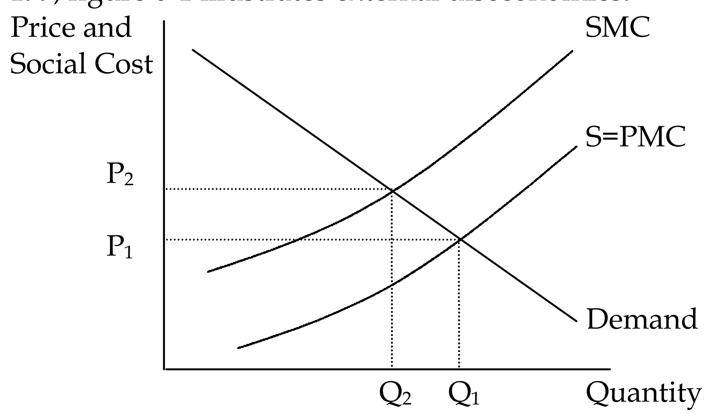
- the environment and economic development:
    - a theme throughout this chapter is the differences in interest in the environment between the politicians and citizens of industrialized countries and those in developing countries; some might even argue that the environment is mainly a concern of only industrialized countries because the environment can be considered a luxury good – LDCs will become concerned about the environment only after they attain a certain level of income
    - however, environmental problems have global effects and the environment is not only a concern for the rich because some of the poorest people suffer most from environmental degradation (for example, clean water and wood for fuel can be scarce – in some cases, people spend half their day acquiring clean water or wood because it has become scarce nearby and they must travel long distances to acquire it)
    - population pressures on the environment are causing increasingly severe problems
    - another theme is the relationship between the discipline of economics and how it perceives the environment; it can seem that the goals of economics (such as growth and efficiency) require a trade-off with the environment; this is perhaps somewhat true but economists (such as environmental economists) have become involved with addressing environmental problems, which are central to the future of economic growth
    - in general, economists believe that the most effective (both in outcome and cost-effectiveness) environmental policies use incentives in a creative way rather than using outright prohibition (a command and control policy); for example, marketable permits and property rights create economic incentives and are both more effective and cheaper than command and control policies
    - economists generally conclude that the best level of pollution is not zero; rather, it is where the marginal cost of pollution to society equals the marginal cost of abatement to society
- a model of external diseconomies:
    - this model considers the pollution that is created along with the production of some good; neither the consumer nor the producer of the product pay for the pollution – instead all of society pays for it; for example: air pollution affects all members of a society, not just those who created the product that produced the pollution nor those who bought that product
    - page 199, figure 6-1 illustrates external diseconomies:



the underlying supply curve is the private marginal cost (PMC) curve, labeled in the diagram a money value on the costs of the pollution (which can include deaths, sickness, deterioration of the environment, etc.) is determined; this can be measured by the additional health cost imposed, the loss of productivity or working life, by surveys asking people how much they would be willing to pay for less pollution, etc.

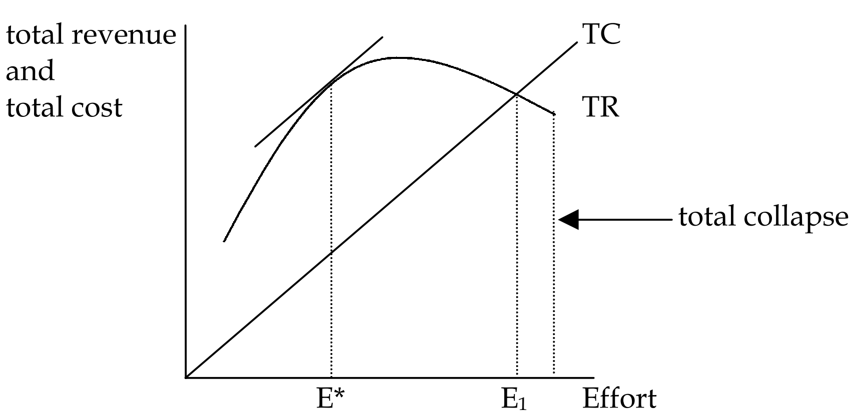
the social marginal cost (SMC) curve considers both the cost of what the producer pays to create the good/service and the externality costs from producing that good/service

if externalities are negative (they are costs to society), then the SMC curve will lie above the PMC curve (as shown in the diagram)

- without government regulation, the firm will produce quantity Q_1, where the PMC curve meets the demand curve
- however, at Q_1 the marginal cost to society (shown by the SMC curve) is greater than the benefit to society (shown by the demand curve); thus, society wants to cut back to producing quantity Q_2, where the marginal cost to society equals the marginal benefit to society; even though pollution is not zero at quantity Q_2, society will still want to produce amount Q_2 because the benefit to society from the goods exceeds the cost of the pollution and of the conventional resources used to produce the goods
- in order to produce the socially-optimal quantity Q_2, the government could limit production to amount Q_2, perhaps by requiring firms that produce the good to have government-issued licenses; only enough licenses would be given out to produce quantity Q_2 (this is a command and control technique if the recipients are forbidden to buy and sell the licenses)
- alternatively, the government could calculate a tax to bring the PMC curve up to the SMC curve; for example, if the vertical distance between the SMC and PMC curves is always the same, then the government could charge a per-unit tax equal to the difference between the SMC and PMC curves; if the difference between the SMC and PMC curves increases with the quantity produced, then the tax schedule could be adjusted accordingly; imposing a tax internalizes the cost of pollution to the producer

• the tragedy of the commons and fishery economics:

- page 202, figure 6-2 illustrates the "tragedy of the commons" by considering "fishery economics:"

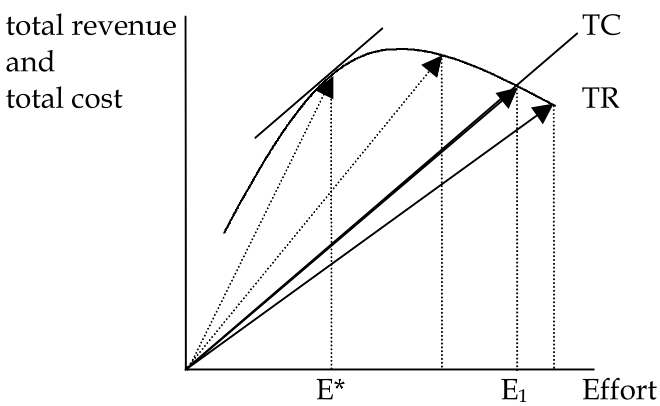


this model illustrates the use of a common resource – in this case, a fishery

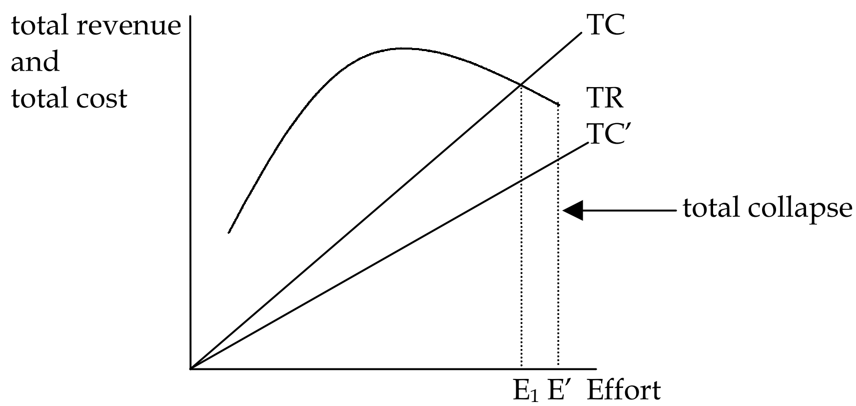
effort expended to catch fish is shown on the horizontal axis; the total cost (TC) of this effort rises proportionally with effort (additional effort does not raise the cost of another unit of effort)

the total revenue (TR) from selling the fish increases and then decreases; it will initially rise with effort to a maximum and then decrease as the fish stock is depleted

- the optimal effort occurs where the slope of the TR curve equals the slope of the TC curve – this is where the marginal revenue (the slope of the TR curve) equals the marginal cost (the slope of the TC curve); this level of effort is labeled E* on the diagram; if the fishing boats are not coordinated, then the level of effort will go to E_1 because individuals do not decide whether to fish or not based on the marginal effect of another boat on <u>total</u> cost and <u>total</u> revenue (they consider only their own cost and revenue);
- assuming that each boat exerts one unit of effort and that each boat will catch the same amount of fish per day, then each boat will receive the average revenue per unit of effort; the average revenue per unit of effort is the total revenue divided by the effort; in the following diagram, the total revenue (the height of the triangle) divided by the effort (the base of the triangle) equals the average revenue per unit of effort (the slope of the ray drawn in from the origin); thus, the revenue per boat equals the slope of the ray:



- as effort increases, average revenue decreases; however, as long as the average revenue per unit of effort (the slope of the ray) is greater than the cost per unit of effort (the slope of the TC curve), boats will be added to the fishery (because the revenue per boat will be greater than the cost per boat); thus, no more boats will be added at the level of effort E_1 because adding a boat will no longer be profitable
- this model explains why decentralization of a common property can lead to severe overuse; it would be more efficient for society to give out enough licenses so that E* effort is exerted
- if the total cost curve were shifted down to TC′ because the cost per unit of effort is less than it is for TC, then boats would be added until the fishery collapses (to the point E′):



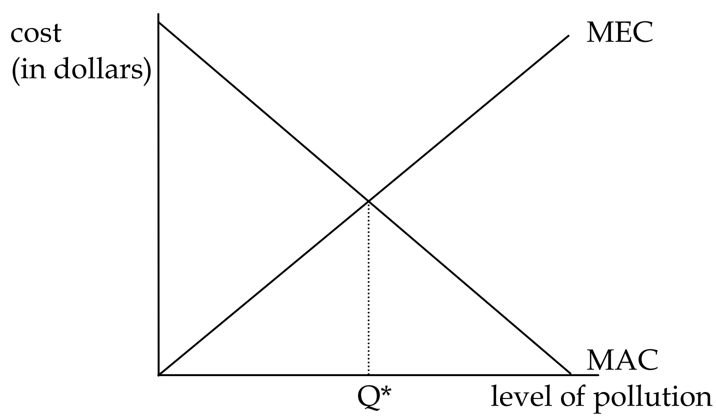
- in pre-agricultural times, human populations were not large enough to bring fisheries to collapse; however, because human populations have become larger, the collapse of fisheries has become a concern

• privatization, collective decision making, and the tragedy of the commons:

- an example of the tragedy of the commons: in medieval times in Europe peasants grazed their animals on publicly owned land, which led to overgrazing because the grass was consumed faster than it could regenerate; if there had been collective decision making that was enforced, this common land could have been used sustainably; eventually, ownership of the land was privatized which led to more efficient land management
- if a lake were owned by a family and the main economic value of the lake were the fish it contains, the family would want to maximize the profit stream from the lake over time; the family will exert E* effort (see the fishery model above); the family bears the marginal cost and earns the marginal revenue, it will not exert effort beyond where marginal cost of effort exceeds the marginal revenue of effort – the family will operate the fishery optimally
- these two examples suggest there are two policies that will lead to efficient operation of a resource – 1) privatization and 2) management of a public resource through governance and enforcement
- privatization:
    - privatizing a common property might not be preferred because it could lead to an undesirable distribution of the property; for example, in Europe, the land was given to wealthy landowners and the peasants were forced to leave
    - however, privatization might be best for some resources
- management of a public resource through a governance structure:
    - citizens could make joint decisions about a fishery and enforce their decisions; for example, government could impose limits on the types of fish caught and require fishing licenses, however, this enforcement is costly to society
    - an example from India: forests are important for fuel and building material but wood has become scarce because of population growth – a village could manage a forest in a controlled manner (such as by working one lot of wood at a time, replanting trees, imposing penalties for using certain lots, etc.); without governance, these lots of wood often disappear

- thus, it is not necessary to privatize land – democratic local management could also be an efficient solution

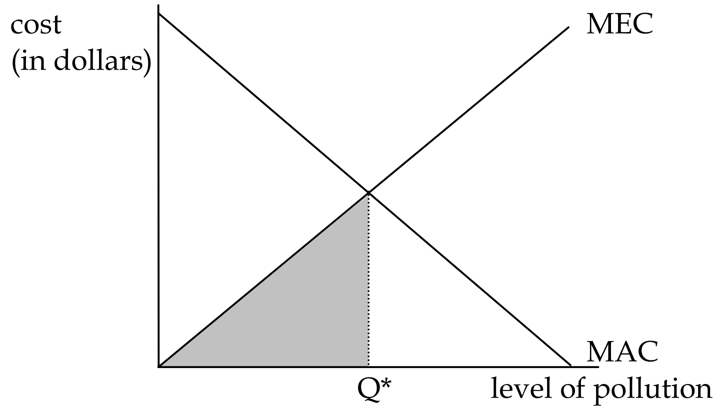
- property rights:
  - if an individual who uses some land (or resource) but does not own it is near the end of his lifetime or plans to move away, then he will exploit the land in the short-term because he has no interest in maximizing the sustainability of the land
  - if he had full private ownership of the land, then he could sell the property at any time and it is in his interest to maintain the sustainability of the land to maximize how much he receives for the land when he sells it; the time-horizon over which the individual is on the land becomes irrelevant because the market value of the land depends on how he leaves it
  - given the right to sell the property, an individual or family will manage the land sustainably rather than exploiting it in the short-term
  - generally, many environmental problems are due to resources being commonly owned rather than privately owned
- the optimal level of pollution:
  - page 211, figure 6-4 illustrates the optimal level of pollution:



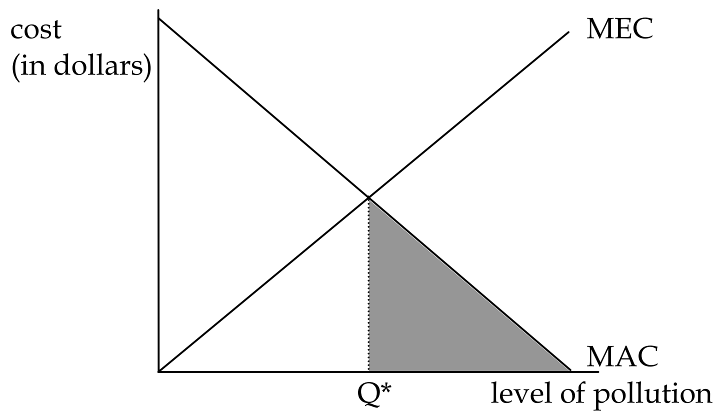
the marginal external cost (MEC) curve illustrates the cost of an additional unit of pollution to society; at low levels of pollution, the marginal cost of another unit of pollution is small; the marginal cost of pollution increases with the level of pollution at some average rate; note that this is not the <u>total</u> cost curve

the marginal abatement cost (MAC) curve illustrates the amount it would cost to abate a unit of pollution; the MAC curve starts from the level of pollution that would take place in the absence of costly abatement actions, and moves to the left; the cost per unit of pollution removed increases from right to left because the units of pollution that are least costly to abate are identified first, followed by ones that are more and more costly to abate

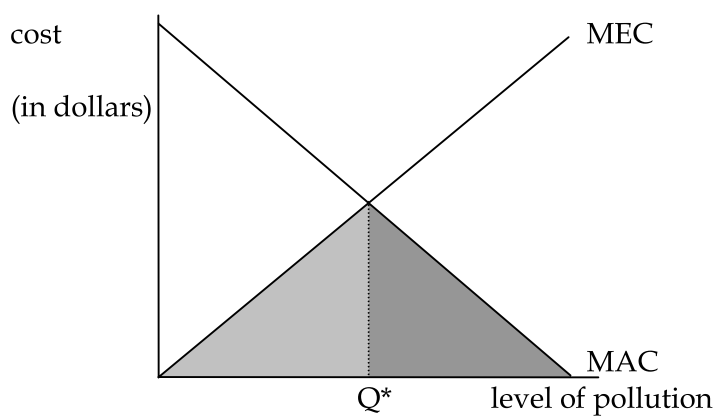
  - the total cost to the environment is the area under the MEC curve (the sum of all the marginal external costs):



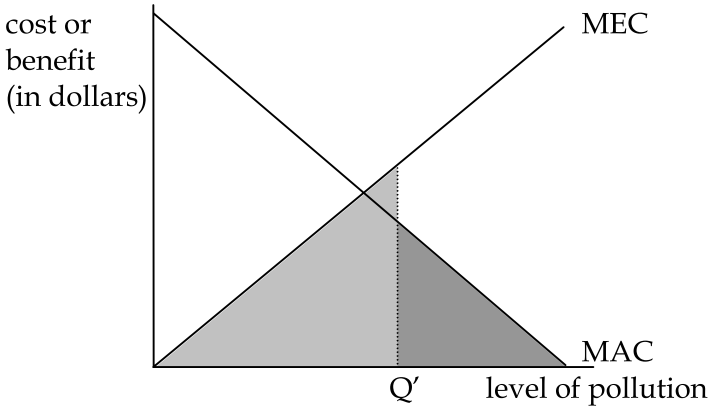
• the total cost of abatement is the area under the MAC curve from the starting point to the level of pollution chosen (here Q*):



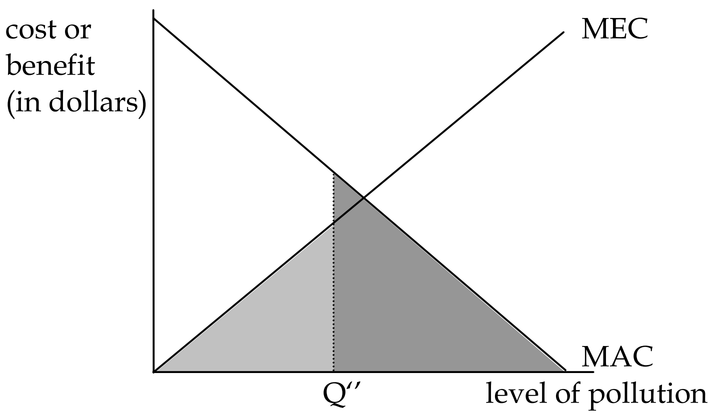
• the optimal level of pollution is at Q*, where the total cost of abatement plus the total cost of pollution is minimized:



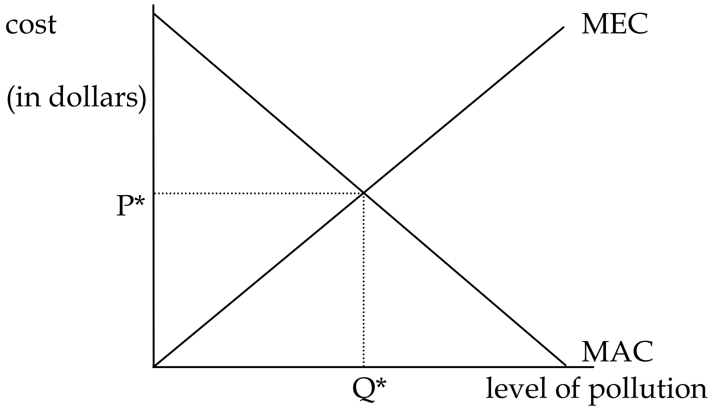
• if the level of pollution, Q′, is greater than Q*, then the cost of abating each of those units of pollution from Q′ to Q* (their respective MAC) is less than the cost of having each unit of pollution (their respective MEC); the sum of the total external cost and total abatement cost is greater at Q′ than it is at Q*:



• if the level of pollution, Q′′, is less than Q*, then the cost of eliminating each unit of pollution from Q′′ to Q* (their respective MAC) is greater than the cost of having each unit of pollution (their respective MEC); the sum of the total external cost and total abatement cost is greater at Q′′ than it is at Q*:



- marketable (tradeable) pollution permits:
  - in order to achieve the optimal level of pollution, a society could determine Q* and implement Q* pollution through regulation
  - for example: the pollution could be some toxic waste that factories will be licensed to release; the total number of licenses will allow a total level of pollution Q* to be released
  - however, regulators do not have information telling them which factories have the lowest costs of abatement; if they regulate without this information, then they could allow a plant to pollute that has a low abatement cost and prevent a plant from producing that has a high abatement cost
  - it would be more efficient if the government gave out enough licenses to pollute so that the total level of pollution were Q* and allowed firms to trade them; if a firm sold its license to pollute, then it would have to stop producing or abate its pollution
  - if enough permits are sold so that the pollution level is Q*, then the price of a pollution permit will be P* in the marketplace:



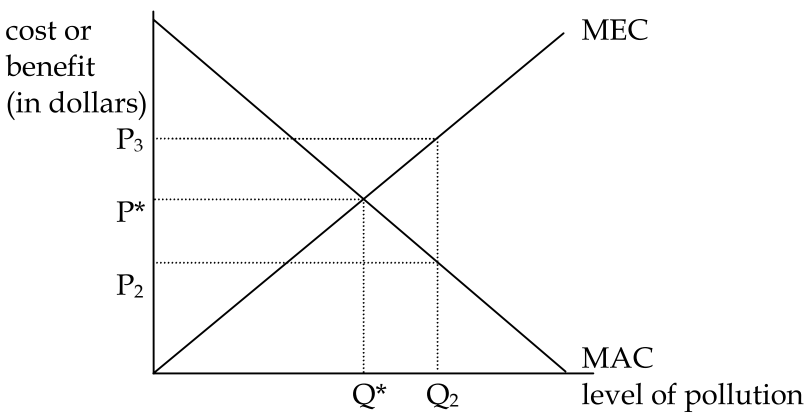
firms with an abatement cost less than P* will sell their right to pollute to firms which have an abatement cost higher than P*

the firm selling the permit will have to clean up, but its cost of abating pollution (where the firm lies on the MAC curve) is less than what it receives from selling the pollution license (P*))

thus, firms with the lowest abatement costs will clean up and the pollution licenses will go to firms which have the highest abatement costs

- allowing permits to be traded lets society abate pollution to a certain level at the lowest cost

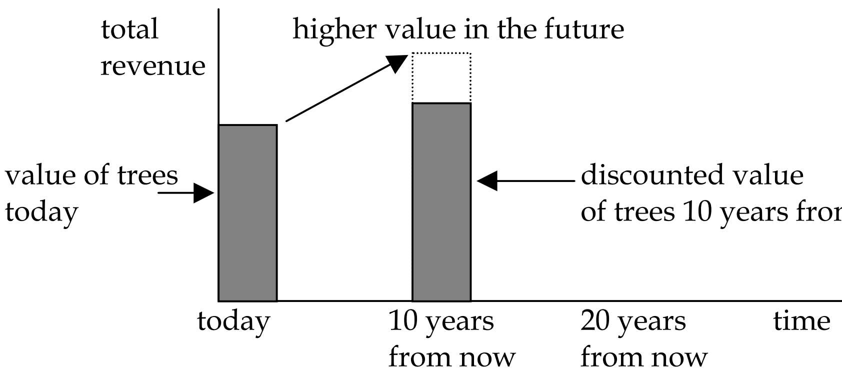
- reducing pollution to optimal after an overallocation of pollution permits:
  - the government might not know the optimal level of pollution because it does not know the MAC and MEC schedules; suppose it sells more permits than is optimal:



  - at Q_2, the price of a pollution permit is P_2 although the cost to society is P_3
  - society could organize itself to buy pollution permits (taking them out of circulation without actually polluting) until the marginal cost of abatement equals the marginal cost of pollution
  - alternately, if pollution were unregulated and the amount of pollution being produced were Q_2, then society could pay firms to abate their pollution; firms would be willing to abate pollution if they received any amount greater than their marginal cost of

abatement; for instance, society could offer P_3 in exchange for pollution abatement to the firm at Q_2 whose marginal abatement cost is P_2
• thus, even if the government does not target the optimal level of pollution, other groups could reduce pollution by paying firms not to pollute
• this is not common because it is hard to organize society; however, one example is conservation groups that raise funds to buy land and take it out of development

• time discounting:
• time discounting is relevant in determining the best time to use a resource (such as when to cut down a forest)
• page 206, figure 6-3 illustrates time discounting for a forest:



• although the money value of the trees in 10 years is greater than the money value of the trees today, the owner will consider the discounted money value in 10 years; he will compare the money value today to the discounted present money value of cutting the trees in ten years to determine when to cut them down
• to determine the current value of the total revenue from selling the trees in ten years, the owner will discount the total money revenue from selling the trees ten years from today:

$$\textit{current value} = R_{10} \times \left(\frac{1}{1+r}\right)^{10}$$

current value = the present discounted value of the total revenue earned from selling the trees in 10 years
R_{10} = the total money revenue earned from selling the trees 10 years from today
r = the discount rate (typically the interest rate)

• in the figure above, the present discounted value of the trees in 10 years is shown as a solid bar while the money value of the trees in 10 years is shown as the dashed bar

• an example of discounting:
• a stand of trees can be cut down today for a market value of \$10,000 or in 5 years for \$15,000
• the present value of the \$15,000 in 5 years can be expressed as:

$$PV = \frac{\$15{,}000}{(1+r)^5}$$

PV = the present value of the \$15,000 in 5 years

r = the discount rate

• if *r* = 6%, then the present value of the $15,000 in 5 years is:

$$PV = \frac{\$15{,}000}{(1+0.06)^5} = \frac{\$15{,}000}{1.338} = \$11{,}208.87$$

comparing the present value of the $15,000 from selling the trees in 5 years ($11,208.87) to the market value of the trees today ($10,000) shows that the discounted revenue earned would be highest if the trees were cut down in 5 years

thus, if the interest rate is 6%, the trees should be cut down in 5 years for the highest revenue

• the present value depends on the discount rate; if *r* = 9%, then the present value of the $15,000 in five years is:

$$PV = \frac{\$15{,}000}{(1+0.09)^5} = \frac{\$15{,}000}{1.538} = \$9{,}748.97$$

comparing the present value of the $15,000 from selling the trees in 5 years ($9,748.97) to the market value of the trees today ($10,000) shows that the revenue earned would be highest if the trees were cut down today

thus, if the interest rate is 9%, the trees should be cut down today for the highest revenue

• there is another similar method that uses discounting to determine whether the trees should be cut down today or in 5 years:

suppose the trees were cut down and sold today and the earnings ($10,000) were invested in a bond; if the interest rate of the bond were 6% per year then the $10,000 would increase in value every year:

value after one year: $(1.06)(\$10{,}000)$

value after two years: $(1.06)^2(\$10{,}000)$

value after three years: $(1.06)^3(\$10{,}000)$

value after four years: $(1.06)^4(\$10{,}000)$

value after five years: $(1.06)^5(\$10{,}000) = \$13{,}382.26$

thus, if the $10,000 revenue from cutting down the trees today were invested at a 6% interest rate, in 5 years the value of the revenue would be $13,382.26, which is less than the $15,000 that could have been earned if the trees were cut down at that time

this method also demonstrates that if the interest rate were 6%, then the greatest revenue would be earned by cutting down the trees 5 years from today it could also be shown using this method that if the interest rate were 9%, the revenue earned would be greater if the trees were cut down today rather than in 5 years

- policy failures:
    - LDCs governments have made policy mistakes that have led to greater pollution and environmental degradation
    - in some cases, rather than using taxes to discourage pollution and environmental degradation, LDC governments have implemented subsidies that are harmful to the environment, such as consumption subsidies for kerosene and Brazil's subsidizing the cutting down of the rain forests
- incorporating measures of environmental depreciation into GNP:
    - GNP does not consider depletion of resources or environmental degradation; adjustments to GNP can take these into account
    - net national product (NNP) adjusts GNP for the depreciation of the physical capital stock (manmade capital); NNP equals gross national product (GNP) minus the depreciation of all physical capital:

$$NNP = GNP - D_m$$

NNP = net national product
GNP = gross national product
D_m = the depreciation of the physical capital stock

- adjusted net national product (ANNP) adjusts GNP for both the depreciation of the physical capital stock and natural capital stock (natural resources):

$$ANNP = GNP - D_m - D_n$$

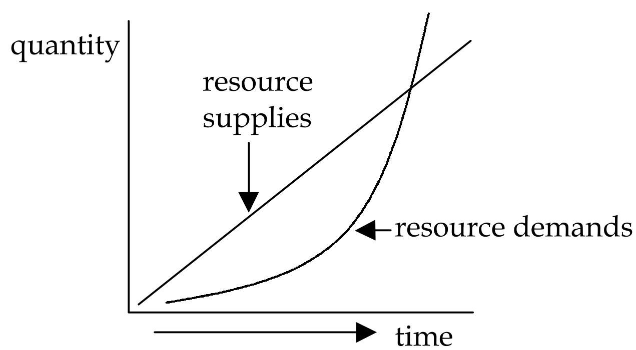
NNP = net national product
GNP = gross national product
D_m = the depreciation of the physical capital stock
D_n = the depreciation of the natural capital stock

- measuring the depreciation of the physical capital stock (D_m):
    1. first, the value of the capital stock is measured by the cost of production of all the capital goods in the economy
    2. then, the rate of depreciation is determined (capital can typically last between 15-20 years)
    3. the depreciation of the capital stock per year equals the value of the capital stock multiplied by the depreciation rate
- measuring the depreciation of the natural capital stock (D_n):
    - the depreciation of the natural capital stock cannot be measured in the same way depreciation of the physical capital stock is measured because natural capital has no cost of production (because nobody created it)
    - the depreciation could equal the cost of replacement of the natural capital; for example, the depreciation of a forest of trees could be valued as the cost of replacing the forest; however, this is impossible for some resources, such as pollution of the atmosphere
    - instead, the depreciation of the natural capital stock is evaluated as follows:

1. each piece of natural capital is valued as the discounted stream of revenue that can be extracted from it; for example: the value of a forest is the stream of revenue that could be generated from logging; some natural capital is not valued because there is no way to evaluate the stream of revenue that it produces, such as the atmosphere
2. the fraction of the stream of revenue that is depleted is determined; for example: if 10% of a forest is logged, then 10% of the forest is depleted
3. the depreciation of the natural resource equals the value of the stream of revenue that is depleted; in other words, the depreciation is the fraction of the stream of revenue that is depleted multiplied by the stream of revenue generated by the natural resource

• environmental economists are working on methods of calculating value of the depreciation of natural resources and the degradation of the environment
• the group Redefining Progress is trying to use measures other than GNP to measure well-being and environmental degradation (http://www.redefiningprogress.org/)

• global sustainability and the Malthusian view:
• page 233, figure 6-7 illustrates the Malthusian view of the global resource balance:



human demands for resources increase over time at an increasing rate (they grow exponentially)

at best, resource supplies only grow at a steady rate (some, like petroleum, don't grow at all)

• according to Malthus, human population grows at a "geometric rate" (exponentially) unless it is checked by war, disease, etc.
• Malthus considered agricultural land as the resource supply; the amount of land brought under cultivation can expand slowly – it is, however, ultimately limited by the surface area of the Earth
• according to this model, eventually the demand for resources will exceed the supply of resources and the result could be environmental disaster
• there is no clear consensus on whether this will happen or not; pessimists extrapolating from the past always predict doom; in contrast, optimists believe technology will always provide a solution
• in either case, if policies to avert environmental disaster are implemented, they should follow economic logic for the greatest effectiveness at the lowest cost

• environmental concern in rich countries vs. in poor countries:

- rich countries have a stronger demand than poor countries for less pollution and environmental degradation
- poor countries are more willing than rich countries to promote economic growth even if it harms the environment, such as China and India
- however, there are mutually beneficial deals – rich countries could offer poor countries an incentive for environmental protection; for example: poor countries could protect the environment in exchange for debt relief