Econ 496/598, Natural Resource Economics

Winter 2012

Assignment 4 suggested answers

Part 1

1. (a) The lower the price elasticity of the demand for oil is, the higher the potential gains by restricting the available quantity in the market will be. Since a cartel will try, by definition, to lower the quantity, a low price elasticity of the oil demand strengthens the cartel. The price elasticity depends on the availability of substitutes and the time horizon under consideration. Therefore, in the short-run, where less substitutes are available, cartels might gain in power. However, in the long run the existence of alternative forms of energy increase the price elasticity of oil, hence the cartel loses its power.

   (b) The other three factors are *(i)* the positive income elasticity of oil demand, showing that the cartel profits are very sensitive to the business cycles (the cartel benefits disproportionately during economic expansion and incurs higher cost during recessions), *(ii)* the non-OPEC suppliers operating as a competitive fringe (the cartel has limited power in the short-run until the fringe exhausts its reserves), and *(iii)* the compatibility of member interests where different amounts of reserves among the cartel members may dictate more or less aggressive policies (in case this happens, the country with the low reserves wants to sell as much as possible in the short run; the best interest of the country with the high reserves is to sustain a relatively low flow of oil in the market; in many cases the reserve-rich country threatens the other countries with retaliation in case they supply excess oil in the market).

   (c) Cartels tend to restrict the quantity. In that sense, cartels might be beneficial for two reasons: first, the allocation of the resource might correct potential issues with the "dictatorship" of the present (where the efficient outcome is defined from the perspective of the current generation); second, by restricting the quantity of oil extracted cartels also limit the amount of pollution associated with the extraction and use of oil. However, these two reasons do not provide sufficient arguments in favour of the oil cartel! The biggest problem is that the price of oil is kept artificially high (perhaps even higher than the price that incorporates the marginal social damage due to pollution) thus turning the economies in other forms of energy that might have even bigger environmental impact (like coal, or nuclear energy). Also, the cost of lower oil quantity includes losses in terms of forgone economic growth (as the economies will be using less efficient forms of energy, hence produce relatively less).

2. (a) First, awarded agricultural subsidies by the Brazilian government increased the rent-bid function of agricultural use, i.e., the land became more and more valuable when used for farming and grazing. Given that increases in population had raised the rent-bid function of residential development, the higher rent-bid function for agriculture implied an increase in the allocated land for farming at the expense of wildlife and forests. Second, an inefficient property rights system allowing land appropriation: people who occupied and used land for at least five years had the right to a piece of land three times the size of the non-forest area they occupied. But

that gave incentives to squatters, to cut down trees in the land they occupied resulting in an increased rate of deforestation.

(b) Poverty is a disincentive for forest preservation. Poor people look at the forest as potentially exploitable land. Massive deforestation leads to depleted soil, poor irrigation and water scarcity, lack of fuels (less burning wood). This starts a positive feedback that creates more poverty that leads to even more deforestation and so on. At a national level poverty is often associated with high levels of national debt. Concerns have been raised that countries with high national debt tend to overexploit their forests in an attempt to cover part of their debt (especially when the interest rate is high and serving the debt requires more funding). The empirical results are controversial. Some studies have shown a positive correlation between public debt and deforestation while other studies fail to do so. More importantly, extending the hypothesis of positive correlation between public debt and deforestation to other resources (like minerals etc.) cannot be empirically justified.

(c) There are six types of public policy currently implemented. These policies include:

(i) *Debt-Nature Swaps*, where nongovernmental organizations (NGOs) buy part of developing countries' public debt (in the secondary market) and they cancel it in return for forest and biodiversity preservation. It has been applied in many countries including Bolivia, Zambia, Ecuador, and Madagascar among others.

(ii) *Extractive Reserves*, where specific forest areas are reserved for indigenous people and their traditional hunting-gathering activities. No other form of economic exploitation or land conversion is allowed in these areas.

(iii) *Conservation Easements and Land Trusts*, where the landowner and a private or public agency sign an agreement that limits uses of the land in order to protect its conservation values. The agency pays some money to the owner (as a compensation for forgone profit) and this payment can be tax-deductable.

(iv) *The World Heritage Convention*, established in 1972 identifies and tries to preserve the cultural and natural heritage of outstanding sites through international cooperation. Ratifying nations can attract attention to their sites and they may use funds specifically raised for preserving these sites (through UNESCO for example).

(v) *Royalty Payments*, where pharmaceutical companies pay royalties to countries whose forests are explored and used in order to invent and produce drugs.

(vi) *Carbon Sequestration Credits*, where countries are awarded CSCs for forest preservation. These credits can be sold in an international market for CO_2 permits.

3. (a) With rising extraction and disposal costs recycling becomes more attractive. Extraction cost of resources, although decreasing some times, eventually increases as reserves are running out and extraction turns to more difficult and less efficient ores. Moreover, disposal costs increase due to overpopulation and urbanization. When processing products for recycling becomes cheaper and more efficient (for example, when collection networks are created) firms can easily turn to recycling. Moreover, consumers are willing to recycle more when the disposal cost is internalized.

(b) The factors that affect the cost of recycling include *transportation*, *labour*, and *processing costs*. Transportation and labour cost decrease with proper networks (for example, proper bins for collecting and shorting different types of recyclable materials). Moreover, labour cost can be sufficiently low as in many occasions less privileged people (homeless) are part of the collection process (this activity can be a significant source of income for these people). Processing costs differ between materials. For example, paper and glass can be processed easier than plastic, as high heat can be used to treat impurities for the former but not for the latter. However, processing costs are in general decreasing as better technologies become available and firms adjust their production process to easy recycling. For example, scrap metal is collected immediately on site in many steel and aluminum factories, thus reducing all the aforementioned costs.

(c) Not necessarily! The weight of the recycling bin outside a house cannot be an unbiased estimator of a household's recycling effort. There are quality differences as well. For example, lower income households are more likely to drink (and recycle) cans of beer while wealthier households consume wine. Obviously, a bottle of wine weighs more than many cans of beer. Also, it would be a good idea to relate the income (and consumption level) of a household to its recycling. This way one can see recycling as a percentage of total consumption and adjust for differences in incomes.

4. (a) The "Prior Allocation" and the "Prior Appropriation" are systems of property rights on water. The property rights of the former are ownership rights while the water rights of the latter are usufruct rights which are rights to use, not rights to own. Therefore, the main difference between the two is that the "Prior Appropriation" doctrine allows the transfer of water away from the stream (up to the amount allowed) while the "Prior Appropriation" allows only the amount that can be currently used in the production process to be extracted. This is the reason why the prior allocation is more efficient: when water can be owned (so, it can be saved for future use), there is incentive for preservation! Worth noticing, however, that these rights are non-transferable, thus not in general efficient.

(b) One rate structure that encourages conservation and reflects rising marginal cost is an *increasing block rate*. With an increasing block rate, the price per unit of water consumed rises as the amount consumed rises. An increasing block rate is considered equitable for residential consumers because low-income users can pay a lower marginal price for the essential units of water. Increasing block rates also mimic increasing marginal cost. *Decreasing (declining) block rates* are inefficient. Additionally, a large burden is put on low-income users by charging them the highest rates for the first units of consumption. Again, with a declining marginal cost, there is little incentive to conserve. Declining block rates also place a larger burden on low-income groups. *Flat fees* are inefficient because with a flat fee, the marginal cost of additional water consumption is zero. Incentives to conserve are nonexistent. *Peak period pricing* is another option for increasing efficiency, but it is a system that is rarely used. Some cities, especially in the arid southwestern U.S. are utilizing seasonal rates.

(c) Three potential remedies include:

(i) *Water Transfers and Water Markets*: The "use-it-or-lose-it" clause of the prior appropriation doctrine does not allow water owners to capture the value of saved water by selling

it. Relaxing this restriction would encourage conservation and allow water to move to higher valued uses by allowing owners to sell conserved water. Water markets and water banks are being increasingly utilized to treat both inefficiencies and scarcity in the short term and the long term.

(ii) *Instream Flow Protection*: The prior allocation and the appropriation doctrine fail to provide adequate protection for instream flows because instream flows historically were not recognized as a beneficial use. Some areas are beginning to recognize instream rights, but they typically have low priority. Creeks that do not cross property lines are not subject to the same legal restrictions, and thus the water rights are more "well-defined." England and Scotland are examples of countries that protect in-stream rights. Fishing rights are selling for large sums of money.

(iii) *Water Prices*: Pricing reform by the elimination of subsidies would also reduce inefficiencies. One example of pricing reform is the Central Valley Project Improvement Act of 1992. The act raises the prices that the federal government charges for irrigation water and allows the transfer of water to new users. While not entirely a full-cost rate, efficiency is improved. Funds are used to mitigate environmental damage to the Central Valley. Water utilities have limited options for improving efficiency in pricing because traditionally these are regulated natural monopolies allowed to cover only the costs of distribution and treatment of water. The water itself is treated as a free good. Additionally, user cost is typically not incorporated in the price, as the monopoly is not allowed to earn excess profits. Incorporation of a user cost would generate profits. Marginal cost pricing that includes a scarcity value would be most efficient.

5. (a) First, increasing urbanization and industrialization results in a very rapid increase in the rent-bid function for residential use. Residential development projects, industrial zones, highways, airports and parks increase in number and size due to this reason. Second, rising productivity of agricultural land allows for relatively high production levels with smaller land parcels. When less agricultural land is needed to feed the same (or higher) population, converting land to residential use can be more profitable.

   (b) The main reasons for converting land to agricultural use include:

   (i) Higher demand for food due to domestic population growth.

   (ii) Openness to trade and exports of agricultural goods increase the foreign demand for agricultural products.

   (iii) Shifting from subsistence crops (like wheat) to "cash" crops (like coffee and cocoa) that increases the profitability of agriculture.

   (iv) New more efficient technologies of production in agriculture.

   (v) Lower transportation costs due to the expansion of a country's infrastructure (highway, railway, etc.).

   (c) Taxes can affect incentives to convert land from one use to another, even when such conversion would not be efficient. *Property taxes* are imposed on land and the facilities on the land. Property tax has two components: (1) the tax rate and (2) the tax base. The tax base

is determined by the market value or by a professional estimator called an assessor. The property tax system can create a bias against land intensive activities as in many occasions the landowner is taxed not based on the current use of the land (for example farming) but on the potential use of the land (if that land can be part of a residential development project). In that case, to avoid overpaying in taxes, the landowner will convert his land from agriculture to residential. The *inheritance tax* can be a significant factor in land conversion since land may have to be sold to pay the taxes.

Part 2

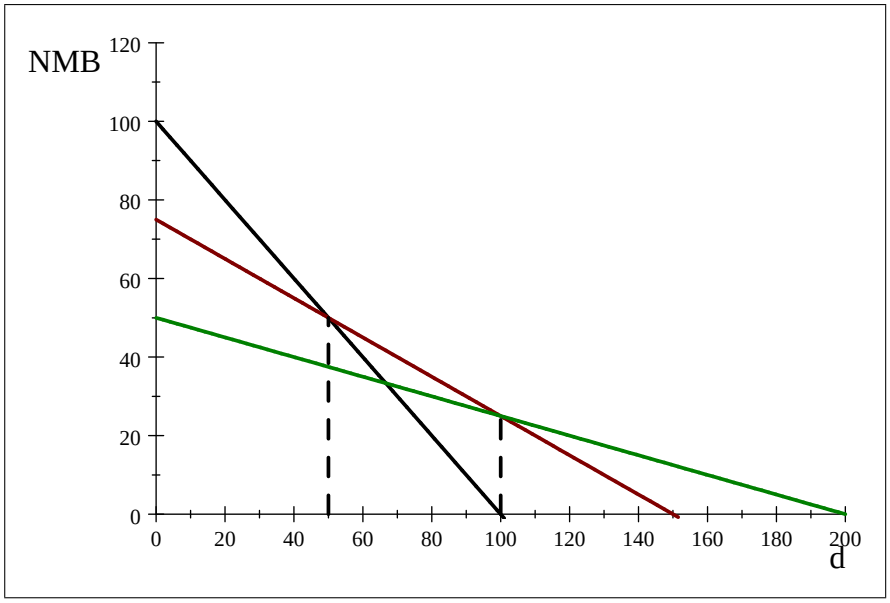
Problem 1. (a) First, by equating the rent-bid functions for residential development and agricultural use we get

$$NMB_R = NMB_A \Rightarrow 100 - d = 75 - 0.5d \Rightarrow d = 50 \; kilometers.$$

Therefore, residential development will stretch out 50 kilometers from the city center and that is the point where agriculture becomes the dominant use of the land. Second, by equating the rent bid-function for agricultural use and wildlife we get

$$NMB_A = NMB_W \Rightarrow 75 - 0.5d = 50 - 0.25d \Rightarrow d = 100 \; kilometers.$$

Therefore, one has to drive 100 kilometers away from the city center to first encounter wildlife. Graphically



(b) The new rent-bid function for residential development is now

$$NMB_R = 100 - d + 10 \Rightarrow NMB_R = 110 - d,$$

and the new rent-bid function for agricultural use is

$$NMB_A = 75 - 0.5d + 15 \Rightarrow NMB_A = 90 - 0.5d.$$

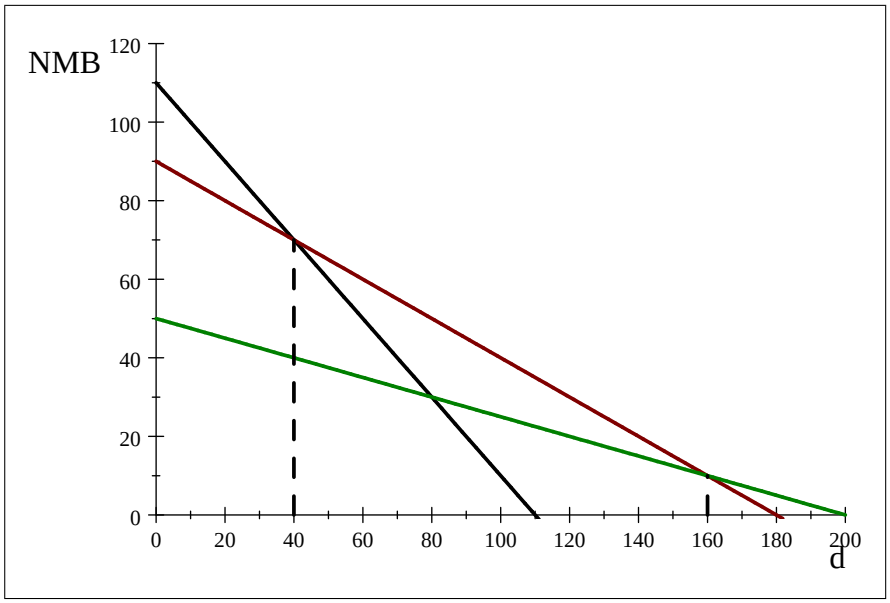
First, by equating the rent-bid functions for residential development and agricultural use we get

$$NMB_R = NMB_A \Rightarrow 110 - d = 90 - 0.5d \Rightarrow d = 40 \; kilometers.$$

Therefore, residential development will stretch out 40 kilometers from the city center and that is the point where agriculture becomes the dominant use of the land. Second, by equating the rent bid-function for agricultural use and wildlife we get

$$NMB_A = NMB_W \Rightarrow 90 - 0.5d = 50 - 0.25d \Rightarrow d = 160 \; kilometers.$$

Therefore, one has to drive 160 kilometers away from the city center to first encounter wildlife. Graphically,



(c) If this is a circular island of 120 kilometer radius (where the city center is located at the center of the island), wildlife won't be present in the island. Residential development will stretch out 40 kilometers from the city center and that is the point where agriculture becomes the dominant use of the land.

Problem 2. (a) Using the Excel Solver we can find that the optimal harvesting age for spruce is almost 20.5 years while for fir the optimal harvesting age is approximately 20 years. The former yields a present value of net benefits equal to \$855.60 while the latter yields \$864.00. Therefore, planting fir is the optimal strategy.

(b) Using the Excel Solver we can find that the optimal harvesting ages for spruce are 13.5 and 21.9 years for the first and second rotation respectively, while for fir the optimal harvesting ages are approximately 13.3 and 19.6 years respectively. The former yields a present value of net benefits equal to \$1287.70 while the latter yields \$1311.75. Therefore, planting fir is again the optimal strategy.

(c) No, the optimal choice remains planting fir. More specifically, using the Excel Solver we can find that the optimal harvesting ages for spruce are 10.43 and 14.57 years for the first and second rotation respectively, while for fir the optimal harvesting ages are approximately 10.42 and 14.58 years respectively. The former yields a present value of net benefits equal to \$1221.12 while the latter yields \$1247.41.