Nov 6, 2006

Name: _____ Pledge (sign): _____

Env Studies 201 Test #2 KEY

Point Total: 100 pts possible

4 pts 1. Give good estimates of (a) the current global population and (b) the current US population.

According to the US Census Bureau on Nov 7: the US population is 300,159,497 (300 million) and the global population is 6,555,505,839 (6.55 billion).

5 pts 2. What are currently the top five energy sources in the US? List them in order, with the most important source first.

Oil, natural gas, coal, nuclear fission, hydroelectric.

4 pts 3. What are Hardin's two solutions to the 'tragedy of the commons?'

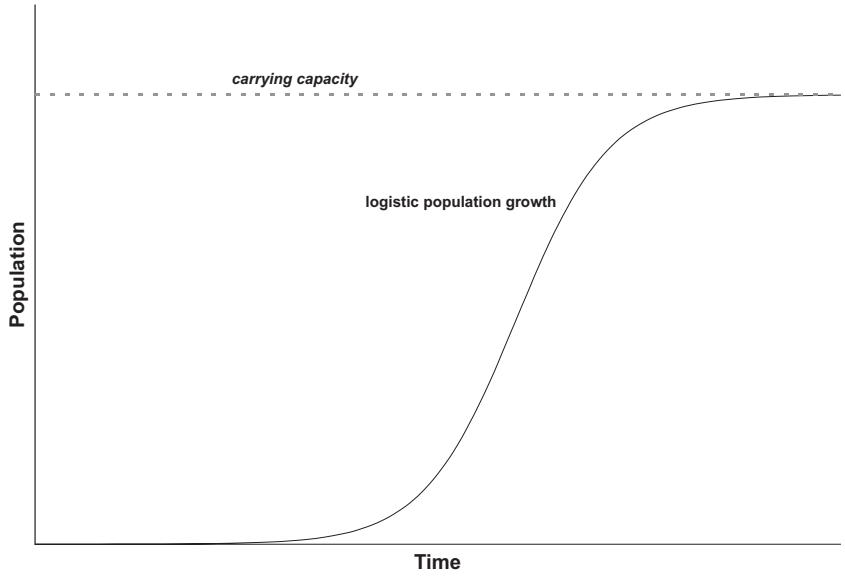
Access to the the commons is controlled by either an owner (privatization) or by the government ('command and control' regulation).

6 pts 4. Describe and briefly explain the distinction between *overshoot and oscillation* and *overshoot and collapse*.

In both cases the carrying capacity is exceeded temporarily because there is a feedback delay on the control of resources on population level. In 'overshoot and oscillation,' the population then falls and fluctuates around the carrying capacity, which was not much affected by the overshoot. In 'overshoot and collapse,' however, the population peaks before falling to a dramatically lower level. The reason is that the overshoot caused serious degradation in the regenerative capacity of various resources and ecosystems, and hence caused a fairly drastic reduction in the planet's carrying capacity.

6 pts 5. What is meant by *logistic population growth*? Illustrate your answer with a labelled graph, and include a definition of the term *carrying capacity*.

Logistic growth is population growth that asymptotically approaches some maximum value: the carrying capacity. The carrying capacity is the maximum (average) population level that can be supported by the resources available in the ecosystem.



5 pts 6. (a) What does the phrase *sustainable agriculture* mean?

Sustainable agriculture consists of practices that meet immediate and long-term food production needs while protecting natural resources. With sustainable agricultural practices (see the next question) food production and distribution must be adequate to feed the entire world now and into the future, accounting for expanding global population. While doing this, agricultural practices must conserve a variety of resources (energy and water sources) and must reduce soil erosion to its replaceable rate. Also, the pollution the is produced must be assimilated rapidly enough so that it doesn't rise to levels that will pose unacceptable risks to humans and ecosystems.

6 pts (b) What are some of the typical practices advocated by supporters of sustainable agriculture? List as many as you can.

- multiple crops
- crop rotation
- mixed crops and livestock
- livestock raised more naturally (free-range, no crowding, no drugs)
- natural pest control, integrated pest management
- natural fertilization (nitrogen-fixers, animal manure, green manure, compost, crop residues)
- soil conservation (reduce erosion), possibly no-till farming

6 pts 7. (a) What are the potential advantages of the hydrogen economy? List as many as you can and briefly (1 sentence each) explain each.

- It provides a way to transition to greater dependence on renewable energy sources. Through electrolysis, hydrogen is a way to store (electrical) energy provided by intermittent sources such as wind or solar energy. Such a system is cleaner, will not run out of fuel, and lessens our dependence on fossil fuel from other countries.
- Fuel cells are an efficient way to generate electricity (they are not heat engines).
- Fuel cells are a clean (and silent) way to generate electricity—they produce only water. In particular, vehicles powered by fuel cells are cleaner because it is easier to control pollution from smaller a number of fixed hydrogen generators than from a large number of mobile (gasoline-powered) vehicles.
- Fuel cells are scalable, so we can go to a distributed generation energy network, which is more reliable than our current system.

6 pts (b) List some potential roadblocks to implementing this energy system. Be complete—list as many items as you can.

- *Production* of enough hydrogen in a manner that is renewable and environmentally friendly. We might desire that this production also be decentralized to some extent (ie, distributed generation), which is another aspect to this challenge.
- *Storage* of hydrogen in a manner that does not waste too much energy
- Creating an infrastructure to *distribute* the hydrogen to end users
- Creating cheap *fuel cells* of all sizes to convert the hydrogen to electricity
- Creating *automobiles* based on fuel cells that are comparable—in price and performance—to those based on combustion engines

8 pts 8. Would Julian Simon be an adherent to *weak* or *strong* sustainability? Briefly justify your answer, making sure to define the two terms.

Simon was an ardent *technologist* who argued that natural resources place no meaningful limits on human activities. We would be an adherent to *weak* sustainability—as much as he could be said to be a supporter at all! The 'weak' adjective describes the extent to which natural resources limit development. Promoters in weak sustainability believe in (nearly) unlimited substitutability between human and natural capital; in other words, the loss of natural resources can be overcome through social institutions and technological advances.

Proponents of strong sustainability believe the opposite: that the limited availability of natural resources provides a strong constraint on economic and population growth. In other words, even if efficiency of use can be increased, there are still some natural resources which are essentially irreplaceable and are necessary to support human activities. The availability of such resources will contain the scale of human activities.

8 pts 9. What is *pesticide resistance* and why is it a problem?

Organisms can evolve and become more resistent to the effects of pesticides. Natural selection will favor organisms that are most immune to the pesticides; these organisms will pass on their genes to the next generation, and so on. It is a problem because it creates a situation—the pesticide treadmill—where greater and greater applications of pesticides are necessary to control the pests. Eventually, the pesticide will need to be abandoned for another type of pesticide and the entire process will begin again. The application of increasing amounts and numbers of pesticides negatively impacts ecosystems and human health.

6 pts 10. (a) What is the *Green Revolution*?

The Green Revolution was the development of high-yield hybrid strains of various crops (wheat, rice, some cereals) in an attempt to increase food productivity. The seeds were developed by the Cooperative Wheat Research and Production Program in Mexico under the direction of Norman Borlaug. The new seeds grow rapidly but only with intense application of fertilizer and water; since they are usually grown in monoculture, chemical pesticides are also usually required to protect the crops.

6 pts (b) What are the environmental costs of the Green Revolution? List as many items as you can.

- Application of fertilizers causes nutrient pollution of waterways (and subsequent eutrophication) and increase in atmospheric nitrous oxide, a greenhouse gas and an ozone depleter.
- Application of chemical pesticides affects human health directly, affects ecosystems, and decreases soil productivity.
- Oxygen depletion and pathogens in aquatic ecosystems due to an increase in organic waste discharge from crop residues and livestock.
- Depletion of aquifers, some of which are recharged very slowly or not at all (so-called 'fossil' aquifers).
- The industrialization of agriculture fostered by the Green Revolution means that farming operations are getting much bigger, so that pollution is more concentrated and disruptive to local ecosystems and human populations.

10 pts 11. How does Hardin's 'tragedy of the commons' lead to environmental degradation? Answer in some detail; use the Prisoner's Dilemma in your explanation.

The lesson of Hardin's tragedy of the commons is that open access to a limited resource—including environmental resources—leads inevitably to the degradation of that resource. Hardin's hypothetical example was that of a common pasture available to a group of herders; each faces the decision of whether to add an additional animal to the herd. Thinking rationally leads every herder to expand the size of the herd indefinitely, leading ultimately to the ruin of the pasture for everyone.

This is similar to the Prisoner's Dilemma. Two robbery suspects are isolated and each is given the opportunity to present evidence against the partner. A prisoner who is silent but it betrayed by the partner will get the maximum sentence (eg, 10 years) while the partner goes free. If they are both silent, they will each get a light sentence for arms position (eg, 6 months). If they both present evidence, they will serve stiffer sentences for armed robbery but will be out on early parole (eg, in 2 years).

Each prisoner faces a choice of remaining silent or betraying the partner. The rational choice for each is betrayal, since with that action they are better off no matter what the partner does. However, both prisoners making the rational choice would NOT lead to a Pareto optimum: with the numbers above, each prisoner would serve 2 years. The Pareto optimum (6 months each) would only be reached if both prisoner's kept silent. The important point is that rational behavior does NOT lead to the greatest aggregate benefit, which is directly contrary to the theory of Adam Smith's 'invisible hand.'

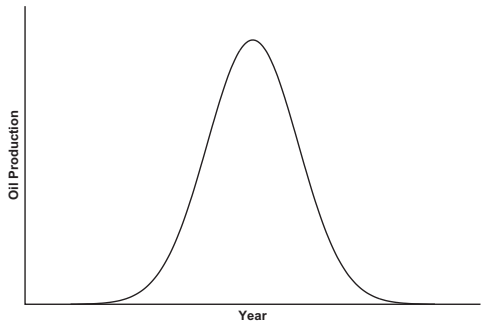
Both cases are similar in that they demonstrate the failure of Adam Smith's 'invisible hand' with respect to common pool resources: rational behavior does NOT lead to a maximum net societal benefit but instead to environmental degradation. If the benefits of environmental common pool resources are not part of marketplace transactions, such resources may be overused and ultimately exhausted.

14 pts 12. Choose *one* of the following and answer *in some detail*. In either case, you might want to use labelled diagrams to clarify your answer.

(a) Campbell and Laherrère predicted 'the end of cheap oil.' What was their reasoning?

With the phrase 'the end of cheap oil,' Campbell and Laherrère were referring to the peak in global oil production, commonly referred to as 'peak oil.' Beyond this point, oil production will decrease. Assuming that demand will stay the same or increase, the price of oil would rise.

Campbell and Laherrère predicted the date of peak oil by assuming that global oil production followed a Hubbert bell curve, as shown in the following figure.



To use this approach to obtain a prediction, Campbell and Laherrère first estimated three numbers:

(1) Cumulative oil production to date. They did this by examining historical records of the world's oil fields.
(2) Reserves left in current oil fields. For all current oil fields, they estimated P-50 numbers and added them.
(3) How much oil is left to be discovered. They did this by fitting an curve to the rate of oil discovery as a function of the date of discovery, and extrapolating into the future.

Adding all three numbers gives us the total amount of oil that have ever existed on Earth (the global 'ultimate recoverable reserve'); this determines the total area under Hubbert's curve. The first number tells us how far along the curve we are—when we reach the mid-point, we are at peak production.

In their 1998 *Scientific American* article, Campbell and Laherrère estimated a value of 1800 Gbo (billion barrels of oil) for this value. The authors also estimated that we have already used 800 Gbo, so that (in 1998) we were not quite at peak oil. They predicted a date of about 2005 for peak oil production.

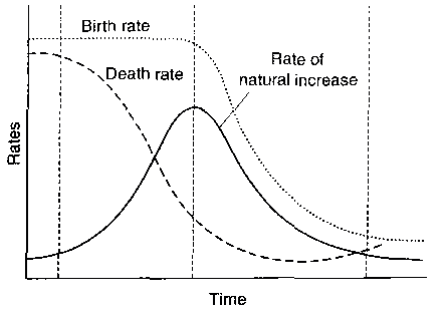
Others place the global reserves at larger values, which pushes the date of peak production back some. Some experts put the value as high as 4000 Gbo, which would push the peak back to approximately 2030.

(b) Two rebuttals commonly used against neo-Malthusians are the existence of *demographic transitions* and *environmental Kuznet curves*. Explain the nature of these two rebuttals.

Malthus believed that population growth would outstrip food production would limit population (in Britain), and that there would be widespread hardship and famine when this occurred. Similarly, modern neo-Malthusians believe that population levels and quality of life will be determined by limitations of one or more of a number of environmental resources—maybe agricultural productivity (like Malthus) but possibly others such as the availability of freshwater, cheap energy sources, or rising pollution levels (due to the inability of the environment to assimilate pollution as rapidly as it is discharged).

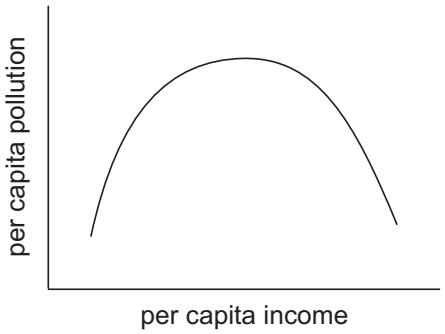
The two rebuttals noted in the question are the same, really: as less-developed ('third world') countries complete their transition to industrialized economies, global population levels will stabilize and pollution levels will be reduced to safe levels. These rebuttals are based on some empirical evidence, and also on the theories that arose to explain these data.

Population levels will stabilize due to the demographic transition, which is shown in the following figure.



Ignoring migration, a country's population grows as long as the birth rate exceeds the death rate. Before the demographic transition, both birth and death rates are high. In the first stage of the transition, death rate falls because of better health care and widespread access to sanitized drinking water. Since death rate has fallen but birth rate remains high, the population will grow; many argue that current global population growth is due to the fact that some third world countries are currently in this stage of the demographic transition. The next stage is marked by a decrease in birth rate, ostensibly as the country urbanizes (typical explanation: having many children is a benefit on a farm but an economic burden in the city) and birth control methods becomes increasingly more available and utilized. Education and empowerment of women is sometimes cited as a factor in this transition. Finally, the transition is complete once the birth rate has fallen to a level comparable to the death rate, at which point the population level is stabilized.

As a country industrializes, its pollution levels often are seen to be described by an environmental Kuznets curve, shown below.



This figure depicts a situation in which pollution levels first rise as a country's economic activity grows, and then falls to low levels. The typical explanation is that initially a country devotes most of its resources to economic growth, including decreasing poverty and increasing spending power of all its citizens (poor and rich). During this time, 'free' common pool resources (eg pollution assimilation) are overused, with little or not thought given to pollution control. Environmental degradation is less important than 'essentials' such as increasing access to essentials such as cheap food and energy, as well as building the infrastructure of a modern economy. At some point, however, increasing pollution levels are seen as decreasing the quality of life and citizens demand that resources are devoted to clean up and pollution prevention, at which point pollution levels fall.