15.3 POPULATION DYNAMICS

Populations have characteristic pattern of increase which are called **population growth forms**. Such growth forms represent the interaction of biotic potential and environmental resistance. The study of population dynamics is done by three approaches (1) mathematical models, (2) laboratory studies and (3) field studies.

The growth is the most fundamental dynamic feature that a species population displays. Populations characteristically increase in size in a sigmoid, S-shaped or logistic fashion. When a few organisms are introduced into an unoccupied area, the growth of the population is at first slow (**positive acceleration phase**), then becomes very rapid (**logarithmic phase**) and finally slows down as the environmental resistance increases (**the negative acceleration phase**) until an equilibrium level is reached around which the population size fluctuates more or less irregularly according to the constancy or variability of given environment. The level beyond which no major increase can occur represents the saturation level or **carrying capacity**. The carrying capacity or equilibrium density is represented by the letter ***K***. It is often useful to define the maximum rate of growth of the population. This parameter, generally termed the **intrinsic rate of natural increase**, is symbolised r_0 and represents the growth rate of a population that is infinitely small. Accordingly such type of population growth can be described by following **logistic equation**:

$$dN/dt = r_0 N (K - N) /K$$

where r_0 = innate capacity of population to increase (birth rate without resource limitation), N = population size and K = highest population density that can be maintained in real environment, at carrying capacity.

There are two main types of population growth forms. (1) J-shaped and (2) S-shaped or sigmoid forms (Fig. 15.8). The growth forms are due to the nature of species and prevailing environmental conditions. In **J-shaped curve** there is a rapid increase in density with the passage of time (called **exponential growth**). The density values when plotted against time give a J-shaped growth curve and at the peak the population growth ceases abruptly due to environmental resistance. For example, the population growth curve in human populations and growth of yeast, *Drosophila* and rabbit under laboratory conditions show an initial slow rate and then it accelerates and finally slows giving the growth curve which is **sigmoid** or **S-shaped**. The peak constant level represented by K or upper level (called **asymptote**) of the sigmoid curve is called the **maximum carrying capacity**. It marks the limit to which the environment can support the population.

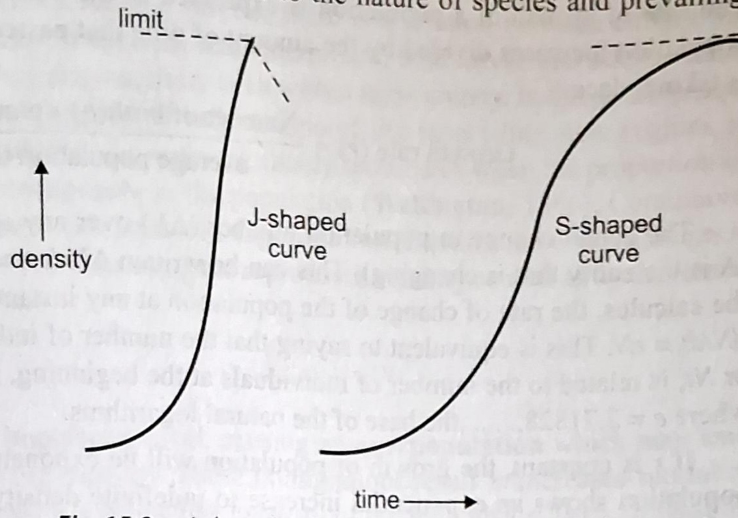

Fig. 15.8. *J-shaped and S-shaped population growth curves.*

Plant Population Dynamics

In many respects, plant populations behave like the animal population, but, they have some unique features such as follows : Most higher plants are **modular** organisms, developing from a single zygote but producing an indeterminate number of repetitive structures, called **modules** vegetatively. A clump of herbs, grasses or trees may be product of one zygote. Plants cannot move to mate or disperse. Thus, they have evolved means as gravity, wind, water flow or animals for dispersal of pollen, seed, vegetative parts, etc. The **seed population** present in the soil for different species are referred to as **seed bank** or **seed pool** (**Silvertown**, 1987). All these seeds do not germinate or all the seedlings do not establish. Some die due to environmental stresses and this is called **environmental sieve** which allows only the stronger individuals to survive. In most cases, the seeds germinate in batches and seedlings of one lot is known as **cohort**. In this way, from a huge seed bank through ecological selection, cohorts are formed and these in turn result into adult population. This process is referred to as **recruitment**. Further, a plant may originate from a vegetative part, called **ramete** (or **tiller**) or from seed called **genet**. Thus, ramete and genet form two levels of population structure. The term **clone** is normally used to designate the population derived from ramete of the same parent plant.

The 3/2 thinning law. Most aspects of growth of population are density related. One important generalisation applied is **3/2 thinning law**. If we plot the relationship between the dry weight and density of shoots (known number of individuals of) in plant population, the line relating weight of each individual to density has a slope of –1.5 (or – 3/2). The slope would be –1, if increasing density has been exactly compensated by reduction in weight of individuals. Thinning is normally inversely density dependent, but does not always occur if the growth of

the plants is extremely plastic. The 3/2 is universal and applied well in a wide variety of pla
from mosses to trees. Exact reason of its occurrence is still not clear.

Growth Rate of Population

The rate of growth of a population is expressed as the number of individuals by which t
population increases divided by the amount of time that passes while this population increa
is taking place:

$$\text{Growth rate } (r) = \frac{\text{Number of birth}(b) - \text{number of deaths } (d)}{\text{average population time internval}}$$

The actual change in population number (ΔN) over any span of time (Δt) is equal to r
(Δ is the entity that is changing). This can be written $\Delta N/\Delta\, t = rN$ or, using the symbology o
the calculus, the rate of change of the population at any instant time (dN/dt) can be expresse
$dN/dt = rN$. This is equivalent to saying that the number of individuals at any arbitrary time
or Nt, is related to the number of individuals at the beginning, N_0, by the equation $Nt = N_0e^{rt}$
where $e = 2.71828$........,the base of the natural logarithms.

If r is constant, the growth of population will be exponential. If r is positive ($b>d$), the
population shows an exponential increase to indefinite density and if r is negative ($b<d$),
shows an exponential decay to extinction. It is impossible for a population to change at a
exponential rate indefinitely. However, there are many cases in which conditions are such
that b is substantially larger than d for a period of time, following which conditions change so
that d becomes much larger than b. The responses of populations to variations of this sort is
an exponential "**population explosion**" during favourable conditions, followed by a "crash"
when conditions change. Diatom populations in Lake Michigan, USA, for example, underg
such exponential increases at different times of years, triggered by variations in abiotic factors
within the lake, followed by equally rapid declines.