Practical 1. Calculating ecosystem services flows and capacity: the case of a forest ecosystem providing timber and rattan.

Imagine a forest divided into 16 different plots/sections of each 1 ha. Each plot has a specific timber stand in year 1, and a specific soil fertility (expressed as soil organic matter content). Within each plot, assume homogeneous timber stands and soil fertility. For reasons of simplicity, timber is quantified in terms of biomass (expressed as ton dry matter/ha). Soil fertility and biomass of the tree stands in year 1 are as follows (note that biomass and soil fertility are 'ecosystem condition' indicators):

System 1. Numbers represent biomass and soil fertility in each plot, in year 1. Every plot is 1 ha.

BASIC DATA

Condition	Soil fertility (% organic matter content)				Biomass (ton/ha)			
	West				West			
North					North			
	1.2	1.2	1.2	1.2	150	150	150	190
	1.2	1.2	1.2	1.3	150	150	150	194
	1.2	1.2	1.3	1.3	150	150	150	188
	1.2	1.3	1.4	1.4	260	298	342	392

The forest is fully grown after 100 years and then contains a biomass of 400 ton dry matter/ha.

Question 1. Calculate the **capacity** of the forest to support timber growth in year 1. Calculate this capacity based on the notion that only the increment per parcel can be harvested. Assume that all biomass can be harvested and is equally interesting to the forester.

The (re-)growth of the forest is given by a logistic growth function

$dB/dt = r*B*(1-B/400)$

with B = Biomass (standing stock), in ton/ha
and r = 0.1*SF (r = the logistic growth factor)
SF = Soil Fertility (expressed in % organic matter)

Calculate the increment (/capacity) in year 1 for every plot, and for the forest area as a whole.

Annual harvest of an increment is not realistic for a forestry operation. The harvest of annual increments could work for, for example, populations of deer in a forest divided into separate habitats, provided this level of control of population numbers would be possible.

Imagine therefore that the forest is divided into 4 concessions, with the following biomass (system 2). The soil fertility is as above.

System 2. Numbers represent biomass per plot. Every plot is 1 ha.

	West			
North				
	0	0	90	90
	0	0	90	90
	200	200	390	390
	200	200	390	390
Average biomass		170		

The corresponding age of the forest is as follows: upper-left corner: 0 years, upper right corner: 25 years, bottom left corner: 50 years, bottom right corner: 100 years. Imagine that the forest is managed with a sustainable forest management system involving one harvest every 25 years. The first harvest takes place in year 1.

Question 2. Which amount of timber (expressed as biomass) can be harvested in year 1 ? Which amount is harvested if expressed on an annual basis (i.e. expressed in ton/year?)

Note that in this management system, the flow of the service equals the capacity of the service to generate an ecosystem service, i.e. harvesting takes place at the maximum sustainable level, given the management system applied to this ecosystem.

Question 3. The harvested amount in system 2 is considerably lower than the amount harvested in system 1. Why is this the case ? And why do foresters world-wide follow a system comparable to system 2 rather than system 1 ?

Note that the capacity to generate a service depends on the management system in place ! And that the management system is determined not only by the maximising physical flows of an ecosystem service but also by economic (and potentially social and institutional) factors.

Now let's return to system 1, but assume that the biomass represents not standing stock of trees but standing stock (in kg/ha) of a Non-timber forest product, for instance rattan. The logistic growth curve, we assume for reasons of simplicity, is the same.

Assume that 20 kg of rattan is harvested in year 1 in every plot. Assume that growth takes place prior to the harvest (i.e. harvest is at the end of the growing season).

Question 4. What is the flow of the ecosystem service 'supply of rattan'? And what is the difference between the flow and the capacity to generate this service (note that you can assume this capacity to be the same as in Question 1, except that it is now expressed as kg rattan instead of ton of wood) ?

Question 5. What is the standing stock (i.e. a 'condition' indicator) in year 2 ?

Now we will increase the complexity of the dynamics of the ecosystem. A low forest cover leads to enhanced erosion, as follows:

$dSF/dt = =0.1 \times e^{(B/400)} - 0.22$

(note that soil organic matter contents gradually decrease in a forest with low biomass, and increase in a full grown forest, in this highly simplified equation)

Question 6. Assume that the harvest of rattan remains 20 kg/ha/year during a 5 year period. Calculate the change in ecosystem capacity (to supply rattan) during this five year period.