

# MATHEMATICAL MODELLING

2024/25

- 2. HOMEWORK -

April 28, 2025

**Handing in your homework.** Homeworks should be submitted via e-classroom

**by midnight on Friday, May 30, 2025.**

Upload a zip file that contains a report and all MATLAB files used in the analysis. The report should be in pdf format and should contain a detailed description of the modelling and your conclusions. Name your zip file **surname\_hw2.zip**.

The homework is worth 30 points.

**Description of the problem.** A team of urban planners and ecologists is devising a city expansion. The area considered for an extension is home to an endangered species and the planners must ensure that some of its habitat is conserved. There are six candidate conservation habitats, each providing a different annual ecological benefit for the species (e.g. taking into account size, food availability, quality of breeding sites etc.) but coming at a different conservation cost.

- I. (10pts) The table below lists the evaluation of annual species benefits and the conservation cost for all six habitats.

Habitat	Species benefit	Conservation cost (€)
1	40	700.000
2	38	600.000
3	30	500.000
4	26	400.000
5	20	300.000
6	18	250.000

Assume that city planners face the following constraints:

- The total available budget is 2.000.000 €.
- At least two habitats must be conserved to support biodiversity.
- At most four habitats can be conserved to allow for infrastructure development.

The goal is to maximize annual species benefit while ensuring that the constraints are met. Formulate the linear program and solve it using MATLAB. Which habitats are selected for conservation and what is the optimal annual species benefit?

- II. (20pts) Suppose that the endangered species exhibits a seasonal migration pattern, requiring different habitats at different times of the year (e.g. suitable breeding sites must be available in the spring and the summer and shelters must be available in the winter, some sites may not be available because of annual floods etc.).

The following table show the suitability of the six habitats in different seasons:  $\times$  denotes that the site is not habitable in the season and the numeric value gives the seasonal species benefit in habitable areas. The seasonal species benefit is obtained only when the species occupies the habitat in that season.

Habitat	Spring & summer	Autumn	Winter
1	20	$\times$	20
2	14	10	14
3	$\times$	10	20
4	10	$\times$	16
5	8	4	8
6	18	$\times$	$\times$

City planners are now faced with the following constraints:

- The total available budget is 2.000.000 €.
- In each of the three seasons at least two habitats must be available to the species.
- At most four habitats can be selected in total to allow for infrastructure development.

The goal is to maximize annual species benefit while ensuring that the constraints are met. Formulate the linear program and solve it using MATLAB. Which habitats are selected for conservation and what is the optimal annual species benefit? Which habitats are occupied in the spring/summer and which in the winter?