

Question 1: Design an Investigation**10 points**

A	Describe one reproductive strategy used by a K-selected species such as the chickadee. Examples of acceptable responses may include the following: (K-selected species) provide considerable parental care for offspring. (K-selected species) have few offspring. (The parents) expend significant energy for each offspring. (Individuals) reproduce more than once in their lifetime. (K-selected species) have a long gestation period/reach reproductive maturity later.	Point 01
B	Based on the information provided, explain how a decrease in spider populations could affect a lower trophic level. Examples of acceptable responses may include the following: - Insects/insect populations would increase because the insects are not being preyed on/eaten as much. - Plants/plant populations would decrease because the number of insects that eat plants will increase.	Point 02
C	Based on the data in Figure 1, identify the number of spiders per sample at 25% nonnative plants. Examples of acceptable responses may include the following: 2.0 2	Point 03
D	Based on the data in Figure 1, describe the trend in the number of insects per sample in relation to the percentage of nonnative plants. Examples of acceptable responses may include the following: - As nonnative plant percentage/percent increases, the number of insects decreases. - As nonnative plant percentage/percent decreases, the number of insects increases. - They have an inverse/indirect/negative relationship.	Point 04
E	Scientists hypothesized that the population of chickadees would be stable or growing with fewer than 25% nonnative plants. Describe one way that the data in Figure 2 support this hypothesis. Examples of acceptable responses may include the following: - Below this level/With fewer than 25%, the growth rate is at/above replacement level. - Below this level/With fewer than 25%, enough reproduction is occurring to replace the population. - Below this level/With fewer than 25%, the population growth rate is positive.	Point 05

F	(i) Identify a likely scientific question for the students' investigation of ant diversity. Examples of acceptable responses may include the following: - Does the number of species/species richness/biodiversity differ between an urban park and a grassland? - Does mowing affect the number of species/species richness/biodiversity?	Point 06
	(ii) Identify the dependent variable in the students' investigation. Examples of acceptable responses may include the following: - Number of ant species - Ant species richness - Presence/absence of different ant species	Point 07
G	(i) Explain why the ant community of the unmowed grassland would be more likely to recover from a disturbance, such as a flood or fire, than the ant community in the mowed urban park would. Examples of acceptable responses may include the following: - With a larger number of species, the grassland is more likely to have some species/individuals with adaptations that allow them to survive. - The grassland is more diverse, so the loss of one species is less likely to cause a collapse (of the whole ecosystem).	Point 08
	(ii) Explain how the results of the investigation could have been altered if students had measured ant biodiversity at a paved playground rather than in the grassland. Examples of acceptable responses may include the following: (The playground) would have fewer species (than the grassland/urban park) because the paved area is not suitable habitat for many ant species. (The playground) would have fewer species (than the grassland/urban park) because humans could trample the ants/ant habitat.	Point 09
H	Describe one effect a paved road in a forest can have on animal species such as deer or bears. Examples of acceptable responses may include the following: - Animals can get hit by cars when trying to cross the road/hunt/migrate. - Fragmentation can lead to isolation of individuals/loss of genetic diversity. - Noise pollution can damage hearing/cause stress/mask the sounds used to communicate/hunt. - The road/noise pollution can cause changes in migratory routes/prevent movement of animals (to access resources). - Species that thrive in edge habitats might increase.	Point 10

Question 2: Analyze an Environmental Problem and Propose a Solution

10 points

A	Identify the sea surface condition for the eastern equatorial area of the Pacific Ocean illustrated in Figure 1. Acceptable identification point: (Ocean water) cooler than average	Point 01
B	Based on the information in Figure 1, identify the climate phenomenon associated with the sea surface conditions shown in the equatorial area of the Pacific Ocean. Acceptable identification point: La Niña	Point 02
C	Based on the information in Figure 2, describe a difference in climate patterns between the regions A and B. Examples of acceptable responses may include the following: - Region A has an increased chance of precipitation, while Region B has a decreased chance of precipitation. - Region A will be wetter, while Region B will be drier.	Point 03
D	Describe one reason why there is an increased risk of flooding in urban areas during extended periods of precipitation. Examples of acceptable responses may include the following: - Impervious/paved surfaces increase runoff/reduce infiltration/reduce absorption. - Parking lots/roads/buildings/sidewalks increase runoff/reduce infiltration/reduce absorption. - There is less vegetation and, therefore, less infiltration/absorption.	Point 04
E	Propose a realistic solution a city could implement to decrease the risk of flooding in urban areas. Examples of acceptable responses may include the following: - Use permeable pavement - Plant vegetation/establish parks/create rain gardens/build green roofs - Install retention ponds/stormwater basins	Point 05

- F** **Justify** the solution proposed in part E by providing an additional advantage other than a reduction in the risk of flooding. **Point 06**

Examples of acceptable responses may include the following:

Solution from part E	Justification of solution with additional advantages
Use permeable pavement	- Increased recharge of nearby aquifers/groundwater - Decreased pollution in runoff
Plant vegetation/establish parks/create rain gardens/build green roofs	- Vegetation absorbs pollutants - Vegetation stores carbon dioxide/produces oxygen - Decreased erosion - Increased/restored habitat for wildlife - Increased biodiversity - Helps reduce urban heat island effect - Aesthetic enjoyment/improved quality of life - Creates jobs (in landscaping/park maintenance)
Install retention ponds/stormwater basins	- Decreased pollution in runoff - Increased habitat/biodiversity

- G** **Describe** one difference between the climate of a temperate seasonal forest and that of a savanna. **Point 07**

Examples of acceptable responses may include the following:

- Temperate seasonal forests have a cooler climate than a savanna.
- Temperate seasonal forests have a stronger/colder winter than a savanna.
- Temperate seasonal forests have four distinct seasons while savannas do not.
- Temperate seasonal forests receive more annual precipitation than savannas.
- Temperate forests receive precipitation throughout the year while savannas have a rainy season/dry season.

- H** **Identify** the ecological process that occurs following a forest fire that leaves the soil intact. **Point 08**
- Acceptable identification point:
- Secondary succession

I	Describe one way burning forests contribute to atmospheric pollution. Acceptable description point: • Burning of trees releases CO ₂ /CO/NO _x /particulate matter/VOCs.	Point 09
J	Describe one sustainable forestry practice that could be used to reduce the occurrence or severity of forest fires. Examples of acceptable responses may include the following: • Prescribed burns can remove excess fuel/dead leaves/underbrush. • Brush removal can remove excess fuel/dead leaves/underbrush. • Selective cutting can create a fire break. • In agroforestry, ground crops that might otherwise be fuel can be harvested/removed.	Point 10

Question 3: Analyze an Environmental Problem and Propose a Solution (Doing Calculations)

10 points

A	Identify an anthropogenic source of particulate matter, other than from motor vehicles. Examples of acceptable responses may include the following: • Coal/fossil fuel combustion • Industrial exhaust • Construction/demolition • Waste incineration • Mining • Burning of biomass • Anthropogenically caused wildfires • Unpaved roads • Agricultural fields	Point 01
B	One way to reduce pollutants associated with motor vehicles is to use a vapor recovery nozzle. Describe one way a vapor recovery nozzle is used to reduce atmospheric pollution. Acceptable description point: • It prevents fumes/vapors from escaping into the atmosphere when gassing/fueling (a motor vehicle).	Point 02
C	Explain how a decrease in the number of people commuting to work in their personal vehicles could lead to a reduction in acid rain. Examples of acceptable responses may include the following: • (A decrease in commuting) would result in lower nitrogen oxide/sulfur oxide emissions from cars/vehicles. • (A decrease in commuting) would lead to less nitric acid/sulfuric acid in the atmosphere.	Point 03

D	Calculate the percent change in gas mileage between the gasoline-powered SUV and the hybrid SUV based on the data provided. Show your work. One point for the correct setup to calculate the percent change in gas mileage. Examples of acceptable responses may include the following: • $(36 \text{ mpg} - 22 \text{ mpg}) / 22 \text{ mpg} \times 100$ • $(36 - 22) / 22 \times 100$	Point 04
	One point for the correct calculation of the percent change in gas mileage. Examples of acceptable responses may include the following: • 63.6% increase • 63.6% • 63.6 • 64% • 64	Point 05
E	Calculate how many more miles the owner can drive in the hybrid SUV in the city than they could have driven in the gasoline-powered SUV. Show your work. One point for the correct setup to calculate how many more miles the hybrid SUV can drive than the gasoline-powered SUV. Examples of acceptable responses may include the following: • $(14 \text{ gallon} \times 36 \text{ mpg}) - (14 \text{ gallon} \times 22 \text{ mpg})$ • $(14 \times 36) - (14 \times 22)$ • $14 \times (36 - 22)$	Point 06
	One point for the correct calculation of how many more miles the hybrid SUV can drive than the gasoline-powered SUV. Examples of acceptable responses may include the following: • 196 • 200	Point 07
F	Propose a realistic solution that schools could implement to decrease energy use for heating and cooling, other than a reduction in the amount of time the school building is occupied. Examples of acceptable responses may include the following: • Implement green building design features • Open windows to reduce use of air conditioning • Use energy-efficient heating and cooling equipment • Adjust the thermostat to reduce use of heat and air conditioning • Install conservation landscaping	Point 08

G	Calculate the energy use in the school building in kilowatts per year using LED light bulbs. Point 09 Show your work. One point for the correct setup to calculate the energy use in the school building in kWh/year using LED light bulbs. Examples of acceptable responses may include the following: • $(2.8 \times 10^4 \text{ bulbs}) \times 0.0085 \text{ kilowatt} \times 2,340 \text{ hours}$ • $(2.8 \times 10^4) \times 0.0085 \times 2,340$
	One point for the correct calculation of the energy use in the school building in kWh/year using LED light bulbs. Point 10 Examples of acceptable responses may include the following (if units are included in the response, kWh/year or kW/year are accepted): • 556,920 • 5.6×10^5 • 5.6E5

Question 1: Design an Investigation**10 points**

A	Based on the data in the graph, identify the number of Common Tern breeding pairs in 1995. Point 01 Acceptable identification point: • 1400
B	Based on the data in the graph, describe the trend in the number of Common Tern breeding pairs from 1995 to 2008. Point 02 Examples of acceptable responses may include the following: • The number of breeding pairs varies but shows an overall decrease. • The number of breeding pairs decreases.
C	A group of students hypothesized that sea level rise will lead to an increase in Common Tern populations. Describe one reason the data in the graph refute this hypothesis. Point 03 Examples of acceptable responses may include the following: • The data suggest that a rise in sea level will decrease the number of breeding pairs. • As sea level rises, fewer breeding pairs will likely lead to smaller populations.
D	Explain how climate change can lead to sea level rise. Point 04 Examples of acceptable responses may include the following: • Increasing global temperatures results in melting glaciers/land-based ice sheets. • Increasing global temperatures causes ocean water expansion.
E	(i) Identify a hypothesis that researchers are likely investigating in the wading bird study. Point 05 Examples of acceptable responses may include the following: • If sea level rises, wading bird diversity/species richness will decrease. • If sea level rises, wading bird diversity/species richness will increase. • Sea level rise will/will not affect wading bird diversity/species richness. • Wading bird diversity/species richness is correlated with sea level rise. (ii) Identify the dependent variable in this study. Point 06 Examples of acceptable responses may include the following: • Number of wading bird species • Species richness of wading birds

F	If the researchers repeated their study, explain how this environmental change could affect the results of the study.	Point 07
	Examples of acceptable responses may include the following:	
	- There would be a decrease in wading birds because PCBs tend to magnify/concentrate in higher trophic levels. - There would be a decrease in wading birds because PCBs can bioaccumulate (in fatty tissue). - There would be a decrease in wading birds because PCBs are toxic/kill birds/make birds sick when ingested. - There would be a decrease in wading birds because of eggshell thinning/developmental deformities/reproductive problems caused by PCBs.	
G	Describe a regulating ecosystem service that can be provided by wetlands.	Point 08
	Examples of acceptable responses may include the following:	
	(Wetlands) filter/purify/improve water (quality). (Wetlands) provide flood regulation/erosion control. (Wetlands) store/sequester carbon.	
H	Explain how increased sediment might lead to a change in the size of the wading bird populations.	Point 09
	Examples of acceptable responses may include the following:	
	(Increased sediment) can reduce the ability of wading birds to see prey/food/fish. (Increased sediment) can reduce/increase the ability of wading birds to hunt. (Increased sediment) negatively impacts organisms in lower trophic levels, reducing food/energy for the wading birds. - Reduced light infiltration can decrease the (number of) primary producers, resulting in less energy for higher trophic levels.	
I	Describe an environmental problem, other than an increase in sediment, that can occur in wetlands that is associated with increased urbanization and development.	Point 10
	Examples of acceptable responses may include the following:	
	- Construction projects can reduce/fragment wetland habitats. - Runoff of fertilizers/wastewater effluent can lead to eutrophication, (decreasing DO and killing fish). - Runoff of litter can kill animals when ingested/tangled. - More impervious structures/roads/buildings/sidewalks/parking lots can lead to flooding. - Runoff of heavy metals/pesticides can kill/weaken organisms when absorbed/ingested. - Noise/light pollution can disrupt hunting/migrating/behavior. - Runoff of oil can block light, preventing photosynthesis. - Increased water use can decrease the amount of groundwater/cause wetlands to dry up.	

Question 2: Analyze an Environmental Problem and Propose a Solution

10 points

A	Based on the information in Figure 1, identify the type of plate boundary that runs beneath Serengeti National Park.	Point 01
	Acceptable identification point:	
	Divergent (boundary)	
B	Based on the information provided, identify the dominant biome within the Serengeti.	Point 02
	Examples of acceptable responses may include the following:	
	- Savanna - Tropical grassland	
C	Wildebeest give birth to their young when new grasses are growing. Based on the information in Figure 2, identify the location in the Serengeti where wildebeest are most likely to give birth.	Point 03
	Examples of acceptable responses may include the following:	
	- Grumeti Game Reserve - The west/northwestern side/edge (of Serengeti National Park)	
D	Explain why resource partitioning allows for the coexistence of the wildebeest and the gazelle in the Serengeti.	Point 04
	Examples of acceptable responses may include the following:	
	(Resource partitioning) reduces the (negative) impact of competition for (limited) resources. (Resource partitioning) allows species to use (limited) resources in different ways/places/at different times.	
E	Describe one way the proposed highway shown in Figure 2 could negatively affect the wildebeest population in the Serengeti.	Point 05
	Examples of acceptable responses may include the following:	
	- Building the highway would fragment/destroy habitat/food/resources. - The highway could prevent/reduce/disturb migration. - Wildebeest could be hit/killed by vehicles. - Noise pollution could cause stress/change migratory routes.	

F **Propose** a solution to the negative effect created by the planned highway described in part E. **Point 06**

Examples of acceptable responses may include the following:

Problem in part E	Realistic Potential Solution
Building the highway would fragment/destroy habitat/food/resources.	- Construct a habitat corridor over/under the highway - Construct the highway over/above the habitat - Relocate the highway north/outside of the migratory path - Expand the national park/create additional protected habitat
The highway could prevent/reduce/disturb migration.	- Relocate the highway north/outside of the migratory path - Construct a habitat corridor over/under the highway
Wildebeest could be hit/killed by vehicles.	
Noise pollution could cause stress/change migratory routes.	- Install a sound barrier to mitigate noise pollution - Relocate the highway north/outside of the migratory path

G **Describe** a characteristic of an invasive species, such as the spotted knapweed, that allows them to outcompete native species. **Point 07**

Examples of acceptable responses may include the following:

- They have many offspring/reproduce quickly/mature early/invest minimal energy in each offspring (tend to be r-selected).
- They can feed on/use many different types of resources.
- They can survive in conditions outside their normal habitat/have a wide range of tolerance (tend to be generalists).

H **Justify** the use of crop rotation as an environmental solution by providing an additional advantage, other than controlling pest populations. **Point 08**

Examples of acceptable responses may include the following:

- Improved soil fertility/soil structure/soil quality
- Increased nutrient cycling/reduction in fertilizer use
- Reduced soil erosion
- Increased food security/crop yield
- Increased biological activity (in the soil)

I **Describe** an environmental problem associated with controlling pest populations with large amounts of pesticide. **Point 09**

Examples of acceptable responses may include the following:

- Pesticides can harm/kill nontarget species.
- Pests can develop resistance to the pesticide.

J **Propose** a solution to controlling pests, other than pesticides or crop rotation. **Point 10**

Examples of acceptable responses may include the following:

- Use biocontrol/intercropping/natural predators
- Trap insects/use mechanical controls to eliminate the pests
- Use genetically modified crops that are pest resistant

Question 3: Analyze an Environmental Problem and Propose a Solution (Doing Calculations)

10 points

A Identify a type of surface mining the company could use to access the coal. **Point 01**

Examples of acceptable responses may include the following:

- Strip mining
- Open pit
- Mountain top removal

B Describe an environmental problem associated with surface mining. **Point 02**

Examples of acceptable responses may include the following:

- Removal of vegetation/soil/rock causes loss/destruction of habitat.
- (Surface mining) causes loss of habitat, which results in loss of biodiversity.
- Removal of vegetation can increase rates of erosion.
- (Surface mining) can lead to contamination of groundwater/surface water/waterways from runoff of sediments/pollutants.
- Removal of vegetation/soil/bedrock/parent material can release dust particles/methane.
- High energy/fossil fuel consumption is needed to operate equipment and leads to air pollution.

C Describe an environmental problem the town could experience as a result of the electricity generation at the coal-burning power plant. **Point 03**

Examples of acceptable responses may include the following:

- Release of air pollutants/toxic metals/particulates/ NO_x / SO_x could lower air quality/result in respiratory problems.
- Release of air pollutants/sulfur dioxides/nitrogen oxides could cause acid rain.
- Greenhouse gas emissions/carbon dioxide/methane/water vapor could lead to altered precipitation/climate/weather/temperature patterns.

D Propose a realistic solution the local government could enact that would reduce the negative environmental consequences of using coal to generate electricity. **Point 04**

Examples of acceptable responses may include the following:

- Require/incentivize the plant to install scrubbers/electrostatic precipitators.
- Incentivize the use of alternative energy sources/energy efficient appliances.
- Incentivize green building design/conservation landscaping/planting trees as carbon sinks.

E Calculate how many pounds of coal would need to be burned to generate enough electricity to power a town with 11,000 houses for a year. **Show** your work. **Point 05**

One point for the correct setup to calculate how many pounds of coal would be needed.

Examples of acceptable responses may include the following:

- $(11,000 \text{ houses} \times 10,640 \text{ kWh per house}) / 0.88 \text{ kWh per lb of coal}$
- $(11,000 \times 10,640) / 0.88$

One point for the correct calculation of how many pounds of coal would be needed. **Point 06**

Examples of acceptable responses may include the following:

- 133,000,000
- 1.33×10^8

F Calculate the percent change in bird species per hectare since the power plant was installed. **Show** your work. **Point 07**

One point for the correct setup to calculate the percent change in bird species per hectare.

Examples of acceptable responses may include the following:

- $(6.0 \text{ species / ha} - 7.5 \text{ species / ha}) / 7.5 \text{ species / ha} \times 100$
- $(6.0 - 7.5) / 7.5 \times 100$

One point for the correct calculation of the percent change in bird species per hectare. **Point 08**

Examples of acceptable responses may include the following:

- -20%
- 20% decrease
- -20

G Assuming that the growth rate remains constant, **calculate** the year in which the population will reach 52,500. **Show** your work. **Point 09**

One point for the correct setup to calculate the year the population will reach 52,500.

Acceptable setup point:

- $(70 / 5.38) + 2022$

One point for the correct calculation of the year the population will reach 52,500. **Point 10**

Acceptable calculation point:

- 2035