn how to become a successful economic modeler! It's a great objective to have, and there are some meta-skills that are worth developing in this class to help you with that:

1. Before coming to me, reflect on what you have tried and write down what didn't work and *why you think it didn't work*. You'll either spot the issue yourself, or come to me with exactly what I need to know in order to help.
2. Consider that you may be confronted with problems in life that cannot be solved so quickly (note: the alternative—a life of solving trivial problems—would hardly be as rewarding), and that not being able to resolve your problem immediately isn't the end of the world. That attitude will keep you from giving up at the first sign of struggle.
3. When programming, there are two things I would focus on: (1) leave lots of comments in your code (so you can understand what you wrote later) and (2) learn to be self-sufficient when debugging coding problems, because your bugs have been squashed many times before (and answered online in great detail).

Course Tools and Materials

I'll be using Moodle to upload any resources (notes, readings, assignments, grades, etc.) we will be using throughout the course, and you'll submit assignments on Gradescope.

We'll use a portion of lecture time and the homework as opportunities to learn Matlab, a programming language built for numeric computing. It's a great resource for us, because models—no matter how simple they look—can become difficult to solve with pen-and-paper rather quickly.

There are two main reasons for using Matlab instead of a competing language: (1) it's very widely used in economics and engineering, and (2) the syntax is incredibly simple compared to other programming languages, which means we can spend less time coding and debugging and more time on the natural resource economics.

Readings

I will occasionally provide links to articles on Moodle, to be read at your leisure. These are simply for framing—they'll provide context for why we might be interested in solving a particular problem. Perhaps this is an exercise you will enjoy: when reading the articles, try to guess how important features could translate to a mathematical model, or change optimal policy.

Our course does not have a book and I will be developing materials from scratch. My plan is to write up short summaries that will complement each lesson in order to help you with your digestion of my lecture material. I recommend taking your own detailed notes in class and then reviewing them alongside my summaries. I will also add online resources to Moodle that I find helpful.

If you really like this class and want to learn more, here are some (higher-level) books that I like:

Conrad and Clark (1987). *Natural Resource Economics: Notes and Problems*.
Clark (1990). *Mathematical Bioeconomics: The Optimal Management of Renewable Resources*.
Hanley, Shogren, and White (2007). *Environmental Economics in Theory and Practice*.
Conrad and Rondeau (2020). *Natural Resource Economics: Analysis, Theory, and Applications*.

Homework

Roughly every other week, there will be a homework problem due at the beginning of class (specifically 8:30am on Tuesday morning for *both* sections, to be submitted as a PDF via Gradescope). Each assignment should take around five to ten hours, assuming that you regularly review your notes outside of class and keep up with office hours. I recommend working on these assignments in groups of two or three—although this isn't necessary or required—and you may submit in up to groups of three (you may work with people in either section and change your groups over time).

I will upload each assignment around two weeks in advance so you can plan your work schedule. Submissions will be graded for effort/completion, and I will provide solutions once everyone has submitted. My late policy is that homework will be accepted for three days, with a 20% penalty per day (i.e. 1% of your final grade/day).

Grading

I won't "give" grades or "take off" points, you'll *earn* them for doing the required work. I also won't measure your performance relative to your peers (i.e. curve your grades) during the term in order for you to have the clearest signal about your performance. I validate a proven understanding of the course material via the following:

30%	Homework Assignments (5% each, x6)
42%	Midterm Quizzes (14% each, x3)
14%	Final Exam Part I (take-home, before finals week)
14%	Final Exam Part II (in-person)

Conduct

These are just a few more things to keep in mind that I put in all my syllabi:

- Missing lecture isn't the end of the world. And you don't need to provide an excuse or apology, but please be in touch if you will be out for multiple days.
- When asking for help outside of class, please be able to show how you have approached your problem. Simply asking for an answer is not a productive use of our time. I hope to facilitate critical thinking, and that takes effort on everyone's part.
- While I'll be accessible by email, I strongly prefer communicating during class/office hours. Regarding boundaries, I do not typically answer emails late at night or on the weekend.
- I will not tolerate academic dishonesty. Colgate University's Academic Honor Code (`here`) requires instructors to report any suspected cheating, plagiarism, or other misconduct.
- You are responsible for your technology problems. Be sure to submit assignments well ahead of the due date if you want to be sure that your submission is received/the proper format/etc.
- You do not have permission to publish my course materials (online or otherwise). I don't want to see my work hosted somewhere like `CourseHero` (see the Academic Honor Code above).
- Please be respectful to your classmates. Refrain from talking during class if it is not relevant to lecture or discussion. Cell phone or tablet use should not detract from your ability to follow along with class. No activity on your part should undermine the efforts of other students.
- I can't recommend Colgate's Writing and Speaking Center (`link`) enough if you want to work on clear and coherent communication. Focused writing takes practice, and college is a great time to put in the hours.
- I understand that you have many other things to handle during the semester, but you have to communicate with me if one of those things (or our thing) is presenting a problem. Please reach out if you think I should be aware of your situation (or a censored version of it).
- In cases where I'm not the appropriate confidant, please seek support from Colgate's Counseling and Psychological Services (`link`). Reaching out to them is never a bad idea.
- If you have a learning disability or a physical disability that requires accommodation, please let me know as soon as possible.
- In order to create an inclusive and intellectually vibrant community, we must understand individual differences and common ground. Colgate University's report on Academic Freedom and Freedom of Expression (`link`) reflects the ideals I seek to uphold in this class.

Course Outline

Principles of natural resource economics

Refresher on static optimization, and the "best" uses for freshwater

Key concepts: [constrained] utility maximization, Lagrange multipliers, comparative statics; subsidies, agriculture, groundwater, the social planner and profit-maximizer

An introduction to numerical methods, and cost-effective pollution control

Key concepts: variables, functions, matricies, root-finding, Newton's method; externalities, cap-and-trade, clean energy, market power, equity

Assessments
Homework 1: Balancing water use upstream and downstream
Homework 2: Combatting local air pollutants
Quiz: Saving some water for the future

Important dates
9/7 - Homework 1 due
9/14 - Homework 2 due
9/16 - Quiz 1 (6 lectures, 24% of course credit completed)
9/21 - No class (no OH on 17th or 22nd)

Introduction to dynamic optimization

Optimal silviculture

Key concepts: discounting, net present value, infinite series, the Faustmann rotation, non-timber values, wildfire risk, ecosystem services, orchards

Mining for non-renewables

Key concepts: economic scarcity, oil extraction and exploration, cartels, natural gas flaring, cryptocurrency mining and proofs of work, discrete-time dynamic optimization, the shooting method

Assessments
Homework 3: Choosing which tree species to plant
Homework 4: Stock-dependent mining costs
Quiz: Optimal oil extraction and the social cost of carbon

Important dates
9/30 - No class (no OH on October 1st, replacement OH on 4th)
10/5 - Homework 3 due
10/12 - No class
10/19 - Homework 4 due
10/21 - Quiz 2 (12 lectures, 48% of course credit completed)

A little optimal control theory

Biological dynamics and differential equations
Key concepts: logistic growth, predator-prey models, phase diagrams, stability of equilibria

Steady-state fishery models
Key concepts: overfishing, open-access vs private property, individual transferable quotas

Fully-dynamic models of the fishery
Key concepts: planning for the future, sustainability, seasonal pricing

Assessments
Homework 5: Anticipating future regulations
Homework 6: Managing species that migrate
Quiz: The collapse of a fishery

Important dates
11/2 - Homework 5 due
11/16 - Homework 6 due
11/18 - Quiz 3 (19 lectures, 72% of course credit completed
Week of 11/22 - Thanksgiving Break (no work due)

A miscellany of other models

Limiting the spread of an invasive species
Key concepts: port inspection, whack-a-mole, cellular automata, spatial modeling

Econometrics for structural modelers
Key concepts: fitting models to data, method of moments, least-squares

Assessments
Final Part I: Climate change impacts on natural resource use
Final Part II: To be determined

Important dates
11/30 - Hand out take-home portion of final exam
12/9 - Last day of class, take-home exam due (23 lectures, 86% of course credit completed)
Final exam: 12/13, 9-11am (Section A), 12/14, 9-11am (Section B)