AP Environmental Science

Summer Reading and Math Practice

"Unless someone like you cares a whole awful lot, nothing is going to get better. It's not." – The Lorax

Dear APES Student,

Welcome to AP Environmental Science! I am excited to share the next school year with you and to challenge you in this college-level course.

APES is probably unlike any other science course you have taken in your high school career, in that it combines aspects of biology, chemistry, geology, oceanography, and geography in a multi-disciplinary study of the interrelationships of the natural world.

Your summer assignment involves three parts:

1. (Short assignment) Review the math work and do all of the practice problems. Use a separate sheet of notebook paper and **SHOW YOUR WORK** for all calculations. ***You will be quizzed on this during the first week of school.***
2. (Ongoing) Look for articles, editorials, videos, or other media on current environmental issues. Bring one article on an environmental issue during the first week of school. **(*No written work required, but will be graded as a quiz grade.*)**
3. (Longer assignment) Read the following two excerpts on Easter Island from *The Cartoon Guide to the Environment* and *Environment: The Science Behind the Stories*. In a 1-2 page reflection paper (typed), answer the following questions:
   - *Describe* the scientific processes involved in reconstructing the history of life on Easter Island.
   - *Explain* how water cycle relates to the presence or absence of trees on Easter Island.
   - *Identify* two major themes are present in the excerpt from *The Cartoon Guide to the Environment*,
   - *Describe* the scientific debates surrounding Easter Island.
   - *Provide evidence* for the paradigm shift proposed by Hunt and Lipo in the excerpt from *Environment: The Science Behind the Stories*.
   - Every author writes from his or her personal worldview and holds certain biases. *Compare and contrast* the bias of the authors of the articles.
   - *Describe* the biases you observe in articles or other writings on current environmental issues.
   - ***This paper will count as a test grade (100 points). All of the above bullet points must be addressed in your paper, and the paper will be submitted via Canvas on the first day of school. Pay attention to the italicized task verbs.***

I will be praying for you this summer and look forward to starting this journey together with you in the fall. You are welcome to email me with any questions this summer.

Mrs. Sandra Watford swatford@ccslancers.com

APES Summer Math Work

You will have a quiz on these math topics during the first week of school. Bring your completed work to class the first day of school.

Beginning in 2020, calculators are now allowed to be used during the APES exam. You may use calculators for the summer work and throughout the school year (scientific or graphing calculator, NOT your phone). Remember to show your setup for each problem in addition to writing the answer. **Please use lined paper for your work and show ALL WORK for each calculation.**

Averages

To find an average, add all the quantities given and divide the total by the number of quantities.

Example: Find the average of 10, 20, 35, 45, and 105.

Step 1: Add all the quantities. 10 + 20 + 35 + 45 + 105 = 215

Step 2: Divide the total by the number of given quantities. 215 / 5 = 43

Percentages

Introduction:

Percents show fractions or decimals with a denominator of 100. Always move the decimal TWO places to the right go from a decimal to a percentage or TWO places to the left to go from a percent to a decimal.

Examples: 0.85 = 85%; 0.008 = 0.8%

Percents can be calculated using the following ratio:

$$\frac{part}{whole} = \frac{percent}{100}$$

Part I: Finding the Percent of a Given Number

To find the percent of a given number, change the percent to a decimal and MULTIPLY.

Example: 30% of 400

Step 1: 30% = .30

Step 2: 400 x .30 = 120

Part II: Finding the Percentage of a Number

To find what percentage one number is of another, divide the first number by the second, then convert the decimal answer to a percentage.

Example: What percentage is 12 of 25?

Step 1: 12/25 = .48

Step 2: .48 = 48% (12 is 48% of 25)

Part III: Finding Percentage Increase or Decrease

To find a percentage increase or decrease, first find the percent change, then add or subtract the change to/from the original number.

Example: Airpods have dropped in price 18% from $139. What is the new price of Airpods?

Step 1: $139 x .18 = $25

Step 2: $139 - $25 = $114

Part IV: Finding a Total Value

To find a total value, given a percentage of the value, DIVIDE the given number by the given percentage.

Example: If taxes on a new car are 8% and the taxes add up to $1600, how much is the new car?

Step 1: 8% = .08

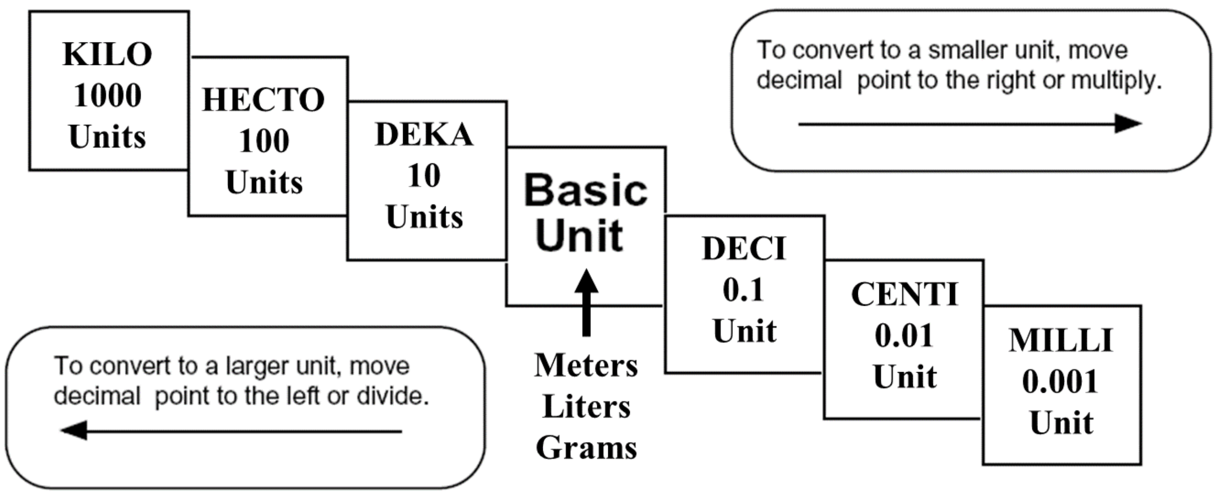
Step 2: $1600 / .08 = $20,000

Practice: Remember to **show all your work**, in particular your setup, and include units if given. Round to the nearest whole number where needed. **Use a separate sheet of notebook paper.**

1. **Find the average of the following numbers: 11, 12, 13, 14, 15, 23, and 29. Round to the nearest whole number.**
2. **What is 45% of 900?**
3. **Thirteen percent of a 12,000-acre forest is being logged. How many acres will be logged?**
4. **A water heater tank holds 280 gallons. Two percent of the water is lost as steam. How many gallons remain to be used?**
5. **14,000 acres of a 40,000-acre forest burned in a forest fire. What percentage of the forest was damaged?**
6. **The Greenland Ice Sheet contains 2,850,000 cubic kilometers of ice. It is melting at a rate of .006% per year. How many cubic kilometers are lost each year?**
7. **235 acres, or 15%, of a forest is being logged. How large is the forest?**
8. **In a small oak tree, the biomass of insects makes up 3000 kilograms. This is 4% of the total biomass of the tree. What is the total biomass of the tree?**

<u>Metric Units</u>

Kilo-, centi-, and milli- are the most frequently used prefixes of the metric system. You need to be able to go from one to another without a calculator. You can remember the order of the prefixes by using the following sentence: *King Henry Died By Drinking Chocolate Milk*. Since the multiples and divisions of the base units are all factors of ten, you just need to move the decimal to convert from one to another.



<u>Example</u>: 55 centimeters = ? kilometers

Step 1: Figure out how many places to move the decimal. *King Henry Died By Drinking…* – that's five places. (Count the one you are going to, but not the one you are on.)

Step 2: Move the decimal five places to the left since you are going from smaller to larger.

55 centimeters = .00055 kilometers

<u>Example</u>: 19.5 kilograms = ? milligrams

Step 1: Figure out how many places to move the decimal. … *Henry Died By Drinking Chocolate Milk* – that's six places. (Remember to count the one you are going to, but not the one you are on.)

Step 2: Move the decimal six places to the right since you are going from larger to smaller. In this case you need to add zeros.

19.5 kilograms = 19,500,000 milligrams

Practice: Remember to **show all your work** and include units if given. **Use a separate sheet of notebook paper.**

9. **1200 kilograms = ? milligrams**
10. **14000 millimeters = ? meters**
11. **670 hectometers = ? centimeters**
12. **6544 liters = ? milliliters**
13. **.078 kilometers = ? meters**
14. **17 grams = ? kilograms**

Scientific Notation

Introduction:

Scientific notation is a shorthand way to express large or tiny numbers. We will consider anything over 1000 to be a large number. Writing these numbers in scientific notation will help you do your calculations much quicker and easier and will help prevent mistakes in conversions from one unit to another. Like the metric system, scientific notation is based on factors of 10. A large number written in scientific notation looks like this:

$$1.23 \times 10^{11}$$

The number before the x (1.23) is called the coefficient. The coefficient must be greater than 1 and less than 10. The number after the x is the base number and is always 10. The number in superscript (^{11}) is the exponent.

Part I: Writing Numbers in Scientific Notation

To write a large number in scientific notation, put a decimal after the first digit. Count the number of digits after the decimal you just wrote in. This will be the exponent. Drop any zeros so that the coefficient contains as few digits as possible.

Example: 123,000,000,000

Step 1: Place a decimal after the first digit. 1.23000000000

Step 2: Count the digits after the decimal…there are 11.

Step 3: Drop the zeros and write in the exponent. 1.23×10^{11}

Writing tiny numbers in scientific notation is similar. The only difference is the decimal is moved to the left and the exponent is a negative. A tiny number written in scientific notation looks like this:

Example: 0.0000000426

Step 1: 00000004.26

Step 2: Count the digits before the decimal…there are 8.

Step 3: Drop the zeros and write in the exponent as a negative. 4.26×10^{-8}

Part II: Adding and Subtracting Numbers in Scientific Notation

To add or subtract two numbers with exponents, the exponents must be the same. You can do this by moving the decimal one way or another to get the exponents the same. Once the exponents are the same, add (if it's an addition problem) or subtract (if it's a subtraction problem) the coefficients just as you would any regular addition problem. The exponent will stay the same. Make sure your answer has only one digit before the decimal – you may need to change the exponent of the answer.

Example: $1.35 \times 10^6 + 3.72 \times 10^5 = ?$

Step 1: Make sure both exponents are the same. It's usually easier to go with the larger exponent so you don't have to change the exponent in your answer, so let's make

$$3.72 \times 10^5 \rightarrow 0.372 \times 10^6$$

Step 2: Add the coefficients just as you would regular decimals. You can use your calculator for this.

$$1.35 + 0.372 = 1.722$$

Step 3: Write your answer including the exponent, which is the same as what you started with.

$$1.722 \times 10^6$$

Part III: Multiplying and Dividing Numbers in Scientific Notation

To multiply exponents, multiply the coefficients just as you would regular decimals. Then add the exponents to each other. The exponents DO NOT have to be the same.

Example: $1.35 \times 10^6 \times 3.72 \times 10^5 = ?$

Step 1: Multiply the coefficients using your calculator.

$$1.35 \times 3.72 = 5.022$$

Step 2: Add the exponents.

$$6 + 5 = 11$$

Step 3: Write your final answer.

$$5.022 \times 10^{11}$$

To divide exponents, divide the coefficients just as you would regular decimals, then subtract the exponents. In some cases, you may end up with a negative exponent.

<u>Example</u>: $5.635 \times 10^3 / 2.45 \times 10^6 = ?$

Step 1: Divide the coefficients.

$$5.635 / 3.45 = 2.3$$

Step 2: Subtract the exponents.

$$3 – 6 = -3$$

Step 3: Write your final answer.

$$2.3 \times 10^{-3}$$

<u>Practice</u>: Remember to **show all your work.** Record your answers in correct scientific notation form. **Use a separate sheet of notebook paper.**

15. **145,000,000,000 – convert to scientific notation**
16. **13 million– convert to scientific notation**
17. **0.000348– convert to scientific notation**
18. **$3 \times 10^3 + 4 \times 10^3$**
19. **$4.67 \times 10^4 + 323 \times 10^3$**
20. **$7.89 \times 10^{-6} + 2.35 \times 10^{-8}$**
21. **$9.85 \times 10^4 – 6.35 \times 10^4$**
22. **$2.9 \times 10^{11} – 3.7 \times 10^{13}$**
23. **13 million minus 11 thousand**
24. **1.32×10^8 X $2.34\ 10^4$**
25. **3.78×10^3 X 2.9×10^2**
26. **$3.45 \times 10^9 / 2.6 \times 10^3$**
27. **$1.98 \times 10^{-4} / 1.72 \times 10^{-6}$**

<u>Dimensional Analysis</u>

<u>Introduction</u>:

Dimensional analysis is a way to convert a quantity given in one unit to an equal quantity of another unit by lining up all the known values and multiplying. It is sometimes called factor-labeling. The best way to start a problem is by using what you already know. In some cases, you may use more steps than a classmate to find the same answer, but it doesn't matter. Use what you know, even if the problem goes all the way across the page!

In a dimensional analysis problem, start with your given value and unit and then work toward your desired unit by writing equal values side by side. Remember you want to cancel each of the intermediate units. To cancel a unit on the top part of the problem, you have to get the unit on the bottom. Likewise, to cancel a unit that appears on the bottom part of the problem, you have to write it in on the top.

Once you have the problem written out, multiply across the top and bottom and then divide the top by the bottom.

<u>Example</u>: 3 years = ? seconds

> Step 1: Start with the value and unit you are given. There may or may not be a number on the bottom.
>
> $$\left(\frac{\text{3 years}}{\quad}\right)$$
>
> Step 2: Start writing in all the values you know, making sure you can cancel top and bottom. Since you have years on top right now, you need to put years on the bottom in the next segment. Keep going, canceling units as you go, until you end up with the unit you want (in this case seconds) on the top.

$$\left(\frac{\text{3 years}}{\quad}\right)\left(\frac{\text{365 days}}{\text{1 year}}\right)\left(\frac{\text{24 hours}}{\text{1 day}}\right)\left(\frac{\text{60 minutes}}{\text{1 hour}}\right)\left(\frac{\text{60 seconds}}{\text{1 minute}}\right)$$

Step 3: Multiply all the values across the top. Write in scientific notation if it's a large number. Write units on your answer.

$$3 \times 365 \times 24 \times 60 \times 60 = 9.46 \times 10^7 \text{ seconds}$$

Step 4: Multiply all the values across the bottom. Write in scientific notation if it's a large number. Write units on your answer if there are any. In this case everything was cancelled so there are no units.

$$1 \times 1 \times 1 \times 1 = 1$$

Step 5: Divide the top number by the bottom number. Remember to include units.

$$9.46 \times 10^7 \text{ seconds} / 1 = 9.46 \times 10^7 \text{ seconds}$$

Step 6: Review your answer to see if it makes sense. 9.46×10^7 is a really big number. Does it make sense for there to be a lot of seconds in three years? YES! If you had gotten a tiny number, then you would need to go back and check for mistakes.

In lots of APES problems, you will need to convert both the top and bottom unit. Don't panic! Just convert the top one first and then the bottom.

Example: 50 miles per hour = ? feet per second

Step 1: Start with the value and units you are given. In this case there is a unit on top and on bottom.

$$\left(\frac{50 \text{ miles}}{1 \text{ hour}}\right)$$

Step 2: Convert miles to feet first.

$$\left(\frac{50 \text{ miles}}{1 \text{ hour}}\right)\left(\frac{5280 \text{ feet}}{1 \text{ mile}}\right)$$

Step 3: Continue the problem by converting hours to seconds.

$$\left(\frac{50 \text{ miles}}{1 \text{ hour}}\right)\left(\frac{5280 \text{ feet}}{1 \text{ mile}}\right)\left(\frac{1 \text{ hour}}{60 \text{ minutes}}\right)\left(\frac{1 \text{ minute}}{60 \text{ seconds}}\right)$$

Step 4: Multiply across the top and bottom. Divide the top by the bottom. Be sure to include units on each step. Use scientific notation for large numbers.

50 x 5280 feet x 1 x 1 = 264000 feet

1 x 1 x 60 x 60 seconds = 3600 seconds

264000 feet / 3600 seconds = 73.33 feet/second

Practice: Remember to **show all your work,** include units if given. Use scientific notation when appropriate and helpful. Some conversions are listed below. **Use a separate sheet of notebook paper.**

Conversions:

1 square mile = 640 acres
1 hectare (Ha) = 2.47 acres
1 kw-hr = 3,413 BTUs
1 barrel of oil = 159 liters
1 metric ton = 1000 kg
1 mile = 5,280 feet 0.062 miles = 1 kilometer

28. **134 miles = ? inches**
29. **8.9 x 10^5 tons = ? ounces**
30. **1.35 kilometers per second = ? miles per hour**
31. **A city that uses ten billion BTUs of energy each month is using how many kilowatt-hours of energy?**
32. **A 340 million square mile forest is how many hectares?**
33. **If one barrel of crude oil provides six million BTUs of energy, how many BTUs of energy will one liter of crude oil provide?**
34. **Fifty-eight thousand kilograms of solid waste is equivalent to how many metric tons?**

Excerpt from *The Cartoon Guide to the Environment* by Larry Gonick and Alice Outwater, ©1996.

CHAPTER 1

FORESTS AND WATER

OUR STORY BEGINS IN A PLACE THAT'S BEEN CALLED THE MOST FAR-FLUNG INHABITED ISLAND IN THE WORLD: ***EASTER ISLAND,*** A 64-SQUARE-MILE SPECK IN THE PACIFIC OCEAN, 2300 MILES FROM ANYWHERE.

"HOW INAPPROPRIATE TO CALL THIS PLANET EARTH, WHEN CLEARLY IT IS OCEAN."

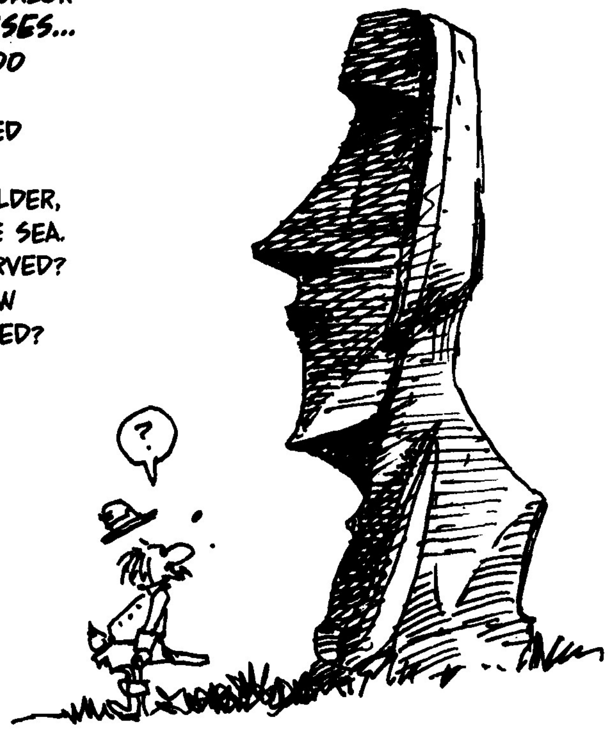
—ARTHUR C. CLARKE

REMOTE, BUT NOT ***DESERTED...*** FROM TIME TO TIME VISITORS DROPPED BY... LIKE THE DUTCH ADMIRAL ***ROGGEVEEN*** IN 1722. ARRIVING ON ***EASTER SUNDAY,*** HE NAMED THE ISLAND AFTER THE DATE OF ARRIVAL, AND LEFT THE FIRST WRITTEN ACCOUNT OF THE PLACE AND THE PEOPLE WHO LIVE THERE.

ACCORDING TO ROGGEVEEN AND OTHER 18TH-CENTURY REPORTS, SOME *3000* ISLANDERS EKED OUT A WRETCHED EXISTENCE BY FARMING BANANAS, SUGAR CANE, AND SWEET POTATOES FROM POOR, ROCKY SOIL. THE ONLY FRESH WATER CAME FROM MURKY LAKES INSIDE VOLCANIC CRATERS. THERE WAS SCARCELY A TREE ON THE ISLAND, AND THE PEOPLE WERE "SMALL, LEAN, TIMID, AND MISERABLE."

2

BUT AMIDST THE SQUALOR WERE SOME ***SURPRISES...*** ESPECIALLY SOME 800 ***MASSIVE STONE STATUES*** SCATTERED ACROSS THE ISLAND, SHOULDER TO SHOULDER, THEIR BACKS TO THE SEA. HOW WERE THEY CARVED? HOW QUARRIED? HOW MOVED? HOW ERECTED? AND BY WHOM?



WHEN THE EUROPEANS ASKED WHERE THE STATUES HAD COME FROM, THE ISLANDERS GAVE THIS REPLY:

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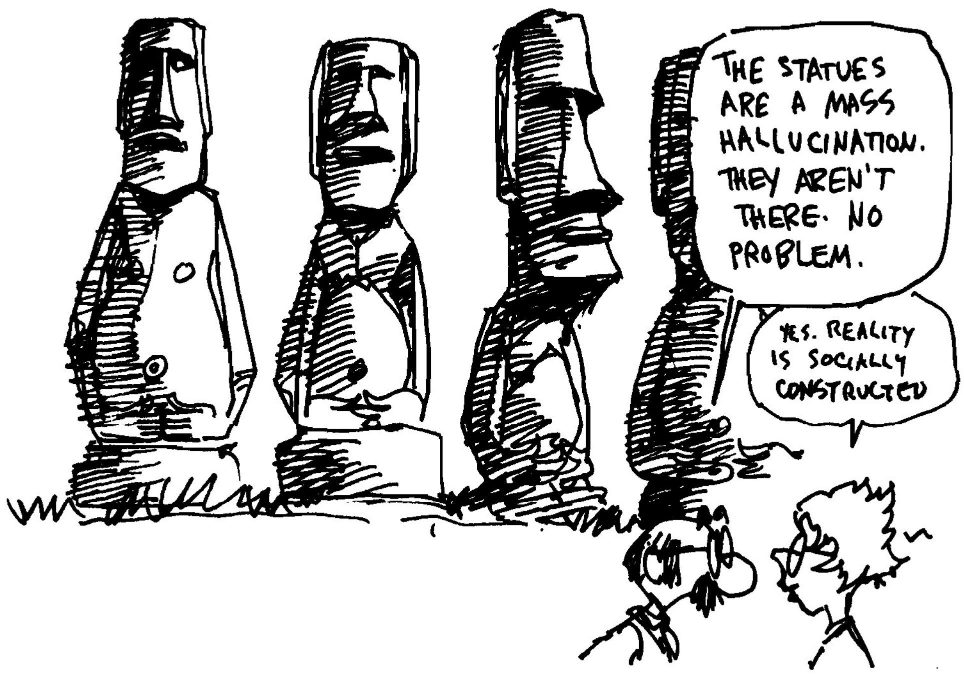
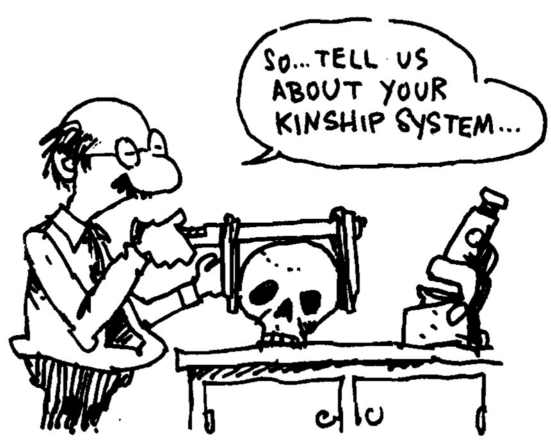
FAILING TO RECOGNIZE SARCASM WHEN THEY HEARD IT, THE EUROPEANS EMBARKED ON A SERIES OF WILD SPECULATIONS THAT HAVE CONTINUED TO THE PRESENT DAY: ***SPACEMEN*** SET UP THE STATUES WITH ***ANTI-GRAVITY DEVICES***... A HIGHLY CIVILIZED ***LOST CONTINENT*** HAD SUNKEN INTO THE SEA, LEAVING ONLY EASTER ISLAND BEHIND... THEY WERE FLUNG INTO PLACE IN ONE PIECE BY ***VOLCANIC ERUPTIONS***, ETC. ETC. ETC.



SINCE THE ISLANDERS HAD EITHER FORGOTTEN WHAT HAPPENED OR DIDN'T FEEL LIKE SHARING, IT WAS LEFT TO WESTERN SCIENTISTS AND HISTORIANS TO PIECE TOGETHER THE STORY WITH ***CALIPERS, SHOVELS, MICRO-SCOPES***, AND ***ETHNO-GRAPHIC SURVEYS.***



AND HERE IS WHAT THEY FOUND OUT...

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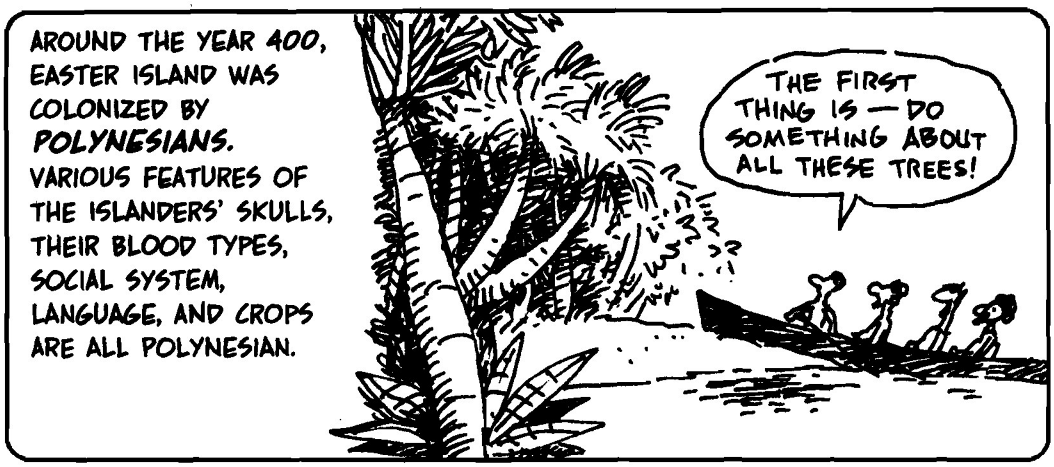
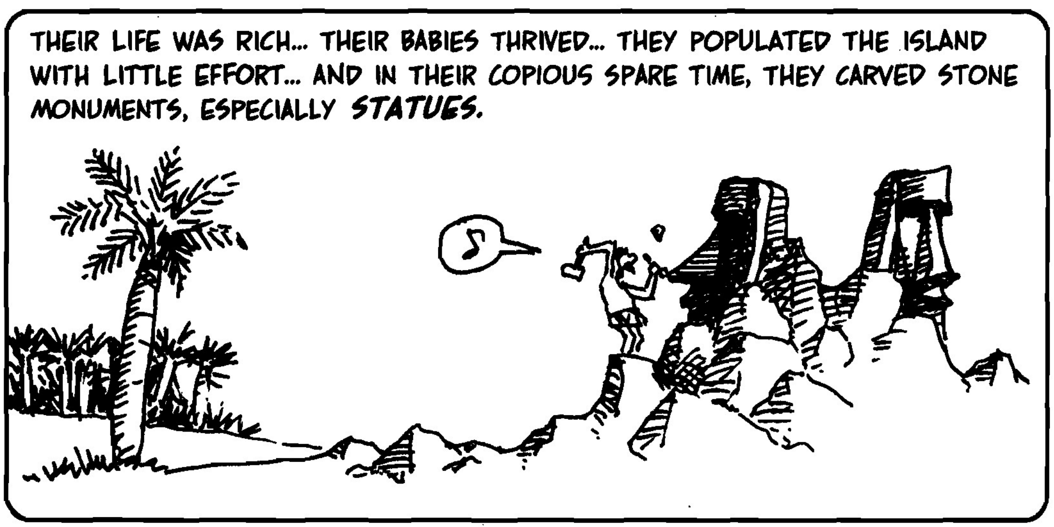


POLLEN SAMPLES TAKEN FROM LAKE BEDS SHOW THAT THE ISLAND WAS THEN THICKLY COVERED WITH VEGETATION. HACKING OUT CLEARINGS FROM THE JUNGLE, THE POLYNESIANS BUILT AND PLANTED, AND SOON THEY ENJOYED A TYPICAL POLYNESIAN DIET OF YAM, TARO, BREADFRUIT, BANANA, SUGAR, COCONUT, CHICKEN, AND POLYNESIAN RAT (SMALL AND TASTY!).



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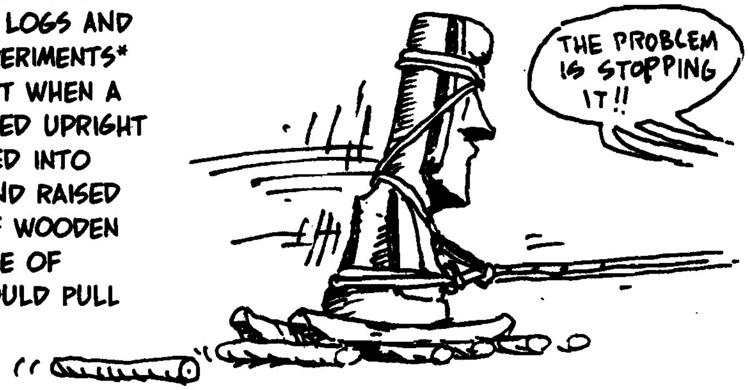
THE STATUES WERE MOVED AND SET UP WITH LOGS AND ROPE. RECENT EXPERIMENTS* HAVE PROVED THAT WHEN A STATUE IS STRAPPED UPRIGHT ONTO LOGS CARVED INTO SLED RUNNERS, AND RAISED ONTO A TRACK OF WOODEN ROLLERS, A COUPLE OF DOZEN PEOPLE COULD PULL IT EASILY!



*BY AMERICAN GEOLOGIST CHARLES LOVE.

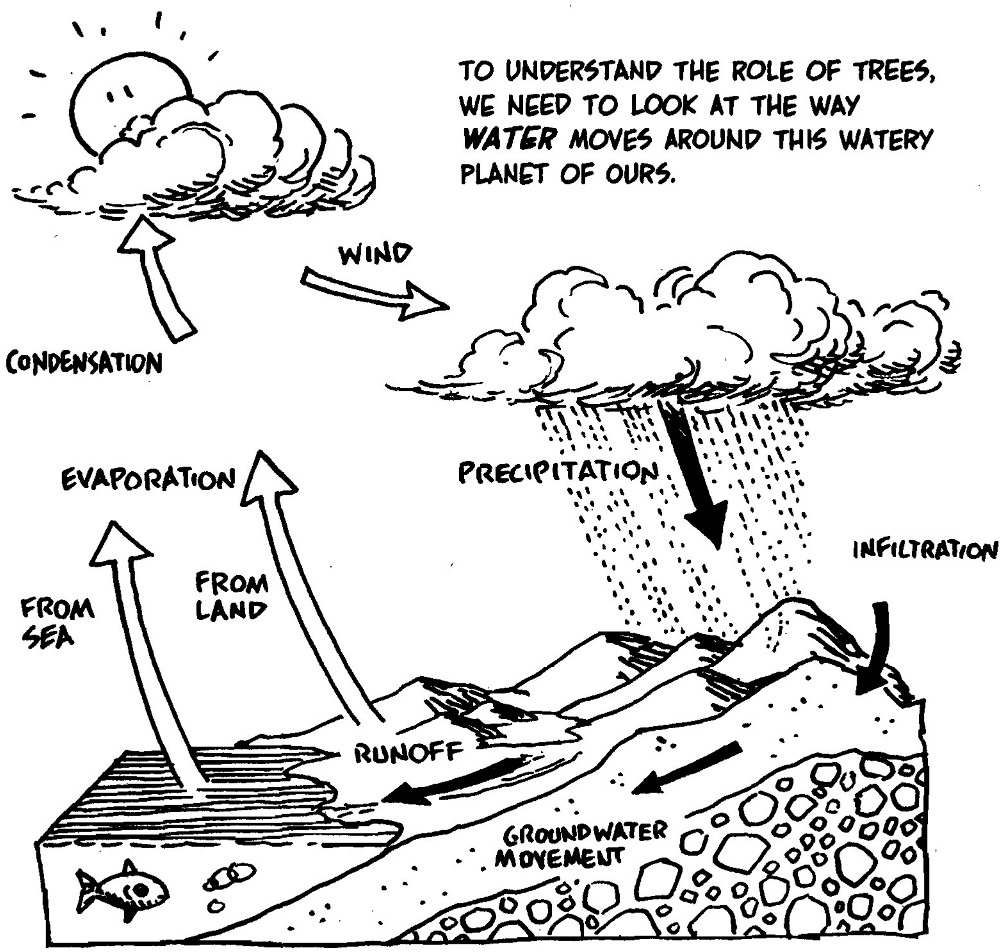
SO THEY CUT DOWN A LOT OF TREES, NOT JUST FOR ROLLING STATUES, BUT ALSO FOR FIREWOOD AND BUILDING MATERIAL...

AND BY THE YEAR 1400, THERE WAS SCARCELY A TREE LEFT STANDING ON EASTER ISLAND...

AND WHAT GOOD ARE TREES?? YOU MIGHT ASK... READ ON...

THE WATER CYCLE

TO UNDERSTAND THE ROLE OF TREES, WE NEED TO LOOK AT THE WAY ***WATER*** MOVES AROUND THIS WATERY PLANET OF OURS.

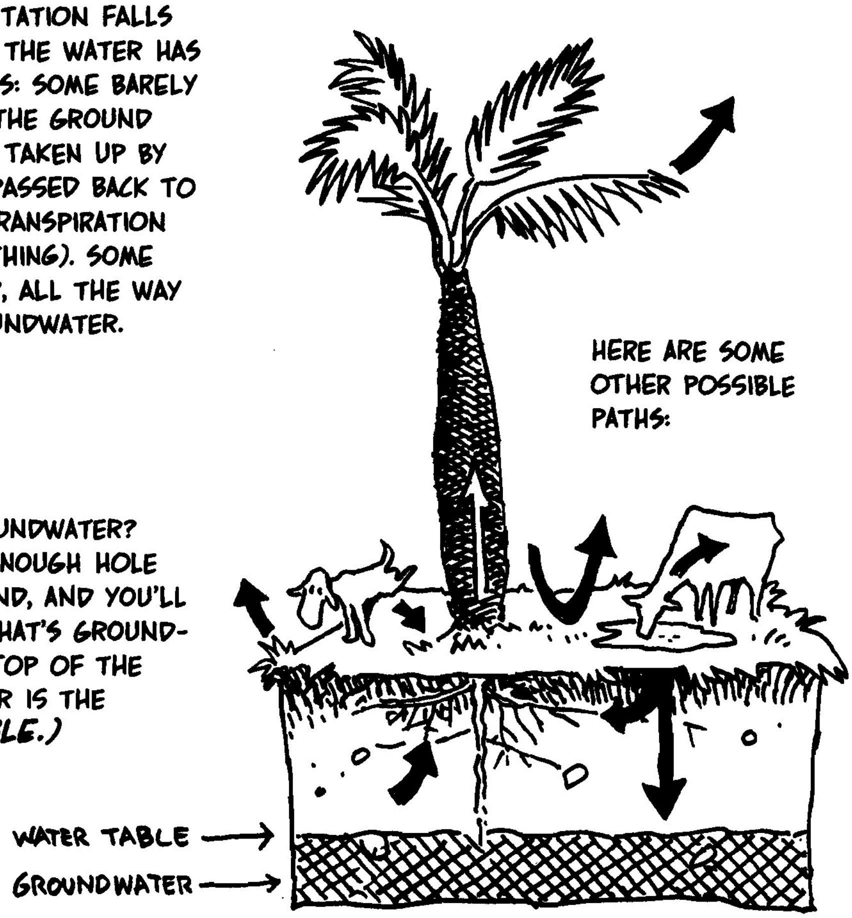


CLOUDS HOLD MOISTURE, WHICH FALLS AS RAIN (OR SNOW, BUT NOT IN POLYNESIA!). IT FALLS WITHIN A ***WATERSHED,*** AN AREA THAT COLLECTS SMALL STREAMS INTO A MAJOR RIVER, AND ULTIMATELY RUNS TO THE SEA. WATER EVAPORATES FROM LAND AND SEA INTO THE AIR, WHERE IT CONDENSES INTO CLOUDS, AND THE CYCLE IS COMPLETED. WATER IN THE ATMOSPHERE IS FULLY REPLACED EVERY ***12 DAYS.***

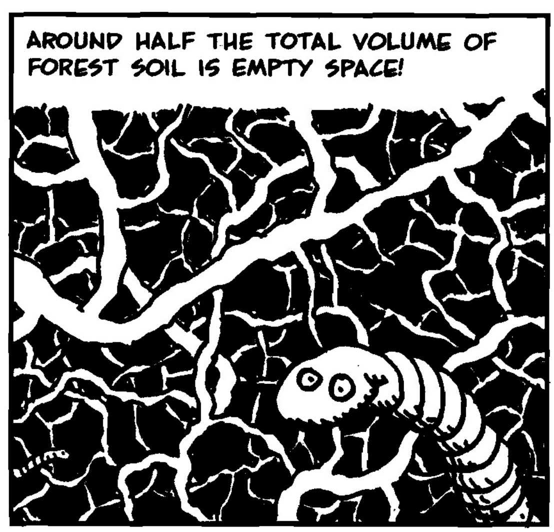
WHEN PRECIPITATION FALLS IN A FOREST, THE WATER HAS MANY OPTIONS: SOME BARELY PENETRATES THE GROUND BEFORE IT IS TAKEN UP BY ROOTS AND PASSED BACK TO THE AIR BY TRANSPIRATION (PLANT BREATHING). SOME GOES DEEPER, ALL THE WAY TO THE GROUNDWATER.

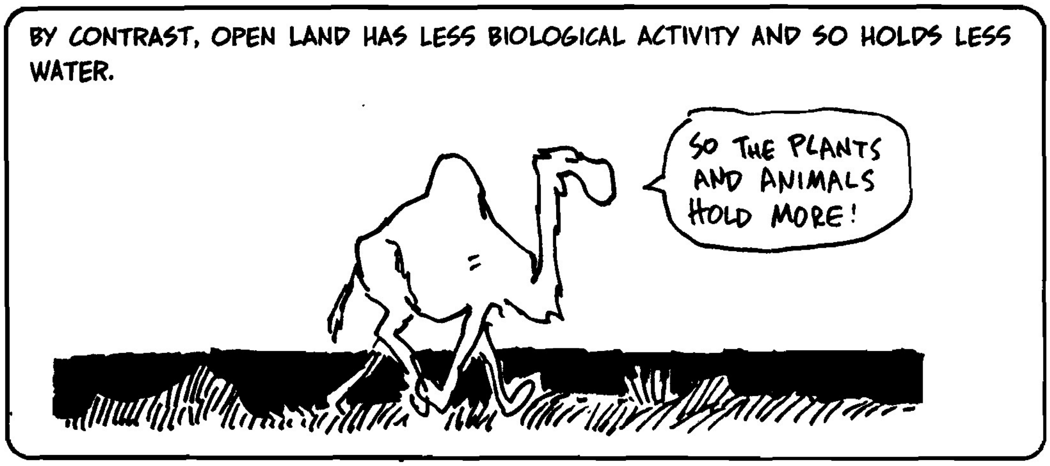
HERE ARE SOME OTHER POSSIBLE PATHS:

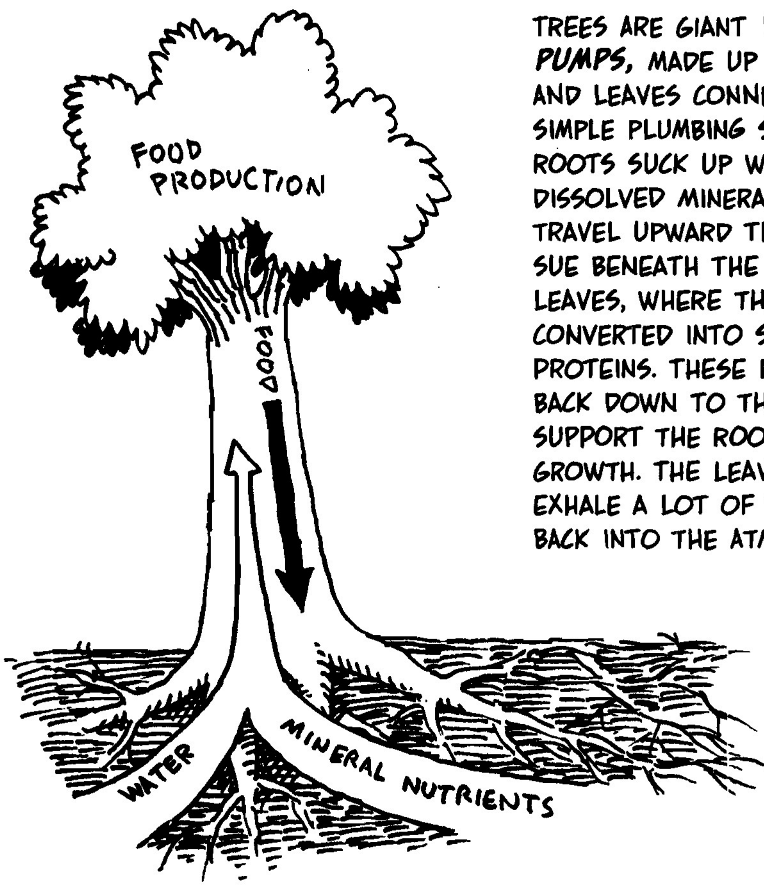
(WHAT'S GROUNDWATER? DIG A DEEP ENOUGH HOLE IN THE GROUND, AND YOU'LL HIT WATER. THAT'S GROUNDWATER. THE TOP OF THE GROUNDWATER IS THE ***WATER TABLE.)***



FOREST SOIL HOLDS A LOT OF WATER BECAUSE IT'S SO ***POROUS:*** A MIXTURE OF CLAY, SAND, AND DECAYING ORGANIC MATTER, THE SOIL IS HONEYCOMBED BY CHANNELS MADE BY ROOTS, BURROWING ANIMALS, AND FUNGI. THE TOP LAYERS TEEM WITH BACTERIA, WHICH BREAK DOWN ORGANIC COMPOUNDS INTO CHEMICAL NUTRIENTS THAT DISSOLVE IN WATER, DRIP DOWN, AND ARE TAKEN UP BY ROOT SYSTEMS.







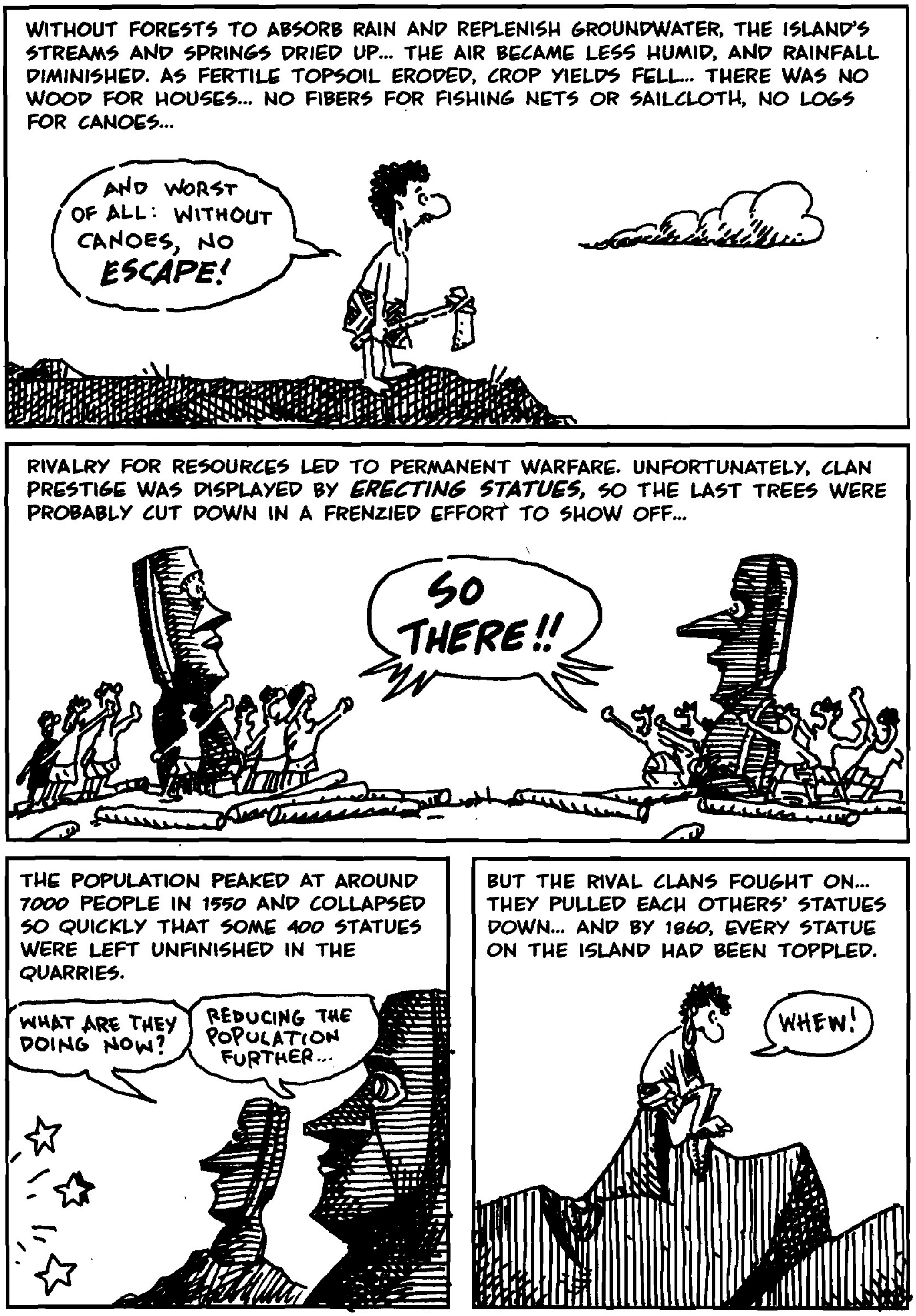
TREES ARE GIANT ***WATER PUMPS,*** MADE UP OF ROOTS AND LEAVES CONNECTED BY A SIMPLE PLUMBING SYSTEM. THE ROOTS SUCK UP WATER AND DISSOLVED MINERALS, WHICH TRAVEL UPWARD THROUGH TISSUE BENEATH THE BARK TO THE LEAVES, WHERE THEY ARE CONVERTED INTO SUGAR AND PROTEINS. THESE FOODS TRAVEL BACK DOWN TO THE ROOTS TO SUPPORT THE ROOTS' FURTHER GROWTH. THE LEAVES ALSO EXHALE A LOT OF WATER VAPOR BACK INTO THE ATMOSPHERE.

UNDERGROUND, HUNDREDS OF MILES OF TREE ROOTS ANCHOR THE TREE TO THE GROUND AND HOLD THE SOIL IN PLACE. MARVELOUS THING, A TREE!

FALLING LEAVES MAKE UP A GOOD PART OF THE DEAD ORGANIC MATTER ON THE GROUND. SHADE REDUCES EVAPORATION FROM THIS MATERIAL, AND SO, IN A SENSE, THE TREE ***MANUFACTURES THE SOIL IN WHICH IT GROWS.***

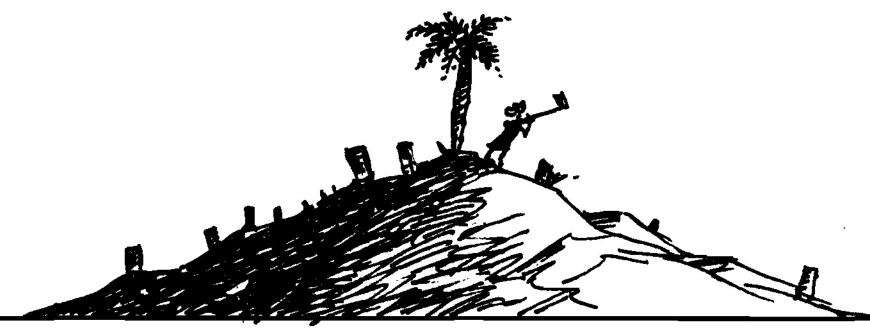
THIS TAKES TIME, OF COURSE. FIRST, SMALL PLANTS PRODUCE A LITTLE TOPSOIL, WHERE BIGGER PLANTS CAN GROW. EVENTUALLY, ENOUGH NUTRIENT-RICH EARTH BUILDS UP TO SUPPORT A FOREST, WITH ALL ITS TEEMING SPECIES.

WHAT HAPPENED ON EASTER ISLAND? WHEN A TREE IS CUT DOWN AND ITS ROOTS DIE, THE TOPSOIL LOSES ITS ANCHOR. 4 TO 5 FEET OF EARTH MAY EVENTUALLY BE WASHED AWAY, AND THERE IS NO QUICK WAY TO REPLACE IT.


WITHOUT FORESTS TO ABSORB RAIN AND REPLENISH GROUNDWATER, THE ISLAND'S STREAMS AND SPRINGS DRIED UP... THE AIR BECAME LESS HUMID, AND RAINFALL DIMINISHED. AS FERTILE TOPSOIL ERODED, CROP YIELDS FELL... THERE WAS NO WOOD FOR HOUSES... NO FIBERS FOR FISHING NETS OR SAILCLOTH, NO LOGS FOR CANOES...
AND WORST OF ALL: WITHOUT CANOES, NO ESCAPE!
RIVALRY FOR RESOURCES LED TO PERMANENT WARFARE. UNFORTUNATELY, CLAN PRESTIGE WAS DISPLAYED BY ERECTING STATUES, SO THE LAST TREES WERE PROBABLY CUT DOWN IN A FRENZIED EFFORT TO SHOW OFF...
SO THERE!!
THE POPULATION PEAKED AT AROUND 7000 PEOPLE IN 1550 AND COLLAPSED SO QUICKLY THAT SOME 400 STATUES WERE LEFT UNFINISHED IN THE QUARRIES.
WHAT ARE THEY DOING NOW?
REDUCING THE POPULATION FURTHER...
BUT THE RIVAL CLANS FOUGHT ON... THEY PULLED EACH OTHERS' STATUES DOWN... AND BY 1860, EVERY STATUE ON THE ISLAND HAD BEEN TOPPLED.
WHEW!

THE POINT OF THIS STORY IS NOT THAT THE PEOPLE OF EASTER ISLAND WERE SOMEHOW STRANGE, SILLY, OR DIFFERENT FROM ANYONE ELSE. QUITE THE CONTRARY: LIKE THE REST OF US, THEY WERE ***CREATURES OF HABIT,*** AND THEIR WAY OF LIFE—FARMING, FORESTRY, BUILDING, AND DISPLAY—WAS HARD TO CHANGE.

EASTER ISLAND IS VERY SMALL. FROM ITS SUMMIT YOU CAN SEE THE WHOLE THING. THE PERSON WHO CUT DOWN THE LAST TREE MUST HAVE KNOWN THERE WERE NO MORE—AND STILL HE CUT IT DOWN.



OUR PLANET, WHILE MUCH LARGER, IS STILL FINITE. LIKE THE ISLANDERS, WE TOO CAN SEE IT ALL, AND LIKE THE ISLANDERS WE HAVE NO MEANS OF ESCAPE. IS IT STILL POSSIBLE THAT WE CAN TAKE STOCK OF OUR RESOURCES AND CHANGE OUR HABITS IN TIME TO AVOID THE FATE OF EASTER ISLAND?

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Excerpt from *Environment: The Science Behind the Stories, AP Edition* by Jay Withgott and Matthew Laposata, ©2021.

Environmental science can help us learn from mistakes

Historical evidence suggests that civilizations can crumble when pressures from population and consumption overwhelm resource availability. Historians have inferred that environmental degradation contributed to the fall of the Greek and Roman empires, the Angkor civilization of Southeast Asia, and the Maya, Anasazi, and other civilizations of the Americas. In Syria, Iraq, and elsewhere in the Middle East, areas that in ancient times were lush enough to support thriving ancient societies are today barren desert. Easter Island has long been held up as a society that self-destructed after depleting its resources, although new research paints a more complex picture (see **The Science Behind the Story**).

The Science behind the story

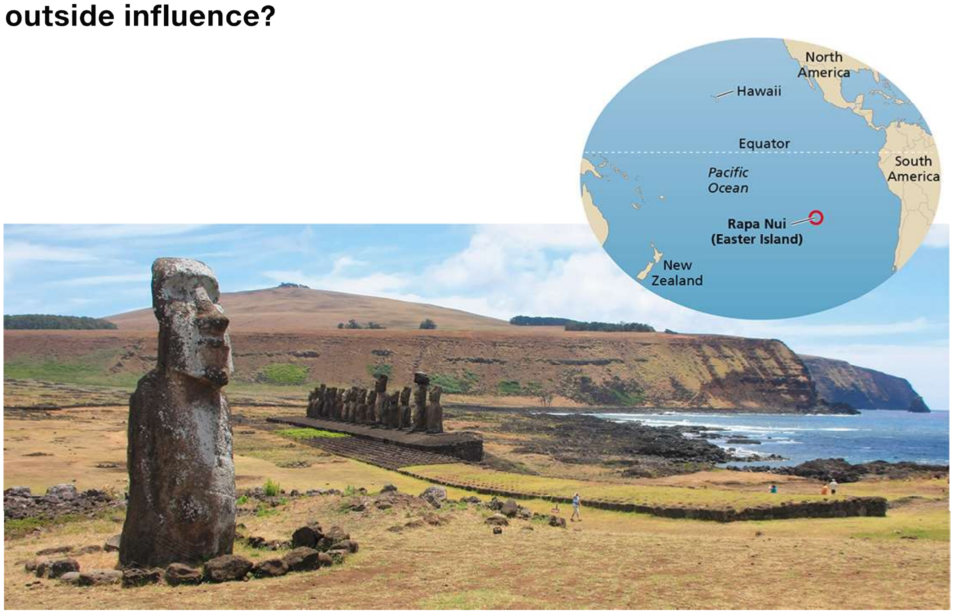
What Are the Lessons of Easter Island?

Terry Hunt and Carl Lipo on Easter Island

A mere speck of land in the vast Pacific Ocean, Easter Island is one of the most remote spots on the globe. Yet this far-flung island—called Rapa Nui by its inhabitants—has been the focus of an intense debate among scientists seeking to solve its mysteries and decipher the lessons it offers. The debate shows how, in science, new information can challenge existing ideas—and also how interdisciplinary research helps us tackle complex questions.

Ever since European explorers stumbled upon Rapa Nui on Easter Sunday in 1722, outsiders have been struck by the island's barren landscape. Early European accounts suggested that the 2000 to 3000 people living on the island at the time seemed impoverished, subsisting on a few meager crops and possessing only stone tools. Yet the forlorn island also featured hundreds of gigantic statues of carved rock (**Figure 1**). How could people without wheels or ropes, on an island without trees, have moved 90-ton statues 10 m (33 ft) high as far as 10 km (6.2 mi) from the quarry where they were chiseled to the sites where they were erected? Apparently, some calamity must have befallen a once-mighty civilization on the island.

Figure 1 Were the haunting statues of Easter Island (Rapa Nui) erected by a civilization that collapsed after devastating its environment or by a sustainable civilization that fell because of outside influence?



Researchers who set out to solve Rapa Nui's mysteries soon discovered that the island had once been lushly forested. Scientist John Flenley and his colleagues drilled cores deep into lake sediments and examined ancient pollen grains preserved there, seeking to reconstruct, layer by layer, the history of vegetation in the region. Finding a great deal of palm pollen, they inferred that when Polynesian people colonized the island (A.D. 300–900, they estimated), it was covered with palm trees similar to the Chilean wine palm—a tree that can live for centuries.

By studying pollen and the remains of wood from charcoal, archaeologist Catherine Orliac found that at least 21 other plant species—now gone—had also been common. Clearly the island had once supported a diverse forest. Forest plants would have provided fuelwood, building material for houses and canoes, fruit to eat, fiber for clothing, and, researchers guessed, logs and fibrous rope to help move statues.

But pollen analysis also showed that trees began declining after human arrival and were replaced by ferns and grasses. Then between 1400 and 1600, pollen levels plummeted. Charcoal in the soil proved that the forest had been burned, likely in slash-and-burn farming. Researchers concluded that the islanders, desperate for forest resources and cropland, had deforested their own island.

With the forest gone, soil eroded away—data from lake bottoms showed a great deal of accumulated sediment. Erosion would have lowered yields of bananas, sugarcane, and sweet potatoes, perhaps leading to starvation and population decline.

Further evidence indicated that wild animals disappeared. Archaeologist David Steadman analyzed 6500 bones and found that at least 31 bird species had provided food for the islanders.

Today, only one native bird species is left. Remains from charcoal fires show that early islanders feasted on fish, sharks, porpoises, turtles, octopus, and shellfish—but in later years they consumed little seafood.

As resources declined, researchers concluded, people fell into clan warfare, revealed by unearthed weapons and skulls with head wounds. Rapa Nui appeared to be a tragic case of ecological suicide: A once-flourishing civilization depleted its resources and destroyed itself. In this interpretation—advanced by Flenley and writer Paul Bahn, and popularized by scientist Jared Diamond in his best-selling 2005 book *Collapse*—Rapa Nui seemed to offer a clear lesson: We on our global island, planet Earth, had better learn to use our limited resources sustainably.

When Terry Hunt and Carl Lipo began research on Rapa Nui in 2001, they expected simply to help fill gaps in a well-understood history. But science is a process of discovery, and sometimes evidence leads researchers far from where they anticipated. For Hunt, an anthropologist at the University of Hawai'i at Manoa, and Lipo, an archaeologist at California State University, Long Beach, their work led them to conclude that the traditional "ecocide" interpretation didn't tell the whole story. First, their radiocarbon dating (dating of items using radioisotopes of carbon;) indicated that people had not colonized the island until about A.D. 1200, suggesting that deforestation occurred rapidly after their arrival. How could so few people have destroyed so much forest so fast?

Hunt and Lipo's answer: rats. When Polynesians settled new islands, they brought crop plants, as well as chickens and other domestic animals. They also brought rats—intentionally as a food source or unintentionally as stowaways. In either case, rats can multiply quickly, and they soon overran Rapa Nui.

Researchers found rat tooth marks on old nut casings, and Hunt and Lipo suggested that rats ate so many palm nuts and shoots that the trees could not regenerate. With no young trees growing, the palm went extinct once mature trees died.

Diamond and others counter that plenty of palm nuts on Easter Island escaped rat damage, that most plants on other islands survived rats introduced by Polynesians, and that more than 20 additional plant species went extinct on Rapa Nui. Moreover, people brought the rats, so even if rats destroyed the forest, human colonization was still to blame.

Despite the forest loss, Hunt and Lipo argue that islanders were able to persist and thrive. Archaeology shows how islanders adapted to Rapa Nui's poor soil and windy weather by developing rock gardens to protect crop plants and nourish the soil. Hunt and Lipo contended that tools viewed by previous researchers as weapons were actually farm implements, that lethal injuries were rare, and that no evidence of battle or defensive fortresses was uncovered.

Hunt, Lipo, and others also unearthed old roads and inferred how the famous statues were transported. It had been thought that a powerful central authority must have forced armies of laborers to roll them over countless palm logs, but Hunt and Lipo concluded that small numbers of people could have moved them by tilting and rocking them upright—much as we might move a refrigerator. Indeed, the distribution of statues on the island suggested the work of family groups. Islanders had adapted to their resource-poor environment by becoming a peaceful and cooperative society, Hunt and Lipo maintained, with the statues providing a harmless outlet for competition over status and prestige.

Altogether, the evidence led Hunt and Lipo to propose that far from destroying their environment, the islanders had acted as responsible stewards. The collapse of this sustainable civilization, they argue, came with the arrival of Europeans, who unwittingly brought contagious diseases to which the islanders had never been exposed. Indeed, historical journals of sequential European voyages depict a society falling into disarray as if reeling from epidemics.

Peruvian ships then began raiding Rapa Nui and taking islanders away into slavery. Foreigners acquired the land, forced the remaining people into labor, and introduced thousands of sheep, which destroyed the few native plants left on the island. Thus, the new hypothesis holds that the collapse of Rapa Nui's civilization resulted from a barrage of disease, violence, and slave raids following foreign contact. Before that, Hunt and Lipo say, Rapa Nui's people boasted 500 years of a peaceful and resilient society.

Hunt and Lipo's interpretation, put forth in a 2011 book, *The Statues That Walked,* would represent a paradigm shift in how we view Easter Island. Debate between the two camps remains heated, however, and interdisciplinary research continues as scientists look for new ways to test the differing hypotheses. This is an example of how science advances, and in the long term, data from additional studies should lead us closer and closer to the truth.

Like the people of Rapa Nui, we are all stranded together on an island with limited resources. What is the lesson of Easter Island for our global island, Earth? Perhaps there are two: Any island population must learn to live within its means, but with care and ingenuity, there is hope that we can.