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

Answers

System 1.

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 regrowth 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.

Answer:

	West			
North	1	2	3	4
1	11	11	11	12
2	11	11	11	13
3	11	11	12	13
4	11	10	7	1

The sum for all parcels is 169 ton biomass/year.

System 2. Four forest blocks

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

Answer: in year 1, an amount of 4 * 390 = 1560 ton can be harvested

Note that both 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 ?

Answer: This is due to the need to harvest large logs, and the occurrence of fixed costs (e.g. for moving tractors to the site)

System 1. heterogeneous forest blocks

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 rattan, a Non-timber forest product. 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 actual harvest and the capacity to generate this service ?

Answer: The flow is 20 kg/parcel/year * 16 parcels = 320 kg rattan/year.

The capacity is the same as in question 1, i.e. 169 kg rattan per year.

	West			
North	1	2	3	4
1	11	11	11	12
2	11	11	11	13
3	11	11	12	13
4	11	10	7	1

The difference is 320 – 169 = 151 kg/year.

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

Answer:

The standing stock in the beginning of the year (opening stock): 3214 kg rattan
Regrowth: 169 kg rattan
Harvest: 320 kg rattan
Standing stock end of the year (closing stock): =3214+169-320 = 3063 kg rattan

Now we will increase the complexity of the dynamics of the ecosystem. A low forest cover leads to enhanced erosion (note that soil organic matter contents gradually 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.

See below. Note that the ecosystem is experiencing a positive feedback mechanism.

YEAR 1

Standing biomass year 1

	West			
North	1	2	3	4
1	150	150	150	190
2	150	150	150	194
3	150	150	150	188
4	260	298	342	392

Soil Fertility in year 1

	West			
North	1	2	3	4
1	1.2	1.2	1.2	1.2
2	1.2	1.2	1.2	1.3
3	1.2	1.2	1.3	1.3
4	1.2	1.3	1.4	1.4

Regrowth year 1

	West			
North	1	2	3	4
1	11	11	11	12
2	11	11	11	13
3	11	11	12	13
4	11	10	7	1

harvest year 1

	West			
North	1	2	3	4
1	20	20	20	20
2	20	20	20	20
3	20	20	20	20
4	20	20	20	20

YEAR 2

Standing biomass begin year 2

	West			
North	1	2	3	4
1	141	141	141	182
2	141	141	141	187
3	141	141	142	181
4	251	288	329	373

Soil fertility begin year 2

	West			
North	1	2	3	4
1	1.13	1.13	1.13	1.14
2	1.13	1.13	1.13	1.24
3	1.13	1.13	1.23	1.24
4	1.17	1.29	1.41	1.44

Regrowth year 2

	West			
North	1	2	3	4
1	10	10	10	11
2	10	10	10	12
3	10	10	11	12
4	11	10	8	4

harvest year 2

	West			
North	1	2	3	4
1	20	20	20	20
2	20	20	20	20
3	20	20	20	20
4	20	20	20	20

YEAR 3

Standing biomass begin year 3

	West			
North	1	2	3	4
1	132	132	132	173
2	132	132	132	179
3	132	132	133	173
4	242	278	317	357

Soil fertility begin year 3

	West			
North	1	2	3	4
1	1.05	1.05	1.05	1.08
2	1.05	1.05	1.05	1.18
3	1.05	1.05	1.15	1.18
4	1.14	1.27	1.42	1.48

Regrowth year 3

	West			
North	1	2	3	4
1	9	9	9	11
2	9	9	9	12
3	9	9	10	12
4	11	11	9	6

harvest year 3

	West			
North	1	2	3	4
1	20	20	20	20
2	20	20	20	20
3	20	20	20	20
4	20	20	20	20

YEAR 4

Standing biomass begin year 4

	West			
North	1	2	3	4
1	121	121	121	164
2	121	121	121	171
3	121	121	124	165
4	233	269	307	342

Soil fertility begin year 4

	West			
North	1	2	3	4
1	0.97	0.97	0.97	1.01
2	0.97	0.97	0.97	1.12
3	0.97	0.97	1.07	1.11
4	1.10	1.25	1.42	1.50

Regrowth year 4

	West			
North	1	2	3	4
1	8	8	8	10
2	8	8	8	11
3	8	8	9	11
4	11	11	10	7

harvest year 4

	West			
North	1	2	3	4
1	20	20	20	20
2	20	20	20	20
3	20	20	20	20
4	20	20	20	20

YEAR 5

Standing biomass begin year 5

	West			
North	1	2	3	4
1	109	109	109	154
2	109	109	109	162
3	109	109	113	156
4	223	260	297	330

Soil fertility begin year 5+H243

	West			
North	1	2	3	4
1	0.88	0.88	0.88	0.94
2	0.88	0.88	0.88	1.05
3	0.88	0.88	0.98	1.04
4	1.06	1.23	1.41	1.51

Regrowth year 5

	West			
North	1	2	3	4
1	7	7	7	9
2	7	7	7	10
3	7	7	8	10
4	10	11	11	9

harvest year 5

	West			
North	1	2	3	4
1	20	20	20	20
2	20	20	20	20
3	20	20	20	20
4	20	20	20	20