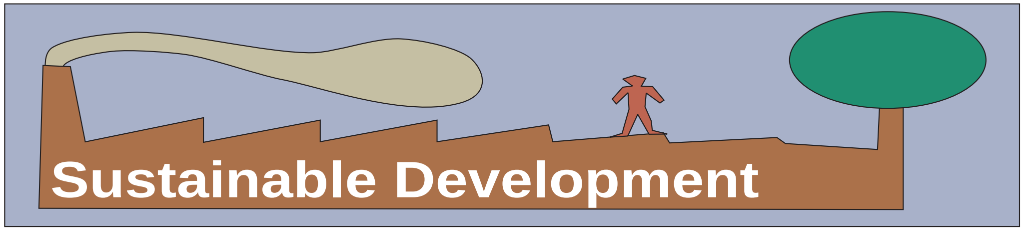
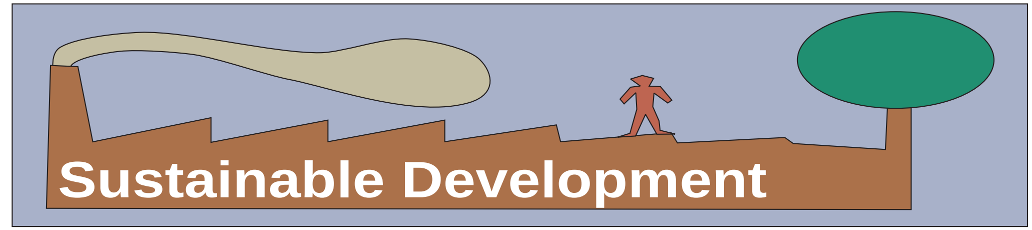




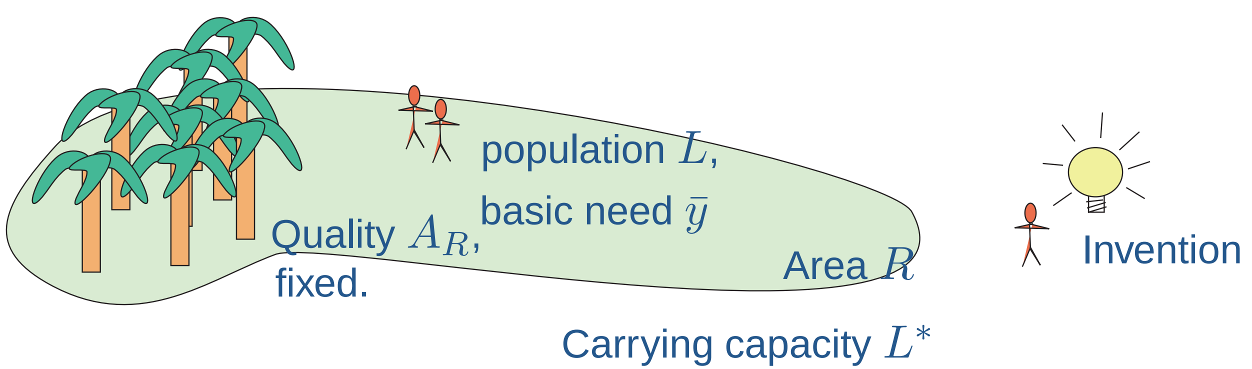
Chapter 2

Malthusian growth

Technological progress and Malthusian growth

We want a model with

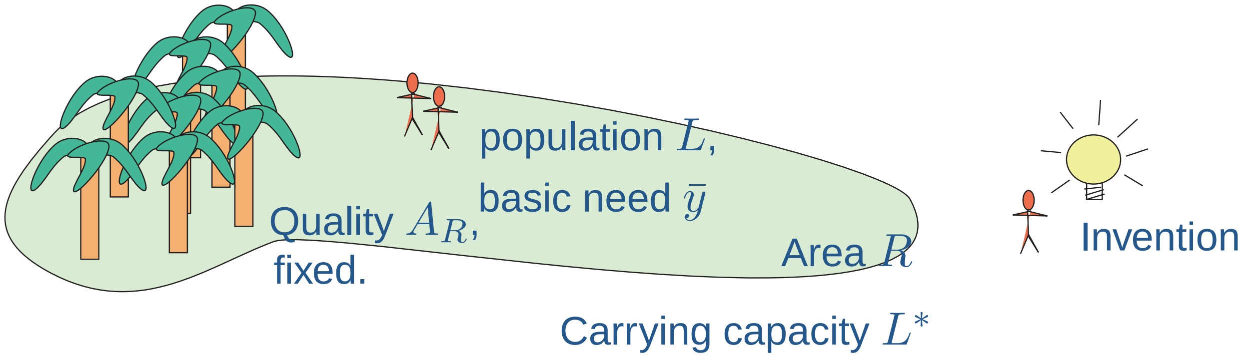
- Land fixed (quality and quantity);
- Basic needs fixed;
- Logistic population growth;
- Carrying capacity determined by productivity in relation to basic needs;
- Productivity grows due to technological progress, linked to population size.



Technological progress and Malthusian growth

- Technological progress and Malthusian growth
- A fragile ecosystem and megafaunal extinction
- The post-Malthusian economy

$$
\begin{aligned}
L_{t+1} - L_t &= \theta L_t (1 - L_t / L_t^*), \\
Y &= (A_L L)^{1-\alpha} (A_R R)^{\alpha}, \\
Y/L &= A_L^{1-\alpha} (A_R R / L)^{\alpha}, \\
\bar{y} &= A_L^{1-\alpha} (A_R R / L^*)^{\alpha}, \\
L^* &= \frac{A_R R}{\bar{y}^{1/\alpha}} A_L^{(1-\alpha)/\alpha}, \\
A_R &= 1, \quad A_{Lt}/A_{Lt-1} = 1 - \delta + \zeta(\Omega L_{t-1})^{\phi}.
\end{aligned}
$$



Technological progress and Malthusian growth

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A_R &= 1, \quad A_{Lt}/A_{Lt-1} = 1 - \delta + \zeta (\Omega L_{t-1})^{\phi}.
\end{aligned}
$$

$\alpha = 0.4$ $\quad$ $\zeta = 0.020012$

$\phi = 0.2$ $\quad$ $\theta = 0.06$

$\delta = 0.02$ $\quad$ $\Omega L(0) = 1.$

$t = 20$ years.

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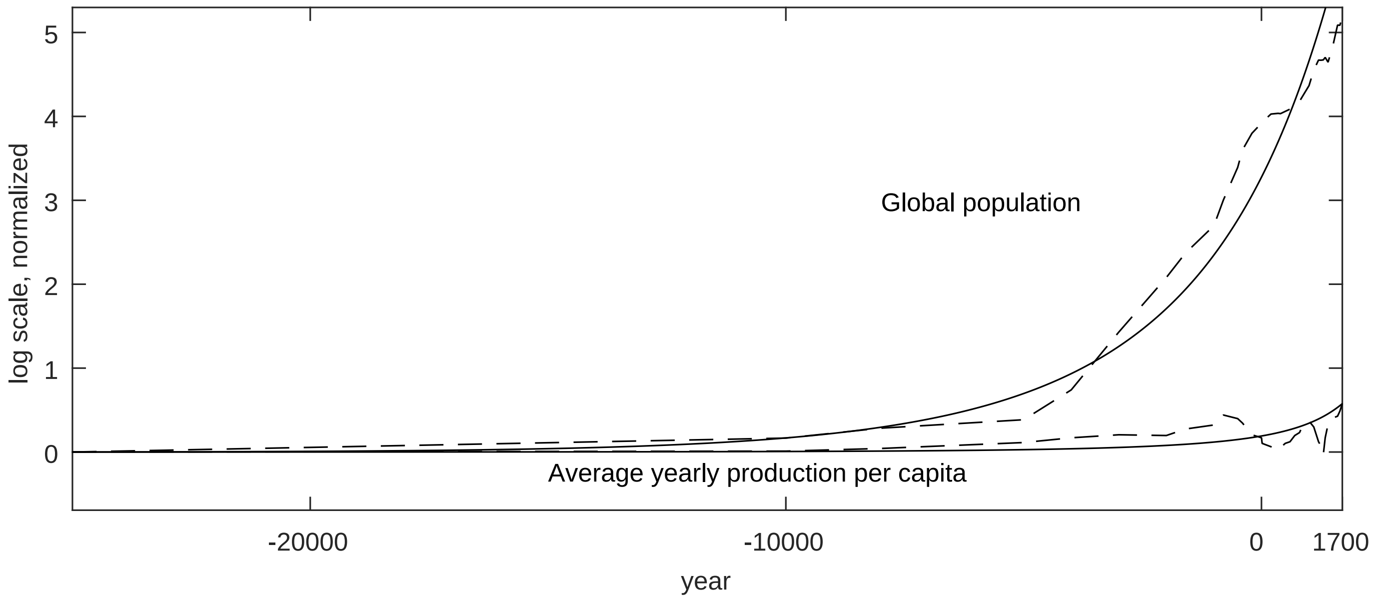

Figure 1: Global product and population. Continuous lines, model simulation; dashed lines, historical data from Brad DeLong.

A fragile ecosystem and megafaunal extinction

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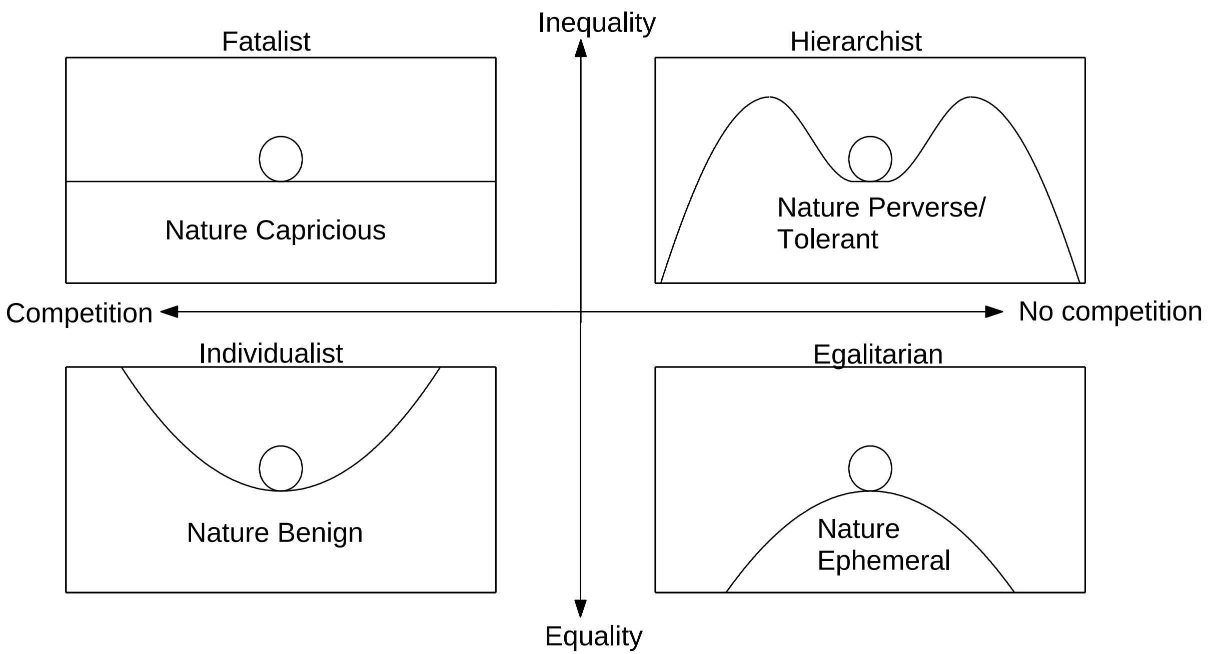
A fragile ecosystem and megafaunal extinction



States of nature, adapted from Thompson et al. 1990

We choose the hierarchist's approach of trying to explain megafaunal extinction as the regrettable result of bad management of the 'resource'.

A fragile ecosystem and megafaunal extinction

Since the extinctions occurred over relatively short timescales compared to preindustrial rates of technological progress, we can safely ignore technological progress in our model.

The simplest possible approach is to build a predator–prey model in which humans are completely dependent on 'harvesting' megafauna, the population of which decline under harvesting pressure.

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A fragile ecosystem and megafaunal extinction

Y is harvest, L human population, N animal population. Linear harvest function, logistic human population growth:

$$Y = \phi L N.$$

$$L_{t+1} - L_t = \theta_L L_t [1 - \bar{y}/(Y_t/L_t)].$$

When $Y/L = \bar{y}$, human popn is stable. Insert $Y/L = \phi N$ to yield

$$L_{t+1} - L_t = \theta_L L_t [1 - \bar{y}/(\phi N_t)]. \quad (1)$$

This is the equation for the dynamics of human population given the animal population. When $N = \bar{y}/\phi$, human popn stable.

Logistic animal population growth, with harvest pressure:

$$N_{t+1} - N_t = \theta_N N_t [1 - N_t/N^*] - \phi L_t N_t. \quad (2)$$

A fragile ecosystem and megafaunal extinction

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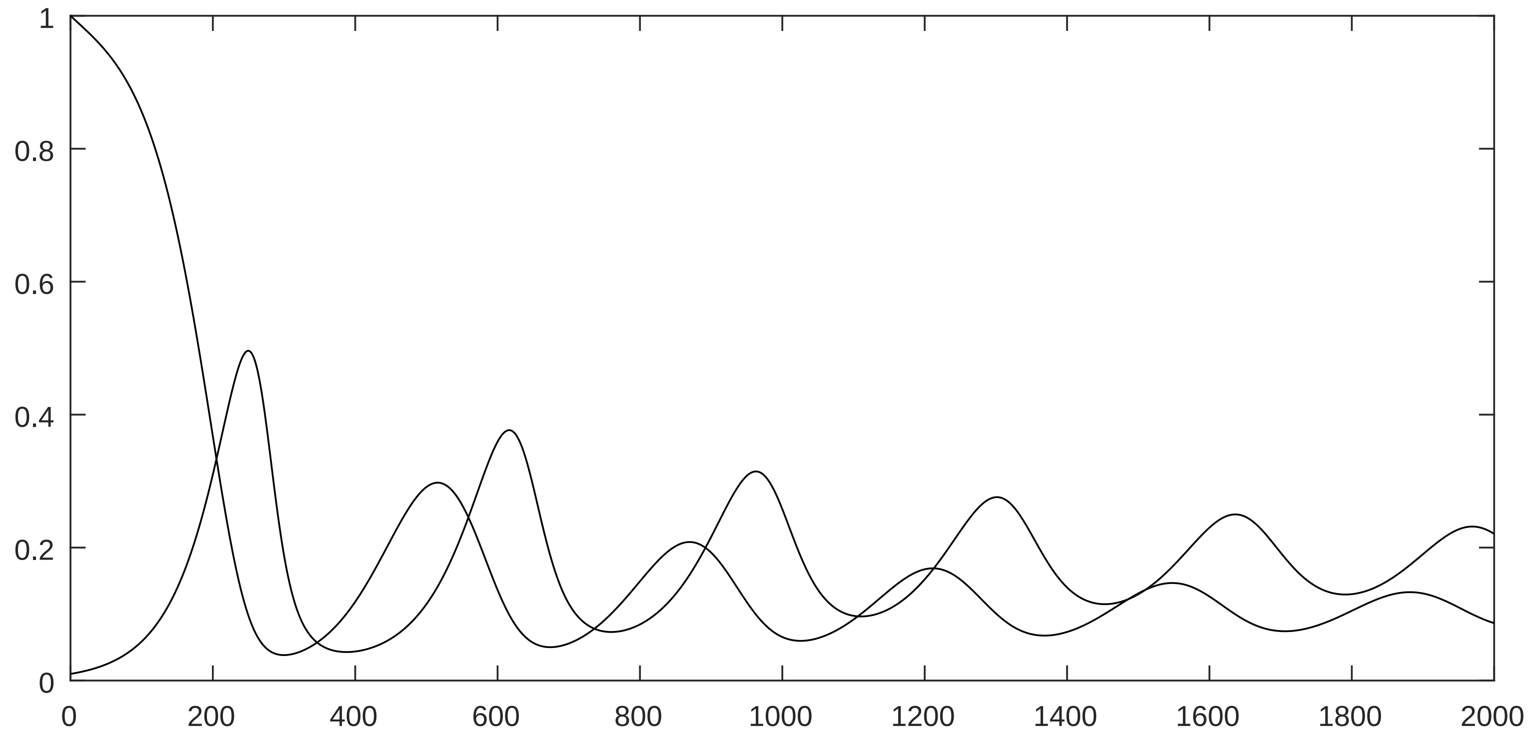

Figure 2: Development of the numerical model over time

A fragile ecosystem and megafaunal extinction

What is the maximum sustainable human population?

Why don't we get there in the simulation?

A fragile ecosystem and megafaunal extinction

The model doesn't lead to extinction. Why not?

How could we adapt the model to deliver extinction?

A fragile ecosystem and megafaunal extinction

Add small animals S:

$$Y = L(\phi_N N + \phi_S S),$$

Stock S adapts instantly to hunting pressure, hence $S = S^* - \phi_S S L$ and $S = S^*/(1 + \phi_S L)$. Then

$$Y/L = \phi_N N + \phi_S S^*/(1 + \phi_S L),$$

and

$$L_{t+1} - L_t = \theta_L L_t \left\{1 - \bar{y}/[\phi_N N_t + \phi_S S^*/(1 + \phi_S L_t)]\right\}.$$

Recall

$$N_{t+1} - N_t = \theta_N N_t (1 - N_t/N^*) - \phi_N L_t N_t.$$

A fragile ecosystem and megafaunal extinction

$$L_{t+1} - L_t = \theta_L L_t \left\{1 - \bar{y}/[\phi_N N_t + \phi_S S^*/(1 + \phi_S L_t)]\right\}.$$
$$N_{t+1} - N_t = \theta_N N_t(1 - N_t/N^*) - \phi_N L_t N_t.$$

Assume $N = 0$. Then we have $Y = L\phi_S S$, $Y/L = \phi_S S^*/(1 + \phi_S L)$, and $L_{t+1} - L_t = \theta_L L_t[1 - \bar{y}/(\phi_S S^*/(1 + \phi_S L_t))]$. Solve for L_t when $L_{t+1} - L_t = 0$ to yield

$$L = S^*/\bar{y} - 1/\phi_S.$$

This shows that if $\phi_S S^* < \bar{y}$ then the small animals are too scarce (or hard to catch) to sustain a human population on their own.

A fragile ecosystem and megafaunal extinction

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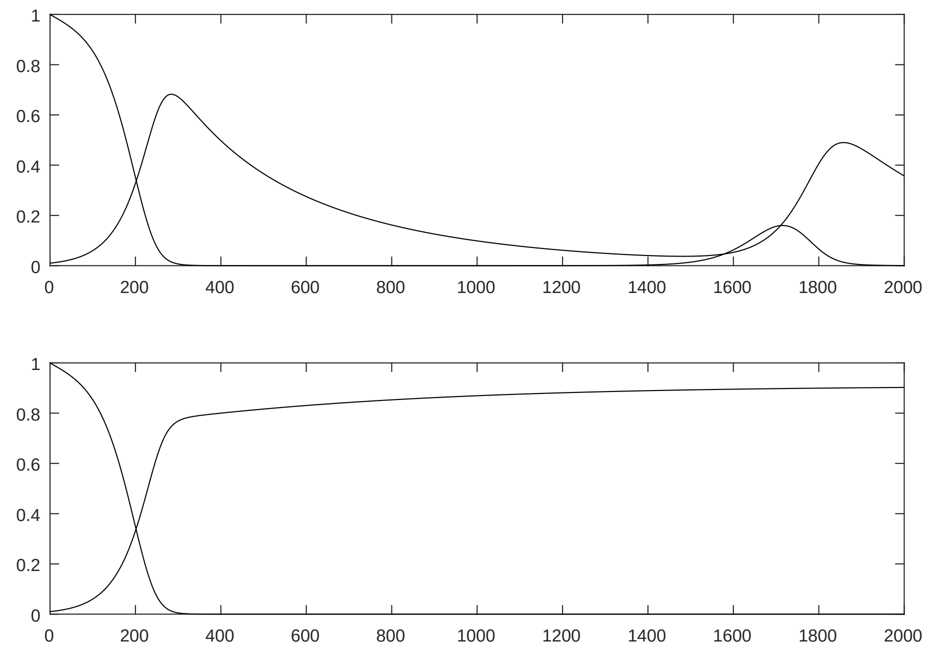

Figure 3: Development of the numerical model over time. Top, $\phi_S S^* < \bar{y}$; bottom, $\phi_S S^* > \bar{y}$.

What is going on here?

The post-Malthusian economy

The post-Malthusian economy

Why are Malthusian models not relevant to modern economies?

At least, not unless we assume cataclysmic environmental damages.

What kind of models are relevant?