Problem Set 3
Introduction to Environmental and Resource Economics, November 23, 2003
Due Nov. 25

1. Suppose that three people live around one of the coal-fired power plants discussed in the last problem set. Because each individual has a different sensitivity to air pollution, each has a different willingness-to-pay (marginal private benefit) for cleaner air:

$$p_1 = 100 - \frac{1}{2}Q \quad (1)$$
$$p_2 = 100 - Q \quad (2)$$
$$p_3 = 100 - 2Q \quad (3)$$

Starting from the status quo level of pollution at $Q = 0$, the marginal cost of cleaning up the air is given by:

$$MC = 200 + \frac{1}{2}Q \quad (4)$$

   (a) Clean air can be considered a public good because its enjoyment is *non-rival* and *non-excludable*. In your own words, define each term. Give two examples of public goods. Is each both non-rival and non-excludable?

   (b) As air quality increases, which individual gains the most benefit? Which gains the least? (It may help you to graph the individual's willingness-to-pay.)

   (c) Construct the marginal social benefit curve for clean air, for $Q < 50$. (You can construct the entire curve if you feel ambitious!)

   (d) What is the socially optimal level of clean air, given your answer from above?

   (e) If provision of cleaner air was left to the free market, how much clean up would occur? (Hint: Would any of the individuals in the market purchase any "clean up" on their own? If not, why not?)

2. This problem is a brain-teaser, but fun! Assume that Pat, Chris, and Sasha all live along a dead-end road in upstate New York. Pat lives at the end of the road, 300 meters from the main road. Chris lives next-closest, 200 meters from the main road. Sasha lives closest, 100 meters away. It snows a lot there in the winter. If each individual shovels their own drive, they can do an OK job of it by putting 10 cents of effort per meter into the job. Thus, the *constant* marginal willingness-to-pay of each person is 10 cents a meter. (This means that each persons MPB curve is a horizontal straight line, and their total private benefit curve is an upward-sloping line with slope 0.10.)

   (a) Assume each person shovels the road up to their own house. Respectively, what marginal social benefits do Sasha, Chris, and Pat's activities generate? (Hint:

Graph the marginal social benefits, with meters from the main road represented on the X axis. This means Sasha lives at 100, Chris lives at 200, and Pat lives at 300.) Are externalities generated by their actions? If so, by who and how much?

(b) Assume that a plowing service is available which would plow the road for 20 cents a meter. Would any of the three residents hire this service on their own? If yes, who would hire the firm, and how far would they contract to have the road plowed? If no, why not?

(c) What is the socially optimal distance to have the road plowed? Why?

(d) Compare the total costs to having the entire road plowed to the total benefits. Would it ever make sense to have the entire road plowed? If it was proposed that the three neighbors have the entire road plowed and split the costs, do you think that all the neighbors would agree to this proposition? If not, can you propose a pricing scheme that might be acceptable to all? (Hint: think about optimal contributions to public goods.)

3. Pat and Chris share a small patch of grass near the creek between their houses and use this patch of land for grazing their goats. Because of all the snow in the winter, the grass on this land grows very lush and thick. The agricultural extension service has estimated that economic returns per goat are highest when only two goats graze the land. At this level, the grass can regenerate in one area as the goat graze in another. Beyond this level, the grass has insufficient opportunity to regenerate, and the goat's feed has to be supplemented through table scraps and Purnia Goat Chow. Three goats on the patch results in a somewhat higher goat chow requirement per goat, and at four goats per patch, the goat chow cost gets to be quite high, although each neighbors can still earn some profit on their production of goat cheese and yogurt.

   Pat and Chris face the following payoffs to each choosing to graze one or two goats, conditional on their neighbor's choice of grazing either one or two goats (Pat's payoffs run across the matrix, and Chris's payoffs run down. The payoff on the left is Pat's and the one on the right is Chris'.):

	Chris grazes 1 goat	Chris grazes 2 goats
Pat grazes 1 goat:	(9,9)	(1,10)
Pat grazes 2 goats:	(10,1)	(4,4)

   - Assuming that Pat and Chris are both self-interested profit maximizers, how many goats would you expect each to graze? (What is the Nash Equilibrium?) Is this the best outcome from a social perspective?
   - Having read the Ostrom article, would you expect that each individual would in fact graze the Nash equilibrium number of goats? If not, why not? (briefly)

4. Sasha and Chris share a small peat bog, from which they harvest peat moss, which they add to their gardens in order to improve their soil. Because of its slow regeneration

rate, peat can be considered a non-renewable resource. Their yearly demand for peat is given by:

$$10 - Q$$

where Q is the quantity of peat. They can harvest peat at a constant marginal cost of \$4. They have a two-year time horizon, and a discount rate of 10%.

(a) If the supply of peat is not limitted, how much will be harvested in each year?

(b) Sasha and Chris discover that the supply is limitted to 10 units. How much peat should they optimally harvest each year? At this level, what is their Hotelling or scarcity rent? Why is it higher for year 2 than for year 1?

(c) How does their optimal peat consumption change over time? Why?

(d) If Sasha and Chris act only in their own self interest (and they can't sell the peat to others), how much peat would you expect to be harvested in each year? Why? What is the present value of the social loss for this harvest pattern?

(e) Sasha and Chris realize that they can develop a compost from goat dung and leaf mulch at about the same cost as harvesting peat. However, it is a renewable resource. It takes about a year to compost completely. If they use it right away, it helps the garden some, but if they let it compost completely, it helps the garden a lot more, since more of the nutrients are available for plants. Assuming the same demand and cost curve from above and the same inital level of compost (10 units), would you expect that the optimal intertemporal use of compost would be the same as that of the peat moss? If not, why not? (Hint: consider the value of leaving some of the compost for next year–how would it compare to the value of leaving the peat moss?)