Poaching and the Dynamics of a Protected Species

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Abstract: Protecting endangered species is a difficult task in developing countries, especially so because individuals living on the edge of a protected area may not place a value on the resource stock in the next period. We develop a model in which an individual derives utility from the consumption (C_t) of harvested bushmeat or the protected species, income from employment (I_t) in the protected area, and time spent on leisurely activities (T_t^L). The myopic individual maximizes a Cobb-Douglas utility function $\mathrm{E}[U_t] = \alpha \mathrm{E}[I_t]^{\beta} (T_t^L)^{\gamma} (1 + \eta C_t^{\omega})$ in each time period t, subject to a Schaefer harvest function $H_t(T_t^H, X_t) = q T_t^H X_t$ for a given population of the protected species X_t. The protected species evolves according to a logistic growth function net of harvest $X_{t+1} = X_t + r X_t (1 - (X_t/K)^z) - q T_t^H X_t$, where T_t^H is the time spent poaching or harvesting the protected species. Poaching is subject to *risky* open access, whereby a fine is incurred by the individual if he/she is caught poaching by anti-poaching units. The probability of getting caught increases in time spent poaching as per the function $\phi(T_t^H) = (T_t^H/T)\exp\big(-\kappa(T - T_t^H)\big)$. A static labor allocation problem for each time period, is coupled with the dynamics of the protected species, to study how the individual maximizes utility by allocating time to wage employment and poaching. The model is solved numerically for steady states for a set of parameter values. Approach paths are studied for different initial conditions for the protected species. In certain cases we observe oscillatory convergence to the analytical steady state; for other parameter values we observe 2^n-point cycles. When n becomes sufficiently large it leads to deterministic chaos

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adfa, p. 1, 2011.

in the dynamics of the protected species. Economic or policy parameters include the wage rate (W) for employment in the protected area, the fine (F) if caught poaching, the level of enforcement or effectiveness $(-\kappa)$ of anti-poaching units, and the black market price of the protected species (P). Increases in the wage rate and fine lower the time spent poaching. Increasing the effectiveness of anti-poaching patrols and lowering black market prices also reduce the time spent poaching. The model reveals that the dynamics of the protected population goes through bifurcation for changes in W, P, F and $-\kappa$ and in some cases gives way to deterministic chaos. Consequently we find that the time spent poaching is influenced by the abundance or scarcity of the protected population. The results of this stylized model of time allocation to poaching and wage employment, and the dynamics of the protected population, point to the importance to studying the effects of conservation policy. Economic or policy parameter changes may induce bifurcation or changes in the qualitative behavior of a protected species' population dynamics.

Keywords: Protected species, poaching, wage, fine, black market prices, bifurcation and deterministic chaos.

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