

Challenges of the Ecological Transition - ETRÉ

Duration: 1 hour All documents forbidden - calculators allowed.

The mark scheme is given for information only.

Except when explicitly requested, you are not expected to write long paragraphs but **to give concise answers, all of which must nevertheless be justified and carefully written.**

The test consists of a single problem, but most of its subparts are independent.

Organization of the test:

- questions on pages 1-2,
- data for the calculations, graphs and resource documents on pages 3-4,
- annex to be handed in with your answers on pages 5-6.

Carbon offsetting through forestation: study of a "carbon neutral" product

✈️ VOLS DIRECTS (2)

15:20 - 16:25

○ Paris (CDG)

○ Nantes (NTE)

✈️ Vol neutre en CO₂

AIRFRANCE

AF7724

In 2020, when certain flights were booked on the Air France website, one could see the label: "CO₂ neutral flight = Vol neutre en CO₂" (Figure 0). The airline explained at the time that it was supporting several "offsetting projects", including a tree-planting program in Kenya.

We will study the mechanisms of "carbon offsetting" through tree planting, before discussing the concept of "carbon neutrality" of a product, service or company in Part 3.

Figure 0: screenshot of the search engine for a flight on the Air France website, July 2020¹

Part 1: Carbon capture and storage by trees: balance calculations (~ / 7 pts)

Part 1.a: From Molecules to Living Beings

The main mechanism of carbon storage by plants is governed by a chemical reaction, the simplified equation of which is: $6 \text{CO}_2 + 6 \text{H}_2\text{O} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6 \text{O}_2$ (eq.1)

1). What is the name of the process described by eq.1?

Part 1.b: At the Forest Ecosystem Scale

2). What is the quantity studied in the report references in extract no.1 (*Report by the French Academy of Sciences, page 3*) ? In what dimensions should flows and stocks be expressed? Criticize the sentence in the extract that is underlined.

3). Justify the sentence: "1 t C/year corresponds to 3.664 t CO₂/year".

¹ This mention of a "carbon neutral flight", and the arguments put forward by the company, caused a stir on social networks. The mention has since disappeared from the Air France website.

4). Based on the data in extract no.1 from the report of the Academy of Sciences, complete Figure 2 of the annual report (page 5, to be returned with your answers).

To do this, you must use the values given in the text to:

- indicate in the boxes the variations in the stocks of the interconnected systems
- indicate the flows between the systems,
- find the change in stock of the {atmosphere} and justify it (briefly).

Part 2: Virtues and Limitations of Reforestation (~ / 7 pts)

5). Complete the diagram given in Figure 3 (page 5, to be returned with your answers), by filling in the blank boxes with the terms "adaptation" and "mitigation", corresponding to the strategies adopted by earth's systems to climate change.

6). Using your knowledge and the extract of text n°2 (page 3), complete table 1 (page 6, to be returned with your answers) using 5 keywords/phrases and briefly explain their positioning in the table.

7). Explain what positive and negative feedback loops are. Give an example of a feedback loop concerning climate change, related to forests. What is the type of feedback in your example (positive or negative) ? Justify your answer.

8). What is an ecosystem service? Give 3 examples of such services provided by a forest and a brief explanation of each.

Part 3: Carbon Offsetting and Neutrality (~ / 6 pts)

Carbon neutrality of a given system (e.g. a company) means that its net CO₂ emissions are zero.

CO₂ emissions from air traffic in France represented approximately 24.3 Mt CO₂ for the year 2019².

9). Based on part 1.b of this test and order-of-magnitude calculations, do you think that the entirety of French air traffic could reach "carbon neutrality" ? Justify your answer.

The National Forestry Office (ONF) calculates the annual carbon compensation of a plantation as being the annual average of the mass of carbon captured (stored) per hectare (ha), considering a lifespan of its plantations of 30 years.

10).

(a) According to the ONF, what would be the annual carbon compensation (in t C.year⁻¹.ha⁻¹) of a plantation of Manchurian ash (see fig. 1, page 4) ?

(b) If the Manchurian ash plantation only lasts 10 years in reality, according to the calculation that would be made by the ONF using the value determined in part (a), what would be the total carbon stored per hectare over 10 years? According to fig. 1, what is the true mass of carbon stored per hectare after 10 years? Compare these two values and comment on the hypotheses made by the ONF.

11). What other issue(s) of carbon offsetting does the extract of text n°3 (page 4) address?

² Estimates made by the Directorate General of Civil Aviation (DGAC), source : *Les émissions gazeuses liées au trafic aérien en France en 2019*, report published in October 2020
https://www.ecologie.gouv.fr/sites/default/files/bilan_emissions_gazeuses_2019.pdf

Data: *Molar masses* $M_C = 12\text{g/mol};$ $M_O = 16\text{g/mol}$

Extract no. 1 : Report by the French Academy of Sciences ³ (translated from French) :

"Flows and stocks are expressed in Mt C/year. An annual stock change of 1 t C/year corresponds to 3.664 t CO₂/year. In metropolitan France, forested areas have sequestered, on average over 2015-2020, a net quantity of 10.2 Mt C/year (30.8 Mt C/year captured by growth minus 20.6 Mt C/year due to harvesting and exploitation of the trees). [Forests and the forestry industry have] sequestered a net 10.8 Mt C/year (10.2 Mt C in forest and 0.6 Mt C in wood products)."

It is specified that the "wood industry" can be subdivided into several sub-sectors, including:

- "wood products", such as wooden furniture, paper or carpentry;
- "wood energy", which refers to all wood used as a primary energy source.

Extract no. 2 : from an article in the journal "Mediterranean Forest": introductory report ⁴

Over the past 15 years, research has resumed in the region and is beginning to yield results. Reforestation methods have also evolved. Recently, aid from the European Community has been added to the efforts already undertaken. This is all very positive and very encouraging. However, let us be careful not to be too optimistic, because there are many caveats in play and I believe that we must also remember them, even if they are sometimes banal.

- First of all, there is a certain uniformity of reforestation, particularly in the choice of species. In Provence-Alpes-Côte d'Azur, which is the region I know best, Austrian black pine and Atlas cedar alone make up more than 2/3 of the plantations.
- This uniformity, it is obvious, increases the risk of spreading diseases or pests over large areas.
- This risk is in addition to the already high risk posed by the permanent danger of fire, reducing the life expectancy of planted trees to a short number of years in the most exposed areas.
- Finally, the objectives of reforestation and the techniques used are not always perfectly aligned. In the Mediterranean hinterland, which is subject to reduced drought, the goal is often very clearly and unambiguously that of timber production. On the other hand, in coastal zones, this often gives way to other objectives, in particular concerns about soil protection or landscape improvement.

³ Les forêts françaises face au changement climatique, report from June 2023
https://www.academie-sciences.fr/pdf/rapport/060623_foret.pdf

⁴ Translated from : D. Alexandrian, B. Le Voyer. Choix des essences et techniques de reboisement, 2^{èmes} rencontres de Forêt Méditerranéenne. Valorisation des patrimoines forestiers méditerranéens. Forêt Méditerranéenne, 1984, VI (2), pp.89-122. Hal 03554592

Extract no.3 : from an article in issue n°61 of the magazine Socialter (Dec. 23-Jan. 24) ⁵

In fact, [carbon offsetting] is a way for companies to acquire a "right to pollute": by buying carbon credits, i.e. tons of carbon absorbed by a project on the other side of the planet, they can continue to emit CO₂ while claiming to be carbon neutral.

(...)

What is overlooked by the operators of forest reserves is that they are often inhabited. To ensure the best rate of CO₂ absorption (...), many reforestation programs have led to massive land grabs, without regard for local populations and their resources. The company Air France was singled out in 2013 by the association Friends of the Earth, alerted by the inhabitants of Madagascar to a carbon offset project involving 470,000 hectares of protected areas: on site, the inhabitants suddenly no longer had access to the land they cultivated.

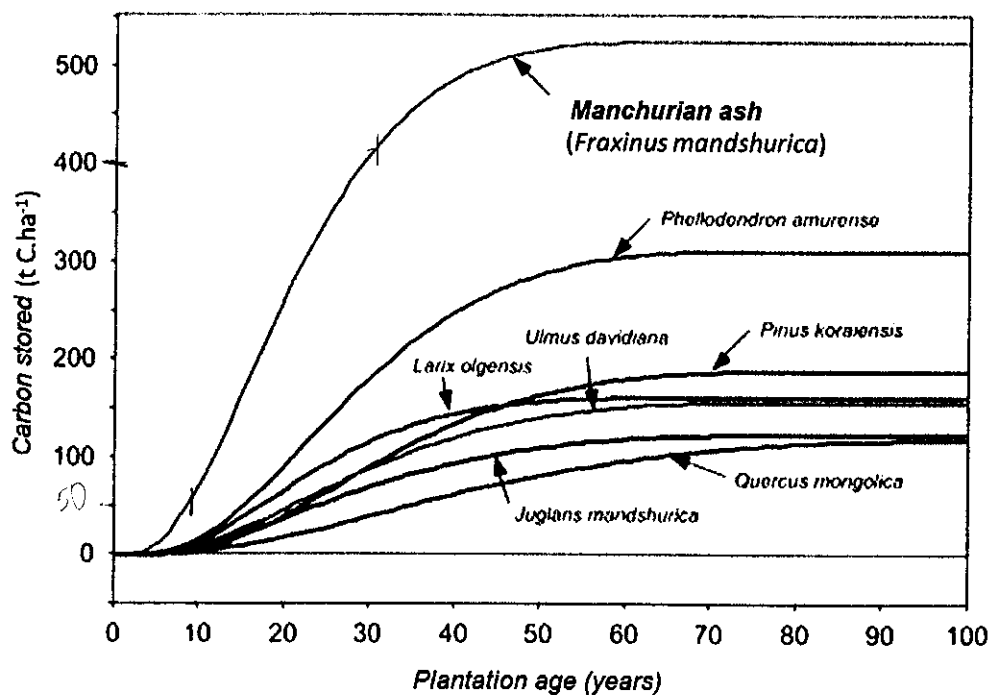


Figure 1: Estimates (from models) of the evolution of the cumulative mass of stored carbon per hectare (1 ha = 10⁴ m²) of ecosystem (including living trees, dead wood and soil) for 7 different species from northern China as a function of plantation age (in years).⁶

⁵ N. Celnik, " Il y'a de la forêt dans le gaz ; le business de la compensation carbone ", Socialter n°61 (Dec. 2023-Jan. 2024)

⁶ Figure extracted and adapted from the article by Thomas S.C., Malczewski G., Sapruff M., J. of Environmental Management, 85 (3), 2007, pp. 663-671 available at:

<https://www.sciencedirect.com/science/article/pii/S0301479706002830>