WILDLIFE HARVESTING

In this unit considers how to estimate an appropriate off take for a wildlife population. It differs according to whether the population is increasing or whether it is stable, and whether or not the environment fluctuates from year to year. Wildlife is harvested for many different purposes. For example, profit as it done in commercial hunting and recreation as in sport hunting.

The operation of wildlife harvesting, be it for recreation or profit, must result in a *sustainable off take*, a yield that can be taken year after year without jeopardizing future yields. In all but special circumstances, the strategy of sustainable harvesting is simple: it is to harvest the population at the same rate as it can increase. Hence, a population increasing at 20% per year can be harvested sustainably at around 20% per year. That proportion of the population can be taken year after year, with the result that the population is held to an induced rate of increase of zero. The use of “rate of increase” as the appropriate harvesting rate is uninfluenced by whether the population is actively spreading, whether it is subject to predation or not, and whether sources of mortality are additive or compensatory.

The details of *sustained-yield harvesting* differ according to whether a harvested population’s key resources are renewable or not, how the harvested population uses those resources, and various interactions between the resources and the harvested population. Most importantly, the dynamics of harvested populations depend on the regulatory strategy (legal limits) used to set harvest levels. There are several harvesting strategies. These include fixed quota harvesting strategy, fixed proportion harvesting strategy, constant effort harvesting strategy and fixed escapement harvesting strategy. We start with a consideration of the most simple harvest strategy: application of a constant harvest quota from year to year.

1. **Fixed quota harvesting strategy**

Most un-harvested populations have a *rate of increase* which, when averaged over several years, is close to zero. Hence, the sustained yield for such a population is also zero. Before such a population can be harvested for a sustained yield it must be stimulated to increase.

A population can most easily be stimulated into a burst of growth by increasing the level of a limiting resource or, much more rarely, reducing the level of predation to which it is subject. The key resource may be nest sites or cover, but in most cases it is food. For example, red kangaroos increase if the pasture biomass exceeds about 200 kg/ha dry weight and decline if it is below that level. The easiest way to increase the average amount of food available to an individual animal is to reduce the number of animals competing with it for that food. The average standing crop of food then rises and the amount available to an individual animal is thereby increased. As a direct consequence the fecundity of individuals is enhanced, and mortality, particularly juvenile mortality, is reduced. The population enters a regime of increase as it climbs back towards its un-harvested density

* 1. ***Harvesting trades off yield against density***

The trade-off between yield and density is the most important thing to know about *sustained-yield* harvesting. In general, the further the density is reduced the higher is the yield as a percentage of population size. The maximum rate of *sustainable yield* is the population’s *intrinsic rate of increase*, but that rate of population growth is obtained only when food (or whatever other resource is limiting) is at a maximum, which in turn usually occurs only when the population is at minimum density.

Whereas *sustained rate of yield* (absolute yield divided by population size) tends to increase as density is reduced, the same is not true of the *absolute sustained yield*. If the population is reduced just a little, the induced rate of increase will be small and the sustained yield will be a small proportion of a relatively large population. The absolute yield will be modest. If the population is drastically reduced, the induced rate of increase will be large and the sustained yield will be a large proportion of what is now a relatively small population. Again the absolute yield will be modest. The highest yield is taken from a density at which the induced rate of increase multiplied by the density is at a maximum. It tends to be at intermediate density levels.

Fixed harvest policies are predicated on sustained use of the *net recruitment* (Net recruitment refers to the difference between population density in year t and population density the previous year, in the absence of harvesting), treating it as a surplus that can be safely harvested without harming resource sustainability in the long term. For example, imagine that we, as population managers, set the harvest at 20 units (Fig. 8.1).

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**Fig. 8.1.**Net recruitment in the absence of harvest in relation to population density, plotted relative to an arbitrary constant level of harvest. At a given harvest quota, there are stable (circle) and unstable (×) equilibria. At population densities above ×, the population would tend to converge on the stable equilibrium. Perturbation of the population below ×, on the other hand, would lead to eventual extinction.

* 1. ***The two levels of sustained yield in constant quota systems***

For a population conforming to the relationship between sustained yield and population size or density given in Fig. 8.1, a sustained yield of a given size may be taken from either of two densities, at the points at which the horizontal harvest line intersects the hump-shaped net recruitment curve. They comprise what is known as a sustained-yield pair. The member of the pair taken from the lower density is to be avoided because its harvesting requires *more effort* than is required to harvest the same yield from the higher density. Even more importantly, any reduction of population density below the level of the sustained-yield pair would inevitably lead to *overharvesting* relative to growth capacity of the population. When a constant number of animals is taken each year from a previously un-harvested population, provided that there is no stochastic variation in weather or other factors that influence net recruitment, the population will decline and stabilize at the upper density for which that harvest is a sustained yield. If that number exceeds the maximum sustained yield, the population would inevitably decline to extinction.

* + 1. ***The maximum sustained yield***

The harvest that intersects the peak of the hump-shaped net recruitment curve (Fig. 8.1) is known as the **maximum sustained yield** (MSY). Harvesting a population at the MSY should never be contemplated. It imparts instability to the population’s dynamics. The MSY can be taken only from the unique MSY density. If the population density has, for environmental reasons (such as drought or crusted snow), dropped below that value then the MSY represents an overharvest and the population’s density is reduced further. Continued harvesting of the MSY will make the problem worse and even lead to extinction.

1. **Fixed proportion harvesting strategy**

If a constant proportion of animals are taken each year from a previously un-harvested population, the population will decline and stabilize, depending on the rate of harvesting, at any level between un-harvested density and the threshold of extinction (Fig. 8.2). So long as the harvest rate does not exceed the maximum intrinsic rate of population growth, harvesting a fixed proportion of the population should settle the population upon a stable population density, generating a sustained yield, even in the presence of stochastic variation in environmental conditions. Provided a wildlife or fisheries manager had perfect information on abundance in any given year before the harvest, a proportionate strategy would be guaranteed to allow sustainable harvests forever. The trouble is, wildlife or fisheries managers rarely have up-to-date information on current abundance, and they must set harvest levels (through licensing or allocation of quotas) long before annual recruitment is known.



**Fig. 8.2** Net recruitment in the absence of harvest in relation to population density, plotted relative to a constant proportionate harvest. The intersection of the net recruitment curve and the harvest line identifies the stable equilibrium, at which off take equals the growth increment to the population.

A fixed proportion harvest strategy is much more sustainable than a fixed quota strategy, at least in the following case.

Note that harvests vary over time to a greater extent using a fixed proportion harvest strategy (Fig. 8.2) than they did under the fixed quota system. This difference in variation arises because harvests are adjusted to absorb the impact of stochastic environmental variation, so quotas drop in years of poor per capita recruitment whereas harvest goes up in years of above-average per capita recruitment.

This variation in harvest provides a stabilizing influence to fixed proportion harvest systems. However, a proportionate harvest strategy can still produce overharvesting when there are several years with unusually low recruitment, because managers do not know with certainty how many individuals have been recruited to the population.

1. **Constant effort harvesting strategy**

A harvest can also be controlled by controlling harvesting effort. Harvesting effort can be regulated by setting a hunting season or by limiting the number of people harvesting the population. The essence of controlling effort is that there is no direct attempt to control the number of animals harvested. An important outcome from controlling effort is that a constant proportion of the population is being harvested. Suppose, for example, that each day harvesters effectively sample 2% of the area inhabited by a harvested species.

If yield is controlled indirectly by limiting harvesting effort (e.g. by limiting the number of hunters), but with no further restriction on yield per unit of effort, those dangerous sources of instability we mention above are eliminated. A fixed effort system will, within limits, harvest the same proportion of the population at high and low density. Yield tracks density, the system automatically producing a higher yield when animals are abundant and a lower yield when they are scarce. A regulatory mechanism is built into the harvesting system itself and it is thus fairly safe so long as the appropriate harvesting effort has been calculated correctly. That is not difficult because fine-tuning of the appropriate effort does not destabilize the system in the way that fine-tuning a quota can. Also, because of the built-in regulation there is not the same need for frequent monitoring.

1. **Fixed escapement harvesting strategy**

In recent years, conservation biologists have argued that the truly safest option is to practice what is called fixed escapement harvesting. The premise of fixed escapement policies is this: rather than trying to maintain high levels of harvests in the face of stochastic variation in resource levels, managers instead choose to place conservation needs ahead of that of resource users. The general procedure is to harvest only “excess” animals above a target threshold, termed the **escapement**. After recruitment takes place the excess is removed by harvesters. This guarantees that recruitment never falls below the threshold, even if it means that no animals are harvested in some years.

This escapement policy is obviously safe, at least in principle. It only becomes unsafe when we are uncertain of the abundance or recruitment. Hence, wildlife or fisheries managers would usually have

to forecast abundance at the beginning of the harvest period from past levels of abundance based on past harvest statistics themselves.