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 **8** 年度大学院修士課程入学試験問題（秋季入試）

令和 **7** 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 20, 2025

Environmental Science

Question 1 Answer the questions below.

(1) Read the paragraph below and state the words and numbers from ① to ⑥ that fit the passage.

In 2015, the Paris Agreement on climate change was agreed upon at the 21st Conference of the Parties (COP21) of the UN Climate Change Conference. The agreement stated to hold the increase in the global average temperature to well below [①] degrees Celsius above [②] levels, and to pursue efforts to limit the temperature increase to [③] degrees Celsius above [②] levels.

The Convention on Biological Diversity is a treaty negotiated at the 1992 Rio Earth Summit. At the 10th Conference of the Parties (COP10) held in 2010, the Nagoya Protocol was formulated on access to [④] and benefit sharing.

The [⑤] Protocol on Substance that Deplete the Ozone Layer, adopted in 1987, is an international agreement to reduce the consumption of chlorofluorocarbons that cause ozone layer depletion. Apart from the ozone, the so-called "Stockholm Convention," which entered into force in 2004, sets forth a process for eliminating dangerous substance such as [⑥].

(2) Explain each of the following words (a) to (e) used in environmental science, in about 4 lines.

(a) Ecological Footprint
(b) One Health
(c) Planetary Boundaries
(d) Material Cycles
(e) ESG

Environmental Science

Question 2 Please answer all of the following questions about air and water pollution in approximately 7 lines each.

(a) Describe the benefits associated with large dam construction and explain how it can affect downstream ecosystems.

(b) What is the difference between a confined and an unconfined aquifer?

(c) Define point and non-point sources of water pollution with two examples of each.

(d) How does ozone (O_3) act differently in the stratosphere *vs.* the troposphere?

(e) Describe two major water-borne diseases and their sources.

(f) Define dissolved oxygen (DO) in water and explain how it is used as an indicator of water quality.

Physics

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

(1) Explain the four terms below within three lines each.
【 Geostationary satellite, Level of free convection, Hadley circulation, Doppler radar 】

(2) Figure 1 illustrates the global mean energy budget of the Earth. Answer the following questions.

(a) Aerosols influence the Earth's radiation budget both directly and indirectly. Provide three examples of natural phenomena that are known to release aerosols.

(b) Describe the roles of clouds on Earth's radiation budget, addressing both shortwave and longwave perspectives, in approximately four lines.

(c) What is the "atmospheric window"? Explain in approximately three lines.

(d) The solar constant of 1370 W m^{-2} is approximately four times greater than the incoming solar energy of 340 W m^{-2} highlighted by the rectangle in Fig. 1. Explain the reason for this relationship using appropriate equations. You may draw diagrams in your answer sheet if necessary.

(e) Describe the impact of land use changes on Earth's radiation budget in approximately three lines.

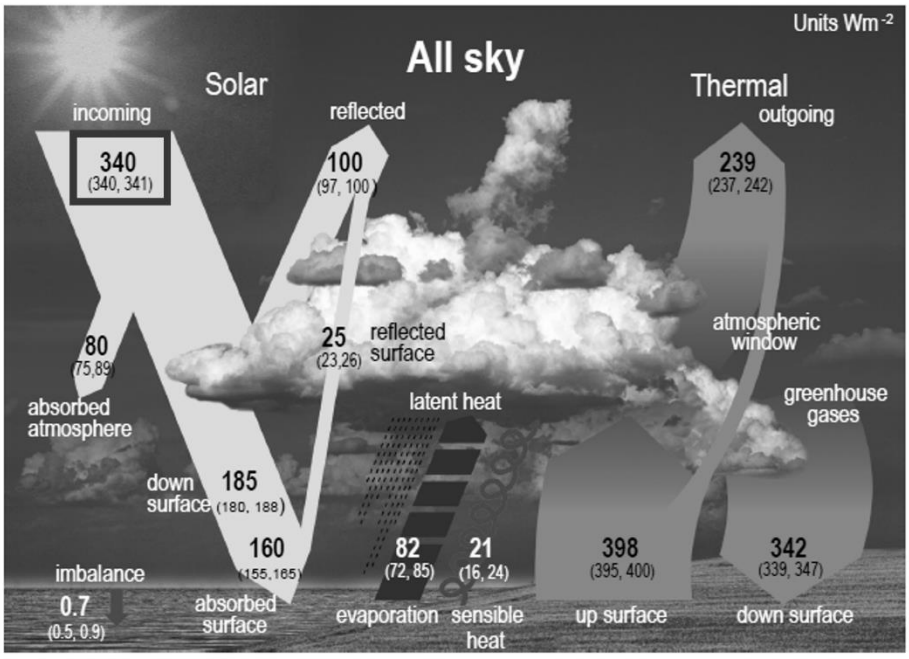

Figure 1: Global mean energy budget of the Earth. Boldface numbers represent energy fluxes in W m^{-2}, and those in parentheses indicate the range of estimation. (Adapted from IPCC AR6)

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(3) Figure 2 illustrates the forces acting on air surrounding a low-pressure system in the Northern Hemisphere. Answer the following questions.

(a) Referring to Fig. 2, choose the most appropriate combination of forces corresponding to A, B, and C from the options i to iv below.

i.	A: Pressure gradient force,	B: Coriolis force,	C: Centrifugal force
ii.	A: Pressure gradient force,	B: Frictional force,	C: Centrifugal force
iii.	A: Coriolis force,	B: Centrifugal force,	C: Frictional force
iv.	A: Coriolis force,	B: Pressure gradient force,	C: Frictional force

(b) Select the most appropriate combination of forces in balance around a tornado from the options i to iii below.

i. Pressure gradient force and Coriolis force
ii. Centrifugal force and Pressure gradient force
iii. Centrifugal force and Coriolis force

(c) At latitude θ, select the most appropriate expression for the magnitude of the Coriolis force acting on an air parcel moving at speed v. Let Ω denote the angular velocity of Earth's rotation.

【 $2\Omega v \sin\theta$, $2\Omega v \cos\theta$, $\frac{1}{2}\Omega v \sin\theta$, $\frac{1}{2}\Omega v \cos\theta$ 】

(d) Near the surface, a wind component directed toward the center of the low-pressure area develops. Explain the reason in about two lines.

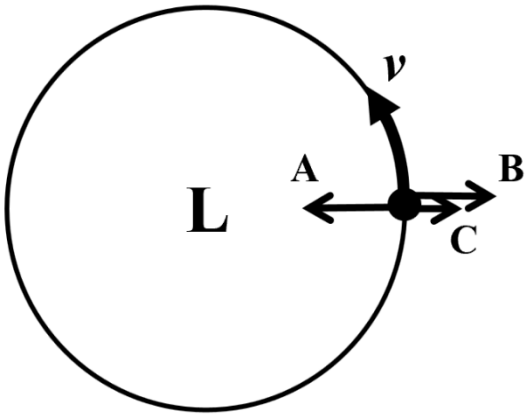

Figure 2: A conceptual diagram illustrating the forces acting on air surrounding a low-pressure system in the Northern Hemisphere. The symbol "L" represents the center of the low-pressure system.

Ecology and Geography

Question 4 Answer the questions below.

(1) Read the paragraph below and answer the following questions (a) to (c).

Materials on the Earth's surface are removed through physical, chemical, and biological processes, gradually wearing down the surface both vertically and laterally. This entire process of landform change is called [①]. It can be categorized according to the type of physical agents of fluid involved, such as wind, rain, rivers, groundwater, snow and ice, and [②]. There are also chemical processes, such as dissolution in water. On the other hand, phenomena in which geomorphic materials are removed primarily by gravity (e.g., rockfall, collapse, landslide, debris flow) are called [③], and are distinguished from [①]. However, since both contribute to lowering the land surface, [①] and [③] are often referred to as denudation.

(a) Write the appropriate words for each of ① to ③.

(b) The lateral component of ① in a river alters its planform. Name one representative landform created by this process and explain how it forms in approximately four lines.

(c) If a large volume of debris produced on a slope moves downslope via process ③ and reaches the river valley below, how might it affect the entire river system? Explain in approximately five lines.

(2) The figure below shows contour lines and the extent of landslides in a mountainous area. Based on this, answer the following questions (a) to (d).

(a) The terminal part of the landslide body caused by the sector collapse in the center of the figure features scattered, small hill-like mounds known as hummocks. Among the areas labeled A to D in the figure, where are the hummocks distributed? Answer using the appropriate letter.

(b) Even when the surrounding land is used for agriculture or residential development, hummocks often remain as forested or green spaces. Explain why this is the case in approximately four lines.

(c) The landform at location E in the figure (shaded in gray) represents the semi-concentric contour lines. Provide the name of this landform.

(d) Was the landform at location E formed before or after the sector collapse? Explain your reasoning in approximately four lines.

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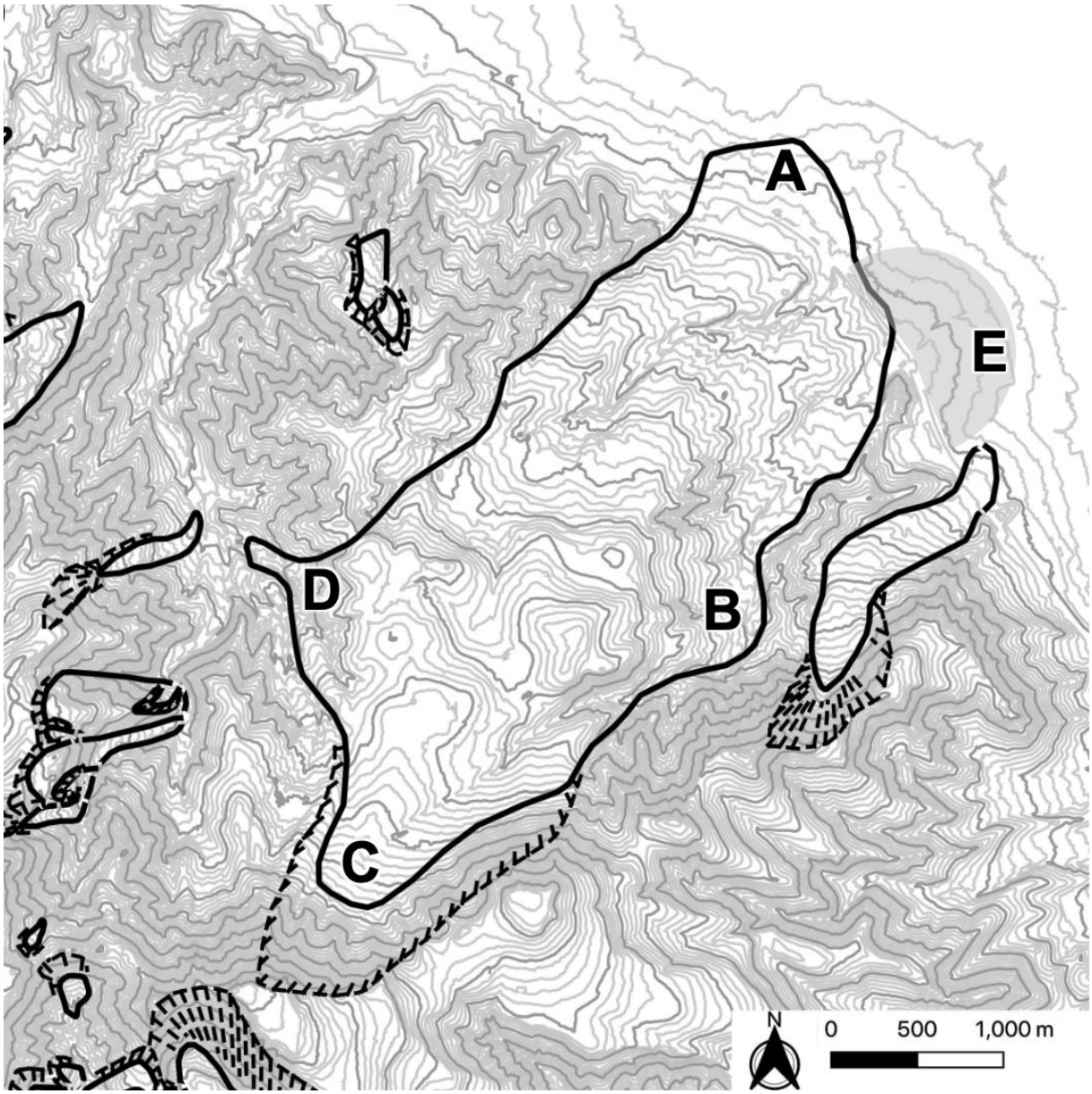

Figure. Gray thin lines: topographic contour lines at 10 m intervals; gray thick lines: topographic contour lines at 50 m intervals; solid black lines: extent of landslide bodies; black dashed lines: main scarps of landslides. The contour lines are based on the Digital Elevation Model of the Fundamental Geospatial Data by Geospatial Information Authority of Japan, and the landslide data are from the Landslide Map by National Research Institute for Earth Science and Disaster Resilience.

Ecology and Geography

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

(1) Explain the meanings of the two ecological terms listed in (i) through (iii) so that their relationships are clear. Provide approximately four lines for each.

(i) photosynthetically active radiation (PAR) and net primary production (NPP)

(ii) interspecific competition and niche partitioning

(iii) intermediate disturbance hypothesis and species diversity

(2) Read the following passage and answer questions (a) through (d).

In recent years, changes in biological communities within wetlands have occurred through the complex interplay of multiple environmental factors, including human disturbances such as (i)land-use change, as well as climate change. To promote the conservation and restoration of ecosystems, it is essential to understand the structure and function of communities, through their ecological (ii)resilience and resistance, in response to disturbances such as biological invasions. For example, elements such as (iii)ecosystem services and (iv)nitrogen cycling are best interpreted through both biotic and abiotic lenses.

(a) Regarding the underline (i), explain how land-use change influences animal migration patterns and genetic diversity, using all three terms, habitat fragmentation, populations and gene flow, in about four lines.

(b) Regarding the underline (ii), explain the difference between them, using biological invasion as an example, in about four lines.

(c) Regarding the underline (iii), explain the difference between provisioning services and regulating services, including one example of each, in about four lines.

(d) Regarding the underline (iv), explain how human-altered nitrogen cycling in wetlands affects plant community structure, using all three terms, fertilizer input, species preference and species diversity, in about four lines.

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(3) Answer all questions in (a) and (b).

(a)

(i) Topography causes environmental variation and affects the distribution of organisms. For example, the windward side of mountains exposed to sea breezes may have rich vegetation, while the leeward side may have sparse vegetation. Explain the reason for this, using the terms “precipitation” and “resources” at least once, in about 4 lines.

(ii) One of the main objectives of species conservation activities is to prevent species extinction. To achieve this objective, it is common practice to prioritize the protection of habitats covering large areas. Explain the reason for this, using the terms “extinction risk” and “population size” at least once, in about 4 lines.

(b) The number of poplar trees established in Yellowstone National Park in the United States showed significant temporal variation in conjunction with the extinction and reintroduction of wolves (Figure below).

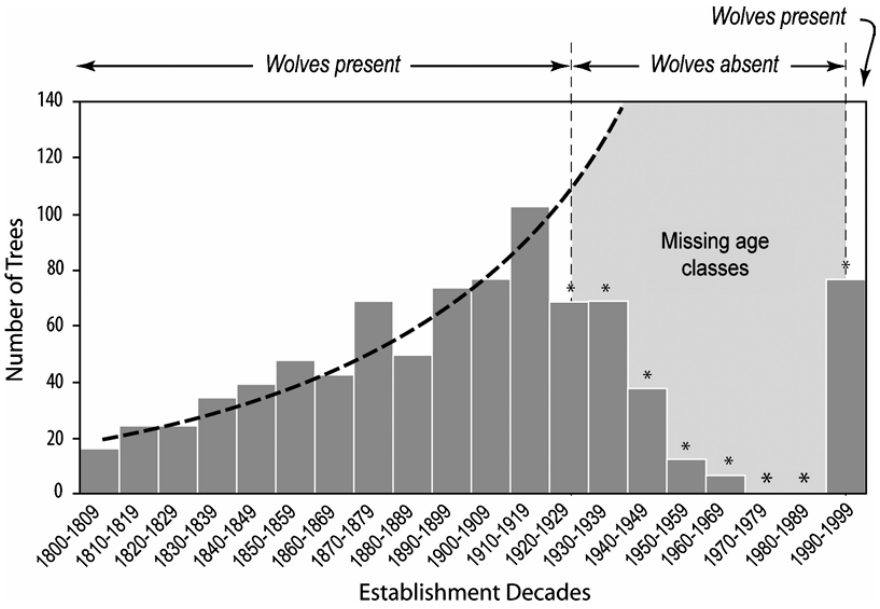


Figure. The dashed line shows the predicted trend in establishment numbers based on data up to the 1910s, and the asterisks indicate establishment numbers that differ significantly from the predicted trend. Missing age classes (absence of tree generations that should have established). Source: Beschta, R. L., & Ripple, W. J. (2010).

(i) The temporal variation in tree establishment numbers shown in the figure is related to trophic cascades. Define trophic cascades in about four lines.

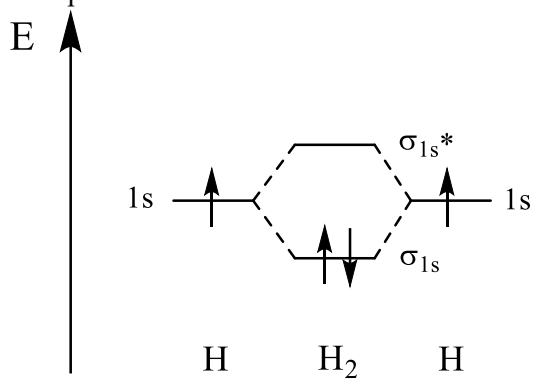
(ii) Explain in about 8 lines, using at least one of the following three terms, why there is a correlation between wolves and tree establishment: “trophic cascade,” “interspecific interaction,” and “population dynamics.”

Chemistry

Question 6 Answer the following questions (1) to (4). In the case of numerical calculations, describe the calculation processes.

(1) Describe the electronic configurations of N_2 and its constituent N atom in the ground state without omission as in the following example. In addition, explain the relationship between the mean inter-nuclear distances of N_2, N_2^- and N_2^{2-} based on the bond order.

example:



(2) Explain structural characteristics of amino acids within two lines. In addition, draw the structures of all dipeptides formed by the condensation of two amino acids, glycine and alanine. Stereoisomers are not considered.

(3) At 15 °C, a 2.5 L flask contains three gases, N_2, He, and Ne. The partial pressures of each are 0.32, 0.15, and 0.42 atm, respectively.

(a) Calculate the total pressure of the gas mixture and the mole fraction of each gas. Answer with two significant digits.
(b) N_2 was selectively removed from this mixture. Calculate the volume (L) of the remaining gas under standard conditions (0 °C, 1 atm) with two significant digits.

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(4) When iron(III) oxide is reduced with hydrogen, metallic iron is formed, which also produces water.

(a) Describe this reaction formula.
(b) Explain whether this reaction proceeds spontaneously under standard conditions at 25 ℃. The following are standard enthalpy changes of formation and standard molar entropies of reactants and products at 25 ℃.

$\Delta_f H°$[iron(III) oxide(s)] = –824.2 [kJ/mol]
$\Delta_f H°$[water(g)] = –241.8 [kJ/mol]

$S°$[iron(III) oxide(s)] = 87.4 [J/(K·mol)]
$S°$[hydrogen(g)] = 130.6 [J/(K·mol)]
$S°$[water(g)] = 188.7 [J/(K·mol)]
$S°$[iron(s)] = 27.3 [J/(K·mol)]