Environmental sensor applications at Experimental Forests: The Smart Forest Network

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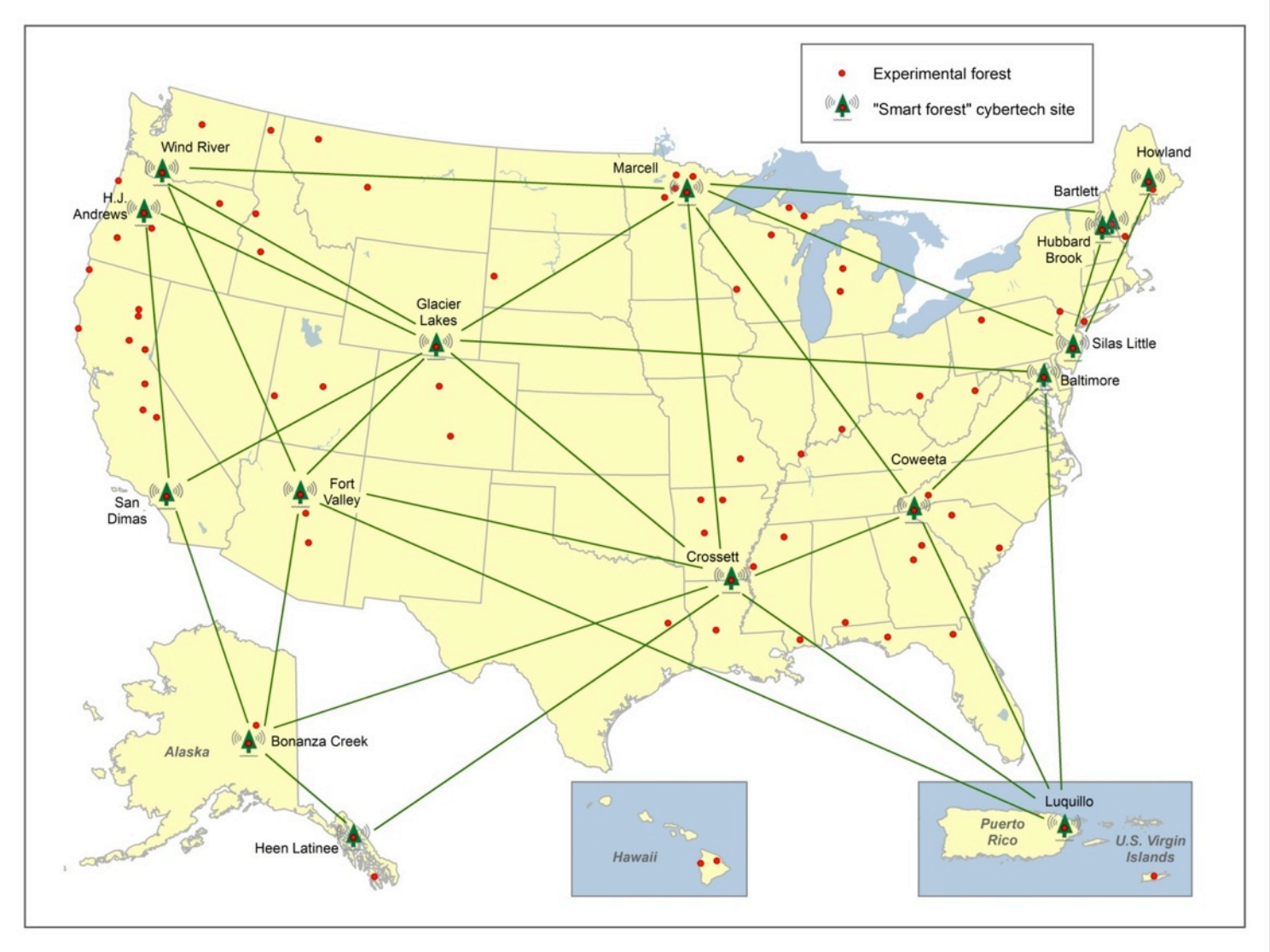
Vision

"…a network of research sites that are equipped with a synergistic 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 regional scales."

Vision

- **State-of-the-art wireless sensor network for capture and delivery of high resolution hydrologic and meteorologic data.**
- **Cyber infrastructure for additional site-specific sensors.**
- **Streaming, *real-time* QC to ensure high quality data.**
- **Data delivery to a central database with a *single* web portal.**
- ***Interactive* data visualizations and content for scientists, educators, and the public.**
- ***Question* driven.**

Vision


Experimental forest
"Smart forest" cybertech site
Wind River
H.J. Andrews
Marcell
Howland
Bartlett
Hubbard Brook
Glacier Lakes
Silas Little
Baltimore
Coweeta
San Dimas
Fort Valley
Crossett
Alaska
Bonanza Creek
Heen Latinee
Hawaii
Luquillo
Puerto Rico
U.S. Virgin Islands

Currently connected:

Bartlett EF, NH
Fernow EF, WV
Howland CEF, ME
Hubbard Brook EF, NH
Marcell EF, MN
NY Urban Field Station

Coming soon:

Baltimore ES, MD
Grey Towers, PA
Pike Bay/Cutfoot EF, MN
Silas Little EF, NJ
Sinkin EF, MO

Installation

Base Equipment

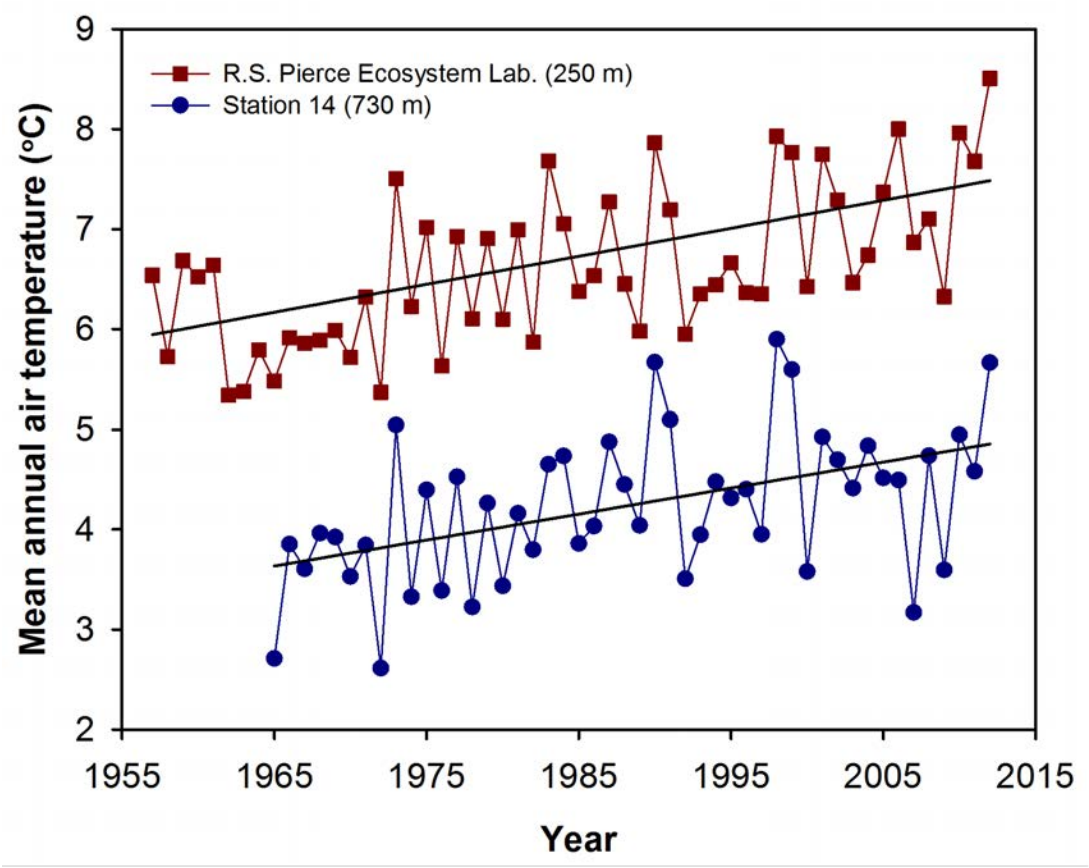
Met Station
Rain gauge (2)
Pyranometer (2)
Wind speed/direction (2)
Air temperature (3)
Relative humidity (3)
Web cam

Soil Stati
Soil moist
Soil temp

Stream station
Stream stage height (1)
Water temperature (1)
Conductivity (1)

Cost = $23,000/site (equipment only)

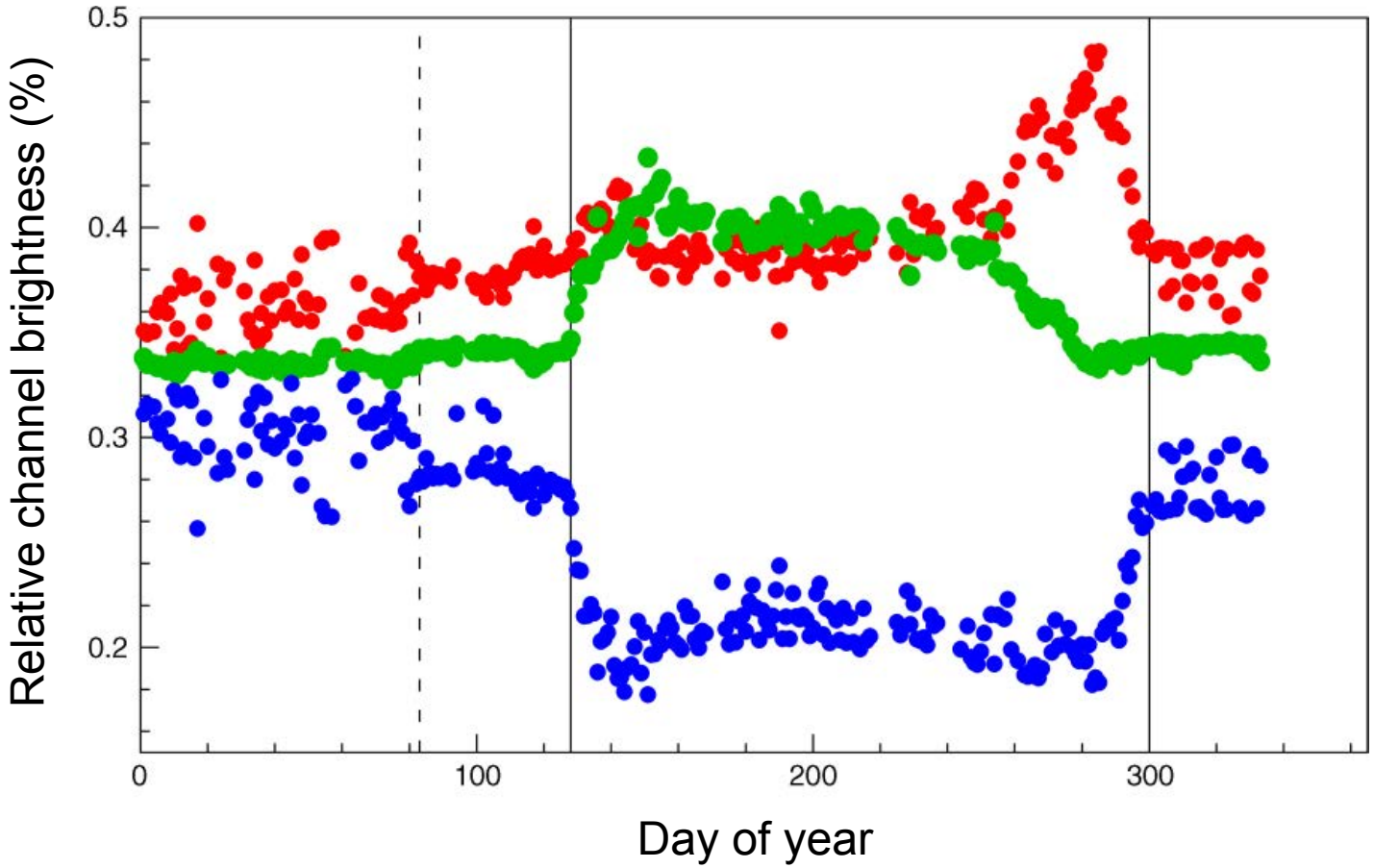
Air Temperature



Webcam Phenology

- 3 megapixel resolution
- Images taken hourly (8am-8pm)
- Archive all images

South Facing Watersheds, Hubbard Brook, NH
Sat Apr 14 12:10:21 EST 2012
Camera Temp 18.0° C



Richardson et al. 2009. *Ecological Applications*

Wireless Communication

Cellular phone

Pro: Easy to set up

Con: Need cell coverage, monthly fee

Radio

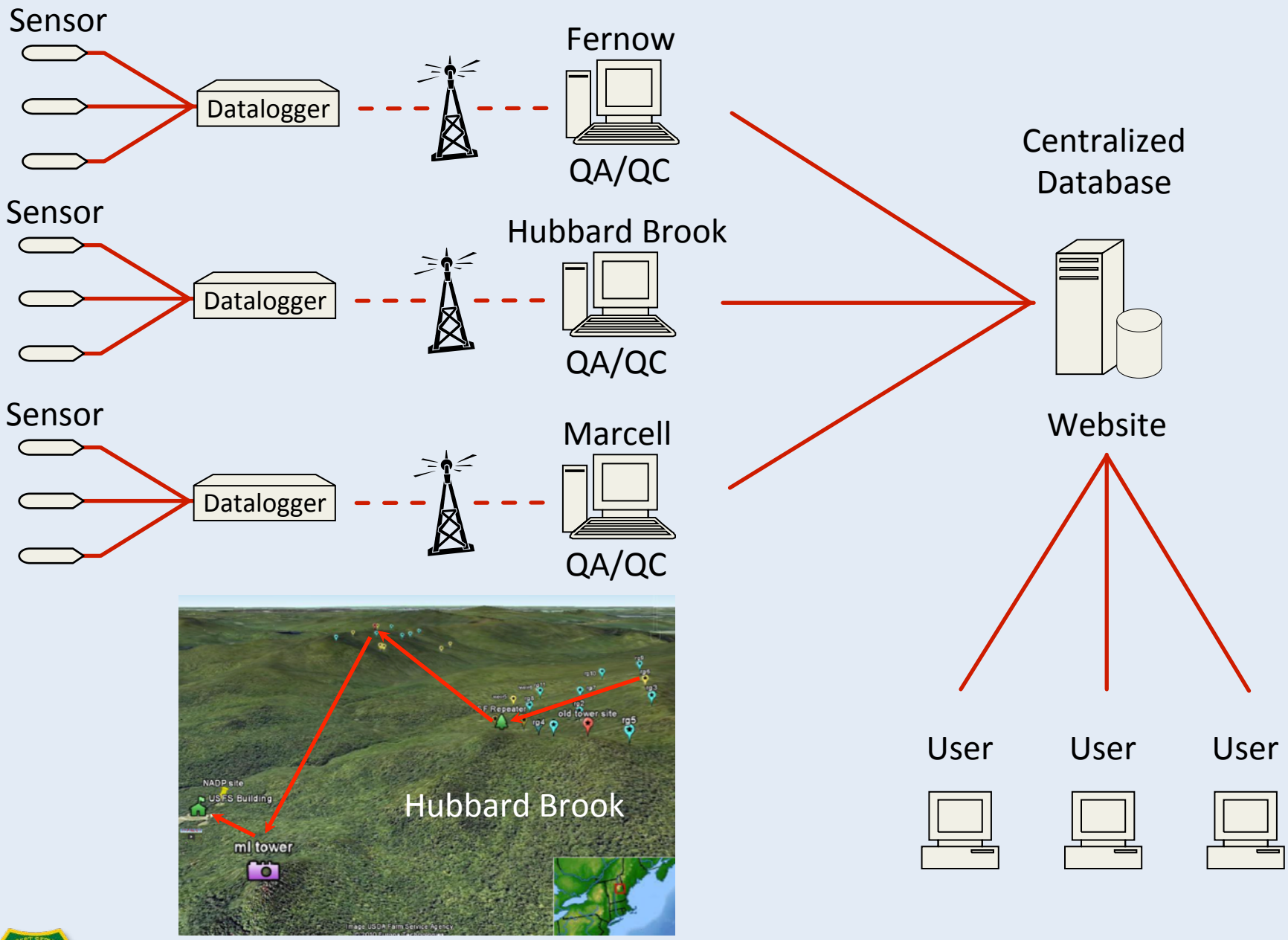
Pro: No monthly fee

Con: Need line-of-site

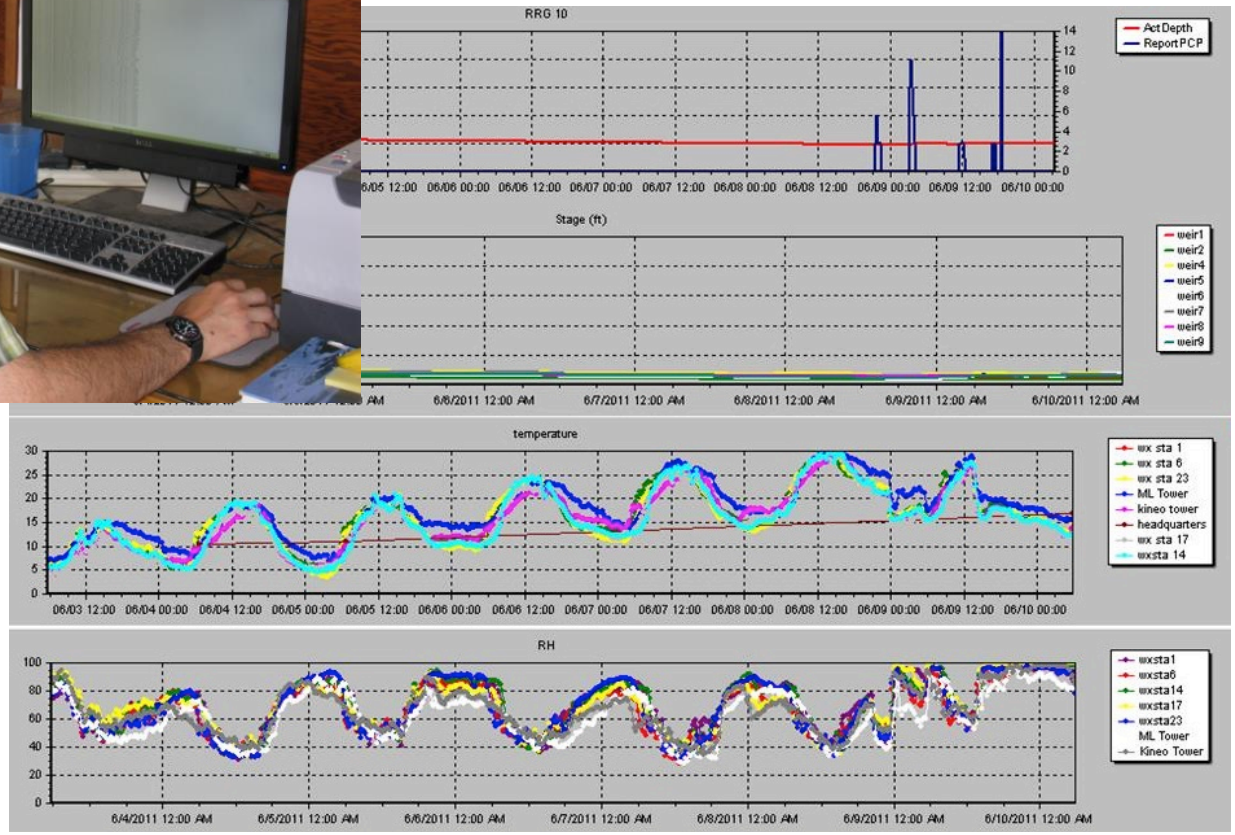
Satellite

Pro: Good in remote locations

Con: Data transfer limitations, monthly fee

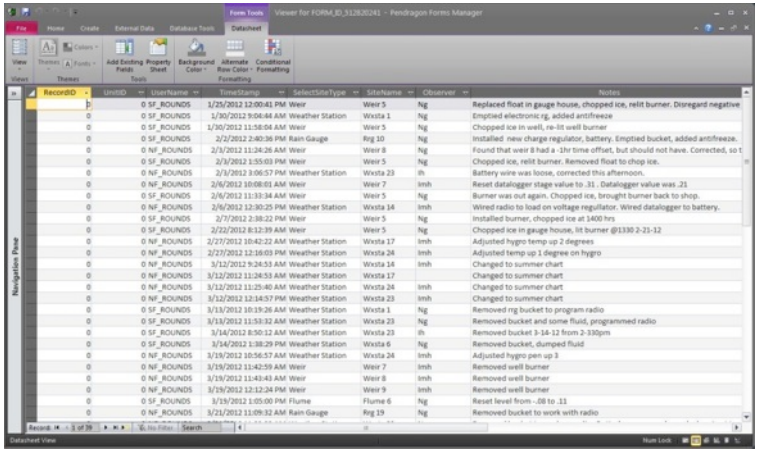

Sensor
Datalogger
Fernow
QA/QC
Sensor
Datalogger
Hubbard Brook
QA/QC
Sensor
Datalogger
Marcell
QA/QC
Centralized Database
Website
User
User
User
Hubbard Brook
NADP site
USFS Building
ml tower
old tower site

Quality Assurance/Quality Control

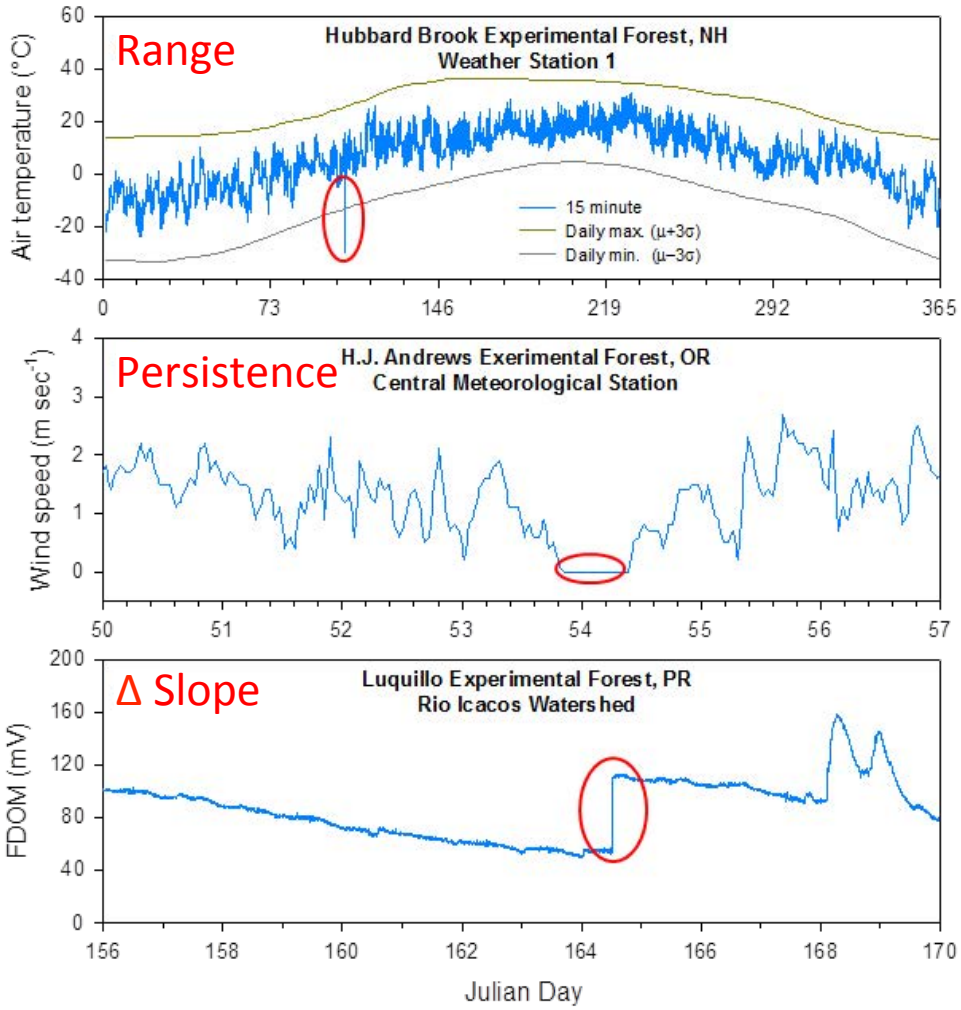


Quality Assurance/Quality Control

1. Replicate sensors
   - Triple redundancy
   - Separate data loggers
2. Plan routine maintenance
   - Repairs in off season
   - Stagger maintenance
3. Keep spare parts on hand
4. Alert system
5. Take notes

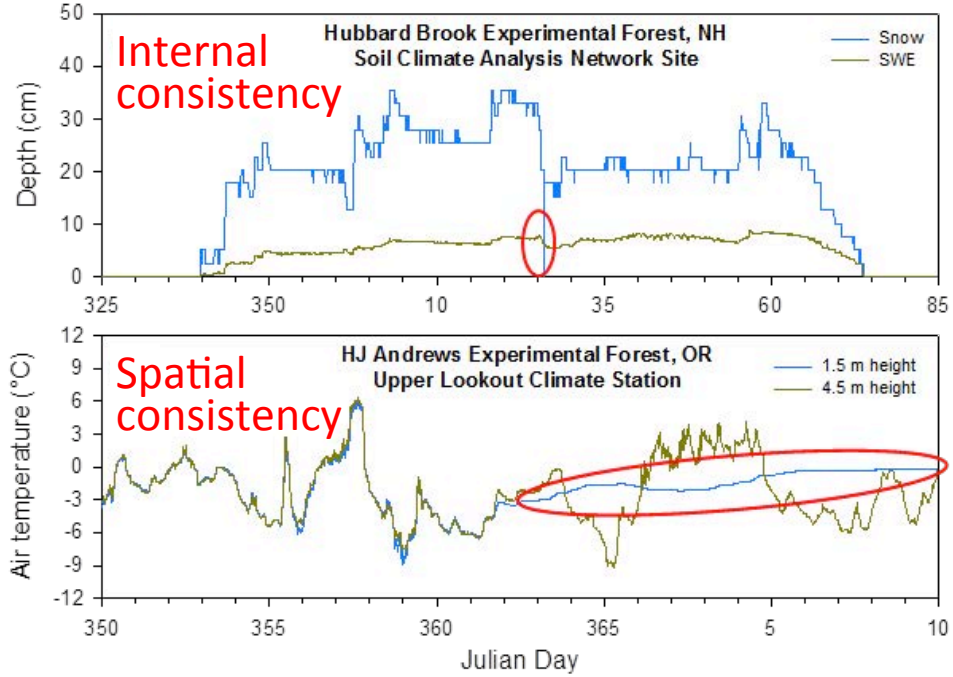


QA/QC

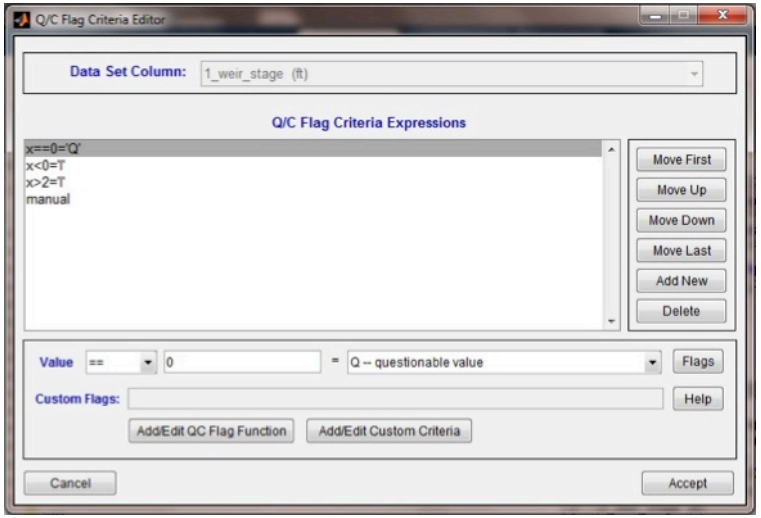


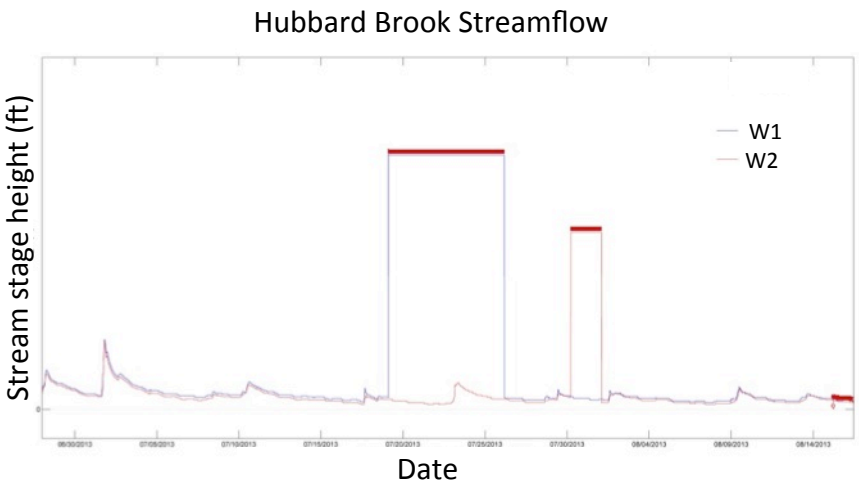
Campbell et al. 2013. BioScience

QA/QC


Internal consistency
Hubbard Brook Experimental Forest, NH
Soil Climate Analysis Network Site
Snow
SWE
Depth (cm)
50
40
30
20
10
0
325
350
10
35
60
85
Spatial consistency
HJ Andrews Experimental Forest, OR
Upper Lookout Climate Station
1.5 m height
4.5 m height
Air temperature (°C)
12
9
6
3
0
-3
-6
-9
-12
350
355
360
365
5
10
Julian Day

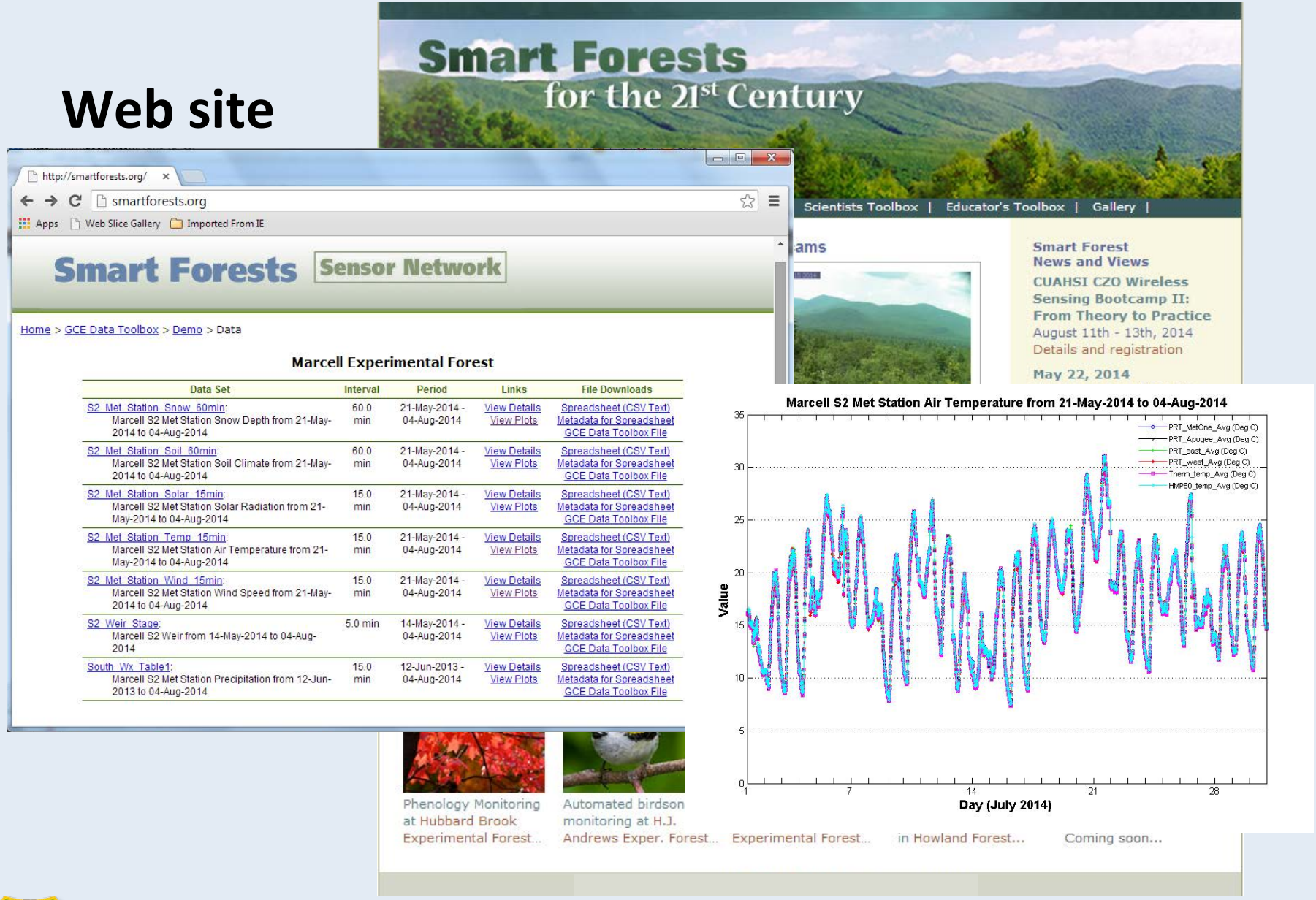
GCE Toolbox for QC





Campbell et al. 2013. BioScience

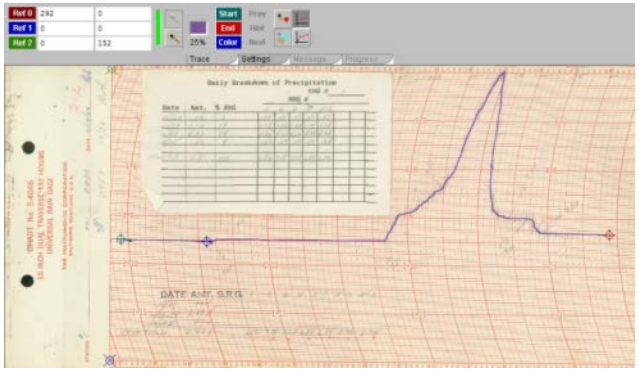
Web site

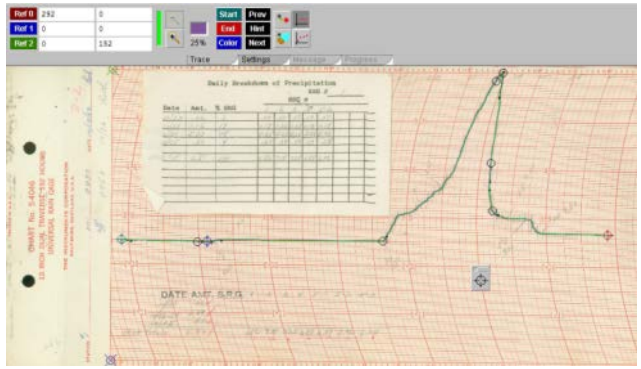

Smart Forests
for the 21st Century
Scientists Toolbox | Educator's Toolbox | Gallery |
Smart Forest
News and Views
CUAHSI CZO Wireless
Sensing Bootcamp II:
From Theory to Practice
August 11th - 13th, 2014
Details and registration
May 22, 2014
http://smartforests.org/
smartforests.org
Apps
Web Slice Gallery
Imported From IE
Smart Forests
Sensor Network
Home > GCE Data Toolbox > Demo > Data
Marcell Experimental Forest
Data Set
Interval
Period
Links
File Downloads
S2_Met_Station_Snow_60min: Marcell S2 Met Station Snow Depth from 21-May-2014 to 04-Aug-2014
60.0 min
21-May-2014 - 04-Aug-2014
View Details View Plots
Spreadsheet (CSV Text) Metadata for Spreadsheet GCE Data Toolbox File
S2_Met_Station_Soil_60min: Marcell S2 Met Station Soil Climate from 21-May-2014 to 04-Aug-2014
60.0 min
21-May-2014 - 04-Aug-2014
View Details View Plots
Spreadsheet (CSV Text) Metadata for Spreadsheet GCE Data Toolbox File
S2_Met_Station_Solar_15min: Marcell S2 Met Station Solar Radiation from 21-May-2014 to 04-Aug-2014
15.0 min
21-May-2014 - 04-Aug-2014
View Details View Plots
Spreadsheet (CSV Text) Metadata for Spreadsheet GCE Data Toolbox File
S2_Met_Station_Temp_15min: Marcell S2 Met Station Air Temperature from 21-May-2014 to 04-Aug-2014
15.0 min
21-May-2014 - 04-Aug-2014
View Details View Plots
Spreadsheet (CSV Text) Metadata for Spreadsheet GCE Data Toolbox File
S2_Met_Station_Wind_15min: Marcell S2 Met Station Wind Speed from 21-May-2014 to 04-Aug-2014
15.0 min
21-May-2014 - 04-Aug-2014
View Details View Plots
Spreadsheet (CSV Text) Metadata for Spreadsheet GCE Data Toolbox File
S2_Weir_Stage: Marcell S2 Weir from 14-May-2014 to 04-Aug-2014
5.0 min
14-May-2014 - 04-Aug-2014
View Details View Plots
Spreadsheet (CSV Text) Metadata for Spreadsheet GCE Data Toolbox File
South_Wx_Table1: Marcell S2 Met Station Precipitation from 12-Jun-2013 to 04-Aug-2014
15.0 min
12-Jun-2013 - 04-Aug-2014
View Details View Plots
Spreadsheet (CSV Text) Metadata for Spreadsheet GCE Data Toolbox File
Marcell S2 Met Station Air Temperature from 21-May-2014 to 04-Aug-2014
PRT_MetOne_Avg (Deg C)
PRT_Apogee_Avg (Deg C)
PRT_east_Avg (Deg C)
PRT_west_Avg (Deg C)
Therm_temp_Avg (Deg C)
HMP60_temp_Avg (Deg C)
Value
Day (July 2014)
Phenology Monitoring at Hubbard Brook Experimental Forest...
Automated birdson monitoring at H.J. Andrews Exper. Forest...
Experimental Forest...
in Howland Forest...
Coming soon...

Integrating new measurements with historical data

Problem: Newer data are collected at 15 minute intervals, but only daily values were read off the charts.

Extracting data from charts

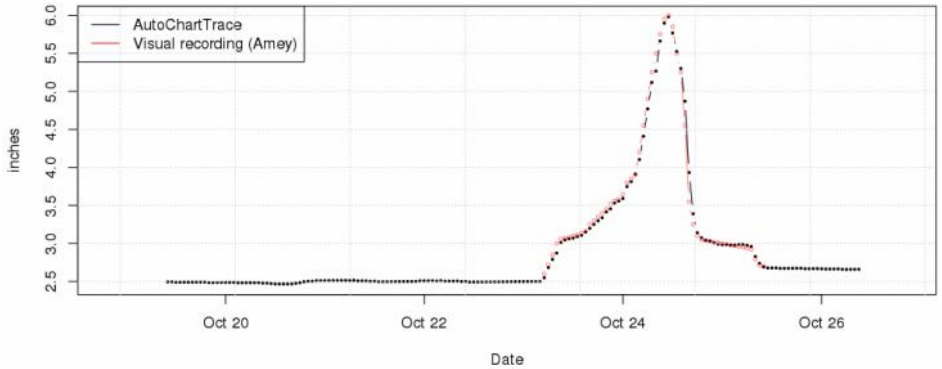




Event total = 6.78in (17.2 cm)

58 years of charts * 52 charts per year = 3,000 charts

5 minutes for a good chart



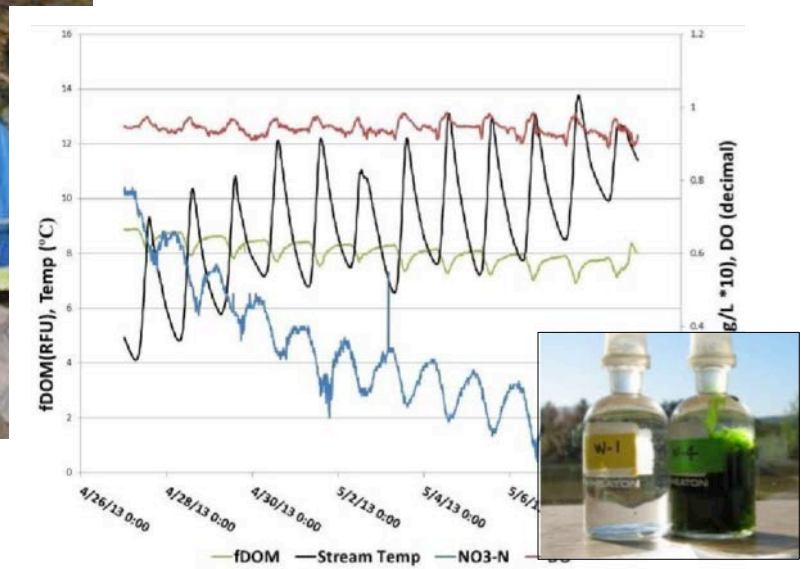
New opportunities for research

- Rapid access to data from multiple sites
- Provide data in a common format
- Plan sampling based on real-time data
- Extreme events
- Provide new scientific insights

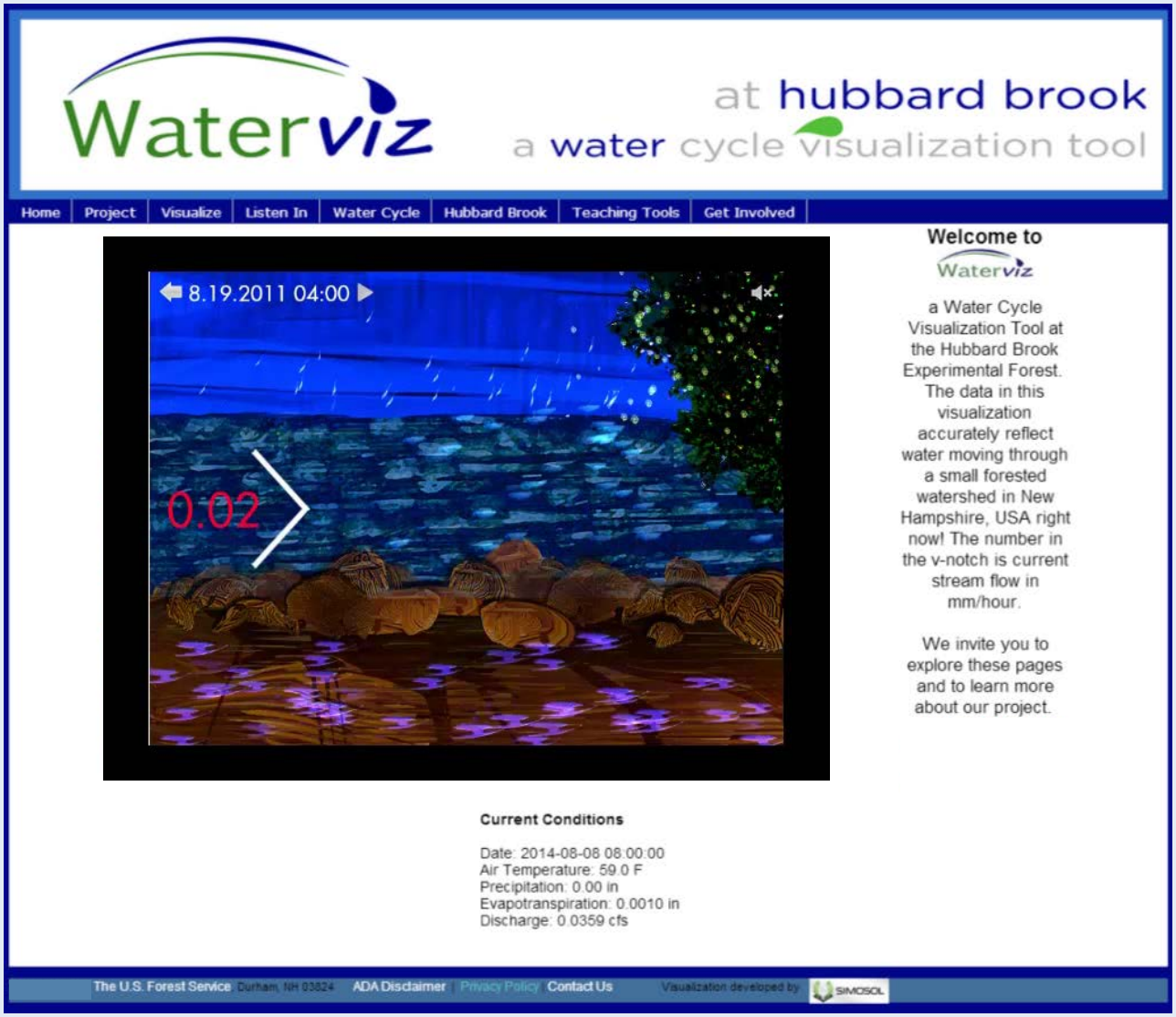
Groffman et al. 2012. BioScience

New opportunities for research

Diurnal changes in stream temp., DOC, NO_3^-, and DO



New opportunities for education and outreach



Acknowledgements

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