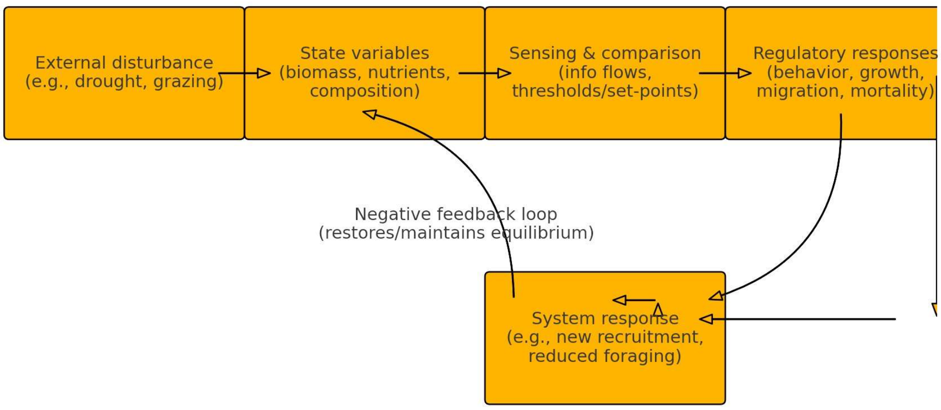
Q3. Describe self-regulation and stability in ecosystems

a) Explain the concept of homeostasis in ecosystems. (4 marks)

Homeostasis in ecosystems is the tendency of key state variables—such as biomass, species abundances, nutrient stocks, and productivity—to remain within bounded ranges despite external disturbances. This stability emerges from **distributed feedbacks** among organisms and between biotic and abiotic components (e.g., resource limitation, density dependence, trophic interactions, and microclimate buffering).

Key points

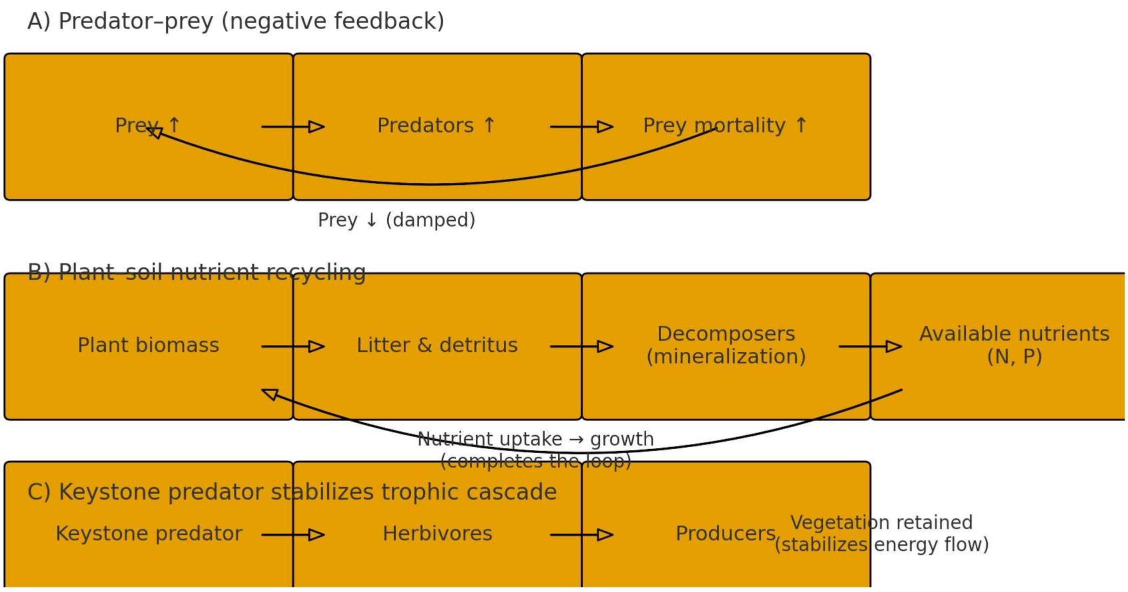
- **Dynamic, not static:** Ecosystem homeostasis means *fluctuations around* moving set-points (seasonal or successional baselines), not a fixed constant.
- **Negative feedbacks dominate stabilisation:** When a variable deviates (e.g., herbivore density ↑), processes are triggered that counteract the change (predation, disease, resource depletion), nudging the system back toward its operating range.
- **Cybernetic framing:**
    - *Sensors/indicators*: organismal responses to resource density, temperature, crowding.
    - *Controllers*: interaction strengths (competition, predation), physiological thresholds, behavior.
    - *Effectors*: changes in growth, mortality, reproduction, dispersal, and decomposition that produce corrective responses.
- 

b) Discuss examples of self-regulating mechanisms in nature. (3 marks)

1. **Predator–prey density feedback (negative feedback):**
   Rise in prey → predator reproduction/survival improves → predation pressure

increases → prey decline → predator numbers subsequently fall. This damping cycle prevents runaway oscillations under many conditions.

2. **Plant–soil nutrient recycling:**
   Plant biomass → litter → microbial decomposition → mineral nutrients (N, P) → plant uptake → biomass. The loop keeps nutrients available locally and stabilizes productivity, especially in nutrient-poor systems.
3. **Keystone predation and trophic cascades:**
   A keystone predator suppresses dominant herbivores, preventing overgrazing and maintaining producer biomass and habitat complexity—stabilizing energy flow and niches for many species.
4. *(Enrichment)* **Density dependence & carrying capacity (K):**
   As populations approach K, resource limitation elevates mortality or reduces fecundity—self-thinning in plant stands is a classic case.
5. *(Enrichment)* **Behavioral/physiological feedbacks:**
   Stomatal closure under vapor-pressure deficit limits water loss and heat stress; colony-level thermoregulation in social insects stabilizes brood temperatures.



c) State two threats to ecosystem stability. (3 marks)

1. **Biodiversity loss (reduced functional redundancy):**
   Fewer species and trait diversity mean fewer "backup" pathways to perform key functions (pollination, decomposition, nutrient retention). Compensatory dynamics weaken, so shocks translate into larger, longer deviations—**resilience** ↓.
2. **Climate change and extremes (risk of tipping points):**
   More frequent heatwaves, droughts, fires, and marine heat events intensify **positive feedbacks** (e.g., vegetation dieback → albedo changes; lake warming → stratification

→ hypoxia). Systems can cross thresholds into **alternate stable states** (eutrophic lakes, desertified rangelands, algal-dominated reefs).

(Other notable threats: habitat fragmentation disrupting dispersal feedbacks; invasive species that re-wire food webs; chronic nutrient loading causing self-reinforcing eutrophication.)