Ecosystem rare rich in information network comprising physical and chemical communication flows that connect all parts and regulate the system as a whole. Accordingly, ecosystem can be considered cybernetic in nature, by control functions are internal and diffuse rather than external and specified as in human engineered cybernetic devices. Redundancy- more than one species capable of performing a given function also enhances stability. The degree to which stability is achieved varies widely, depending on the rigor of the external environment as well as on the efficiency of internal controls. There are two kinds of stability:

(i) Resistance stability (Ability to remain "steady" in the face of stress)
(ii) Resilience stability (Ability to recover quickly) the two may be inversely related.

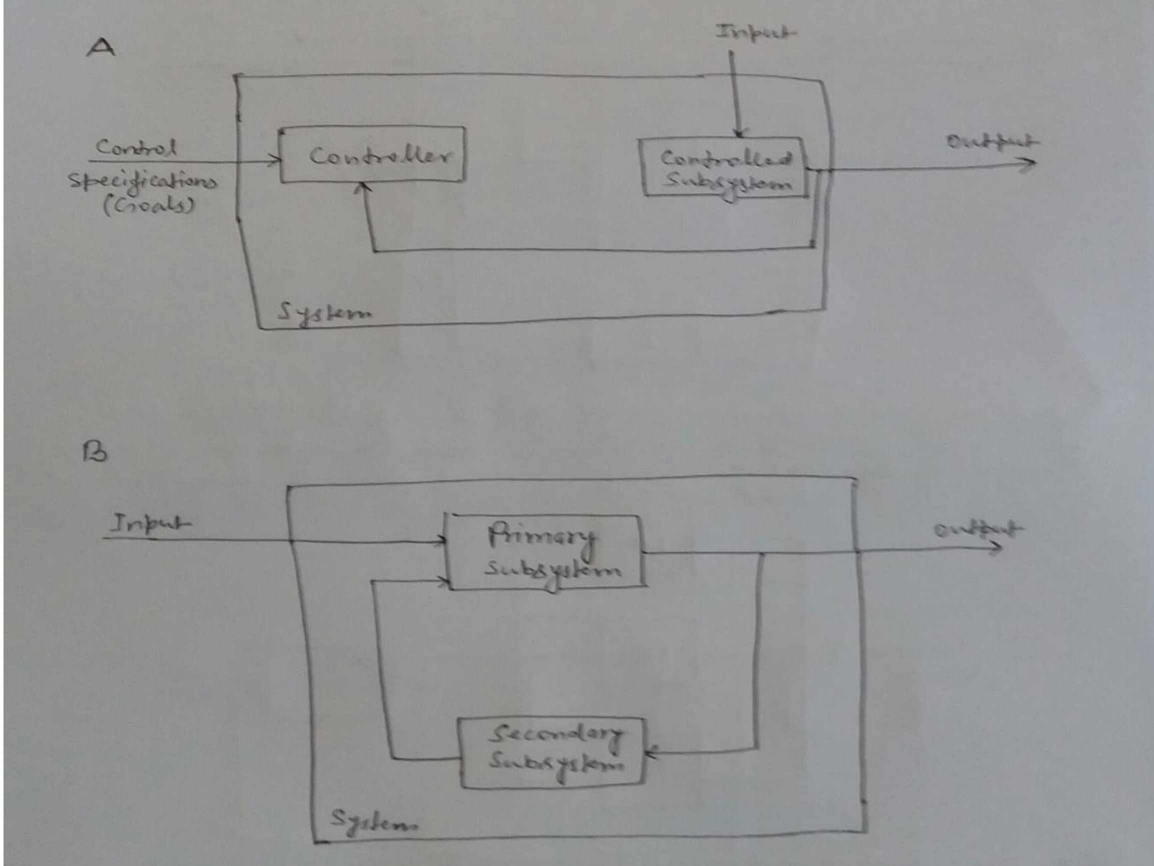

Fig:1- Feedback control systems: A. Model appropriate for human made automatic control systems and homeostatic, goal-seeking organismal systems. B. Model appropriate for nonteleological systems, including ecosystems, where control mechanisms are internal and diffuse, involving interaction between primary and secondary subsystems.

Principles of cybernetics are modeled in figure 1, which compares a goal-seeking automatic control system with specified external control as in a mechanical device (A) with a non-teleologic system with diffuse subsystem regulation as in ecosystem (B). In any case, control depends on feedback, which occurs when part of the output feeds back as input. When this feedback input is positive (like compound interests, which is allowed to become part of the principal), the quantity grows. Positive feedback is deviation accelerating and, of course, necessary for growth and survival of organisms. However, to achieve control- For example, to prevent the overheating of a room or the overgrowth of a population-there must also be negative feedback. The energy involved in a negative feedback signal is extremely small compared with energy flow through the system, whether it is a house-hold controlled heating system, an organism, or an ecosystem. Low-energy components that have very much amplified high-energy feedback effects are major characteristic features of cybernetic systems.

Science of cybernetics, as founded by Norbert Wiener (1948), embraces both inanimate and animate controls. Mechanical feedback mechanisms are often called servomechanisms by engineers, while biologists use the phrase homeostatic mechanisms to refer to organismic systems. Homeostasis (from homeo=same; stasis=standing) at the organisms level is a well known concept in physiology. In servomechanisms and organisms, a distinct mechanical or anatomical “controller” has a specified “set point” figure 1-. In the familiar household heating system, the thermostat controls the furnace; in a warm-blooded animal, a specific brain center controls body temperature. In contrast, the interplay of material cycles and energy flows, along with subsystem feedbacks in large ecosystems, generates a self-correcting homeostasis with no outside control or set pint required (figure 1).

One difficulty in perceiving cybernetic behavior at the ecosystem level is that components at the ecosystem level are coupled in networks by various physical and chemical messengers that are analogous to but far less visible than nervous or hormonal systems of organisms. Simon (1973) has pinted out that “bond energies” which link components, become more diffuse and weaker with an increase in space and time scales. At the ecosystem scale, these weak but very numerous bonds of energy and chemical information have been called the “invisible wires of nature” (H.T. Odum, 1971), and the phenomenon of organisms responding dramatically to low concentration of substances is more than just a weak analogy to hormonal control. Low energy causes producing high energy effects are ubiquitous in ecosystem networks. For examples

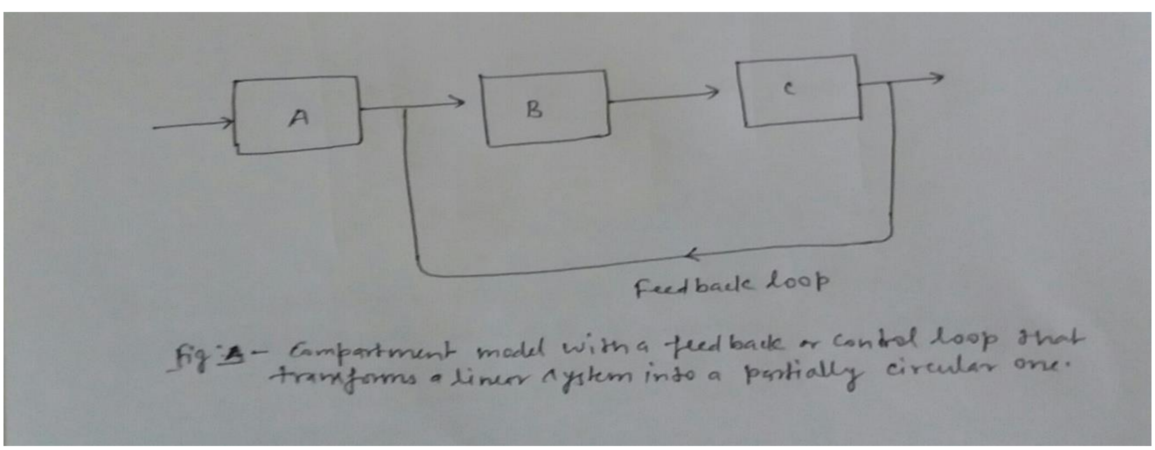

Fig A- Compartment model with a feedback or control loop that transforms a liner system into a partially circular one.

Tiny insects known as parasitic hymenoptera in a grassland ecosystem account for only a very small portion of the total community metabolism, yet they can have very large controlling effect on total primary energy flow by the impact of their parasitism on herbivorous insects. In a cold spring ecosystem model, described by Patten and Auble (1979), a small biomass of carnivores improbably regulates bacteria through a feedback loop in which only 1.4 percent of the energy input to the system is feedback to the detrital substrate of the bacteria. In Figure of ecological system are (figure A, B) this phenomenon is commonly shown as a reverse loop in which “downstream” energy of low quantity is feedback to an “upstream” component with a greatly augmented effect in controlling the whole system. This type of amplified control, by virtue of position in a network, is exceedingly widespread and indicates the intricate global feedback structure of ecosystem.

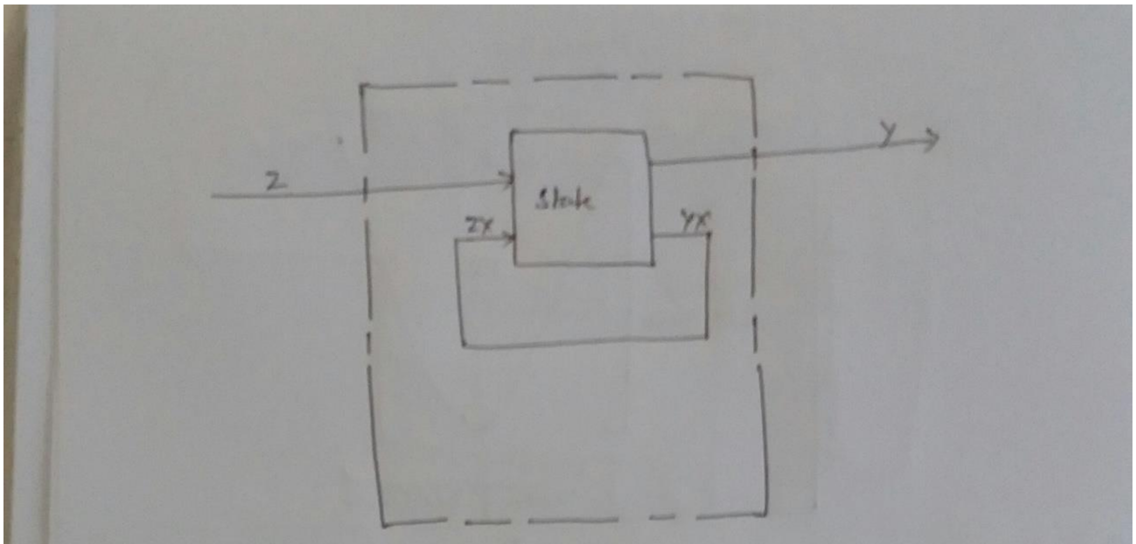

Fig: B A general systems model with inputs Z and output Y. The state of the system and its behaviour over time depend on the interaction of external input Z with internal feedback loop input ZX.

In addition to feedback control, redundancy in functional components also contributes to stability. For example, if several species of autotrophs are present, each with a different temperature operating range, the rate of photosynthesis of the community as a whole can remain stable despite changes in temperature. Beyer (1962) has demonstrated this kind of homeostasis in a microcosm experiment. In figure 3 compares negative feedback control with redundancy control, or what Hill and Durham (1978) and Hill and Wiegert (1980) call “congeneric homotaxix”. In figure 2 three components (A,B,C) having a similar function are arranged in parallel to show how they can compensate for one another by providing alternate pathways for energy and material flows. In this manner a controlled response to a disturbance can be achieved without feedback.

Homeostatic mechanisms have limits beyond which unrestricted positive feedback leads to death unless adjustment can be made. As stress increases, the system, although controlled, may not be able to return to exactly the same level as before. In fact, C.S. Holling (1973) has developed a widely accepted theory that populations and, by inference, ecosystems have more than one equilibrium state and often return to a different one after a disturbance. Remember how CO_2 introduced into the atmosphere by human activities is largely, but not quite, absorbed by the carbonate system of the sea and other carbon storages, but as the input increases, new equilibrium levels in the atmosphere are higher. In this case, even a slight shift may have far-reaching effects. On many occasions, really good homeostatic control comes only after a period of evolutionary adjustment.

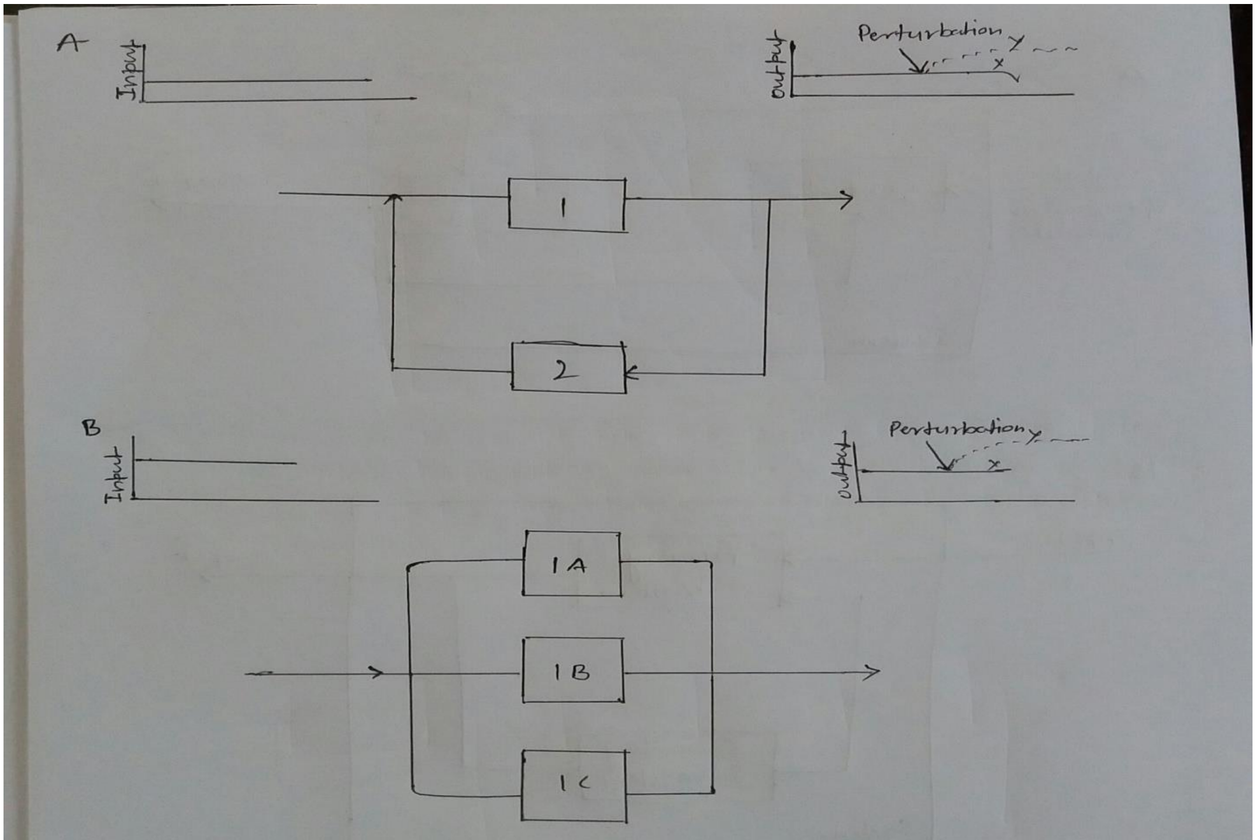

Fig:2- Two contrasting mechanisms for maintaining stability in an ecosystem: A. by negative feedback, and B, by redundancy in functional components. In both cases output, x, remains unchanged following a perturbation, in contrast to a deflected output, y, as would occur in the absence of a controlled response.

The stability actually achieved by a specific ecosystem depends not only on its evolutionary history and on efficiency of internal controls but also on the nature of the input environment and perhaps also on complexity. Generally, ecosystems tend to become more complex in benign physical environments than when subjected to stochastic input disturbances such as storms. Functional complexity seems to enhance stability more than structural complexity, but cause-and-effect relationships between complexity and stability are little understood.

Part of the difficulty in dealing with the concepts of homeostasis and stability is semantic. A dictionary definition of the term “stability” is for example, “The property of a body that causes it, when disturbed from a condition of equilibrium to develop forces or moments that restore the original condition". For ecological perspectives two kinds of stability can be contrasted as shown in figure 3.

(i) Resistance stability indicates the ability of an ecosystem to resist perturbations (disturbances) and maintain its structure and function intact.

(ii) Resilience stability indicates ability to recover when the system is disrupted by a perturbation.

Growing evidence shows that these two kinds of stability may be mutually exclusive, or to put it in order words, it is difficult to develop both at the same time.

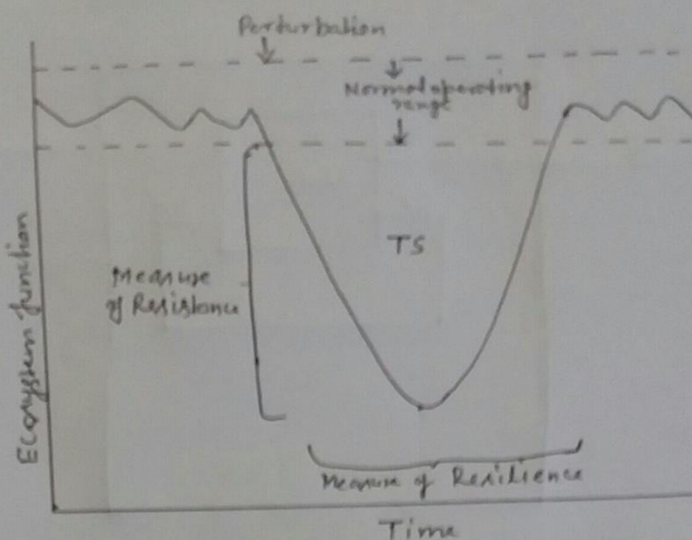

Fig:3- Resistance and resilience stability. When a perturbation causes a major ecosystem function to deviate from the normal operating range, the degree of deviation is a measure of relative resistance, while time required for recovery is a measure of relative resilience. The area under the curve is a relative measure of total stability (TS).

Reference:

E.P. Odum: Basic Ecology