Econ674

Economics of Natural Resources and the Environment

Session 1

The Range and Scope of Natural Resource and Environmental Economics

The Scope of Natural Resource Economics

- 1. Natural resource economics is the study of environments from which resources used in economic activity are extracted. Examples include agricultural production, exhaustible resource mineral extraction, renewable resource extraction such as forestry and fishing.
- 2. Natural resource economics also includes the amenity value of wildlife, as in parkland and recreational forests.
- 3. All natural resource decisions are governed by the legal environment in which such resources are produced and consumed.
- 4. In turn, the legal environment, and the technology by which natural resources are consumed, also shapes the pricing of natural resource use.
- 5. Beyond the legal environment and the state of technology that affect the level of prices, natural resource decisions also are governed by the underlying laws of thermodynamics.

The Scope of Natural Resource Economics - 1

- 1. The first law states the constancy of matter and energy in the universe, a principle first enunciated by Lord Thompson in the late 18th century.
- 2. The second law defines the efficiency of any energy conversion process: $E = 1 - T_1/T_2$, where T_1 is the ambient temperature and T_2 is the combustion temperature of any engine.
- 3. Together these two laws also define the concept of entropy, which is a measure of disorder in any given environment. Typically, for any given economic process, one looks for low entropy choices as they appear to have the lowest transactions costs, after which one moves to higher entropy forms of energy consumption.
- 4. Fossil and nuclear fuels tend to have relatively low levels of entropy, while renewable resources such as wind and solar, tend to have higher levels. Unless offset by technological innovations, higher entropy levels generally have deterred more widespread commercial applications.

The Scope of Natural Resource Economics - 2

- 1. Market prices may reflect an imperfect guide to the economic value of natural resources, in which case, corrective, or shadow, prices, may be needed to achieve a given level of efficiency.
- 2. Determining the economic value of natural resources requires not only an understanding of the laws of thermodynamics, but also how market forces achieve a given level of efficiency.
- 3. Economic efficiency has a fairly precise set of norms in economic theory, but for any given degree of economic efficiency, it may not correspond to some level of environmental efficiency.
- 4. Environmental efficiency refers to the ability of natural environments to make the most productive use of natural processes. From this we have the notion of the carrying capacity of an environment, and the notion of environmental sustainability.
- 5. The challenge for economics is to find pricing solutions to natural resources that are consistent with environmental sustainability.
- 6. Such pricing solutions typically arise in the context of economic models. However, traditional economic models often overlook how the consequences of economic activity bear directly on the environment.

The Scope of Natural Resource Economics - 3

- 1. Natural resource models inevitably raise normative questions regarding the present and the future, in particular the choice of an appropriate rate of discount for a given level of investment in which the natural environment is affected.
- 2. Beyond environmental and economic models is the larger question of global climate change - the extent to which is is taking place, the extent to which it is affected by human intervention, and whether global climate change is irreversible or part of some larger geophysical cycle.
- 3. Recent studies such as the IPCC's Stern Report, place emphasis on the role of irreversibility on climate change, and on the normative value of undertaking action now to avoid irreversible losses in the future.
- 4. The foundation of IPCC studies builds on climate change observations on which forecasting models have been derived. What many such forecasting models have ignored is the role of pricing, in particular the pricing of energy and natural resources in shaping any particular scenario.
- 5. At a macroeconomic level, policy choices involving the environment require the continued accumulation of natural scientific evidence and its integration with economic forecasting models that can provide a consistent basis from which coherent public policies can be derived.
- 6. Economists have relied on a variety of welfare policy criteria to evaluate any particular approach to natural resources and the environment. These criteria include: the Pareto criterion, the Kaldor criterion, the Samuelson criterion, and the Rawlsian criterion, among others.

The Scope of Natural Resource Economics - 4

- 1. Nothing better illustrates the welfare question than the choice of evaluation criteria in capital budgeting decisions.
- 2. Investments typically are evaluated on the basis of three inter-related criteria: the Net Present Value (NPV), the Internal Rate of Return (IRR), and the Benefit-Cost ratio (BCR).
- 3. The NPV criterion derives from the application of an exogenous selected discount rate, presumably at the opportunity cost of capital, to derive the economic value of an investment.
- 4. However, there is no clear correlation between the level of investment required and the NPV such that a clear ranking of superior investments is not obvious.
- 5. Correspondingly, the IRR is that rate of discount that reduces the NPV of an investment to zero and is determined endogenously from a given schedule of costs and benefits from a project. It does permit a rank ordering of investments, from which an economy's aggregate marginal efficiency of investment (MEI) function can be derived.

The Scope of Natural Resource Economics - 5

- 1. The difficulty with the IRR criterion is that where there is more than one change in the algebraic sign of an investment's cash flow, multiple solutions can be derived. This is known as polynomial ambiguity.
- 2. Selecting which IRR as acceptable depends whether the opportunity cost lies above or below all possible solutions, or lies in between. Ambiguity arises when the opportunity cost lies in between multiple IRR values.
- 3. The Benefit-Cost ratio (B/C ratio) is simply the present discounted value of benefits divided by the present discounted value of costs. As long as the NPV is positive, the B/C ratio will be superior to one, but which in general will be inferior to the IRR. Adoption of the IRR for a project reduces the B/C ratio to unity, the limit value of acceptability of a project.
- 4. Given the laws of thermodynamics, any capital budgeting decision and ranking will be upwardly biased in terms of acceptability. The challenge for natural resource economics is to incorporate external effects into the valuation of capital budgeting investments, from which policy judgments may be formed, using established welfare criteria by public policymakers.

The Scope of Natural Resource Economics - 6

- 1. All natural resource decisions are affected by underlying perceptions and valuations regarding the level of risk. Risk can take many forms - economic, political, financial, and environmental. Deterministic decisions that ignore the level of risk will produce biased outcomes that may not be either economically or environmentally sustainable.
- 2. Risk is considered to be measurable, based on past observed forms of behavior. However, in some cases, one does not have objective metrics of the level of risk, in which case, uncertainty, or subjective estimates of risk, will be used. The question is whether subjective measures are consistent in and through time, as new information becomes available. The relevance of uncertainty to natural resource decisions is particularly significant in the case of irreversibility of decisions, as in whether global warming can be contained, and which in turn invokes normative value judgments about the future.

Natural Resource and Environmental Economics: The Classical Perspective

Classical economics

- Natural resource and environmental issues were major concerns in the writings of the classical economists in the 18th and 19th centuries
- Increase in agricultural productivity during the period
- A central issue in classical economists was the question of what determined
  1. Standards of living and
  2. Economic growth
- Natural resources were seen as important determinants of national wealth and its growth
- One issue addressed is standard of living in the long run given fixed/limited supply of land which was considered a necessary input to production and exhibited diminishing returns
- This led to the conclusion by early classical economists that
  - economic progress is a transient feature of history, and
  - an eventual stationary state is inevitable with bleak prospects for the majority of the people
- **Adam Smith (1723-1790):** is the first to systematize the argument for the importance of markets in allocating resources (invisible hand)
- This gave the basis for modern economics including resource and environmental economics

Natural Resource and Environmental Economics The Classical Perspective - 2

- **Thomas Malthus (1766-1834):** put these arguments most forcefully by noting that given
  - Fixed land quantity,
  - A tendency for positive population growth and
  - diminishing returns in agriculture

  these implied a tendency for output per capita to fall
- Those who now question the feasibility of continuing long-run economic growth are referred to as 'neo-Malthusians' Examples include (the Club of Rome 1972 *Limits to Growth* Report; Paul Ehrlich - *The Population Bomb*)

- **David Ricardo (1772-1823)**: formalized and extended the notion of a (Malthusian) steady state by noting that:
  - land parcels are of varying quality (replacing Malthus's assumption of a fixed stock of land) and
  - Expansion of agricultural output is possible by increasing the intensive margin or increasing the extensive margin

  However, in either case, returns to the land input were taken to be diminishing.

  The principal reason for the notion of diminishing returns to land input was the absence of any consideration of technical change.

Natural Resource and Environmental Economics The Classical Perspective - 3

- **John Stuart Mill (1806-1873)**: gives a full statement of classical economics at its culmination by noting that
  - the idea of diminishing returns is useful but there is a need to recognize the countervailing influence of the growth of knowledge and technical progress (apparently output per person was rising in Britain at the time)
  - Stationary state attained at a higher level of material prosperity
  - Mill had a broader view of role of natural resources than his predecessors to include amenity values in addition to agricultural and extractive uses of land

Natural Resource and Environmental Economics: The Neoclassical Perspective

- The concept of value as an important basis for differences:
  - For classical economists value was labor power embodied in output (Karl Marx).
  - Neoclassical economists explained value as being determined in exchange reflecting both preferences and costs of production; and price and value ceased to be distinct.
- This change in emphasis paved the way for the development of contemporary welfare economics
- Marginal analysis formalized earlier notions of diminishing returns via diminishing marginal productivity
- **William Stanley Jevons (1835-1882) and Karl Menger (1840-1921)**: They formalized theory of consumer preferences using utility & demand theory
- Their emphasis was on structure of economic activity and efficiency, rather than aggregate level of economic activity
- They displayed less concern over continuing economic growth, apparently due to the expected inevitability of growth in western Europe at the time

Natural Resource and Environmental Economics: The Neoclassical Perspective -2

- **Leon Walras (1834-1910)**: He developed general equilibrium theory, providing a rigorous foundation for the concepts of efficiency and optimality
- **Alfred Marshall (1842-1924)**: He developed the partial equilibrium framework of supply and demand based, and an explicit analysis of price determination.

Keynesian economics

- The depression in the 1930s provided a background for the development of the theory of income and output determination by John Maynard Keynes (1883-1946)
- This switched attention to aggregate supply and aggregate demand, and reasons for market failures to achieve optimal aggregate levels of economic activity (largely ignored in initial developments in neoclassical economics)
- This indirectly stimulated a resurgence of interest in growth theory in the middle of the twentieth century
- But early neoclassical growth models almost ignored land, or any natural resources, from the production function. These models ignored the earlier classical pre-occupation with limits to growth arguments based on fixed land inputs.

Natural Resource and Environmental Economics: The Welfare Perspective

Welfare economics

- Welfare Economics (WE) provides a framework for making normative judgments about alternative economic activities
- Rankings of alternative allocations are only possible if one is prepared to accept some ethical criteria
- The most common ethical criterion adopted by economists is utilitarian moral philosophy developed by David Hume, Jeremy Bentham and John Stuart Mill
- For utilitarians, social welfare is some weighted average of the total utility levels enjoyed by all individuals in a society

- Economists tried to use methods to rank different states of the world that
  - require little/no use of a social welfare function
  - makes little use of ethical principles
  - but are useful in making prescriptions about resource allocation
- Economic efficiency (or Pareto optimality) is what economists have come up with as a result of this quest
- Given certain conditions, an economy organized as a competitive market will attain economic efficiency
- Where the conditions do not hold:
  - markets do not attain efficiency in allocation, and
  - a state of 'market failure' is said to exist.
- Much of the contemporary literature on market failure stems from work by Arthur Cecil Pigou (1920), Nicholas Kaldor (1939), and Francis Bator (1958).

Natural Resource and Environmental Economics: The Welfare Perspective - 2

- Pollution entered economics as an example of the general class of externalities.
- Early work in the analysis of externalities and market failure
- The first systematic analysis of pollution as an externality is found in Pigou (1920).
- Cost-Benefit Analysis (CBA) emerged in the 1950s and 1960s as a practical tool for applied welfare economics and policy.
- CBA has had a profound influence on the development of environmental economics
- Key contributors include John Krutilla (1958), Amartya Sen (1972), Partha Dasgupta (1972), and Pearce (1990).
- Beginning in the 1970s, neoclassical models of growth began to incorporate explicit consideration of the efficient and optimal depletion of natural resources.
- Advances in dynamic optimization techniques (Kuhn-Tucker (1958), and Optimal control (Stokey, 1982), including optimal control and dynamic programming, were subsequently adapted to natural resource economic theory and models.
- Oil price shocks and environmental movements in the second half of the 20th century also contributed to increased interest in resource and environmental economics as they raised important issues to be examined
- In the latter twentieth century, valuation of environmental resources to include such considerations as amenity, were incorporated in natural resource theory and models.