Attention teachers:

1. The slideshow runs from page 2-38. To display slides via projector, go to View tab and choose Full Screen Mode.

1. There are notes that accompany many of the following slides; it is recommended that the information contained within the notes be communicated to your students as they view the show. Choose from the following options to do so:
   a. Notes have been condensed and are located at the end of the show (pages 39-53). Print these out, keep next to you and narrate as students view show (recommended). **OR**
   b. View on screen (students will be able to see as well): Open the Layers Panel tab on left of window. You will see a layer called “Presentation Notes.” Click the eye icon to toggle the display of the layers on or off. When turned on, for every page that has notes you will see a PDF Sticky Note in the top left. If you hover over that Note or double-click to open a pop-up, you will be able to view the content within the Note.

Hubbard Brook Research Foundation's
Data-based Inquiry Lessons

Introduction to the Hubbard Brook Experimental Forest

HBRF

This slideshow serves to support our *Data-Based Inquiry Lessons* which were developed in partnership between the Hubbard Brook Research Foundation and the USDA Forest Service/Northern Research Station. Funding was also provided by the Long Term Ecological Research (LTER) Network's Schoolyard Program.

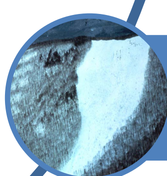
Unless otherwise noted, all photos and images are courtesy of the scientific community of the Hubbard Brook Ecosystem Study (www.hubbardbrook.org). Thanks to Ian Halm and Tammy Wooster for their helpful input.

The Hubbard Brook Experimental Forest

- Where and why?

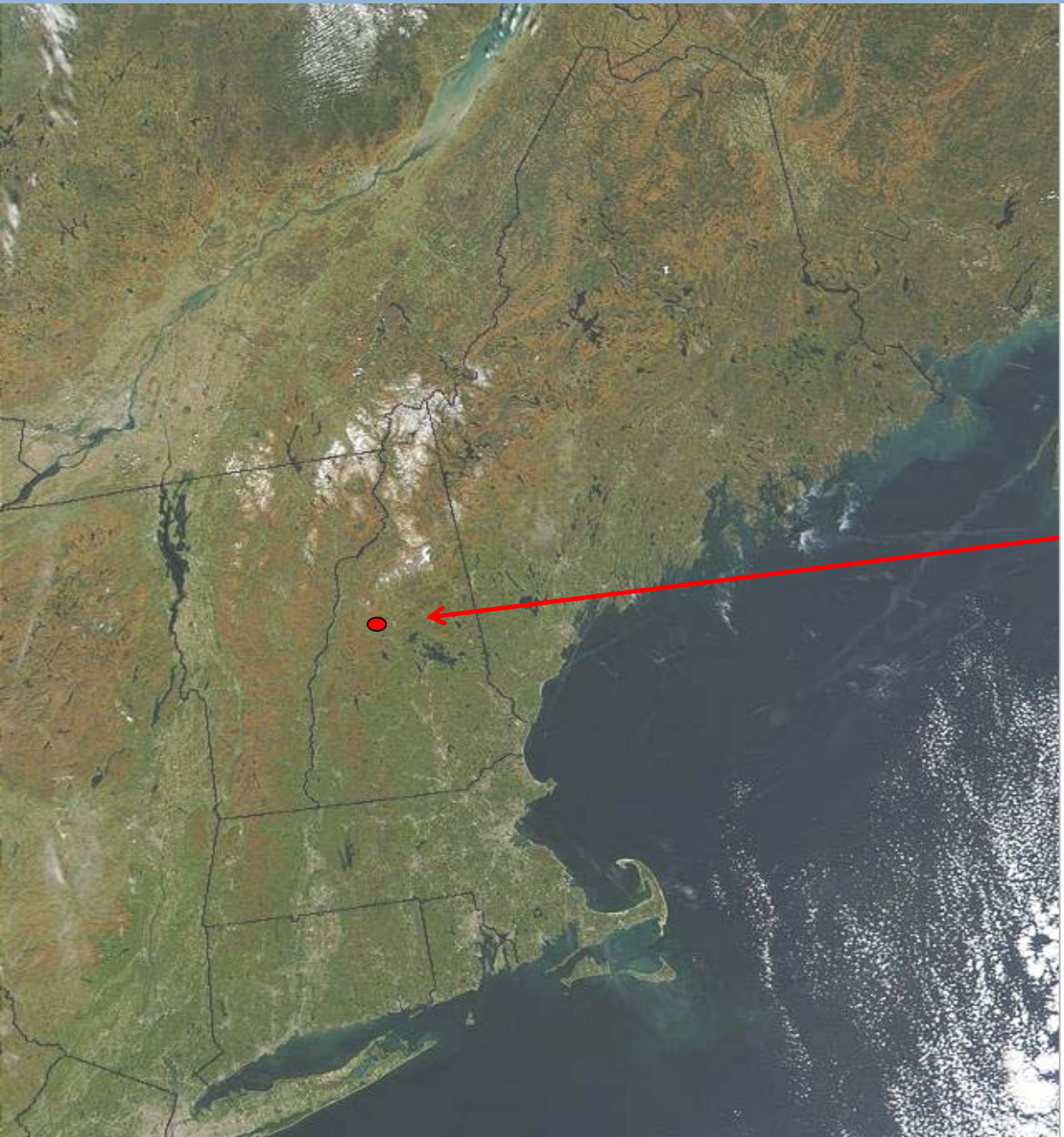
- Hydrology: inputs and outputs

- Biogeochemistry



- Watershed experiments

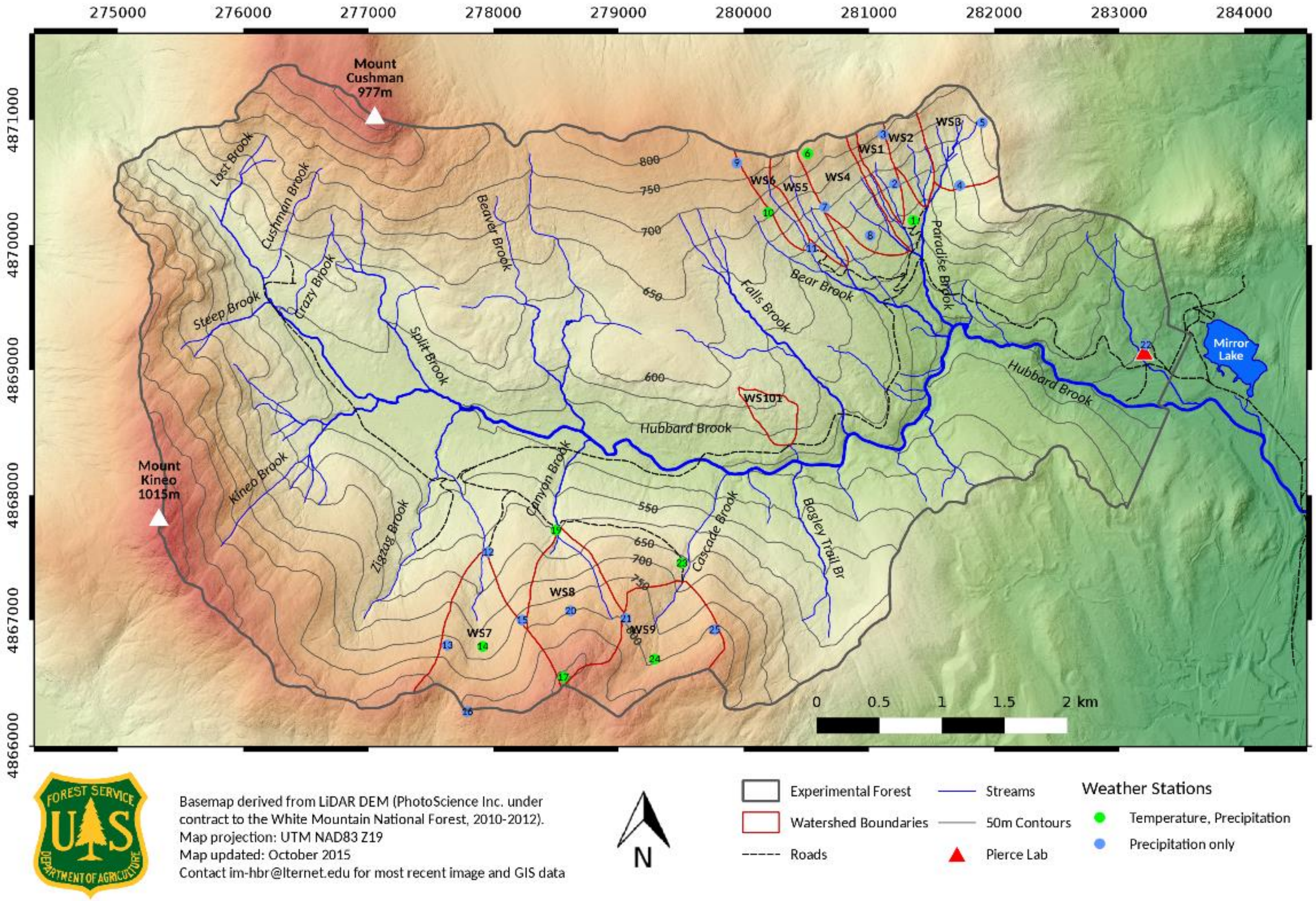
HBEF: where and why?



Hubbard Brook Experimental Forest, Woodstock, NH

Hubbard Brook Experimental Forest

Hubbard Brook Experimental Forest



Basemap derived from LiDAR DEM (PhotoScience Inc. under contract to the White Mountain National Forest, 2010-2012).
Map projection: UTM NAD83 Z19
Map updated: October 2015
Contact im-hbr@lternet.edu for most recent image and GIS data

Why create an Experimental Forest?

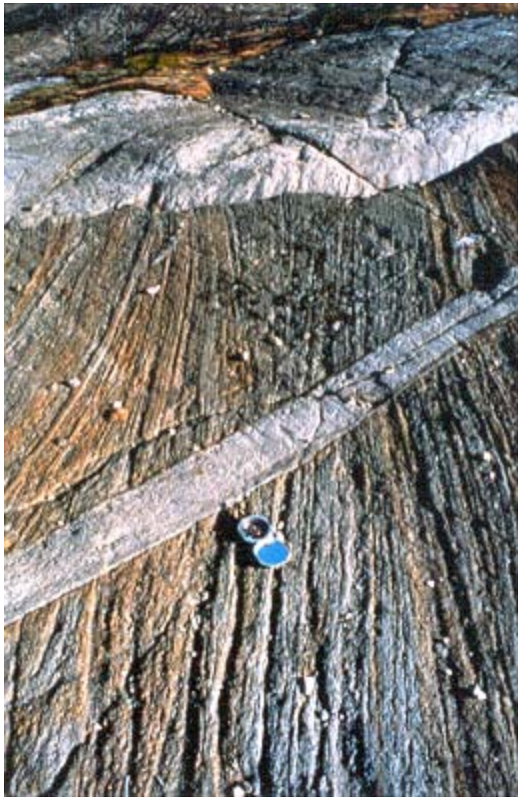
New Hampshire's forests were heavily logged in the late 1800's and early 1900's.

People wondered about the effects of logging on rivers.

The Hubbard Brook Experimental Forest was established in 1955 to study the relationship between water and forests:

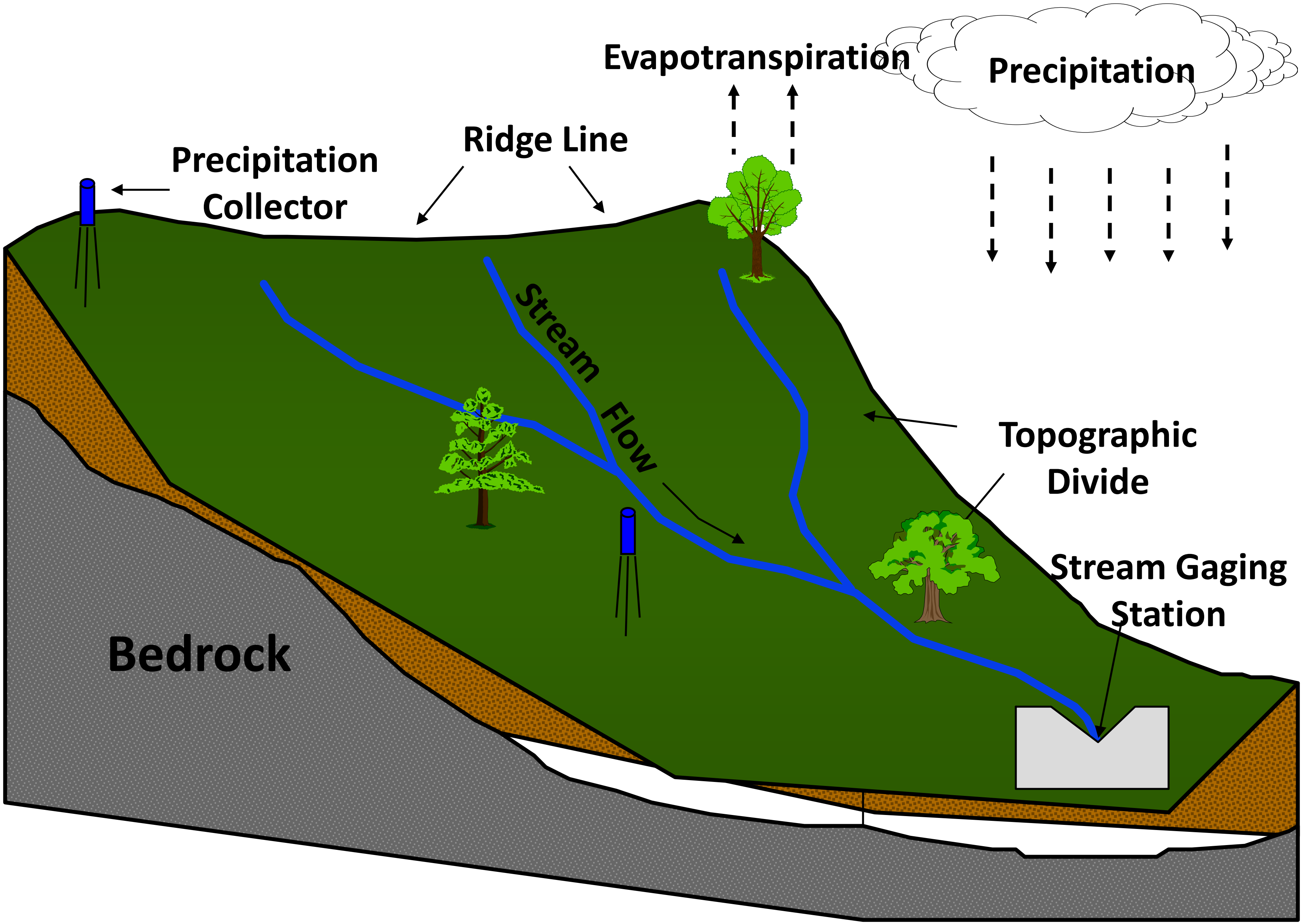
- Do trees prevent erosion?
- Do trees help control floods?
- What is the impact of forests and forest removal on water yield and quality?

The Hubbard Brook valley is a good place to study *hydrology*, the relationship between water and forests.



http://www.summitpost.org/welch-dickey-loop-trail/images/p-156252

Hydrology: inputs and outputs



We measure inputs and outputs to the ecosystem

Precipitation collectors to measure water **inputs**

Weirs built on streams to measure volume of water leaving each small watershed (**outputs**)

Inputs

enter an ecosystem through precipitation and dry deposition.

Rain gauge stations are found all around the HBEF.

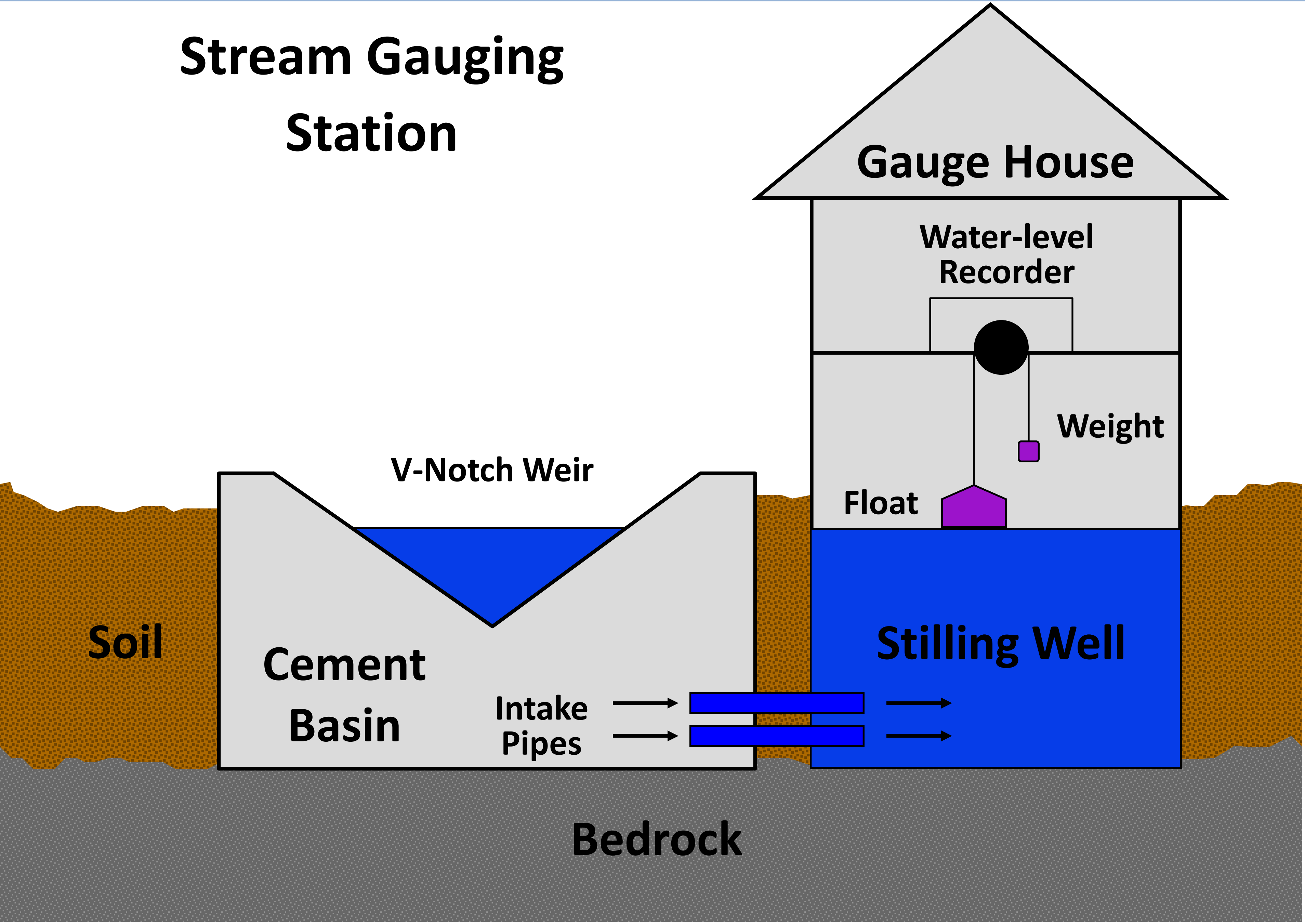
The gauge on the right measures the amount (volume) of precipitation.

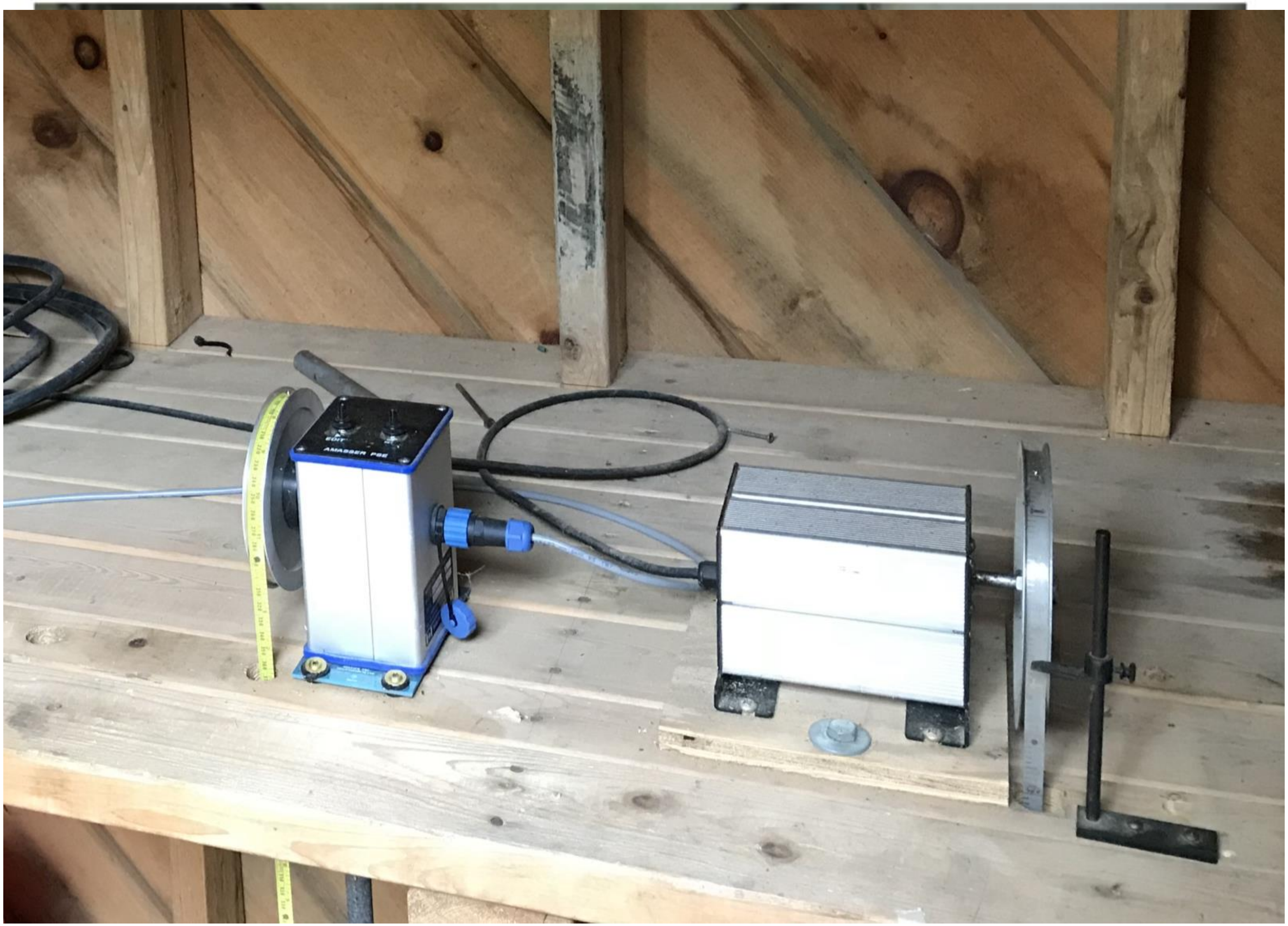
The gauge on the left measures when the rain is happening (timing) and volume of precipitation.

ETI rain gauges record the timing and amount of precipitation.

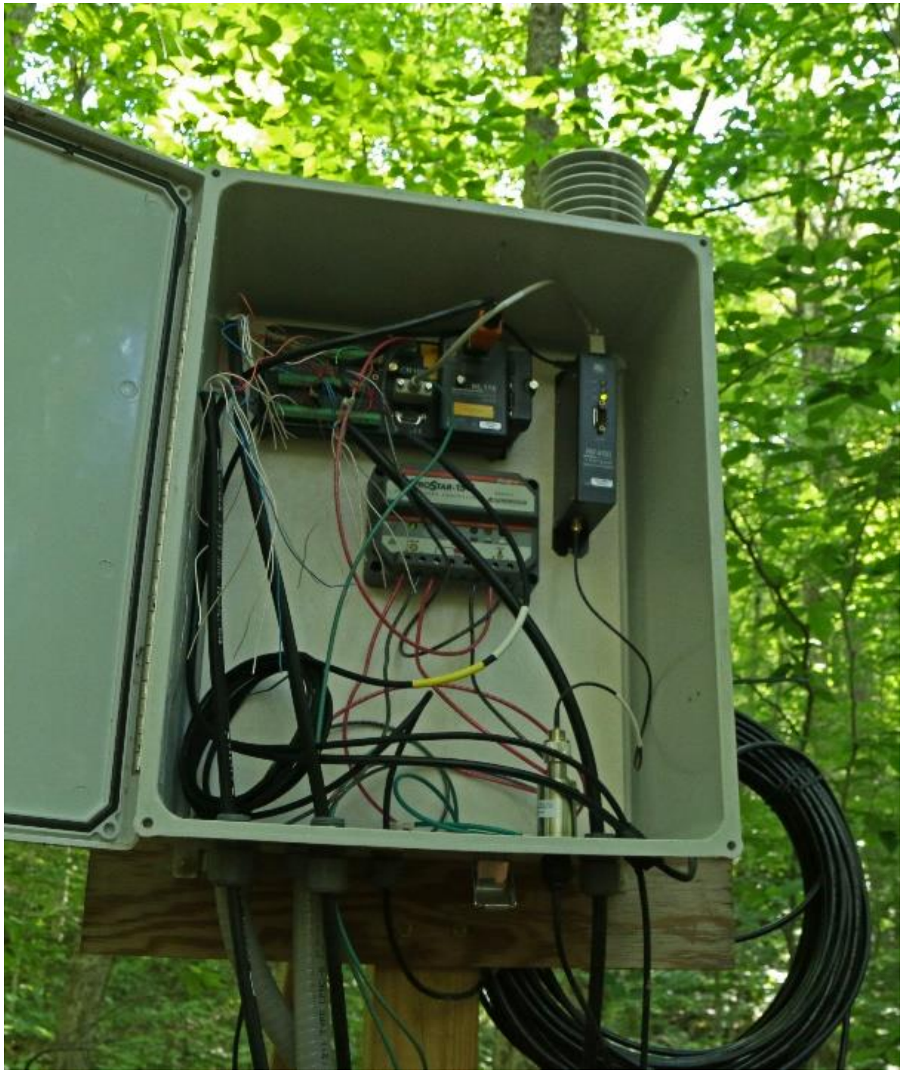
Outputs

Stream Gauging Station





The shaft recorder in the still house records the level of the stream.



Data are recorded with Campbell CR1000 dataloggers, and the data are sent wirelessly by high frequency radios to a computer at Forest Service Headquarters.

Water levels are also monitored on the outlet of nearby Mirror Lake.

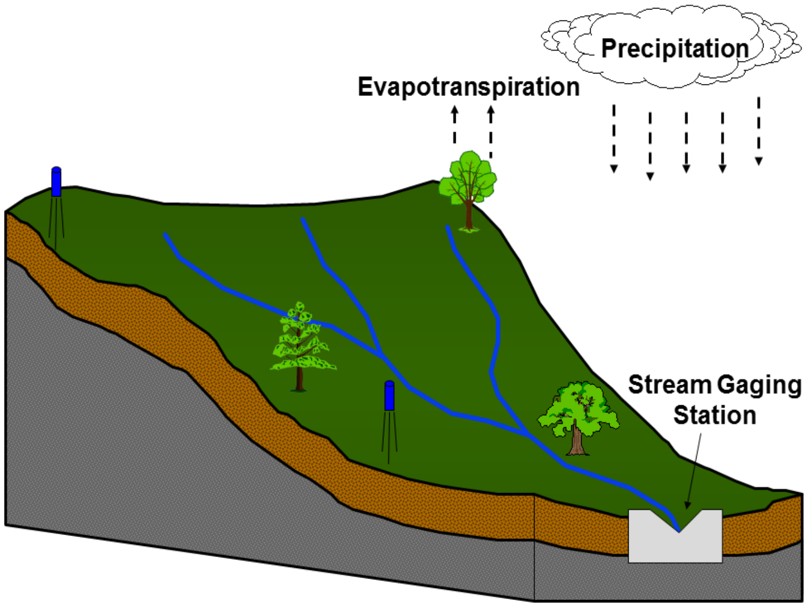
Hydrology: inputs and outputs

Water levels are recorded digitally, stored on a datalogger, transmitted to a computer at a base station, and shared on the Internet.

Knowing quantities of inputs and outputs makes it possible to construct a water budget.

Example:

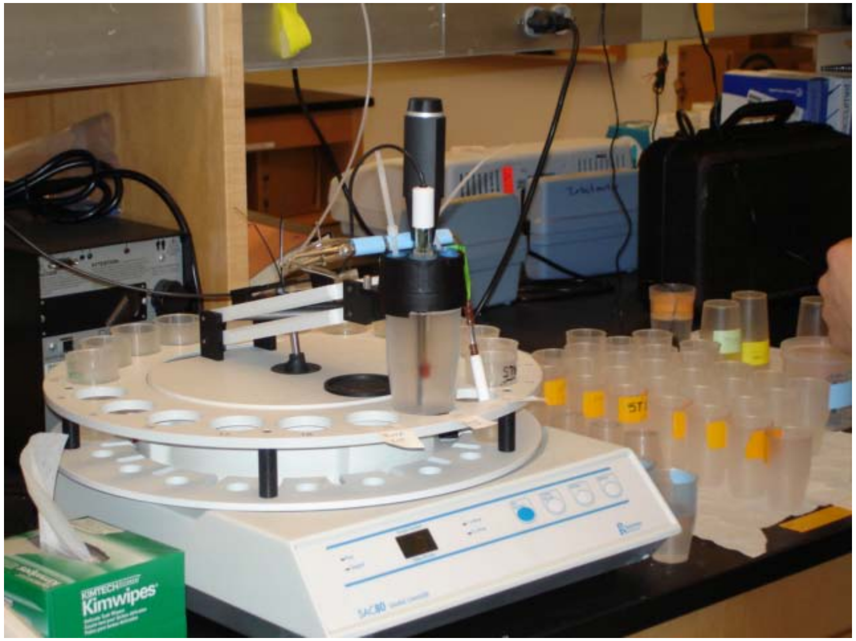
- If 1,490 mm water entered a watershed as precipitation and
- 1,090 mm water exited in streamwater, we can calculate
- 400 mm water was returned to the atmosphere by evaporation and transpiration.

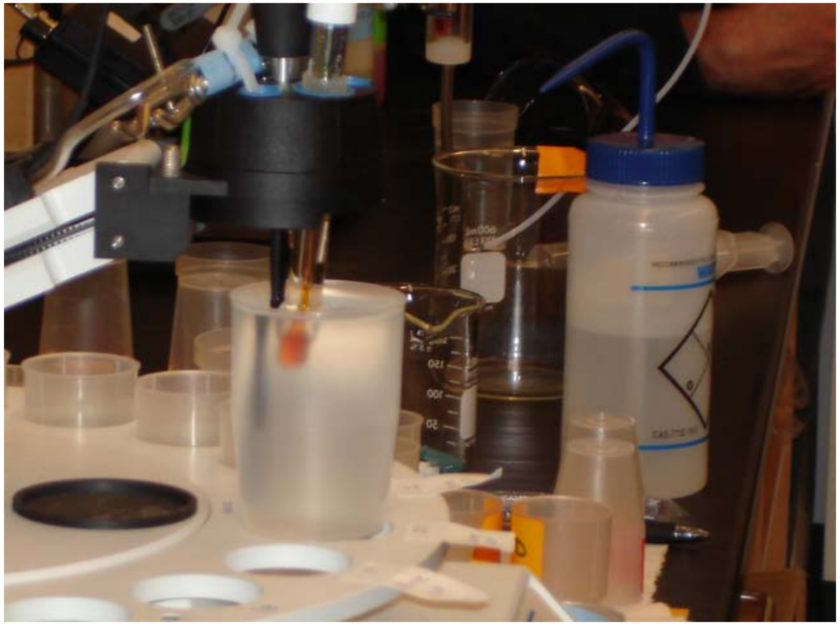


In 1960, a scientist named Herbert Bormann realized that if the *chemistry* of input and output water were measured, people could construct nutrient budgets for whole ecosystems.

This technique is called the *Small Watershed Concept* and is used to study the inputs, outputs and movement of elements in an ecosystem.

All of the hydrological measurements that began in 1955 are still measured today, but in the 1960’s, the focus expanded and the chemistry of precipitation and streamwater began to be analyzed.





The concentrations of calcium, magnesium, potassium, sodium, aluminum, ammonia, nitrate, sulfate, chloride, phosphate, and silica (silicon dioxide), as well as pH are measured in precipitation and streamwater on a weekly basis.

Monitoring chemical inputs and outputs lets people think about the cycles of elements and their *interactions with* and *incorporation into* living things.

This field of science is called *biogeochemistry,* and focuses on chemical cycles which are either driven by or have an impact on biological activity, such as carbon, nitrogen, calcium and sulfur.

Example of an element/nutrient budget for calcium:

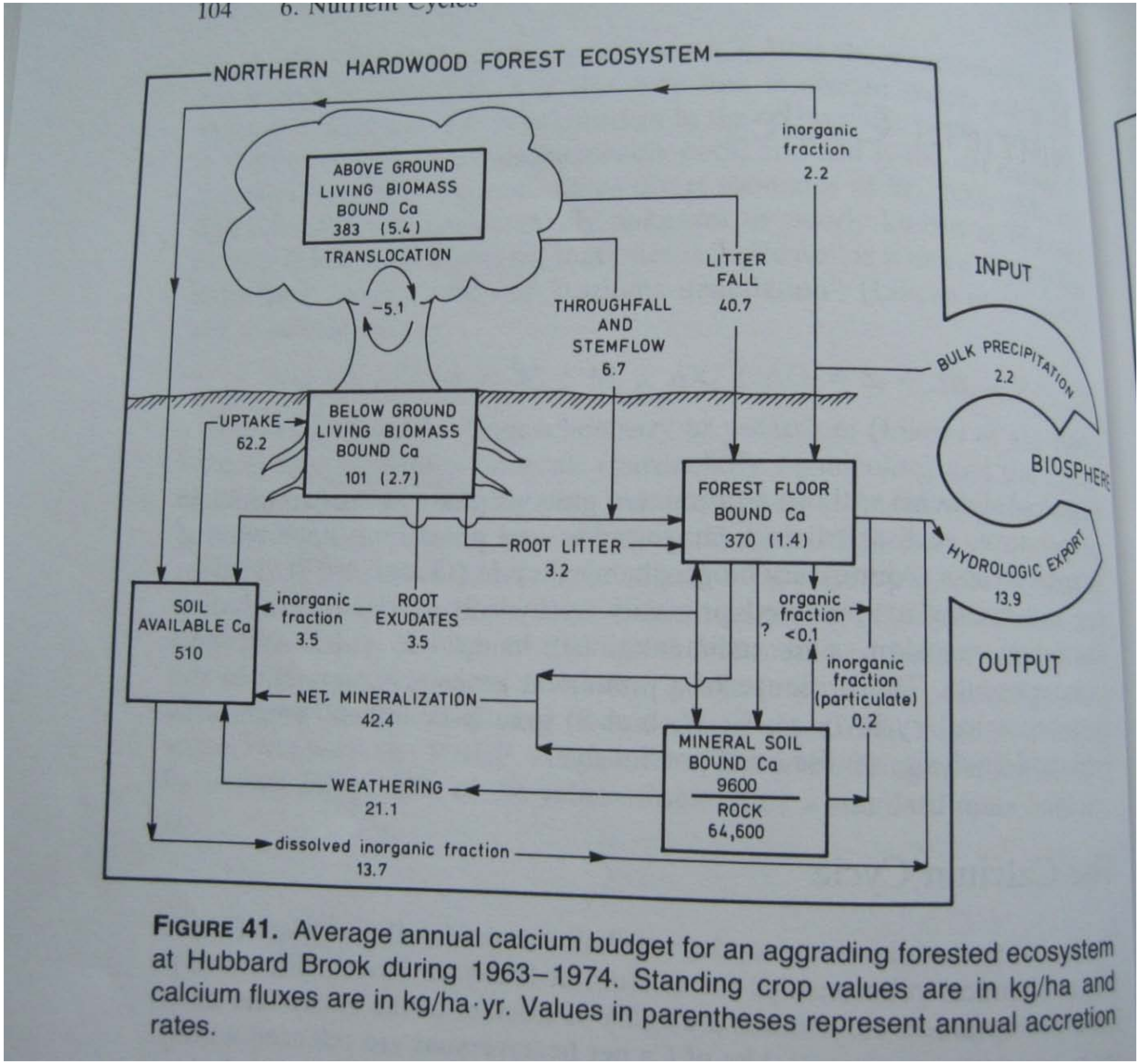


FIGURE 41. Average annual calcium budget for an aggrading forested ecosystem at Hubbard Brook during 1963–1974. Standing crop values are in kg/ha and calcium fluxes are in kg/ha·yr. Values in parentheses represent annual accretion rates.

From Likens, G.E. and Herbert F. Bormann. *Biogeochemistry of a Forested Ecosystem*. New York: Springer-Verlag, 1995.

And another, for sulfur:

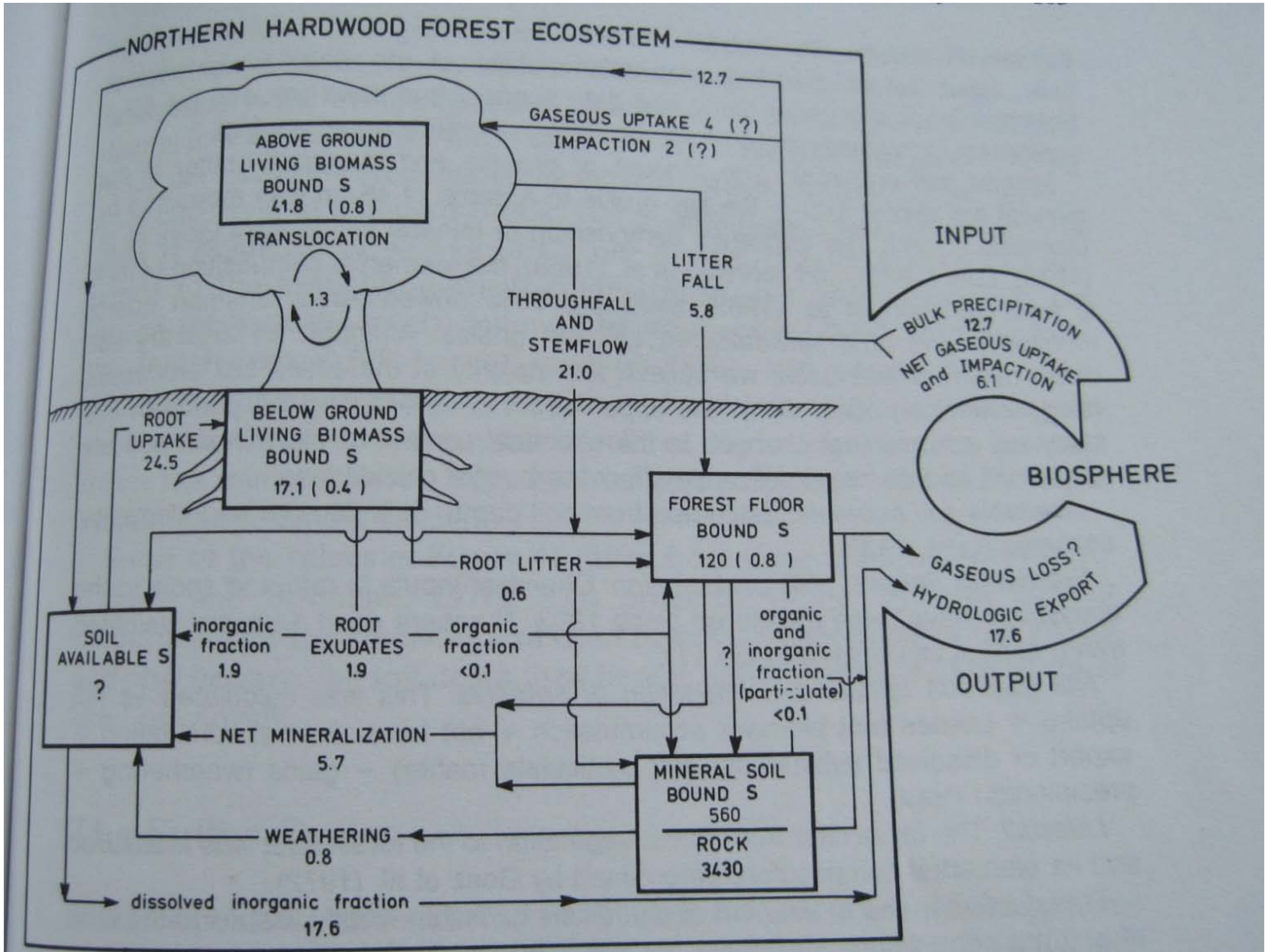
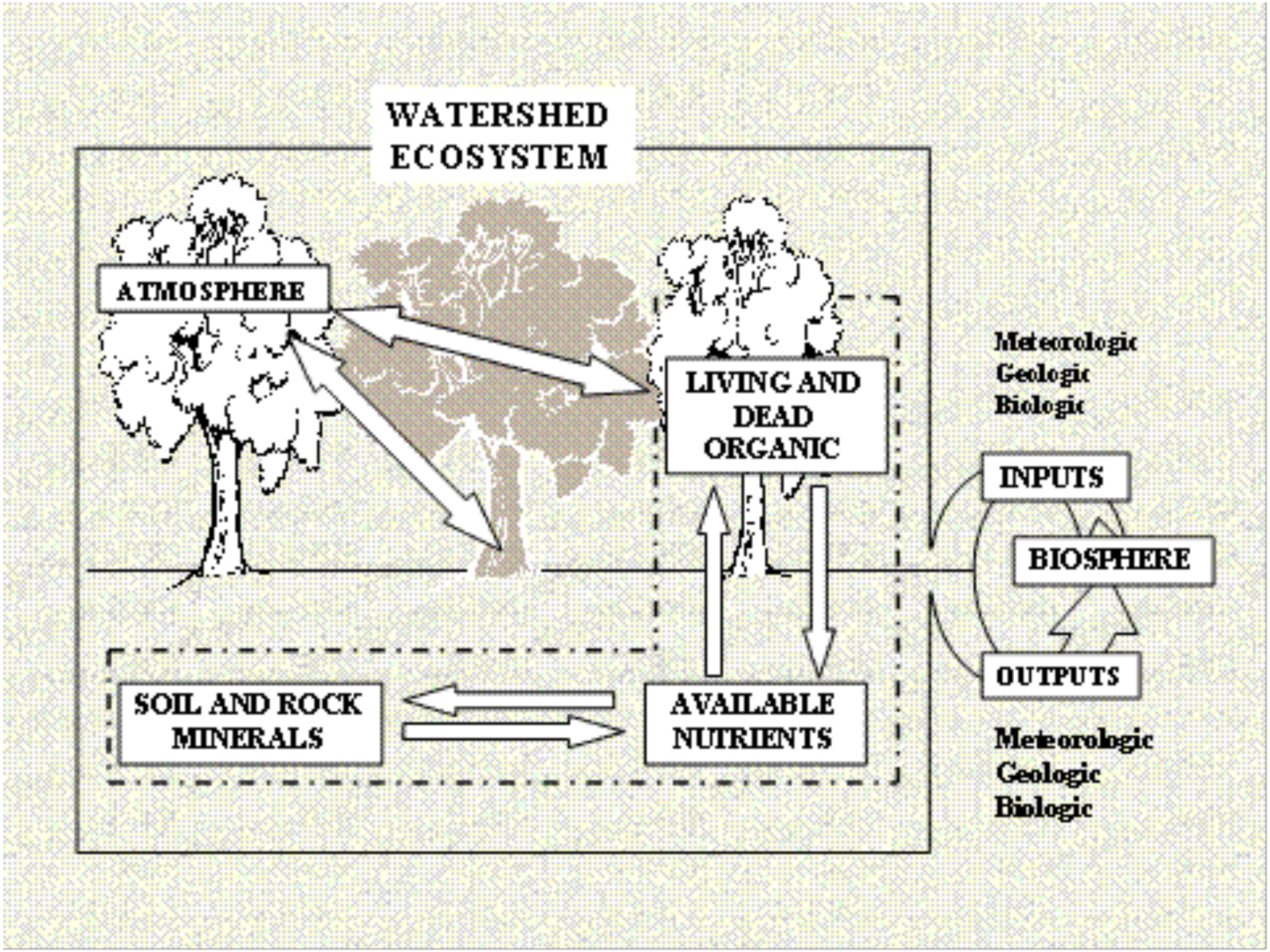


FIGURE 42. Average annual sulfur budget for an aggrading forested ecosystem at Hubbard Brook during 1963–1974. Standing crop values are in kg/ha and sulfur fluxes are in kg/ha·yr. Values in parentheses represent annual accretion rates.

From Likens, G.E. and Herbert F. Bormann. *Biogeochemistry of a Forested Ecosystem*. New York: Springer-Verlag, 1995.

In 1965, scientists began using the gauged watersheds as experimental ecosystems for studies of elemental budgets and cycles.

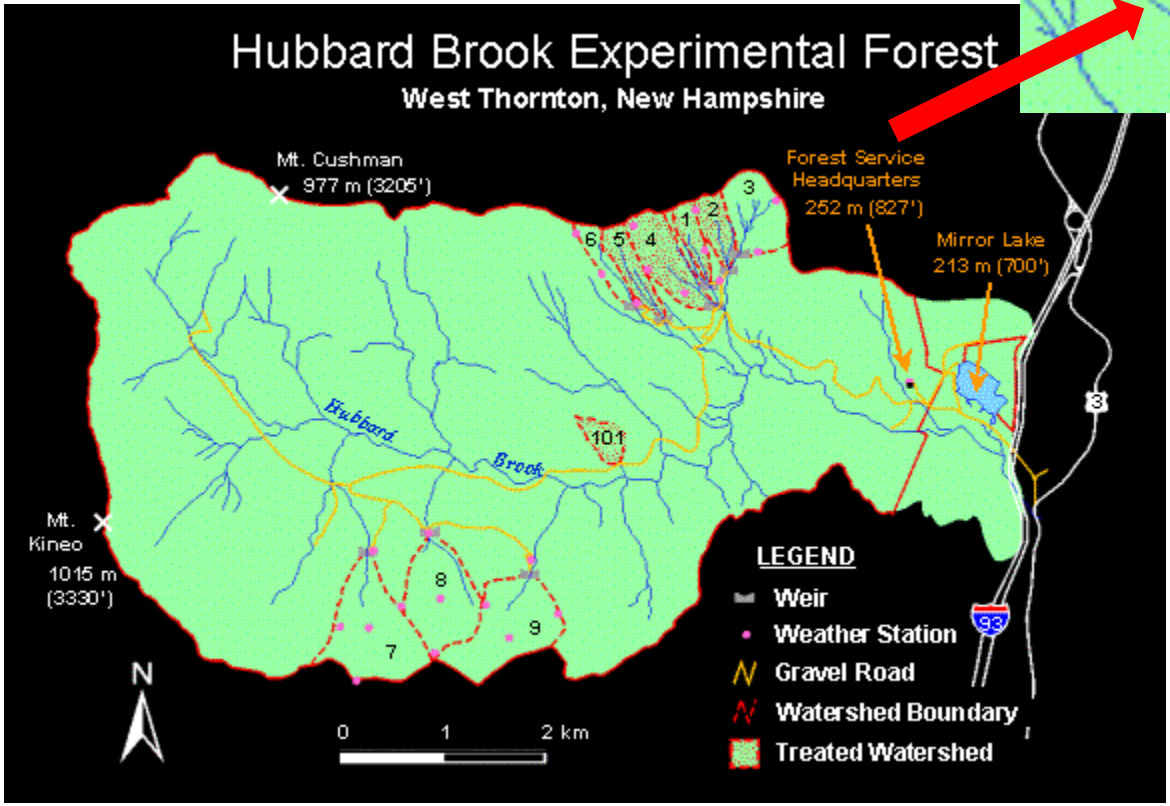
Biogeochemistry

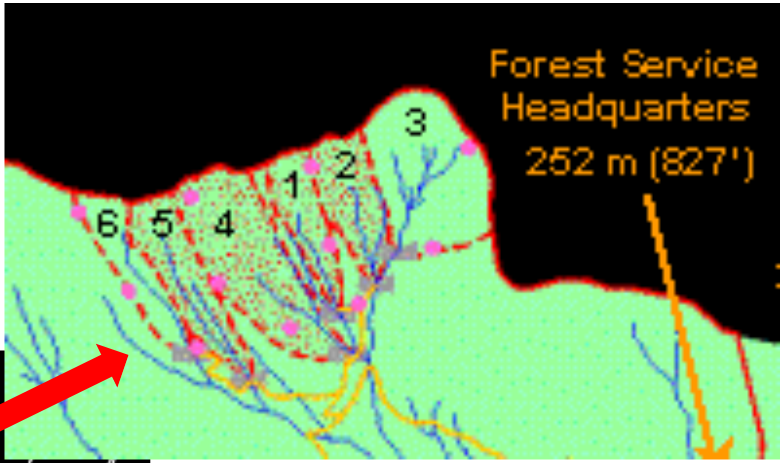


Bormann FH, Likens GE. 1967. Nutrient cycling. *Science* 155(3761):424–29

Small watershed experiments

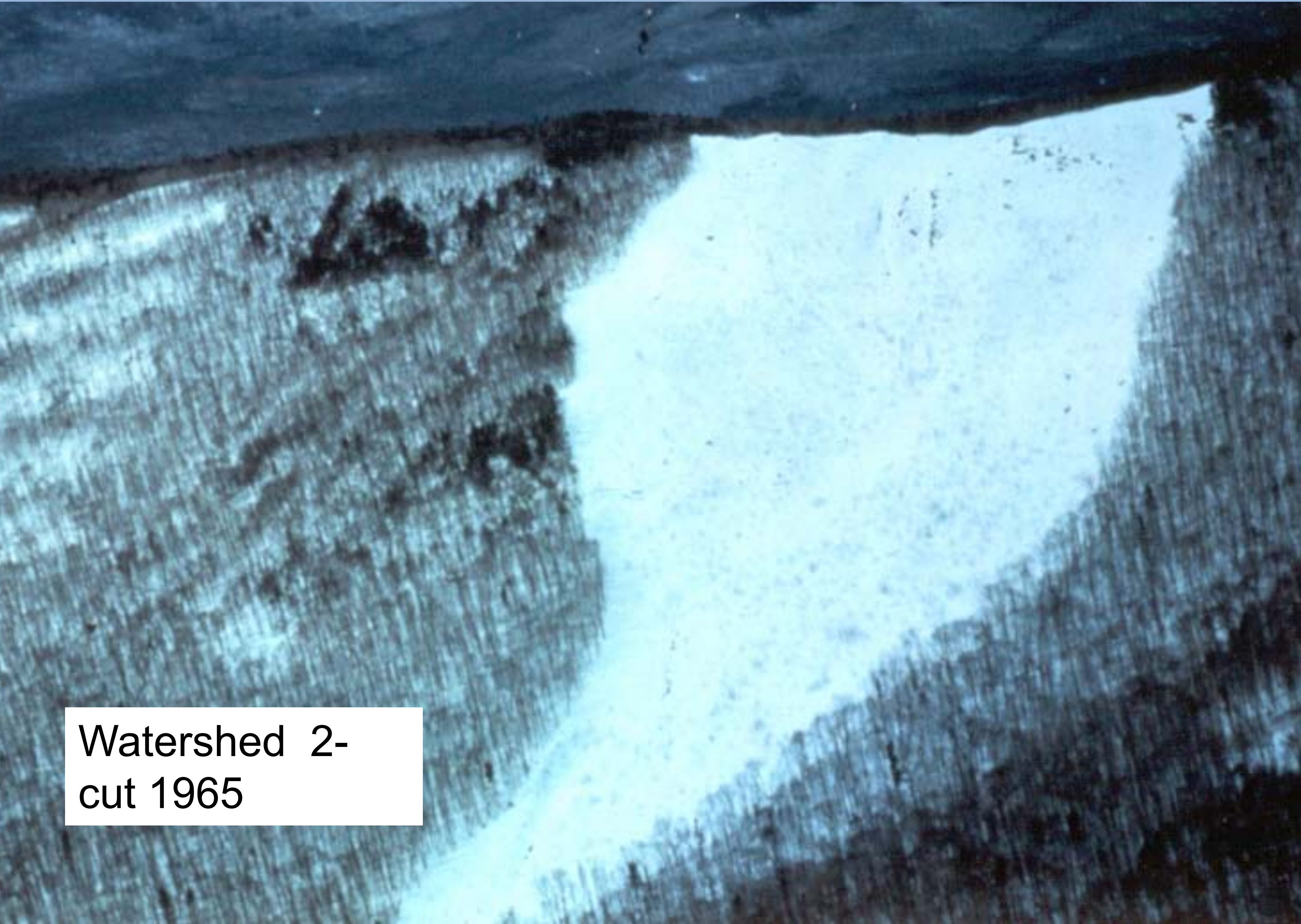
Watershed experiments





Watersheds 3 and 6 are in this photo but cannot be distinguished from the surrounding forest. These two watersheds act as *reference* watersheds.

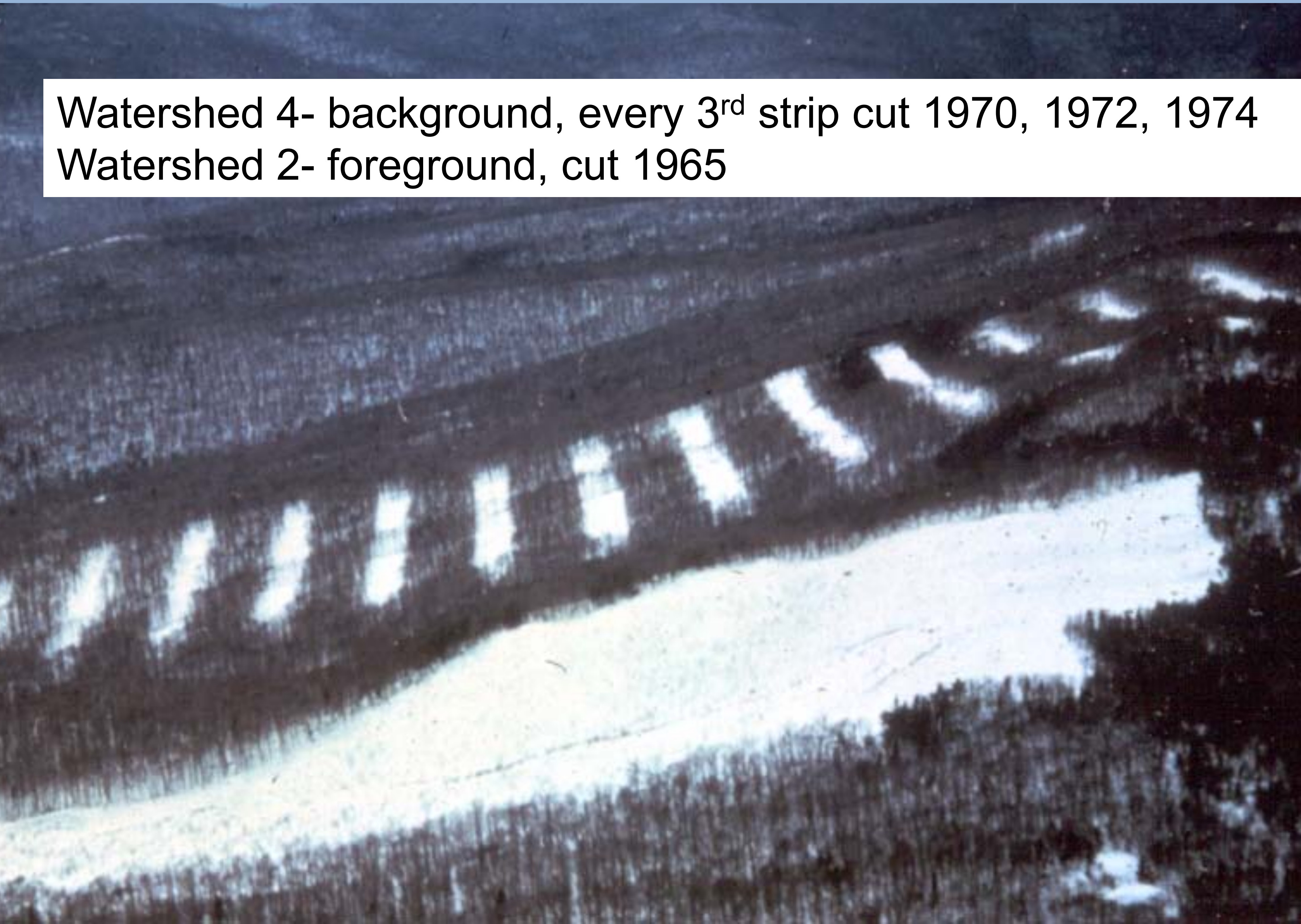
Watershed experiments



Watershed 2-
cut 1965

Watershed experiments

Watershed 4- background, every 3rd strip cut 1970, 1972, 1974
Watershed 2- foreground, cut 1965



Watershed experiments

Watershed 5- cut winter of 1983-84

Watershed experiments

Watershed 1- calcium applied over entire watershed in 1999

The Hubbard Brook Ecosystem Study pioneered the small watershed technique as a method of studying ecosystem processes.

We hope you enjoyed the show and have a better appreciation for ecological research at the HBEF. Come visit us sometime!