Chemical Engineering 4G03

Tutorial 3 Practice Activity

Here for your own benefit and practice (best to do it individually)
Recommended completion: End of week 04 (or before midterm exam)
Grading: 0% (Practice for assignments and tests)

Problem Adapted from Rardin (2017) Chapter 4

Background

Natural Resources Canada is considering the allocation of a large plot of forest in British Columbia to a variety of prescribed foci. The forest in question has been separated into $\boldsymbol{i} \triangleq$ **seven analysis regions**, each of a certain total area (in acres). Each region of the forest may have any portion of it dedicated to one of $\boldsymbol{j} \triangleq$ **three prescriptions** focusing on timber manufacturing ($j = 1$), animal grazing ($j = 2$), and wilderness preservation ($j = 3$). Under each prescribed plan, every acre of forest has an expected net present value (NPV), pre-calculated based on vegetation density, location, accessibility, and so-on. The index dimensions for the data available to you are:

- $i \triangleq$ the analysis area number ($i = 1 \ldots 7$).
- $j \triangleq$ the plan prescription number ($j = 1 \ldots 3$).

The table on the next page indicates the various NPVs, timber, grazing and wilderness preservation scores of each acre of each section if that acre is allocated to a certain prescription. Specifically:

- $S_i \triangleq$ the total number of acres in analysis area i (note the 000's).
- $NPV_{i,j} \triangleq$ the net present value of *every acre* of area i if that acre is allocated to planning prescription j (in $ per acre).
- $T_{i,j} \triangleq$ the timber production of *every acre* of area i if that acre is allocated to planning prescription j (in feet of timber per acre).
- $G_{i,j} \triangleq$ the animal grazing potential of *every acre* of area i if that acre is allocated to planning prescription j (animal-months of grazing per acre).
- $W_{i,j} \triangleq$ the wilderness index of *every acre* of area i if that acre is allocated to planning prescription j (a relative ranking on a scale from 0 to 100).

We wish to choose **how much of each forest section should be allocated to each of the three prescribed plans to maximize the NPV of the forest**. Moreover, we want to obey the following constraints:

- We must produce a **minimum of 40 million feet of timber** to supply the forestry industry.
- We must have a **minimum of 5000 animal-months of animal grazing** be available for wildlife.
- The average **wilderness index of the entire forest must be at least 70**.

Area i	Acreage S_i (000's)	Prescription j	NPV $NPV_{i,j}$ ($)	Timber $T_{i,j}$ (ft)	Grazing $G_{i,j}$ (--)	Wild Index $W_{i,j}$ (--)
1	**75**	1 (timber)	503	310	0.01	40
		2 (grazing)	140	50	0.04	80
		3 (wilderness)	203	0	0	95
2	**90**	1	675	198	0.03	55
		2	100	46	0.06	60
		3	45	0	0	65
3	**140**	1	630	510	0.04	45
		2	105	57	0.07	55
		3	40	0	0	60
4	**60**	1	330	112	0.01	30
		2	40	30	0.02	35
		3	295	0	0	90
5	**212**	1	105	40	0.05	60
		2	460	32	0.08	60
		3	120	0	0	70
6	**98**	1	490	105	0.02	35
		2	55	25	0.03	50
		3	180	0	0	75
7	**113**	1	705	213	0.02	40
		2	60	40	0.04	45
		3	400	0	0	95

Tasks

Your FIRST task, which is JUST as important as the actual coding, is to formulate the problem that will maximize the NPV of the forest allocation while obeying the constraints above. *Hint:* you might need to come up with one more constraint of your own. You are encouraged to formulate this with continuous variables (we are allowed to allocate half-acres, for example).

This will be great practice for your assignments and tests. However, if you want to skip the formulation for this tutorial and focus primarily on the GAMS coding aspect, you are welcome to refer to the file `T03_Formulation`, which has the formulation for this problem already completed. Make sure you understand it!

Your SECOND task is to take your formulated problem and the data in the table above, code the problem up in GAMS, and solve it. Have fun!