

## Questionnaire 1 - System Dynamics ‘Pen & Paper’ Test

Please answer the questions below. The questions require only a qualitative, not quantitative, answer. We remind you that this test is anonymous

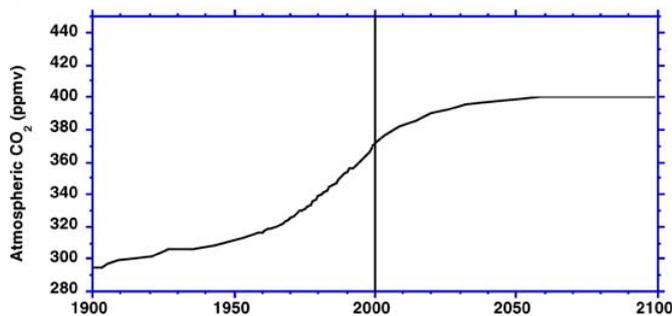
### Question 1: stocks and flows

[Allow approx 10 mins for this question (although you may finish sooner!)]

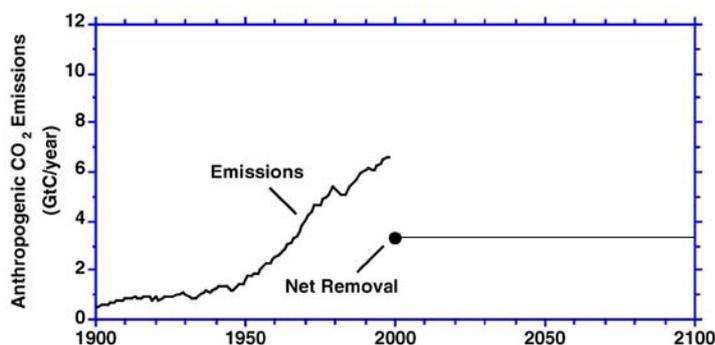
The Intergovernmental Panel on Climate Change (IPCC) has stated that carbon dioxide (CO<sub>2</sub>) and other greenhouse gas emissions are contributing to global warming.

The amount of CO<sub>2</sub> in the atmosphere is affected by natural processes and by human activity. CO<sub>2</sub> emissions resulting from human activity have been growing since the start of the industrial revolution. Natural processes gradually remove CO<sub>2</sub> from the atmosphere (e.g. plant life taking up CO<sub>2</sub>). Currently this rate of removal of CO<sub>2</sub> is approximately half the rate at which CO<sub>2</sub> is added to the atmosphere and consequently concentrations have increased from preindustrial levels.

Now consider a scenario in which the concentration of CO<sub>2</sub> in the atmosphere gradually rises to 400 parts per million, which is about 8% higher than the level in 2000, and then stabilises by the year 2100, as shown here:



The graph below shows CO<sub>2</sub> emissions from human activities. The black dot shows the rate at which CO<sub>2</sub> is removed from the atmosphere in 2000. Please draw your estimate (*a qualitative estimate, you do not need to draw a numerically exact curve*) of an emissions trajectory between 2000 and 2100 that could produce the CO<sub>2</sub> concentration graph above. Assume the rate of CO<sub>2</sub> removal remains constant (as shown by the horizontal line extending between years 2000 to 2100),



Please provide any comments or explanations here:

## Question 2: Feedback loop

[Allow approx 10 mins for this question (although you may finish sooner!)]

An isolated location of stunning beauty is developed for tourism. For the sake of simplicity, the dynamics of this fictitious system can be interpreted in terms of the interaction between three components: a) the tourists, b) the environment and c) the tourist infrastructure. The expected relations between these components are very well known:

- More (less) tourist infrastructure leads to more (less) environmental degradation;
- More (less) tourists lead to more (less) environmental degradation;
- a healthier (worse) environment attracts more (less) tourists
- there is a natural positive feedback loop between tourist and infrastructure: more (fewer) tourists lead to more (less) tourism infrastructure and more (less) tourism infrastructure leads to more (fewer) tourists
- tourists are deterred by other tourists (tourists want peace and solitude to interact with Nature)
- Infrastructure degrades over time
- the environment has a natural recovery rate

Recently the system has not been properly managed and you have been asked to help designing an intervention which can provide long term improvement in the condition of the environment and long term increase in numbers of tourists. You have four options for intervention:

- (a) Infrastructure regulations are imposed, requiring that the environmental impact of any existing infrastructure is halved. There is no restriction on building more infrastructure, but each new building or facility must meet the prescribed standard. These changes are government funded at no cost to companies or tourists.
- (b) Tourists are required to halve their per-capita environmental impact. This is done at no cost to the tourists or tourist companies and does not change the attractiveness of the location to tourists.
- (c) A tax is imposed on tourism infrastructure (the tax revenue is not given to tourists or tourism companies and nor is it invested in environmental protection – its sole role is to act as a disincentive to invest in tourism infrastructure).
- (d) There is a government-funded one-off environmental restoration intervention. (One-off addition to Environment at the time of intervention.)

Given the cause-effect relationships described previously, which of the above interventions is more likely to provide the desired long-term increase in both the environmental health and the number of tourists? Note that three of these interventions, while producing a short-term environmental improvement, lead to long-term further degradation or return to the current state of environmental health. Only one of the following interventions can produce the desired long-term behaviour. Which one?

Also, please provide any comments or explanations here: