PALEO-CLIMATE
MODULE

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Paleoclimate

Vocabulary

Analog analysis:

A method for analyzing and interpreting paleoenvironments that can be based on either statistics or qualitative observations. The basic principle is that of uniformitarianism – the present is the key to the past. In our exercises we rely on defining qualitative modern pollen-vegetation-climate relationships to aid in interpreting past changes.

Biostratigraphy:

The spatial relationship between biological indicators found in sedimentary deposits. These relationships have a time component: in unmixed deposits the lowermost sediments are the oldest and uppermost units the youngest.

Conifers/Coniferous:

Plants with needle-like leaves.

Deciduous:

Plants that shed there leaves in winter, often having broad leaves. Note that larch, a conifer, is deciduous.

Deposit:

Sediment put down on the earth's surface in the past either by natural or human action. An archaeological deposit was created by people in the past. It can include soil, artifacts, features, or other traces of human activity that signals anthropogenic (human) involvement in the deposition process. Deposits usually form layers or "strata" that stack up horizontally like a layer cake with the oldest at the bottom and the youngest at the top. As a result the oldest archaeological deposits (or geological deposits, such as volcanic ash layers) are found below younger ones, allowing us to develop histories of events by studying the stratigraphy. Even so, material within deposits can be out of place (for a number of reasons, like the action of burrowing animals) resulting in the possibility of misinterpretation of the stratigraphy of a site or excavation. (see Stratigraphy Module).

Gradient:

Change in one variable with respect to another variable. In palynology this change is always in respect to geography or spatial distribution, for example a temperature or a vegetation gradient reflects changes in climate or vegetation over a specific region.

Paleo:

Prefix indicating "past."

Palynology:

The study of pollen and spores. The applications are widespread from providing pollen counts during allergy season to interpreting paleoenvironments. A palynologist is a specialist in the field of palynology.

Pollen:

Microscopic grains produced by higher plant forms (angiosperms and gymnosperms; flower and seed producing plants), containing male genetic material required for sexual reproduction. A dusting of pollen is often seen on surfaces as a yellowish powder during the flowering season. Note: pollen is both the singular and plural form. It is incorrect to refer to "pollens."

Vocabulary

Pollen assemblage:
The combination of pollen and spores that characterize a specific pollen zone in a diagram or a specific vegetation type in modern studies.

Pollen diagram:
The basic tool for interpreting palynological records. It consists of an x-y plot of pollen and spore values vs. depth or time. Values, plotted along the x-axis, are usually percentages but can also represent pollen accumulation rates. The shallowest depths and youngest ages appear at the top of the y-axis.

Pollen spectrum/spectra:
Percentages of all pollen and spores from a single (spectrum) or multiple (spectra) sediment samples. Pollen assemblages consist of 2 or more spectra.

Proxy data:
A type of data that is used as a substitute measure for another parameter. For example, current temperatures can be measured using a thermometer. However, it is impossible to directly measure paleotemperatures because paleothermometers do not exist. Therefore, we use another data type or "proxy" (e.g., pollen) which has a known relationship to temperature (e.g., different vegetation types have different temperature requirements) to infer past changes.

Radiocarbon date:
A numerical date which approximates time of death of an organism (plant or animal) based on the amount of radioactive carbon (prone to decay) that remains in it. Radiocarbon dates are often used by earth scientists and archaeologists to understand the time lines of events, geological or cultural, respectively.

Spore:
A microscopic grain produced by lower plant forms (cryptograms) and containing genetic material for asexual reproduction. Unlike the higher plants, cryptograms have no true flowers or seeds.

Years BP (years before present):
The amount of time which has passed between the occurrence of an event and the year A.D. 1950.

Zone:
1) The combination of plant communities into a unique vegetation type that has a regional geographic distribution and is associated with specific climatic characteristics;
2) used in pollen diagrams as a basic unit for interpretation; each pollen zone represents a change in vegetation type and must include at least 2 pollen spectra.

Background Information

Knowledge of past landscapes and climate is an important element of interdisciplinary studies of the past. Although these types of investigations are valuable in and of themselves, they can provide essential information to archeologists who wish to better understand possible human-environment interactions. Such research also can provide useful insights into questions related to future climates and likely landscape responses (e.g., by looking at warm periods in the past, palynologists hypothesize that arctic tundra will disappear and be replaced by birch, poplar, and larch forests).

Many types of paleoenvironmental data are used to unravel the past. Here we focus on palynology, the study of microscopic pollen and spores (to simplify we will use only pollen in our discussion and examples). By taking cores from organic deposits, such as lakes or peats, palynologists can trace the vegetation history of a region by counting the numbers of pollen grains. Their percentages reflect the plants, and thus plant communities, that produced them. Unfortunately, there is not a one-to-one relationship between plants and pollen, although the greater the relative percentage of a given pollen type, the greater the number of plants on the landscape. Therefore, the first step in reconstructing the paleovegetation is determining the characteristic pollen "signature" that identifies modern vegetation types. The modern pollen rain is sampled from the most recent deposits in a lake or peat, for example from a 1-cm^3 specimen of sediment taken from the mud-water interface of a lake. The pollen percentages are plotted and then can be evaluated qualitatively (e.g., by comparing the pollen assemblages to a map of vegetation types) or using statistical analyses. Once the modern pollen-vegetation relationships are established, then paleovegetation can be inferred by searching for analogs of the ancient pollen samples to modern ones. Often this is done qualitatively, as we will do in our exercises, but standard statistical analyses are also used.

Because paleoclimatologists do not have thermometers or rain gages buried in their sites, they must rely on proxy data (i.e., data that indirectly reflects climate). Pollen is one of the best proxies because: 1) vegetation types are strongly controlled by climate; 2) the relationship between modern pollen assemblages and differing vegetation types is well established; and 3) pollen is an abundant and ubiquitous fossil. The first step for inferring paleoclimate is to determine the relationship of present-day vegetation and climate in the study region. This can be done by comparing gradients in maps of temperature or precipitation to vegetation maps (qualitative method) or by assigning modern climate values to the modern pollen sites (quantitative method). Next the fossil samples are counted and plotted in a pollen diagram. Based on the pollen assemblage, scientists then can interpret the past climate either qualitatively (e.g., cooler and drier than present) or with numerical values taken from the modern climate assignments.

Name: ______________________________

Question Set 1

Activity 1 Questions: Climate and Vegetation; Modern Calibration

Question 1:

If you wanted to live in the warmest area of the Kuril Islands during the summer, which island would you choose? The coolest island during summer? If you wanted to live in the warmest island during winter, would you have to move from your summer island? In each case, what type of vegetation would grow on your island?

Question 2:

Access to fresh water can be a problem in the Kuril archipelago, because some islands have no fresh water and other islands have only small streams. Rain and snow, of course, are also sources of fresh water. If you could not depend on a stream for water, which island(s) might you chose for a summer (winter) settlement, based on the map of July (January) precipitation? If you lived in the Kuril Islands 1,000 years ago, what other landscape elements might you consider in your winter settlement?

Name: ______________________________ **Question Set 1**

Activity 1 Questions: Climate and Vegetation; Modern Calibration

Question 3:

If you were the chief palynologist, how would you summarize the qualitative vegetation-climate relationships for the other scientists working on the Kuril Biocomplexity Project? Fill out the table below to answer this question: first give each vegetation zone a ranking (e.g., vegetation with the warmest July temperatures is given a rank of 1; coolest July temperatures a rank of 4). Rank only those climate variables that influence the vegetation. Provide a qualitative description (e.g., warm, wet summers; warmest, wettest winters) for each vegetation type.

Vegetation type	July temp. rank	Janurary precip. rank	Qualitative description
Meadows with thickets			
Meadow			
Birch forest			
Conifer forest			
North temperate forest (Kunashir)			
South temperate forest (Hokkaido)			

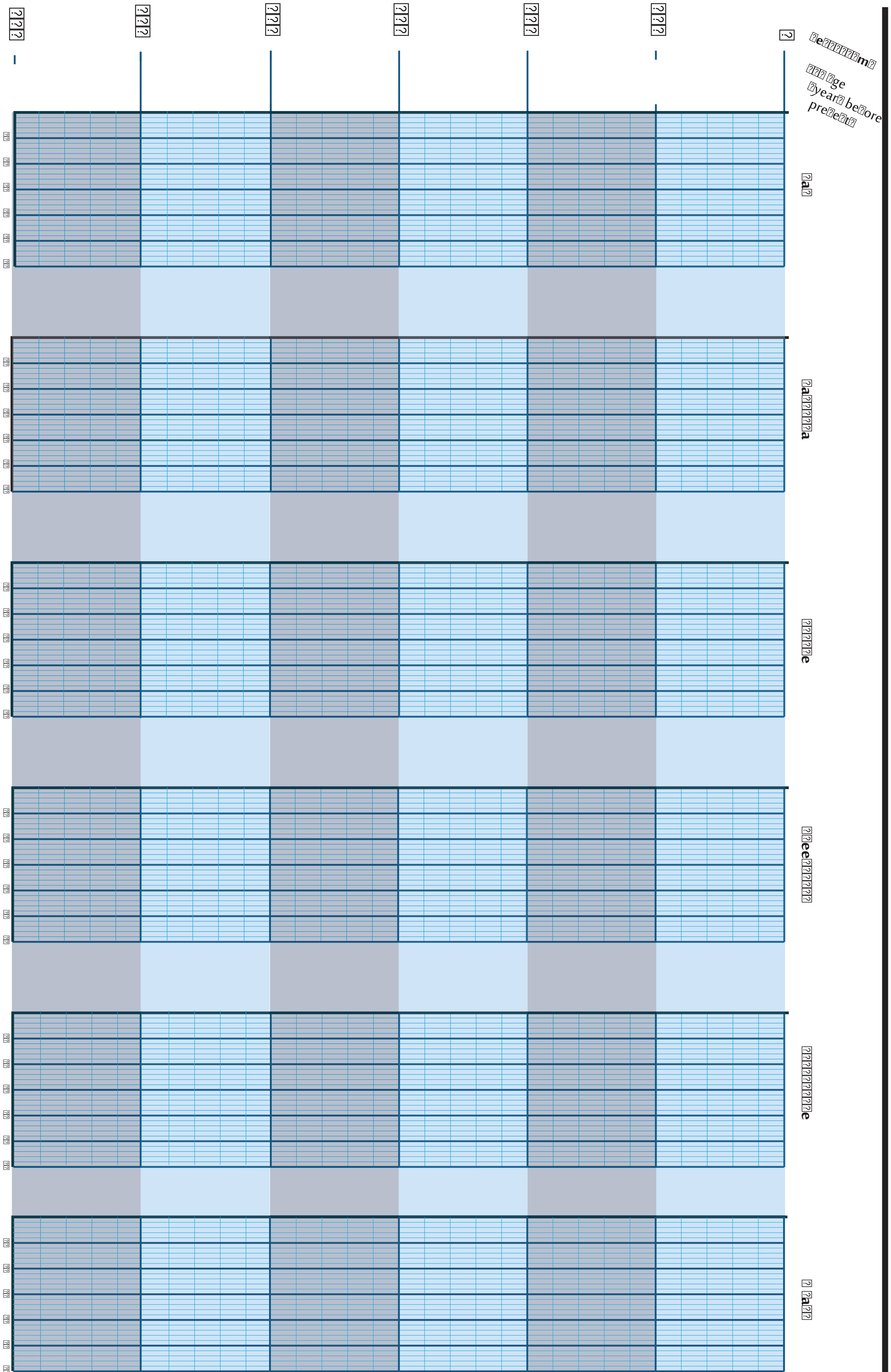
Name: ______________________________ **Activity 2**

Activity 2: Pollen Diagram Plotting and Interpretation

Instructions:

As the chief palynologist on the project, you have spent a month doing field work and 6 months in the laboratory. Now you are ready to interpret your data. Using the pollen diagram template and the quantitative results of pollen counting from a core from the Kuril Islands, which you can find on the next pages, create a pollen diagram to visually represent changes in Kuril vegetation through time. Don't forget to plot the radiocarbon dates to have an idea of when the changes in vegetation took place. Do you see distinctive pollen assemblages for the different vegetation types? How many? What is the pollen "signature" for each vegetation zone?

Name: ____________



The Kuril Biocomplexity Project: www.kbp.org

Pollen Percentages

Depth (cm)	oak	magnolia	spruce	tree birch	shrub pine	grass
0	0	0	1	40	23	10
10	0	0	1	37	20	8
20	0	0	0	35	20	10
25	0	0	0	30	22	10
30	0	0	0	25	25	15
40	0	0	0	28	25	12
50	0	0	1	37	23	8
60	0	0	0	40	20	10
80	0	0	0	40	20	10
100	0	0	1	40	21	9
120	0	0	1	40	22	12
140	0	0	1	40	20	10
160	0	0	2	37	18	8
180	0	0	5	35	20	10
190	0	0	30	20	15	5
200	0	0	37	20	15	5
210	0	0	40	20	15	5
230	30	5	7	13	12	3
240	33	5	5	12	13	3
250	35	5	5	15	15	5
270	50	7	0	10	5	3
290	55	10	0	7	5	3
320	60	15	0	5	2	3
350	55	12	0	5	2	3
370	55	10	0	5	5	3
400	50	10	0	7	5	3
410	45	9	0	10	5	3
430	35	5	0	12	12	5
450	33	5	0	12	12	5
480	35	5	0	15	15	5
500	30	5	0	15	15	5
520	2	0	0	2	20	10
540	0	0	0	0	25	15
550	0	0	0	1	25	15
560	0	0	0	0	10	15
580	0	0	0	0	2	30
600	0	0	0	0	2	45

Radiocarbon Dates

Depth	Date	Error
75	500	10
125	2100	40
250	4000	75
370	5300	60
420	6100	100
560	8060	80
600	8970	50

Name: ______________________________ **Question Set 2**

Activity 2: Pollen Diagram Plotting

Describe the vegetation history of your island for your colleagues. Use the handout called "Modern vegetation type & climate change by latitude" to determine how climate changes through the 8,000 years recorded in the core.

Name: ______________________________

Activity 2

Modern vegetation type and climate change by latitude