SSE 2300/CE4990: System Dynamics

Population Dynamics and Carrying Capacity

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Underlying Ideas

The following are some ideas that drive the reasoning presented here:

- There cannot be growth forever in a system that has finite resources.
- Such a system will initially exhibit exponential growth until it starts approaching the limits to growth. Meanwhile the growth will be fueled by a positive feedback, i.e. growth will promote more growth.
- As the system approaches its limits to growth, a negative feedback will commence (or become increasingly strong). This feedback will not enhance growth in the system.
- When the negative feedback is equal to the positive feedback that fuels growth then the system will show no growth and be at stable equilibrium.
- When the negative feedback overwhelms the positive feedback the system will show exponential decay.

Causal Loop Diagram

Underlying Theory

System population at any time = P

Net finite resources in the system = R_0

Let per capita resource consumption = R

Carrying capacity: The limiting population that the system can support given the resources: $C = \frac{R_0}{R}$

Consider the quantity $\frac{P}{C}$.

Also consider fractional birth rate b, and fractional death rate d. Both these quantities are functions of $\frac{P}{C}$.

Time rate of change of population $= (b - d)P$.

Hence the following conditions hold:

$\frac{P}{C} < 1$, when $(b - d) > 0$: Desirable

$\frac{P}{C} = 1$, when $(b - d) = 0$: Stable Equilibrium

$\frac{P}{C} > 1$, when $(b - d) < 0$: Undesirable