Lesson 5

CARRYING CAPACITY

Aim

Understand carrying capacity and its importance in managing wildlife populations.

INTRODUCTION

Wildlife managers differ to farmers in an agricultural setting in the way that they manipulate animal populations. This is due to the different goals of wildlife managers as opposed to those of farmers. A wildlife manager might manipulate an animal population, but wildlife managers are aware of the environmental constraints on the population. Wildlife managers allow for predation and natural environmental changes. They are looking for a balance between the environment and the species. Whilst this might involve occasionally culling species or initiating breeding programs, it is still very different to agricultural animal production. But one thing that is common to both disciplines is the need to be aware of the carrying capacity of a certain area.

Consider the situation of a long drought and its effect on an agricultural enterprise vs a wildlife park. A farmer would try to maximise profit, and this would usually take the form of providing extra feed for his herd. A wildlife manager would not attempt to increase animal numbers and some individuals would die. The reasons for allowing nature to simply take its course include:

- The act of providing food to wildlife during drought will mean that a populations' resistance to future droughts will be weakened. Animals that would have died out in the drought survive, reproduce and pass on their genes. The weak survive where nature would have culled them.
- Whenever a manager intervenes, there are flow-on effects. For example, a wildlife manager who provides extra food during a drought to one species may inadvertently provide more food for the predators of that species. The population of predators then increases, and this may then mean that the predator then decimates the population of the original species.
- Keeping animals alive where nature might otherwise cull them means they are still consuming resources such as grazing fodder. During a drought, this grazing fodder is already scarce. Allowing animals to live and feed through a drought can have a dramatic effect on the amount of food that is available. Many animals may then simply starve to death and could have irreversible impacts on the plant diversity of the area.

There are other examples of ways which wildlife managers can intervene in the population they are managing. In some instances, intervention is necessary. This may because of fragmentation or other changes to habitats, the invasion of pest species or due to critically low numbers within a wildlife population. However, managers need to be aware that their actions may have far reaching, long term effects that extend well beyond the one species that is being manipulated.

Exponential Population Growth

Animals generally give birth to more offspring than will survive to an age where they are able to reproduce. This is especially true in smaller animals. This birth rate allows for the inevitable number of deaths caused by disease, competition for resources and predation. Imagine a situation where such factors were eradicated and deaths no longer balanced out the surplus births. The result would be a population that would grow indefinitely. In fact, such populations can grow at an ever increasing rate of increase – this is known as exponential growth.

It can happen only where there is abundant food, space and resources, and where disease is not a big problem. The rate of population increase is only countered by the reproductive make up of the species. Populations of bacteria, yeast and small mammals such as mice are able to undergo such growth due to their high reproductive capacity. This type of growth is unsustainable, as it very quickly exhausts available resources. Thus populations that do experience exponential growth only do so for a relatively short period before other factors reduce the rate of increase.

As a population becomes denser, there may be factors that come into play that cause higher death rates and lower birth rates. These are known as density dependent factors. Density dependent factors include food supply, disease and predation. Usually where a population is near the centre of its geographical range, its growth is heavily determined by density dependent factors. Below is a graph showing a population in which both its birth rate and death rate are density dependent (k is the point of equilibrium).

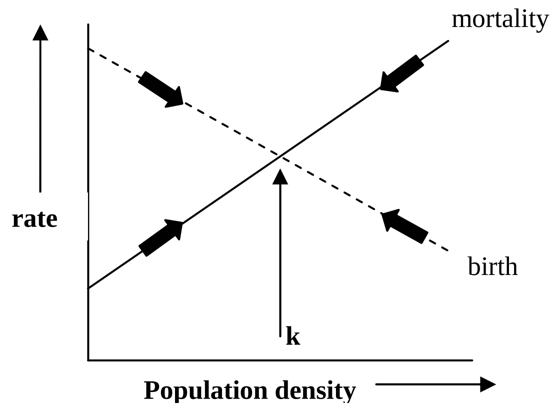


Figure 1: Density dependent population

On the periphery of the geographical range, factors independent of density are more influential. These include mostly weather related factors such as rain, temperature extremes and flooding.

What is Carrying Capacity

A given environment can produce a finite amount of food per year. The amount of animal food present is an obvious limiting factor to the population of animals that can be supported. If more animals are placed in an area than the food source can support, the productivity of the area will be damaged and so will the productivity of the animals. Carrying capacity is the maximum density of animals which a given area will support.

To get a concept of carrying capacity, imagine an area with no wildlife. If one were to release animals in to it, the number of animals would increase slowly at first but will soon rapidly increase as advantage is taken of the plentiful food supply. This is known as the accelerating phase of increase.

As the animals increase in number, so too does the competition for food. As the area can only provide a set amount of grass, there is a limit to how many animals can be supported. The increase in animal numbers will begin to slow – this is known as the decelerating phase of increase. Over time, the numbers of animals will not increase at all. This means that the birth and death rates of the population have reached equilibrium. This is known as the stabilisation phase. In reality, animal numbers may actually increase until they exceed the available resources. This means they reproduce over the carrying capacity of the area. This can result in:

- (i) Extinction
- (ii) Stability
- (iii) Cyclic

Once an animal population reaches its carrying capacity, the rate of increase slows and then stops. The population neither increases nor decreases.

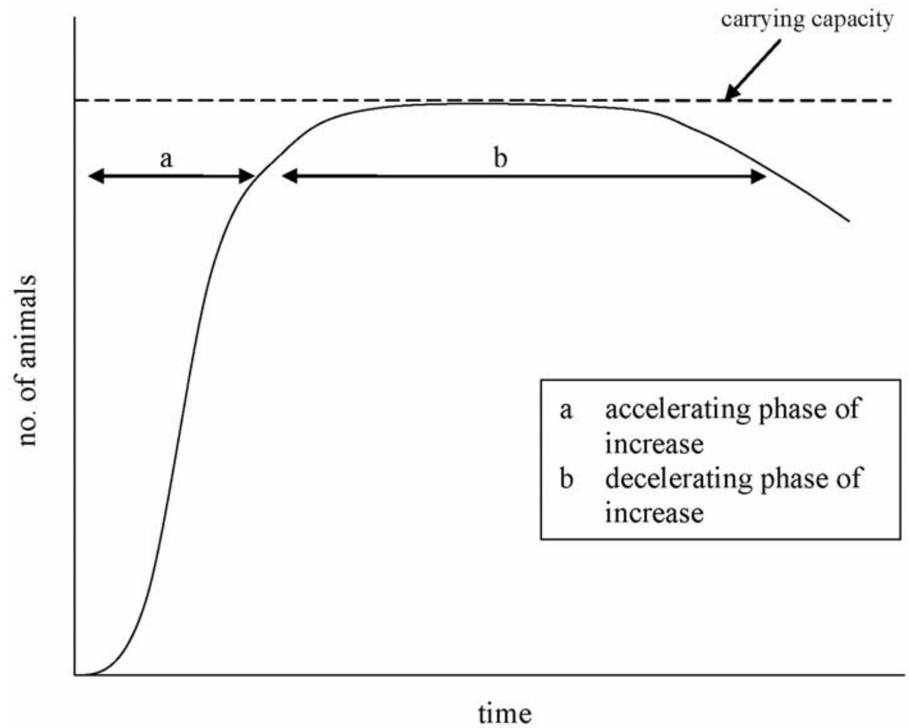


Figure 2: Carrying capacity

In some situations, such fisheries and game parks where hunting is allowed for sport, some animals are removed or harvested. This will reduce the population and the pressure on the resources. As the amount of food subsequently increases, the population can then increase again. Similarly, if a large number of animals is removed, the natural increase in the population will be quite high. In some situations, it can be useful to keep the population below the carrying capacity. This means resources are not exhausted, and the population is always replenishing itself. When many different species are present, it can be very difficult to determine the carrying capacity of an area. Where a manager has total control over the number of animals to keep in a certain area, the best results are achieved where the animals are all kept just below carrying capacity. Overstocking has serious, long term repercussions for an environment.

FISHERIES - STOCK MANAGEMENT

Stock Identity

When fish stock is being exploited commercially, management needs the answers to three questions:

- Which fish belong to the group to be managed?
- Which fish do not belong to this group?
- What is the geographical range of the stock?

The answers to these questions are very important, but they are not easily obtained. For example, if fish have a regular migratory pattern between different regions, the imposition of catches in one region will not prevent stock depletion if the catches in other regions are excessively high.

Stock identity can be researched in many ways, with many different pieces of information being able to be utilised in decision making. Often with the accumulation of more evidence, the initial conclusions will be modified.

One method of investigating stock identify is to tag fish and monitor the locations where the tagged fish are recovered. However, tagging fish is a difficult process, and some fish may even die while being tagged or at a later stage after tagging. The results also depend on the number of fish recovered. If 80% of the fish tagged in one region were recovered in another region, it would be safe to assume that the fish in both regions belonged to the same stock. However, if only 10% were recovered, it would be difficult to determine if the fish in both regions were of the same stock. Other methods of examining stock include:

- Studies of morphology or body form. Clear differences would suggest that the fish seldom intermingle.
- Investigating the distribution of species could be investigated seasonally to find any evidence of migrations between regions, and if gaps in the distribution are regularly maintained. In a given region, if the fish are only a certain size of age, for example very old fish, or if spawning never occurs where the fish are, it can be presumed that the fish have moved in from another region.

Stock Assessment

When the stock identity has been established, determining both the abundance of the fish in the stock and the proportion of the stock that can be harvested is necessary. This is very important if the management measure is to be carried out as a catch quota. Various techniques can be used for these purposes, and they range from the analysis of catch statistics to direct surveys.

The direct survey method is best illustrated by an example. Some bottom trawls would be conducted at several randomly selected locations lying in the stock range. If the total area is known, the mean density of fish per unit area can be calculated. This figure is multiplied by the total area over which the species is distributed, and so the size of the population can be estimated. Knowing this area is necessary, and the method is based on several assumptions:

- That fish are randomly distributed throughout the known range
- That all the fish in the area over which the trawl passes are caught
- That no fish are found in the area above the trawl.

If the last two assumptions are incorrect, the size of the population would be underestimated. Should the fish not be randomly distributed, an overestimation would be made.

Each assessment method is based on one, or more assumptions, so employing a selection of different assessment methods is better. If the answers to the different assessments agree, confidence in the result is increased. If they disagree, one is at least aware of the uncertainties into the possible causes of discrepancies can take place.

Stock Biomass

For any given living resource (whether commercial fish species, endangered bird species, etc) the biomass is defined as the abundance of mass, which is never static. There are gains and losses over time, due to births, deaths and migration. Mortalities may be due to fishing or natural causes such as disease or predators. One way to envision this may be to visualise the process occurring in a water tank. The tank has water gains and losses represented by the flow through pipes. The net production of the tank is the difference between the gains and the losses. When the quantity of liquid entering the tank equals the liquid flowing out, the system is in equilibrium, and net production would be at zero.

When the biomass of a resource is zero, that is when there is no stock, there will be no growth potential and its net production will be zero. In the same way, when the size of the resource is equal to the maximum the ecosystem can support, that is the carrying capacity of the ecosystem, there is no further growth potential. At the intermediate levels conditions will favour the growth of stock. At low stock sizes conditions are very favourable for the growth of stock, especially individual fish, because there will probably be an over abundance of food. However, because of the low level, net production will be low. At levels close to carrying capacity, the conditions for growth in particular fish will be less favourable, because food will be scarce and harder to find. Although, in these conditions, there will be many fish, the growth rate of each individual will be low and their capacity for reproduction may be decreased. The net production of stock will be small. At moderate fish population densities there will be enough individuals with good opportunities for growth. It is in these, without fishing, that net production will be at its greatest.

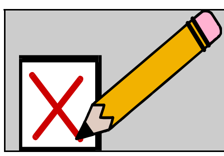
Stock Management Methods
It is theoretically possible to maintain the stock in equilibrium by the simple method of adjusting the flows in the pipes that lead in and out of the tank. The flow related to fishing that human beings find easiest to adjust, is the *catch*. When a catch is set equal to net production of the stock without fishing, the size off the stock should not change if fishing is introduced. The catch is then equal (t) the *equilibrium yield*.

If the stock size is at a level providing the highest net production without fishing and the catch is equal to this production, the catch is equal to the *maximum equilibrium yield*. Management objectives for fish stocks should be to adjust fishing so that the abundance of fish would move towards, and hold at the level that provides maximum equilibrium. However, consideration must be given to the fact that the other flows may also change. For example:

- altered environmental conditions may influence the resources;
- an increase in predators may reduce population of the resources and thereby reduce growth production of the resource;
- an increase in other organisms that feed on the same food, may decrease growth potential.

These factors add complications to the estimate of the size of the possible catch, but in spite of this, the most effective method of limiting the impact of man on a fish stock, or for that matter any other marine resource, is by fixing a ‘catch quota’.

Quotas are usually based on quantity caught, size or sex, depending on the 'fish' species. Crabs are one non-fish group that have sex and size restrictions in many parts of the world.

	**SELF ASSESSMENT** Perform the self assessment test titled ' test 5.1’ If you answer incorrectly, review the notes and try the test again.

SET TASK
Research the difference between r and K strategists in animals giving examples of each (there is information on this in your text to get you started).

	**ASSIGNMENT** Download and do the assignment called ‘Lesson 5 Assignment’.