

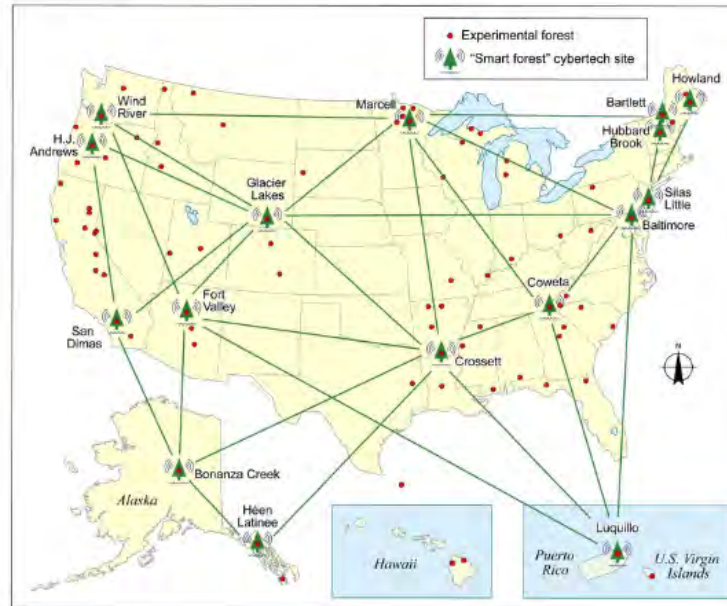
Smart Forests for the 21st Century:

How Cyber Technology and Big Data
are Changing Environmental Sciences

NRS Smart Forests



The New "Business as Usual"



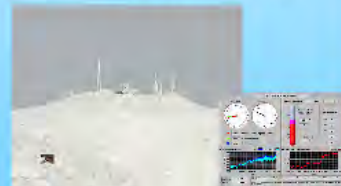
New Opportunities for Education and Outreach



RealTime Data Access



Access to Data From Difficult Locations



Access to Data From Difficult Times



New Scientific Insights



Smart Forests for the 21st Century:

How Cyber Technology and Big Data
are Changing Environmental Sciences

Lindsey Rustad, Northern Research Station, December 2013

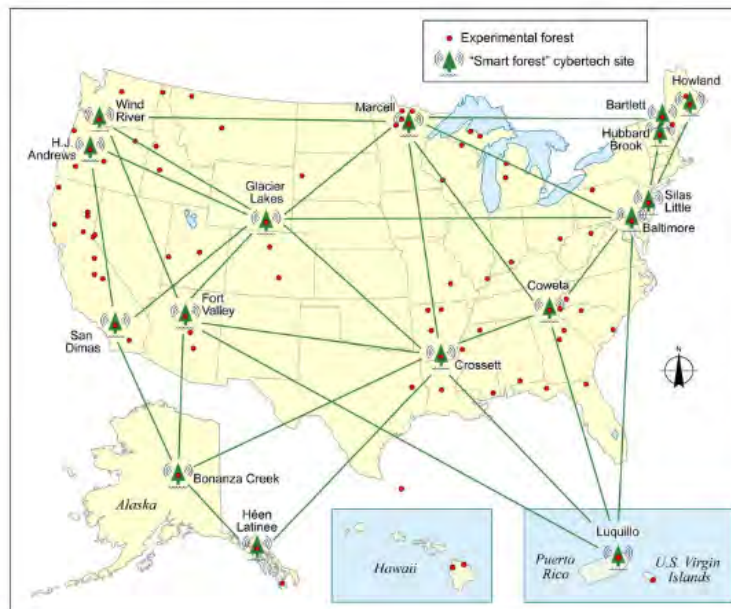
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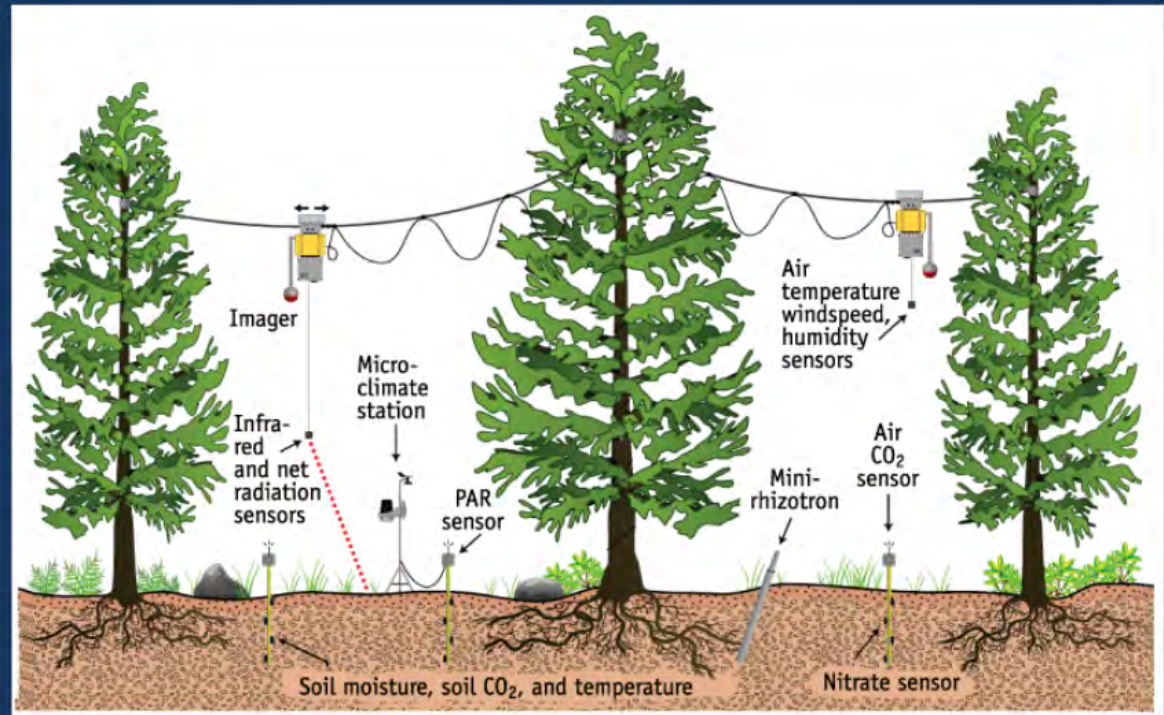
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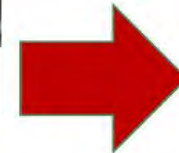


Smart Forest at a Single Site

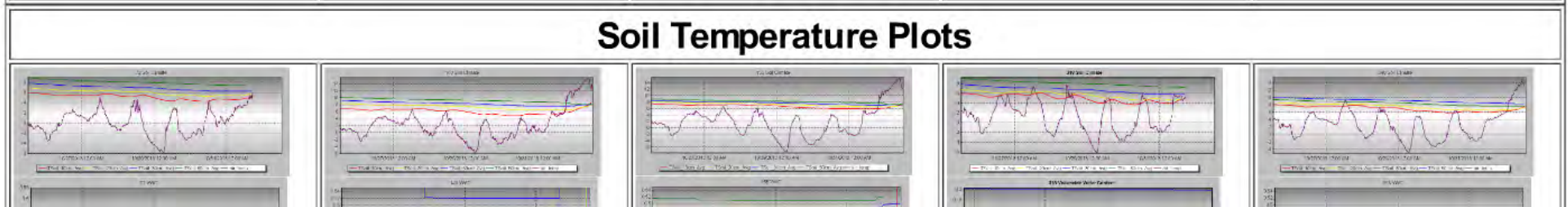
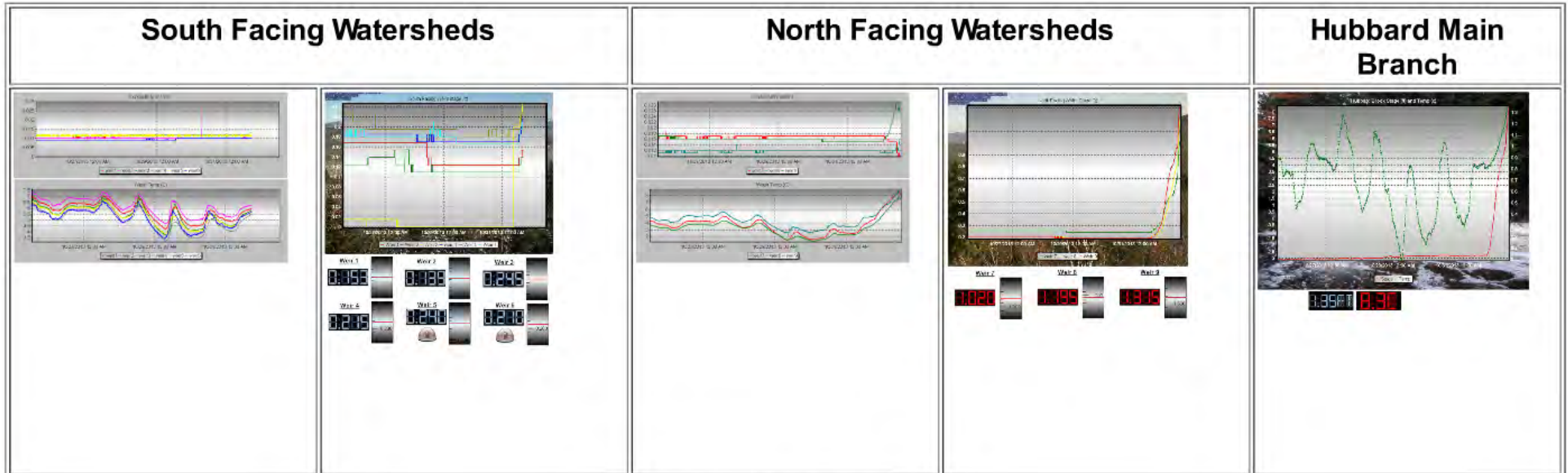
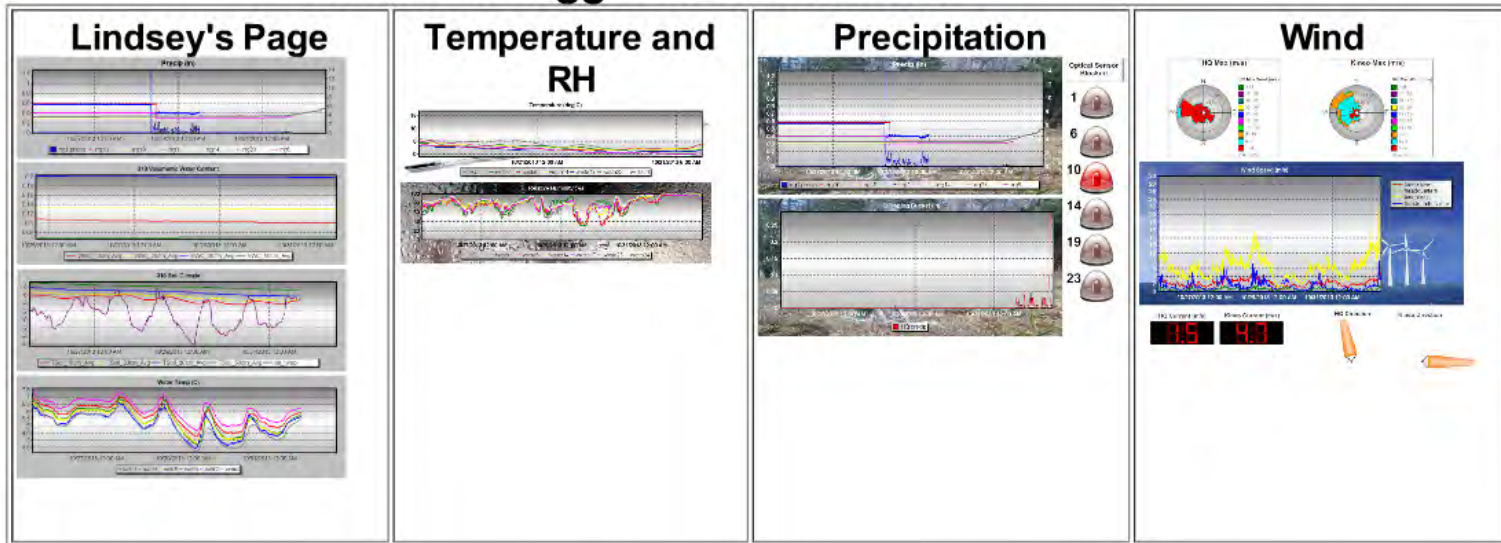
Hubbard Brook Experimental Forest, NH



Out with the OLD! In with the NEW!



Realtime Loggernet Quicklooks



Smart Forests Provide a *Virtual* Window on Our Watersheds



Webcams

Click on thumbnails below to go to the Phenocam site for more information on these images and to access the image archive.



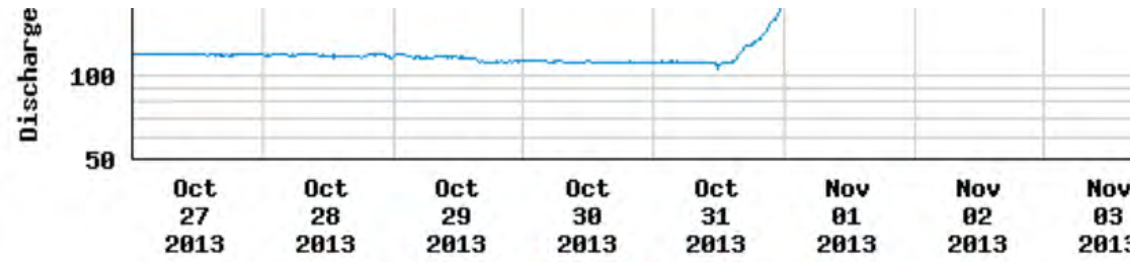
RealTime Data Access



Visibility 10.00 mi
 Wind Chill 27°F (-3°C)
 Last Update on 3 Nov 9:35 am EST

WALD BRIDGE, ME | 3 DAY FORECAST | WINDS FROM N

Gray/Portland, ME
 NWS Weather Forecast Office



---- Provisional Data Subject to Revision ----

△ Median daily statistic (19 years) — Discharge

Graph courtesy of the U.S. Geological Survey

Hubbard Brook Ecosystem Study

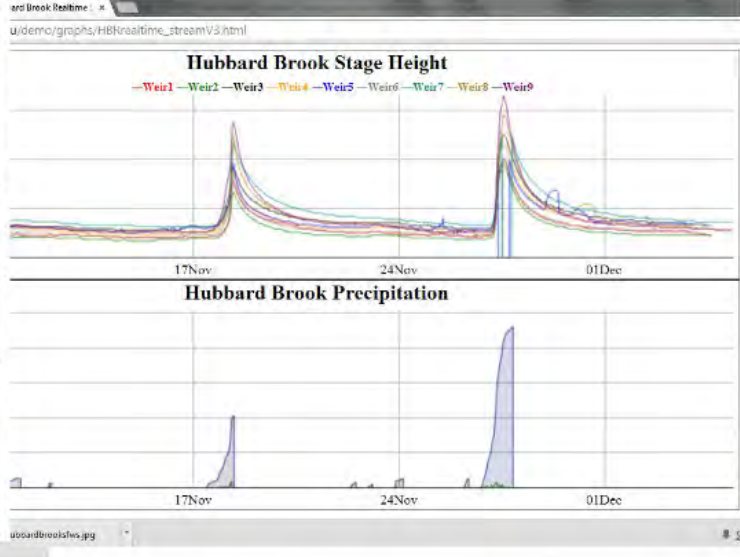
Hubbard Brook is a 1000-acre watershed in the White Mountains of New Hampshire. It is the only watershed in the world where all precipitation is measured.

Weather Station

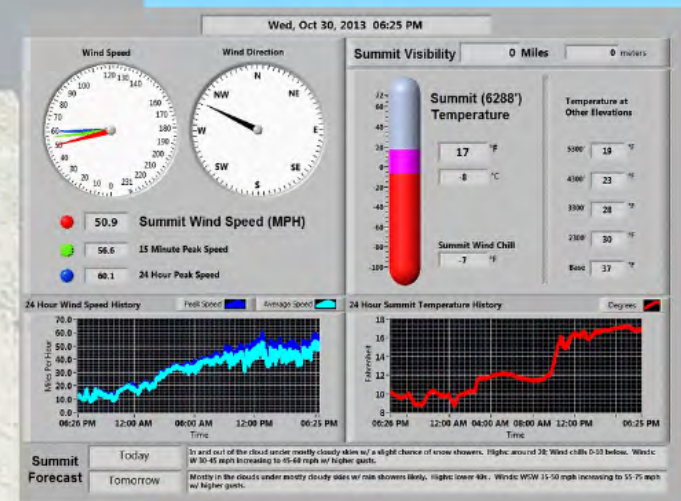
Station	Wx14	Wx17	Wx23	Wx24	Wx6
Temperature (°C)	0.0	0.0	0.0	0.0	0.0
Precipitation (inches)	0.0	0.0	0.0	0.0	0.0
Wind Speed (mph)	0.0	0.0	0.0	0.0	0.0

Water Quality

Date	Temp (°C)	pH	DO (mg/L)	Conductivity (µmhos/cm)
09/27/10	12.1	5.8	1.2	100
10/01/10	10.5	5.5	1.0	100
10/05/10	8.9	5.2	0.8	100
10/09/10	7.3	5.0	0.6	100
10/13/10	5.7	4.8	0.4	100
10/17/10	4.1	4.6	0.2	100
10/21/10	2.5	4.4	0.0	100
10/25/10	0.9	4.2	0.0	100
10/29/10	-0.7	4.0	0.0	100
11/02/10	-2.3	3.8	0.0	100
11/06/10	-3.9	3.6	0.0	100
11/10/10	-5.5	3.4	0.0	100
11/14/10	-7.1	3.2	0.0	100
11/18/10	-8.7	3.0	0.0	100
11/22/10	-10.3	2.8	0.0	100
11/26/10	-11.9	2.6	0.0	100
12/01/10	-13.5	2.4	0.0	100
12/05/10	-15.1	2.2	0.0	100
12/09/10	-16.7	2.0	0.0	100
12/13/10	-18.3	1.8	0.0	100
12/17/10	-19.9	1.6	0.0	100
12/21/10	-21.5	1.4	0.0	100
12/25/10	-23.1	1.2	0.0	100
12/29/10	-24.7	1.0	0.0	100
01/02/11	-26.3	0.8	0.0	100
01/06/11	-27.9	0.6	0.0	100
01/10/11	-29.5	0.4	0.0	100
01/14/11	-31.1	0.2	0.0	100
01/18/11	-32.7	0.0	0.0	100
01/22/11	-34.3	-0.2	0.0	100
01/26/11	-35.9	-0.4	0.0	100
01/30/11	-37.5	-0.6	0.0	100
02/03/11	-39.1	-0.8	0.0	100
02/07/11	-40.7	-1.0	0.0	100
02/11/11	-42.3	-1.2	0.0	100
02/15/11	-43.9	-1.4	0.0	100
02/19/11	-45.5	-1.6	0.0	100
02/23/11	-47.1	-1.8	0.0	100
02/27/11	-48.7	-2.0	0.0	100
03/01/11	-50.3	-2.2	0.0	100
03/05/11	-51.9	-2.4	0.0	100
03/09/11	-53.5	-2.6	0.0	100
03/13/11	-55.1	-2.8	0.0	100
03/17/11	-56.7	-3.0	0.0	100
03/21/11	-58.3	-3.2	0.0	100
03/25/11	-59.9	-3.4	0.0	100
03/29/11	-61.5	-3.6	0.0	100
04/02/11	-63.1	-3.8	0.0	100
04/06/11	-64.7	-4.0	0.0	100
04/10/11	-66.3	-4.2	0.0	100
04/14/11	-67.9	-4.4	0.0	100
04/18/11	-69.5	-4.6	0.0	100
04/22/11	-71.1	-4.8	0.0	100
04/26/11	-72.7	-5.0	0.0	100
04/30/11	-74.3	-5.2	0.0	100
05/04/11	-75.9	-5.4	0.0	100
05/08/11	-77.5	-5.6	0.0	100
05/12/11	-79.1	-5.8	0.0	100
05/16/11	-80.7	-6.0	0.0	100
05/20/11	-82.3	-6.2	0.0	100
05/24/11	-83.9	-6.4	0.0	100
05/28/11	-85.5	-6.6	0.0	100
06/01/11	-87.1	-6.8	0.0	100
06/05/11	-88.7	-7.0	0.0	100
06/09/11	-90.3	-7.2	0.0	100
06/13/11	-91.9	-7.4	0.0	100
06/17/11	-93.5	-7.6	0.0	100
06/21/11	-95.1	-7.8	0.0	100
06/25/11	-96.7	-8.0	0.0	100
06/29/11	-98.3	-8.2	0.0	100
07/03/11	-99.9	-8.4	0.0	100
07/07/11	-101.5	-8.6	0.0	100
07/11/11	-103.1	-8.8	0.0	100
07/15/11	-104.7	-9.0	0.0	100
07/19/11	-106.3	-9.2	0.0	100
07/23/11	-107.9	-9.4	0.0	100
07/27/11	-109.5	-9.6	0.0	100
08/01/11	-111.1	-9.8	0.0	100
08/05/11	-112.7	-10.0	0.0	100
08/09/11	-114.3	-10.2	0.0	100
08/13/11	-115.9	-10.4	0.0	100
08/17/11	-117.5	-10.6	0.0	100
08/21/11	-119.1	-10.8	0.0	100
08/25/11	-120.7	-11.0	0.0	100
08/29/11	-122.3	-11.2	0.0	100
09/02/11	-123.9	-11.4	0.0	100
09/06/11	-125.5	-11.6	0.0	100
09/10/11	-127.1	-11.8	0.0	100
09/14/11	-128.7	-12.0	0.0	100
09/18/11	-130.3	-12.2	0.0	100
09/22/11	-131.9	-12.4	0.0	100
09/26/11	-133.5	-12.6	0.0	100
09/30/11	-135.1	-12.8	0.0	100
10/04/11	-136.7	-13.0	0.0	100
10/08/11	-138.3	-13.2	0.0	100
10/12/11	-139.9	-13.4	0.0	100
10/16/11	-141.5	-13.6	0.0	100
10/20/11	-143.1	-13.8	0.0	100
10/24/11	-144.7	-14.0	0.0	100
10/28/11	-146.3	-14.2	0.0	100
11/01/11	-147.9	-14.4	0.0	100
11/05/11	-149.5	-14.6	0.0	100
11/09/11	-151.1	-14.8	0.0	100
11/13/11	-152.7	-15.0	0.0	100
11/17/11	-154.3	-15.2	0.0	100
11/21/11	-155.9	-15.4	0.0	100
11/25/11	-157.5	-15.6	0.0	100
11/29/11	-159.1	-15.8	0.0	100
12/03/11	-160.7	-16.0	0.0	100
12/07/11	-162.3	-16.2	0.0	100
12/11/11	-163.9	-16.4	0.0	100
12/15/11	-165.5	-16.6	0.0	100
12/19/11	-167.1	-16.8	0.0	100
12/23/11	-168.7	-17.0	0.0	100
12/27/11	-170.3	-17.2	0.0	100
12/31/11	-171.9	-17.4	0.0	100



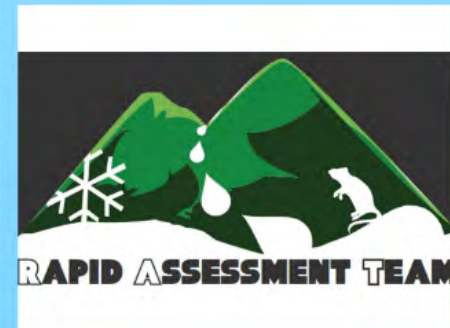
Access to Data From Difficult Locations





01.11.2017 17:45:00

Access to Data From Difficult Times



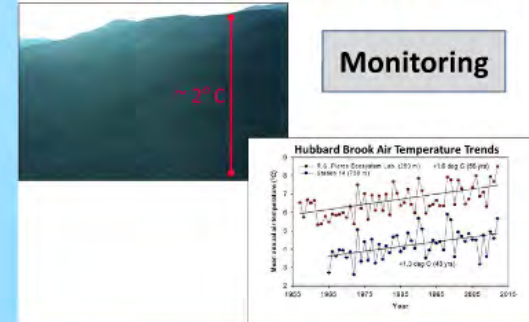


RAPID ASSESSMENT TEAM

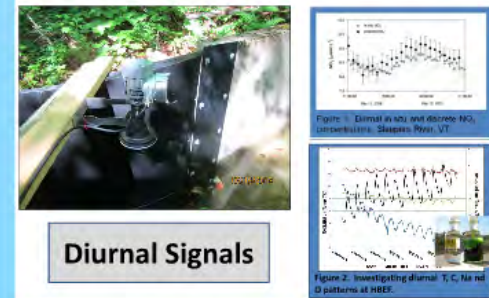
New Scientific Insights



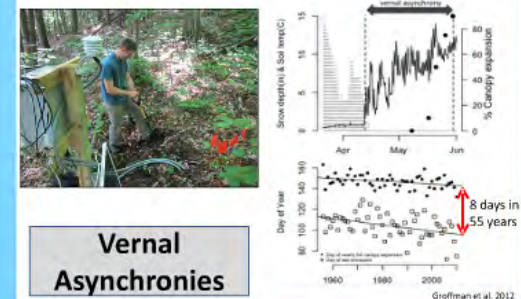
Known Knowns



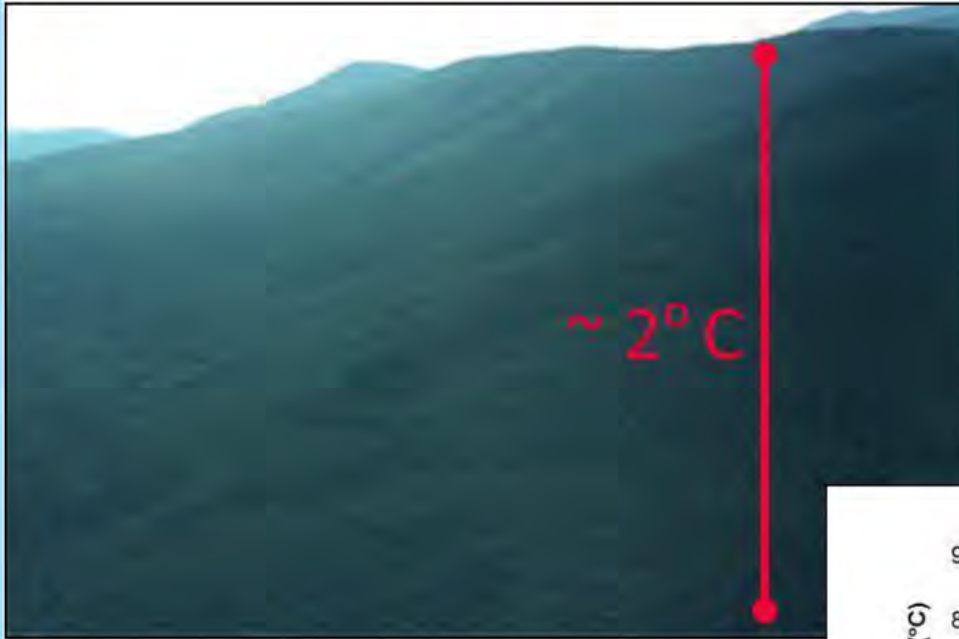
Known Unknowns



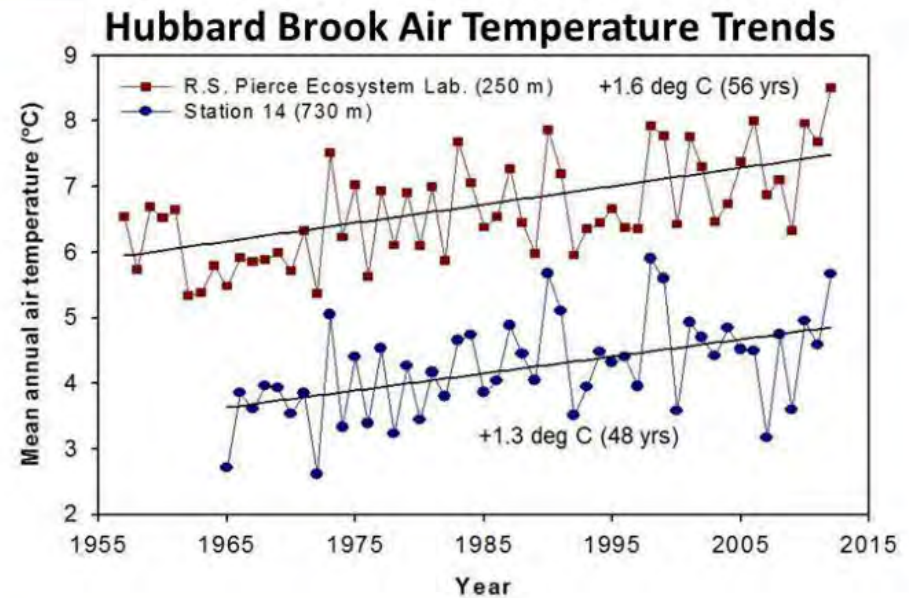
Unknown Unknowns



Known Knowns



Monitoring



Known UnKnowns



Diurnal Signals

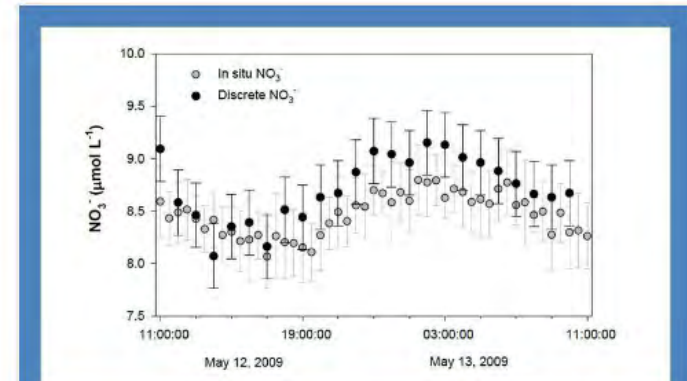


Figure 1. Diurnal in situ and discrete NO_3 concentrations, Sleepers River, VT

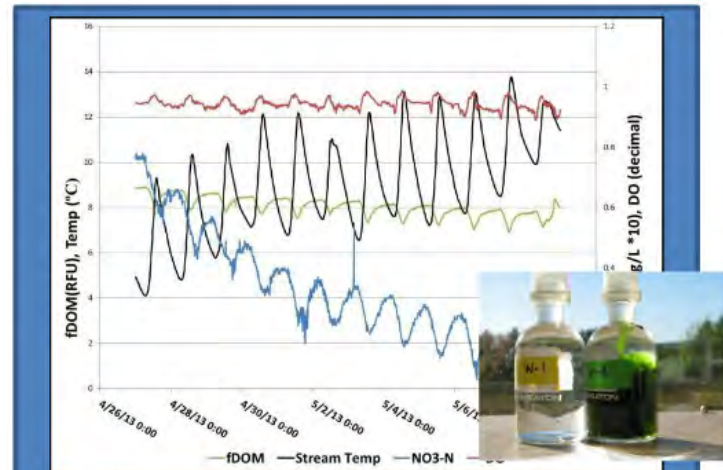
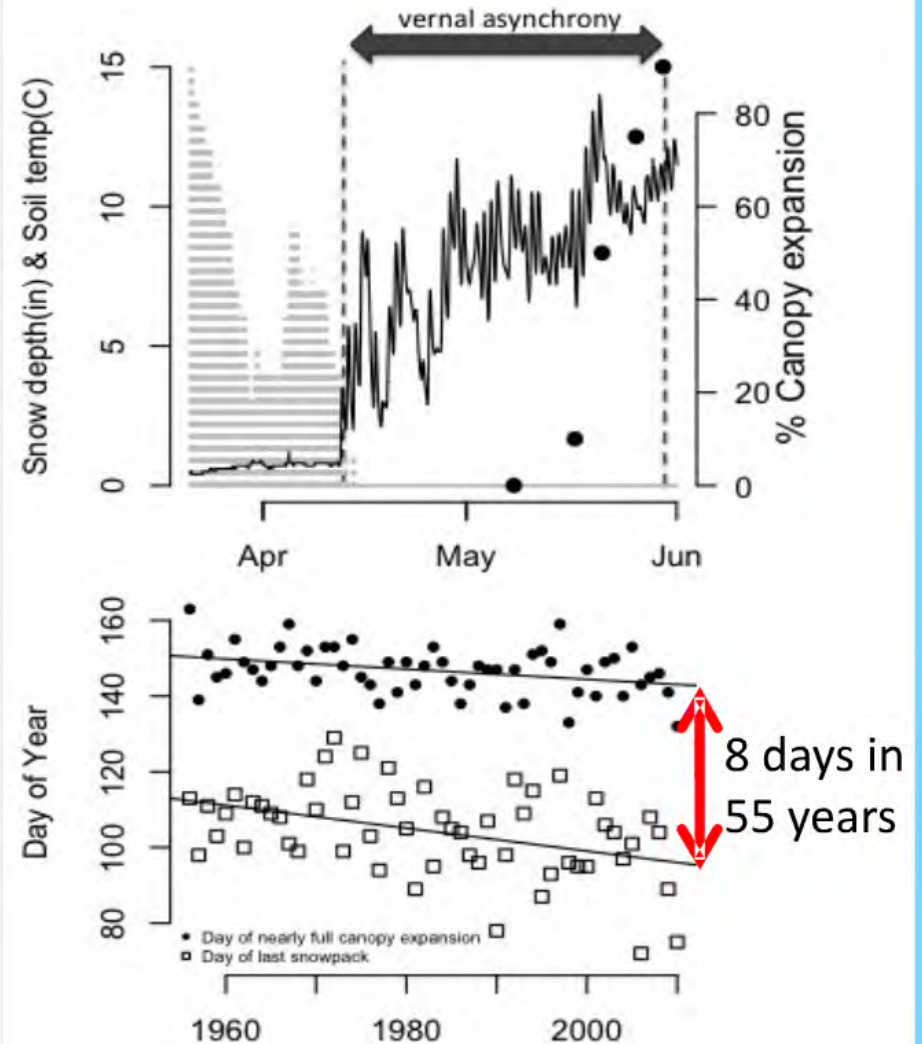


Figure 2. Investigating diurnal T, C, Na nd O patterns at HBEF.

UnKnown UnKnowns

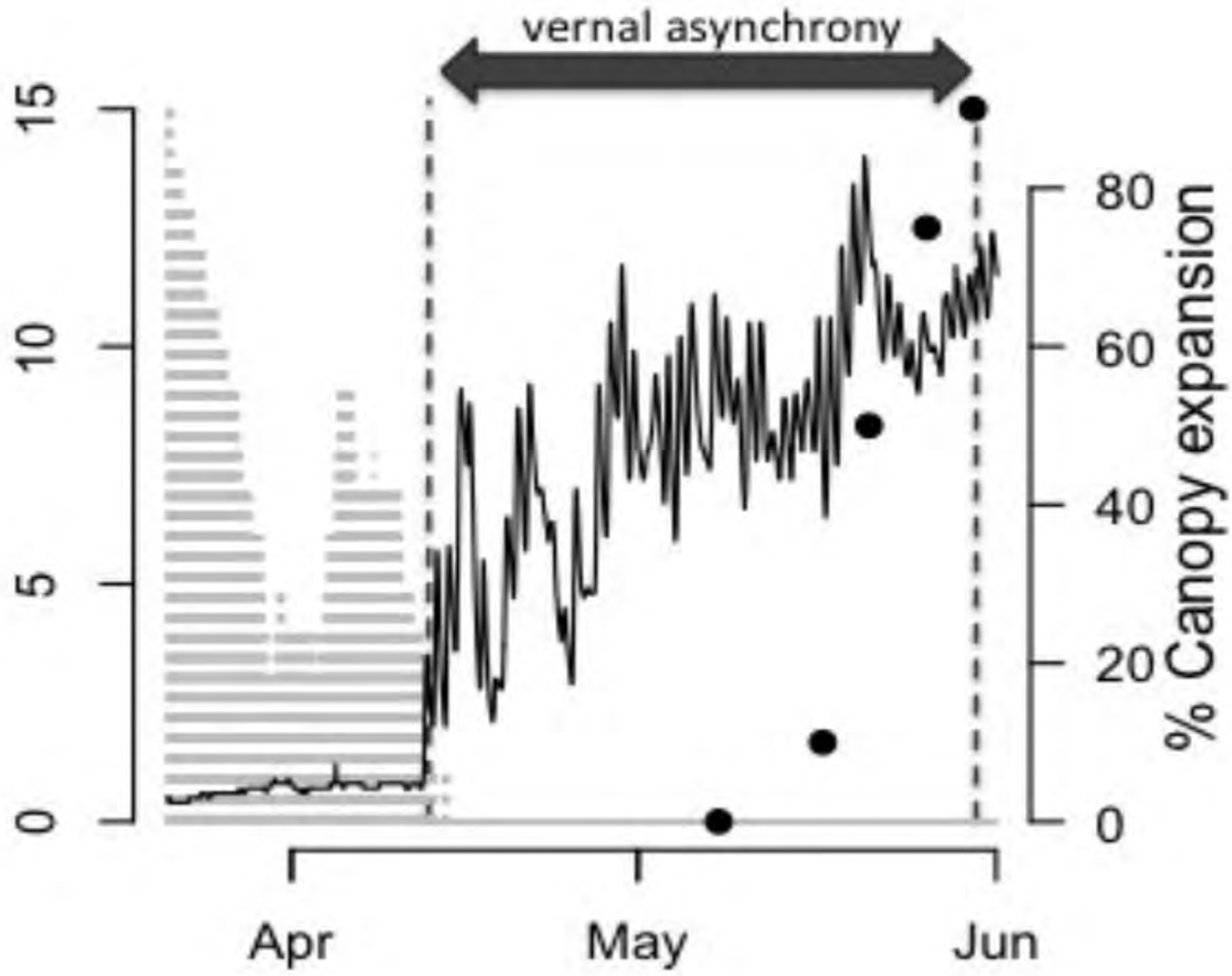


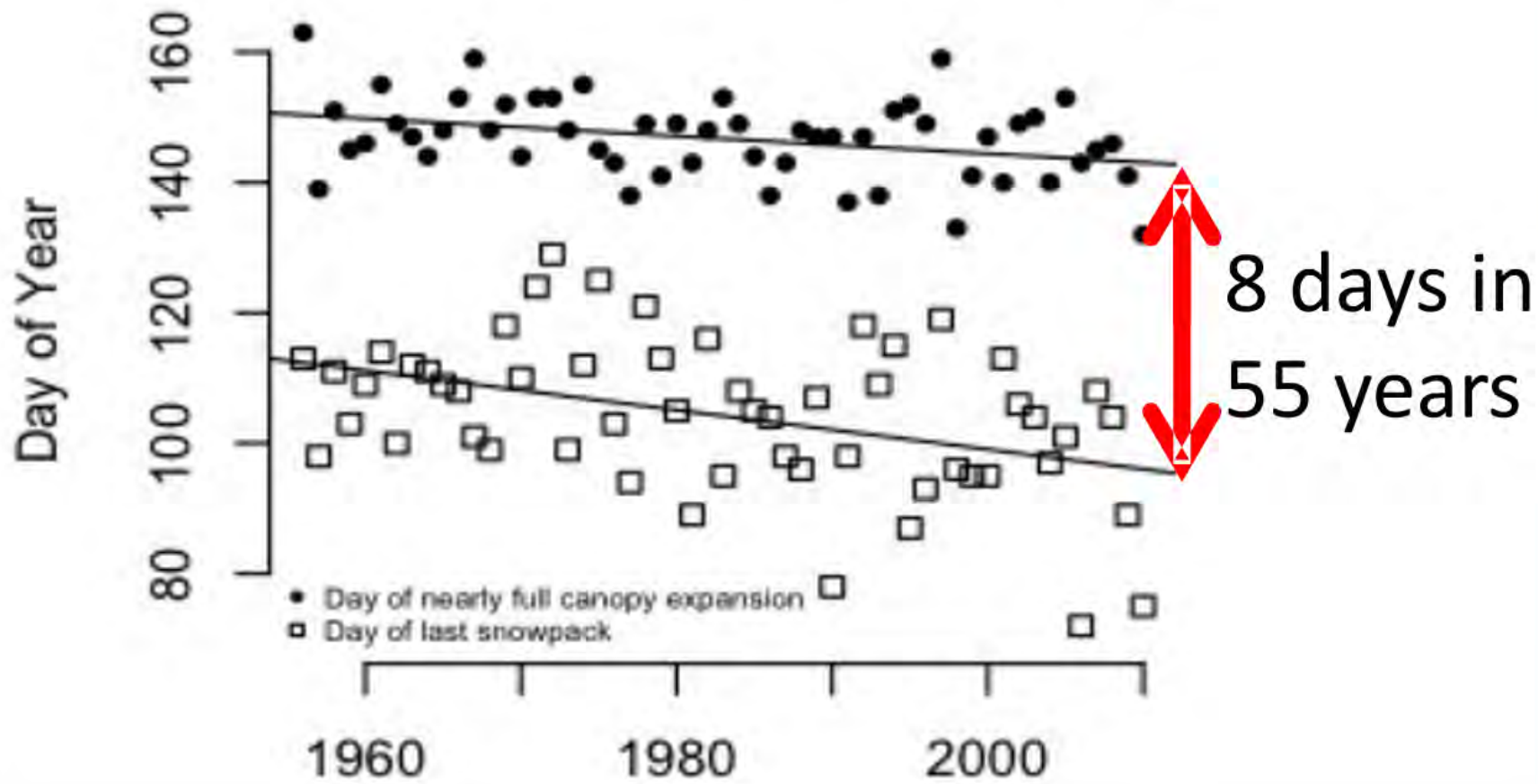
Vernal Asynchronies



Groffman et al. 2012

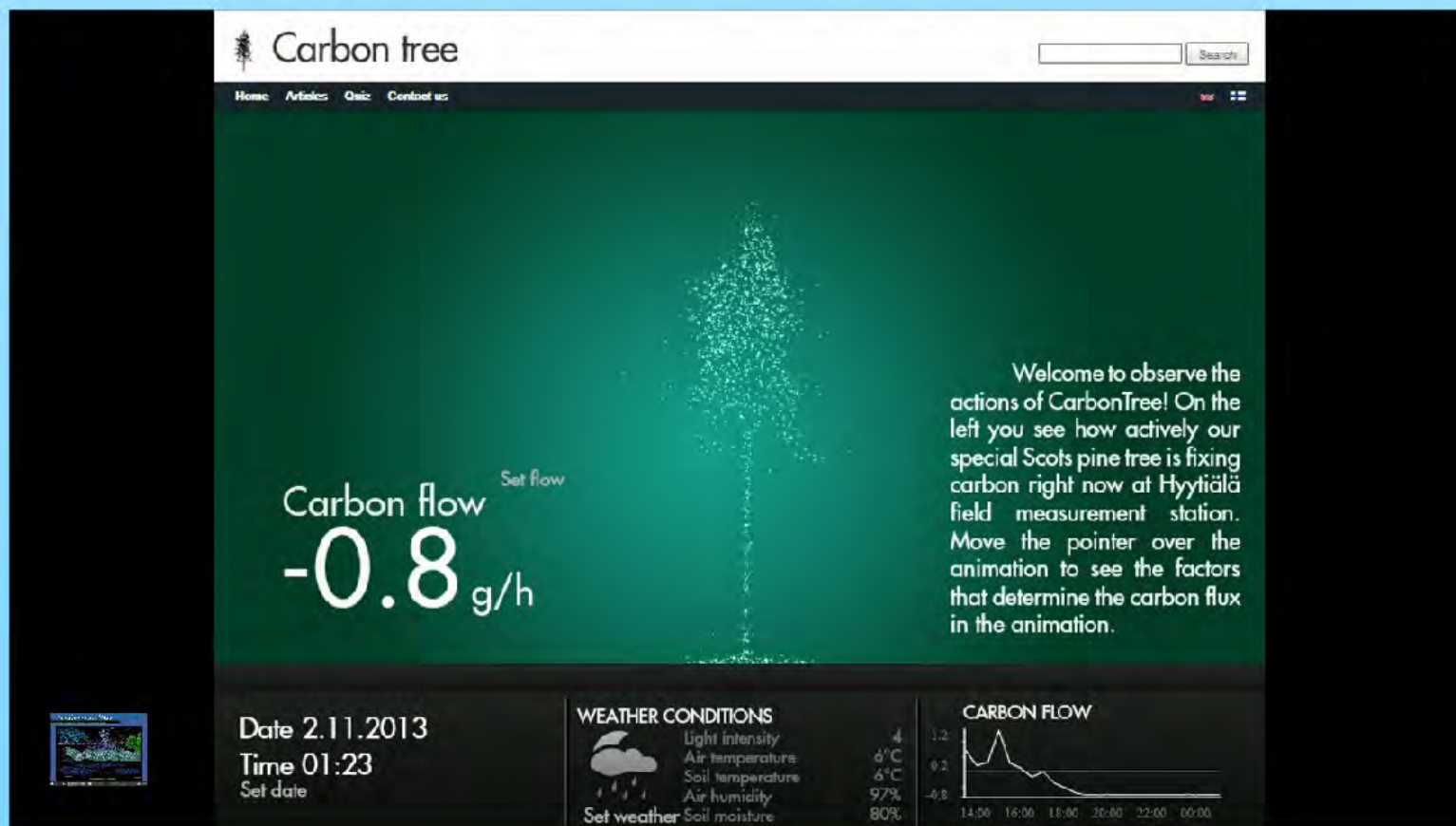
Snow depth(in) & Soil temp(C)





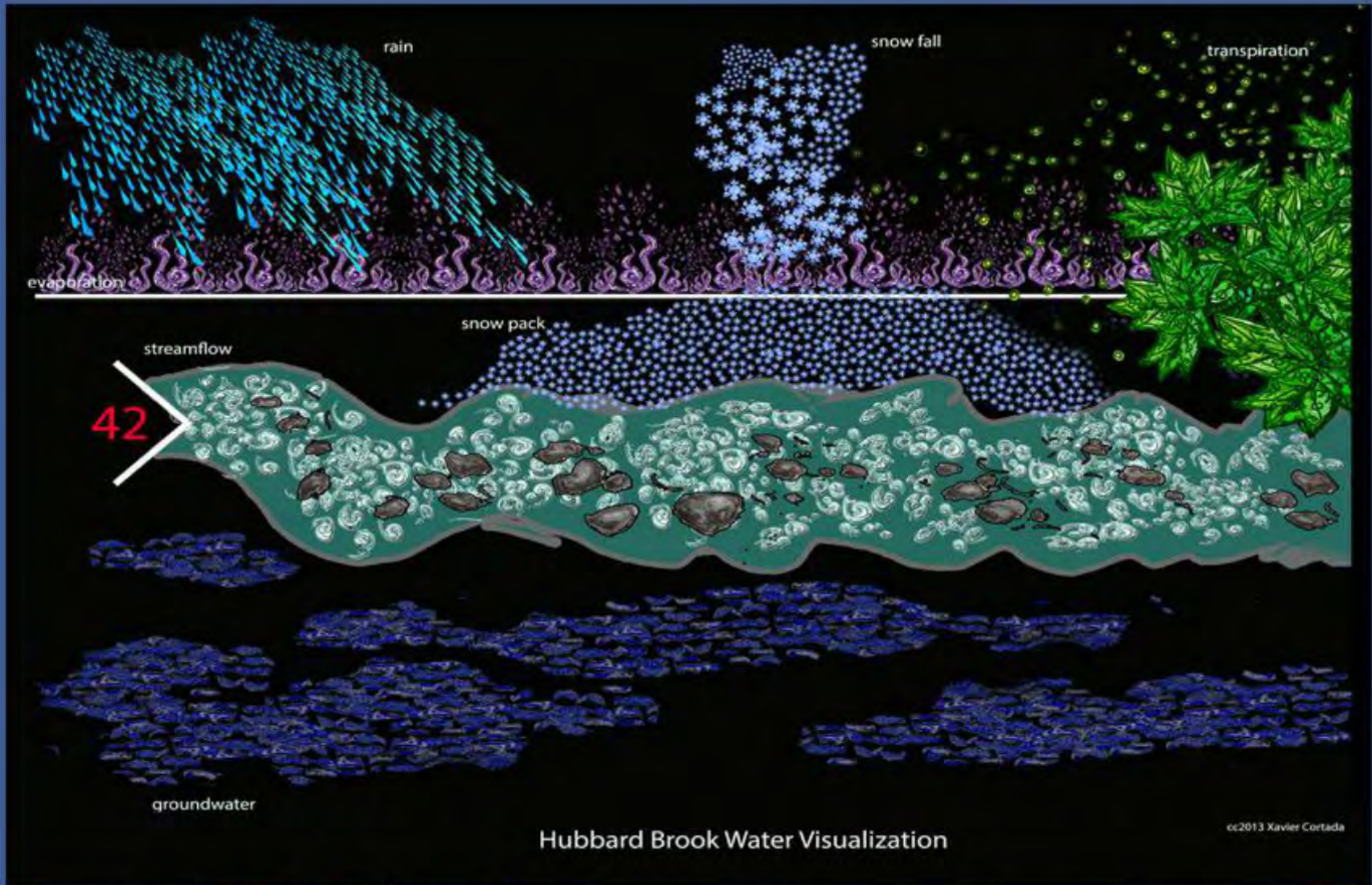
Groffman et al. 2012

New Opportunities for Education and Outreach



Hubbard Brook Water Cycle Viewer

Project [The Water Cycle](#) [Water Cycle Simulator](#) [Hubbard Brook](#) [Realtime Data](#) [Webcam](#) [Contact Us](#)



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Vision for Smart Forests

“...a network of long-term research sites that are equipped with an integrated technological platform, combining high frequency, real-time sensor-based measurements with traditional ecological field-scale studies, designed to monitor and respond rapidly to environmental change at the local to continental scales.”

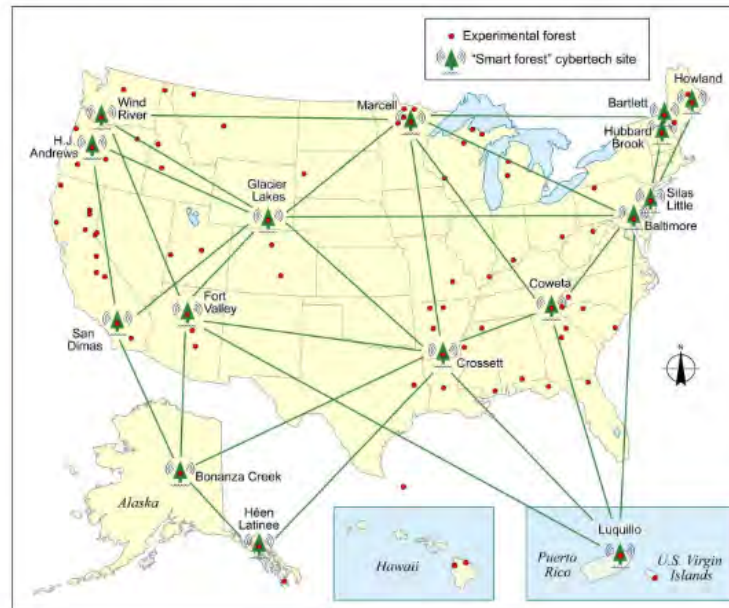
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