Question 1

A landowner controls a wildlife stock which grows according to $dX_t / dt = F(X_t) - q_t$. Suppose that the value per unit animal hunted is fixed as p, and that the hunting cost depends only on the harvest, $C_t = C(q_t)$, where $C'(q_t) > 0$, $C''(q_t) > 0$ and $C(0) = 0$. The landowner profit per at time t is thus $\pi_t = pq_t - C(q_t)$.

a)Give first an interpretation of the equation $dX_t / dt = F(X_t) - q_t$. Discuss also the realism of the hunting cost function.

b) Formulate the optimal management strategy of the landowner. Find the optimality conditions. Substitute away the shadow price, and find the differential equations of the system in the variables q_t and X_t. Find next the isoclines and analyze the dynamics using phase plane diagram.

c) Characterize the steady-state, and show how the price p and the discount rent δ influence the optimal steady-state stock and hunting.

d) Assume that natural growth is governed by $F(X_t) = rX_t(1 - X_t / K)$. Interpret the parameters of this function. Find how these parameters influence the above optimal steady-state.

e) The wildlife causes a negative externality due to crop and grazing damages for the farmers living in the area. Assume that the damage function may be written as $D_t = D(X_t)$ with $D'(X_t) > 0$, $D''(X_t) \geq 0$ and $D(0) = 0$. Formulate the social planner problem and characterize the steady state. Compare with the landowner optimization problem.

Question 2

a) Explain and discuss some basic elements of a tradable emission permit system (‘cap and trade’).

b) Discuss the Environmental Kuznets Curve concept.

c) The CO2 emission in a given country at a given point of time (year) may be written through the so called PAT identity $E_t \equiv P_t \bullet (X_t / P_t) \bullet (E_t / X_t)$ with P_t as the human population size, (X_t / P_t) as GDP/capita and (E_t / X_t) as the emission intensity (CO2 /GDP). The last factor is usually referred to as technology. Assume the population growth rate to be0.5 % per year, and GDP/capita growth to be 2.0 % per year. Assume that the emission should be halved during the period of 20 years. By how much must the emission intensity (CO2 /GDP) be reduced in % per year to meet this target? Calculate also the change in the emission intensity with zero GDP/capita growth.

Question 3

a)Consider a hydropower investment project. I is the investment cost and $D_t = D > 0$ is the operating profit (electricity sale minus operating costs), assumed to be fixed through time. With δ as the discount rate and when investment takes place instantaneously, the present-value of the project is defined by $PV = -I + \int_0^T De^{-\delta t} dt$. Calculate PV .

Next, calculate PV when the operating time of the project is infinite such that $T = \infty$. Under what conditions will the project be carried out?

Calculate also PV under the assumption that electricity production becomes more profitable and the operating profit grows over time with an annual growth rate $\beta > 0$, $D_t = D_0 e^{-\beta t}$.

b) Consider an even aged stand of trees planted at a piece of land at $t = 0$. The biomass at time $t \geq 0$ is given as V_t . How may the time profile of V_t look like? Illustrate with a figure.

The planting cost is c_0 and the net sale price (net of logging costs) of the biomass is given by p_t . Characterize and interpret the optimal logging time when the land has no opportunity value after logging. What is the effect of the discount rate?

Assume now instead that the land *after* logging has an opportunity value Q_t at every point of time. Characterize the optimal logging time when this opportunity value is included. Compare with what you found without this value.