AAE / ECON / Forest 531 (Natural Resource Economics)

Midterm Exam. Monday, October 29, 2007.

Suggested Solutions

Please answer the following five questions, worth a total of 30 points. Question 1 is worth 10 points; questions 2 through 5 are worth 5 points each. Good luck.

1. **Mathematics / Derivation (10 points)**: Consider the optimal management of a renewable resource where the net benefits of using the resource in time t are defined as $\pi_t = 0.5X_t^2 + 10Y_t$, and the resource has a natural rate of growth described by $F(X_t) = X_t - 0.5X_t^2$. Assume a discount rate of δ=0.05. Solve for the maximum sustained yield (X^{MSY}, Y^{MSY}) and the bio-economic steady-state (X^*, Y^*). Recall that the bio-economic steady-state is the set (X^*, Y^*) that maximizes the present value of the net benefits from using the resource. Compare the two outcomes and provide intuition.

   The maximum sustained yield occurs where F'(X)=0:

   $$F'(X) = 1 - X = 0 \Rightarrow X^{MSY} = 1$$

   Therefore, $Y^{MSY}=F(X^{MSY})=1-0.5=0.5$.

   The bioeconomic steady-state can be derived by appealing to the fundamental equation of renewable resources:

   $$F'(X) + \frac{\partial \pi / \partial X}{\partial \pi / \partial Y} = \delta$$
   $$\Rightarrow 1 - X + X/10 = \delta$$
   $$\Rightarrow (1-\delta)/0.9 = X$$
   $$\Rightarrow X^* = 0.95/0.9 = 1.06$$

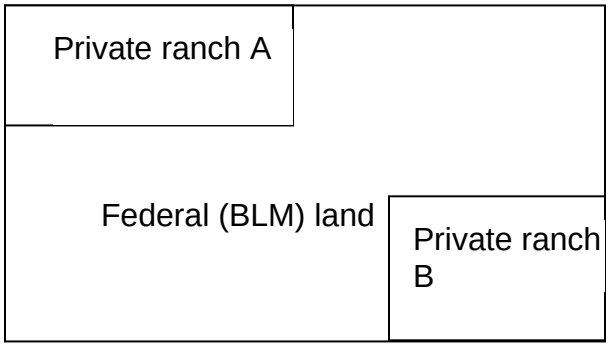
   Therefore, $Y^*=F(X^*)=1.06-0.5(1.06)^2=0.4982$.

   So, $X^*>X^{MSY}$ and $Y^*<Y^{MSY}$. Differences arise because i) the bioeconomic steady-state considers economic parameters and MSY doesn't, and ii) the marginal stock-effect (1.06/10) is greater than the discount rate. The marginal stock-effect is large because the net benefits of the resource are increasing in stock-size ($\partial \pi / \partial X > 0$), so a larger stock yields benefits that are not accounted for in maximum sustained yield.

Short Answer Section (2-5 sentences; 5 points each)

Questions 2 and 3 are related.

Some background information regarding livestock grazing permits on government-owned land in the western United States. Livestock grazing permits on federal land managed by the Bureau of Land Management (BLM) allow the permit holder to graze cattle each year on BLM land. A typical situation is the one shown in the figure below, in which livestock owners have private ranchland for grazing, as well as permits for grazing on adjacent public land. Note that stocking a fixed land base with too much livestock can diminish the future productivity of the land.



2. Consider a management regime in which a permit **does not restrict the number of animals per acre**; rather, it grants the permit holder the right to use a certain block of federal land for grazing for **one year**. Permits are auctioned by the BLM at the start of each year. So, for instance, with reference to the figure above we might expect that each year various ranches, including ranches A and B, bid for grazing rights on the BLM land shown in the figure, with one ranch winning the right to graze the BLM land for the year. Permits are not transferable. Under this management regime, would you expect more or less livestock on the private ranch lands than on the BLM land? Explain your answer.

This policy creates an open access scenario, and similar to the classic open access result, we expect more livestock on the BLM land than on the private land. Since the permit is annual, the permit holder has no incentive to recognize the shadow value of the future productivity of the land. Therefore, the permit holder ignores the potential future benefits from a reduction in current stocking because those benefits will accrue to other (future) ranchers and/or the government. On private land, the landowner expects to capture future benefits from grazing – through use or sale – and so has an incentive to account for the shadow value of the land.

3. Now suppose that permits are **permanent and transferable, rather than annual**. In other words, permits are auctioned once, and the buyer has the right to graze the land permanently or transfer the permit to another rancher. Compare the number of livestock on BLM land in this situation to that on private land, and to that for your answer in 2. Explain.

Since the permits are permanent and transferable, future benefits from a reduction in current stocking accrue to the permit holder. The permit holder would solve a dynamic optimization problem and recognize the shadow value of the future productivity of the land. So, we would expect grazing to be about the same as on private land. To the extent that grazing remains the best use of the land, a long-term grazing permit is indistinguishable from ownership.

4. Suppose you manage a wine cellar with fixed storage space and have to choose when to sell each bottle of wine. The value of each bottle V(t) is increasing over time at a decreasing rate: V'(t)>0 and V''(t)<0. Once you open a bottle you free up storage space for a fresh bottle with value V(0). The optimal time to sell each bottle is defined by what necessary condition? Explain your answer.

Since there is fixed storage space, this problem is structurally the same as the Faustmann rotation in Forestry. First, define $V^*(0)$ *as the optimized present value of space for one bottle of wine in the cellar:*

$$V^*(0) = \max_T \frac{V(T)}{e^{\delta T} - 1}$$

where T is the rotation length for a bottle of wine and δ is the discount rate. The necessary condition for the optimal time to sell each bottle is:

$$V'(T) = \delta\left[V(T) + V^*(0)\right]$$

where V'(T) is the marginal value of waiting as defined by the change in the bottle's value. The marginal cost of waiting is comprised of two terms: δV(T) represents the amount earned by selling the bottle and investing the proceeds, while $\delta V^*(0)$ *represents the rental value of the storage space, which is a measure of the costs of delaying all future wine sales.*

Note: Question #5 on back.

5. Consider the decision to harvest an old-growth forest when the future amenity values of the standing forest are uncertain. Under what conditions would harvest be *ex-ante* efficient and *ex-post* inefficient? Explain your answer.

Cutting an old-growth forest is irreversible because most of the amenity values are not provided by young forests, and it takes centuries for old-growth to develop. Therefore, harvest would be ex-ante efficient if the expected net value of cutting exceeds the option value of preservation. The option value of preservation arises because of the irreversible nature of the harvest decision and accounts for the ability to optimally choose harvest in the future once the amenity values of the standing forest are revealed. The harvest decision would be ex-post inefficient if the future amenity values ended up being significantly high such that the present value of the time-path of realized amenity values exceeds the one-period harvest benefits.