北海道大学大学院環境科学院
環境起学専攻

Division of Environmental Science Development
Graduate School of Environmental Science, Hokkaido University
Course in Human and Ecological Systems, Course in Environmental Adaptation Science, and Course in Global Environmental Management

令和 6 年度大学院修士課程入学試験問題（秋季入試）

令和 5 年度 10 月入学大学院修士課程入学試験問題

Entrance Examination

専門科目

Specialized Subjects

[留学生用]
For international students

- **Six questions are given in the subjects of Environmental Science (2 questions), Physics (1 question), Ecology and Geography (2 questions), and Chemistry (1 question). Candidates are required to answer 2 questions out of 6 questions.**
- **Use one answer sheet for each question.**
- **Backside of answer sheet can be used if necessary.**
- **Specify the subject name and the question number on each answer sheet.**

August 22, 2023

Environmental Science

Question 1 Answer questions (1) to (6).

(1) Describe the advantages and disadvantages of biodegradable plastics in seven to eight lines, including the following words.
biomass, microplastics, carbon neutrality

(2) Polychlorinated biphenyls (PCBs) had been once widely used as electrical insulators and heat transfer media. Explain why they still remain in the environment even though their production and use have long since been banned, in three to four lines.

(3) Explain what environmental problems nitrogen dioxide (NO_2) and dinitrogen monoxide (N_2O) cause in three to four lines.

(4) The 21st century is often referred to as the "century of water". Explain why water is an important issue in the 21st century in about four lines.

(5) The use of renewable energy is growing rapidly around the world. Each method has its advantages and disadvantages, and the main methods used vary from country to country. List three disadvantages of photovoltaic power generation and explain in seven to eight lines.

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(6) Answer questions (a) and (b), based on the following text.

More than 450 representative authors from more than 130 countries wrote the IPCC Fourth Assessment Report with the help of more than 800 collaborators. Even so, the IPCC Fourth Assessment Report was still criticized for the erroneous statement " (X) ", which became a major problem, and for being overly cautious in its treatment of sea-level rise. (i)<u>These problems can lead to a loss of credibility in the IPCC among the general public and policymakers and intensify criticism by climate change skeptics</u>.

(a) Choose the appropriate sentence from (A) to (D) below, which is suitable to fill in the blank (X).

(A) By the middle of this century, mean annual river discharge and water availability will decrease markedly in arid mid-latitude regions and arid tropical regions.
(B) Increases in sea surface water temperatures will cause frequent bleaching phenomena and widespread mortality of corals.
(C) Himalayan glaciers could melt to a fifth of current levels by 2035.
(D) Malnutrition, increased disease, and disasters adversely affect the health status of many people.

(b) Explain what the IPCC is doing to solve the problem described in underlined sentence (i), in about three lines.

Environmental Science

Question 2 Read carefully the paragraph below and answer questions (1) to (6).

Biodiversity can be perceived in multiple levels, 1) one of which is species diversity. More than half of the described species belong to the group of (①), and in total the known species number reaches to an approximately 1.7 million. Currently, the species extinction rate has accelerated and the decreasing trend of species diversity is concerned. In fossil Age, the extinction rate is estimated to be around (②) per year, and recently this rate has increased substantially by (③) times. The main causes of this trend are hunting, habitat modifications, and introduction of invasive species, and 2) international conventions have been enacted to promote the protection of species diversity. As a cause of further accelerating these effects, and possibly in a different mechanism, 3) the environmental changes of both marine and terrestrial ecosystems due to climate change have been concerned.

(1) Choose the appropriate word for (①) from below.
【fungi, amphibian, insect, algae】

(2) Choose the appropriate words each for (②) and (③) from below.
【1－10, 10－100, 100－1000, 1000－10000】

(3) Concerning the part underlined 1), write down two other levels of biodiversity.

(4) Concerning the part underlined 2), write down two major examples. Furthermore, describe their respective aims each within three lines.

(5) Concerning the part underlined 3), figure 1 below conceptually describes vertical vegetation distribution at present and 100 years ahead in the mid-latitude areas. In the future of 100 years ahead with a temperature rise, explain how this ecosystem is predicted to be affected in five lines.

(6) Graphically describe how the vertical distribution of vegetation was like in the cold period approximately 20,000 years ago.

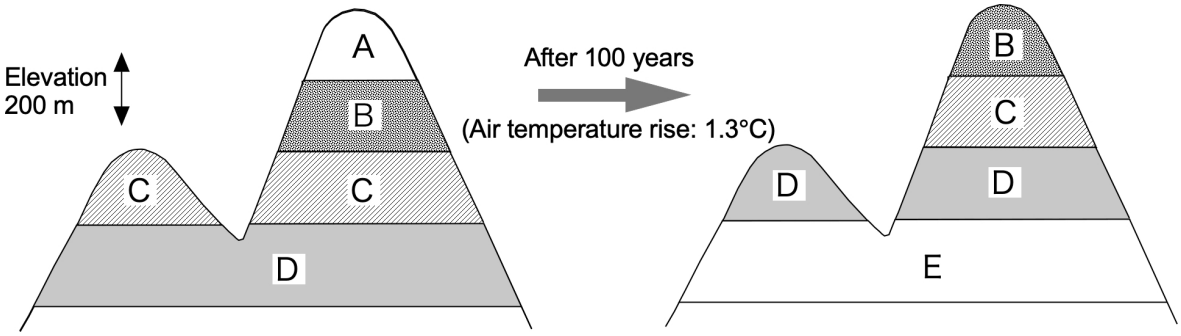

Figure 1

Physics

Question 3 Answer the following questions (1) to (3).

(1) Explain the terms below within three lines each.

【Terms】Convective available potential energy (CAPE), Coastal upwelling, Equivalent potential temperature, Walker circulation

(2) Answer the following questions about the distributions of upper tropospheric geopotential height in January.

(a) Figure 1 was drawn using the "reanalysis data" produced by Japan Meteorological Agency. Explain what "reanalysis data" is within four lines. The answer must include the methodology to produce "reanalysis data".

(b) Describe within four lines the difference in upper tropospheric geopotential height between northern (Fig. 1a) and southern (Fig. 1b) hemispheres together with the reason(s) of the difference.

(c) Based on Fig. 1a, suggest two regions where the wind speed in upper troposphere is high.

(d) Describe the common characteristics of extratropical cyclones in the regions suggested in (c). The Answer must be within four lines and use the term "baroclinic instability".

(e) Based on Fig. 1c, explain likely weather conditions in Japan during late-January in 2018 within four lines.

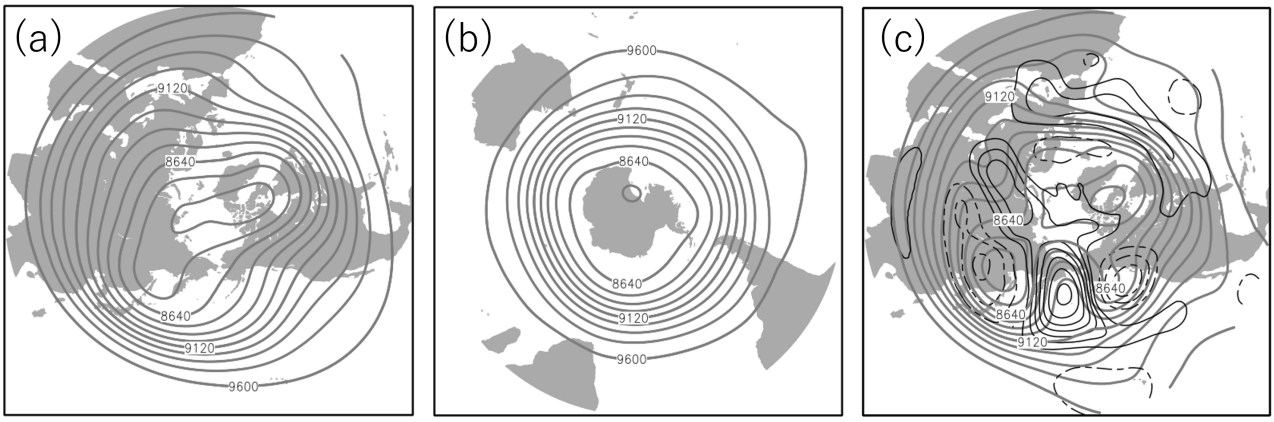

Figure 1: Distributions of climatological upper tropospheric (300 hPa) geopotential height (unit: meter, gray lines) in (a) northern and (b) southern hemispheres. (c) Same as (a) but for the distribution in late-January in 2018 (gray lines). Thin black lines in (c) represent the deviation from the climatology and the counter interval is 60 m. Dash lines denote the deviation is negative. (Data source: JRA-55 reanalysis data)

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(3) Figure 2 shows time variation of atmospheric boundary layer in a sunny day. Figure 3 is the vertical distributions of meteorological elements at a certain time in the same day. Answer the following questions.

(a) Answer most appropriate words in English to fill【X】and【Y】in the figure.

(b) What is "specific humidity"? Answer it within three lines explaining the definition and unit.

(c) Select one out of A to C in Fig. 2 as most appropriate time when the elements can be observed like Fig. 3, and explain the reason for the selection within three lines.

(d) In Fig. 3, there is a layer where the potential temperature is nearly constant regardless of the height. Answer the rate of air temperature change with height in this layer in the unit of °C/100m.

(e) Draw a figure about the vertical distribution of relative humidity on your answer sheet assuming the conditions shown in Fig. 3, and describe its characteristics within three lines.

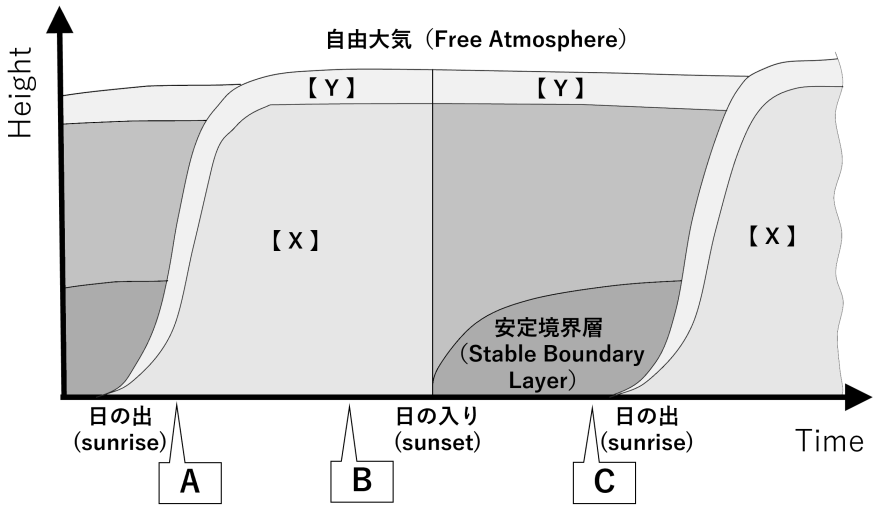

Figure 2: Time variation of atmospheric boundary layer in a sunny day.

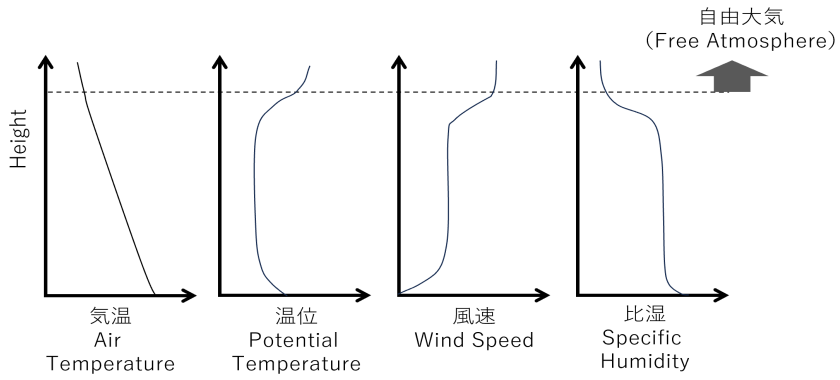

Figure 3: Vertical distribution of the meteorological elements in the atmospheric boundary layer.

Ecology and Geography

Question 4 Answer all the questions (1) to (2).

(1) In the high latitude zone and the mid-latitude alpine zone, air temperatures drop well below 0 °C during winter time. Under this circumstance, the ground layers freeze and thaw in shallow depth, and perennial ground ice often grows in the deep layers. In relation to this, answer the following questions.

(a) Explain the shape and formation process of following periglacial landforms.

(ⅰ) sorted patterned ground
(ⅱ) ice wedge polygon
(ⅲ) pingo

(b) Permafrost is the ground that remains subzero temperature at least for two consecutive years. Explain how thawing of the upper permafrost layer under a centrally heated building affects the building, including the countermeasures for minimizing the effects.

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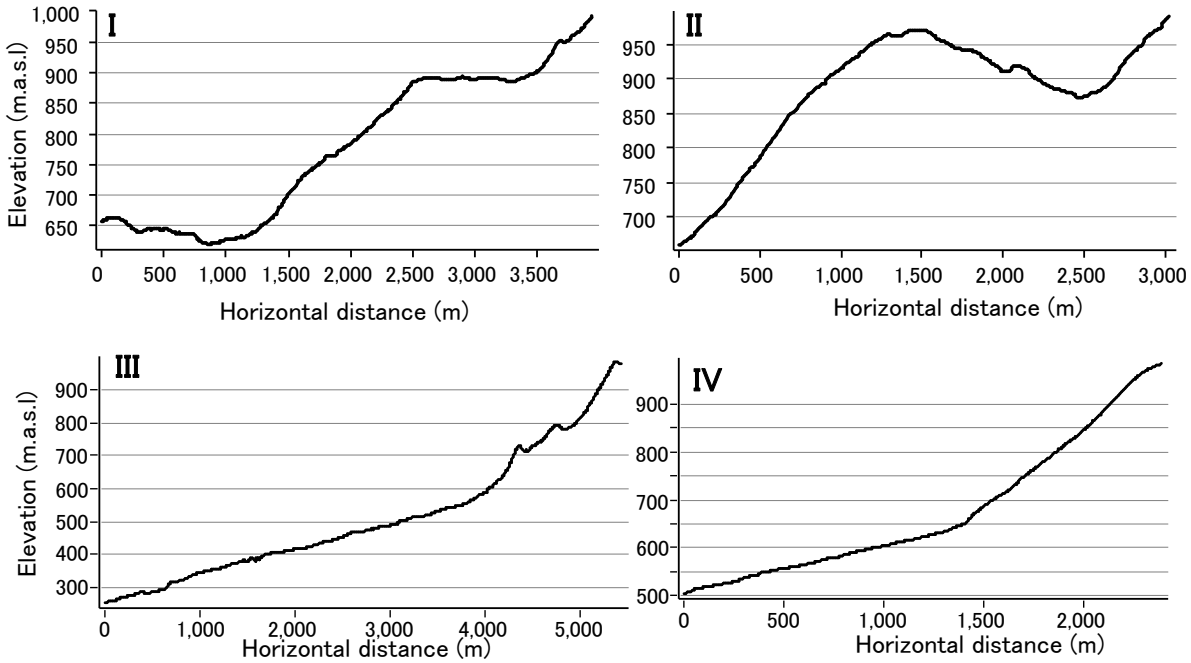
(2) The next page shows the topographic contour map (Fig. A), geological map (Fig. B), and vegetation map (Fig. C) of Mts. Tarumae and Fuppushi, which situated on the southern shores of Lake Shikotsu, Hokkaido. In relation to these figures, answer the following questions (a) to (c).

(a) From mountain hut (location **a** in Fig. A) to Mt. Tarumae west peak (location **b** in Fig. A), the trekkers follow trekking route of either ① or ② (Fig. A). Choose the appropriate cross section that corresponds to each from the I, II, III and IV below.



(b) Volcanic activities have greatly influenced in the formation of Mts. Fuppushi and Tarumae. Explain the formation processes to their present mountain form, referring to the topographic contour map (Fig. A) and geological map (Fig. B).

(c) Primary vegetation covering this area is bare land, grassland, subalpine forest, and mixed conifer and broadleaf forest (Fig. C). The later two are partly influenced anthropogenically and afforested area and cropland occur in the area. Describe the backgrounds of the vegetation cover distribution, referring to the zonation of national park area (Fig. C), contour map (Fig. A), and geological map (Fig. B).

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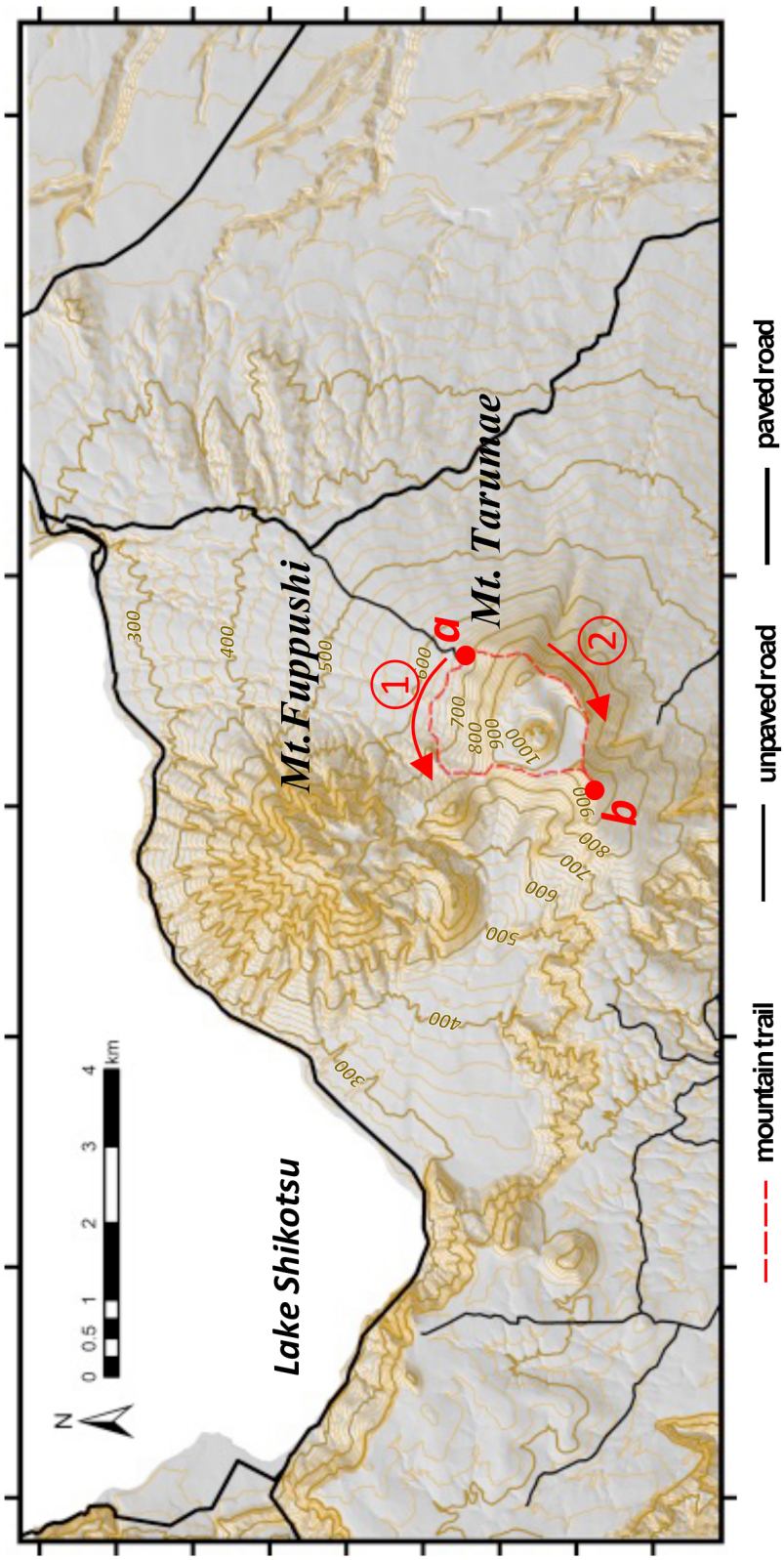

Fig. A Topographic Contour map

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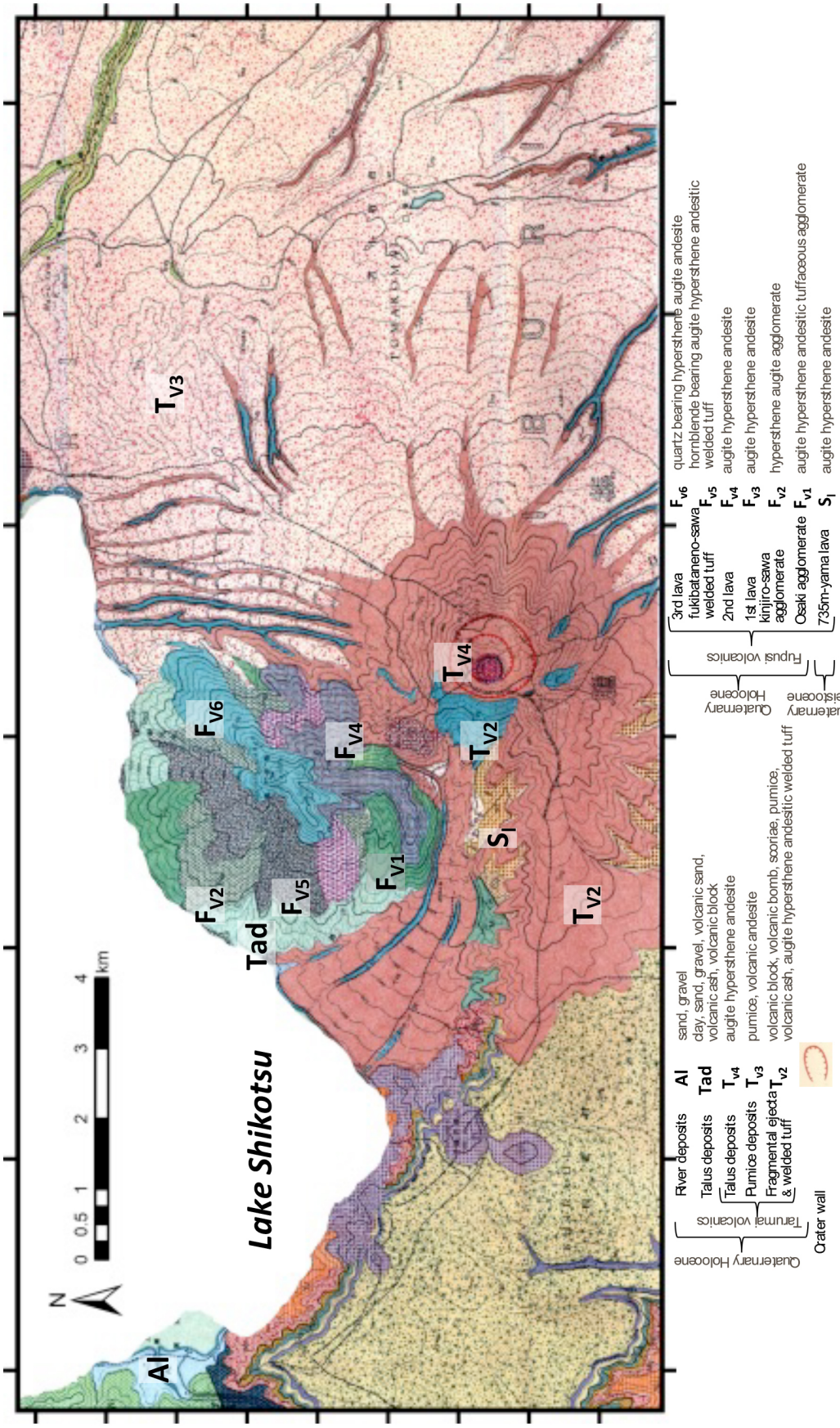

Fig. B Geological map, source of reference: Shigeo Doi (1957), Geological map of Japan, 1:50,000 scale, Tarumaizan (Sapporo-41), Geological survey of Hokkaido, revised by Graduate School of Environmental Science, Hokkaido University (https://www.hro.or.jp/list/industrial/research/eeg/development/publications/maps/5gm00.html#04041)

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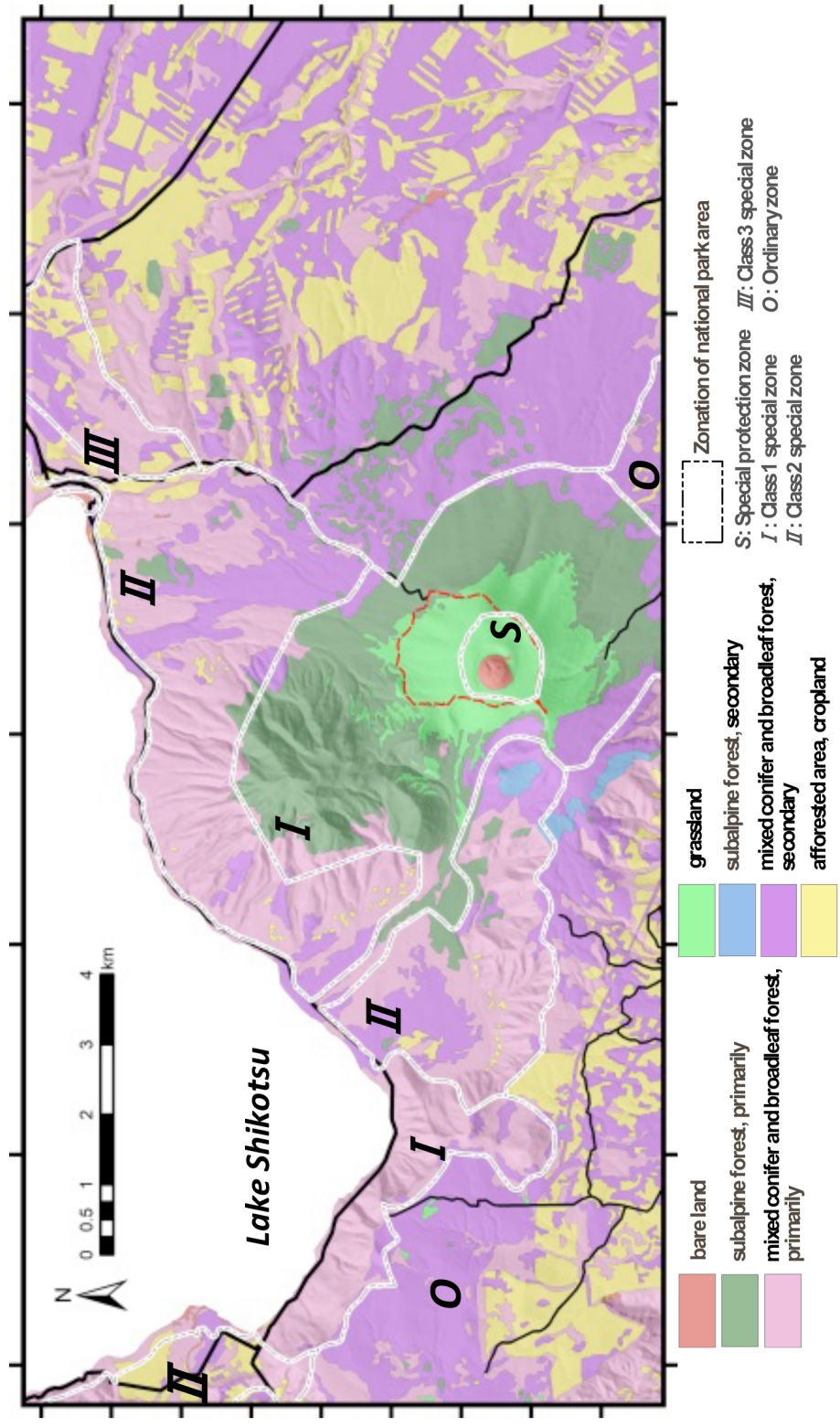

Fig. C Vegetation map and zonation of national park, This map is modified from GIS data of 1:25,000 scale vegetation map, Tarumaesan, created by Biodiversity Center of Japan, Ministry of the Environment. (http://gis.biodic.go.jp/webgis/sc-025.html?kind=vg67)

Ecology and Geography

Question 5 Answer all the questions (1) to (3).

(1) Ecological terms are given in (i) to (v). Explain the ecological definition or meaning of each term from (i) to (v).

(i) mycorrhizal fungi
(ii) interspecific competition
(iii) carrying capacity
(iv) beta-diversity (β-diversity)
(v) mixed conifer-hardwood forest

(2) Answer the questions (a) to (f), based on the following text.

Biomes include forests, grasslands, deserts, and (i)tundras. The distribution and structure of these biomes are determined primarily by [(A)] and [(B)]. For example, in deserts, (ii)succulent plants such as cacti may be dominant. Furthermore, forests are often divided into tropical rainforests, (iii)deciduous broad-leaved forests and (iv)coniferous forests. (v)After disturbances, ecological succession can be seen, and the species composition and dominant species change alter toward the climax along with changes in the resources of light and soil.

(a) For the underlined (i), explain the characteristics based on the dominant species and lifeforms.

(b) For the underlined (ii), explain the characteristics of photosynthesis.

(c) For the underlined (iii) and (iv), write a representative species name, which becomes potentially dominant, on each biome.

(d) Fill appropriate words in (A) and (B) in random order.

(e) For the underlined (v), explain the mechanism of succession from the viewpoint of resources of light and soil.

(f) Consider what biome in the text has the highest net primary productivity. Firstly, show the name of the biome and explain why the net primary productivity is the highest in that biome. Then, describe the characteristics of soil formation process in the biome.

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(3) Read carefully the paragraph below and answer all the questions (a) to (e).

Conservation biology strives to avoid (i)the extinction of species. From studies of extinction rates, it became apparent that the risk of extinction for a species with a (ii)metapopulation structure is influenced by the [(A)] and [(B)] of its populations, and by rates of [(C)] among them. These scientific knowledge about ecosystem provides foundation to efficient strategy in conservation planning. It is often the case that conservation planners begin with an inventory of remaining areas of natural suitable habitat and an evaluation of the risks to populations in those areas. Furthermore, the protection of as many habitat patches as possible, (iii)giving priority to those with the largest area, is generally preferred. Planners also must (iv)consider opportunities for individuals to move among populations in designing corridors connecting habitat patches.

(a) For the underlined (i), describe examples of negative influences of species extinction on functions of ecosystems.
(b) For the underlined (ii), describe its definition. In the answer, define the term "population" and use it at least once.
(c) For the brackets (A) to (C), write down appropriate words for each. (A) and (B) are in no particular order.
(d) For the underlined (iii), explain one of the reasons.
(e) For the underlined (iv), the conservation practice substantially differs depending on the type of target taxa, for example between butterflies and large mammals. Explain one of the reasons.

Chemistry

Question 6 Answer the following questions (1) to (5).

(1) In about five lines, using the words neutron, proton, and positron, explain the factors that determine the stability of the nucleus and the form of beta decay of the radioactive isotope.

(2) Ethanol and dimethyl ether are structural isomers. Explain in about three lines why there are differences in melting point, boiling point, and solubility in water between them, even though they have the same molecular weight.

(3) Assume that the heat amount that one adult generates at rest is 75 watts. If one adult is at rest in an environment of 27 degrees Celsius, what is the amount of entropy increase per minute that the adult brings to the outside world? In this case, the amount of entropy change at the environment is assumed to be the same for an irreversible and reversible process.

(4) Mn^{3+} and Fe^{3+} are trivalent ions of neighboring transition elements in the periodic table, but their oxidizing power is very different. Which has stronger oxidizing power? Explain why in about five lines, based on their respective electron configurations.

(5) Helium molecules (He_2), consisting of two atoms, do not exist as stable molecules in the environment of the earth's surface. However, in a discharge tube with vacuum discharge and slight helium addition, it is observed that excited helium molecules (He_2^*) can exist. Explain the reason for this by drawing an energy level diagram of those molecular orbitals.