

The Marcell Experimental Forest Research Catchments

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Abstract

The Marcell Experimental Forest (MEF) in northern Minnesota, USA may be the longest running research and monitoring program on the hydrology of peatland catchments. The MEF sits astride a continental divide where the headwaters of the Mississippi, St. Lawrence, and Hudson Bay adjoin. When established in 1961, the MEF, with little topographic relief and large fractions of watersheds in peatlands, was distinct from the steep, mountainous catchments that typified other research catchments of the USDA Forest Service. This terrain and the presence of peatlands are representative of vast areas of the Northern Hemisphere, and the research program fills an important role in environmental monitoring and research in hydrology, ecology, biogeochemistry, and environmental change. During the 1960s, six research catchments were established and hydrological, meteorological, and water chemistry monitoring were initiated. Since then, the research and collaborations have proliferated to include new monitoring and ecosystem manipulations, with several paired-watershed studies, that allow the assessment of land management and environmental change effects on forests, water availability, and biogeochemical cycles. Research at the MEF remains vibrant, especially now that the site hosts a large-scale climate manipulation study (the SPRUCE Experiment). Herein, we present information on the site, contacts, long-term monitoring, experiments, and key findings.

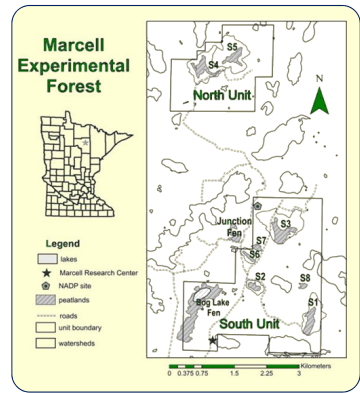
THE MARCELL EXPERIMENTAL FOREST RESEARCH CATCHMENTS

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INTRODUCTION:

- 1960s: Established to address a research gap on low-topographic relief catchments with uplands that drain to peatlands.
- Now, nearly 6 decades of data, findings, & site knowledge.



The Marcell Experimental Forest (MEF) in northern Minnesota, USA, where six catchments & other sites are part of a long-term research program.

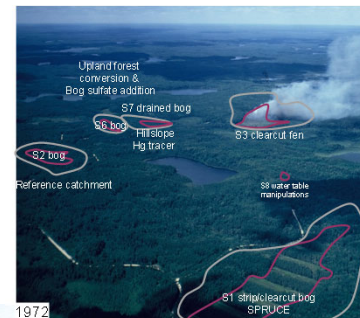


Photo of the South Unit showing some experimental & reference catchments.

MARCELL EXPERIMENTAL FOREST (MEF)

<https://www.nrs.fs.fed.us/ef/marcell/>

<https://www.fs.usda.gov/rds/efrdata/efr1>

STUDY AREAS

- Six research catchments (9 - 72 ha) for long-term monitoring & experimentation.
- Plot to landscape level studies of ecosystems at multiple additional sites.

FUNDING:

- USDA Forest Service funds long-term research.
- US Federal, State, & non-governmental funds for short-term studies.

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SITE CHARACTERISTICS

- Northern Minnesota, USA.
- 47.51°N, 93.47°W.
- Mississippi River & Hudson Bay headwaters.
- Continental, warm summer climatic region (Koppen).
- MAP = 780 mm, ~1/3 as snow. MAT = 3.4°C (-40 to 40 °C).
- Boreal peatland vegetation (*Picea*, *Larix*, & *Sphagnum*).
- Mixed northern forests on uplands: *Populus*, *Betula*, *Picea*, & *Pinus*.
- Glacial till & outwash sands (>50 m deep) & Precambrian bedrock.
- Surface elevation 412 - 438 m (12 m max. relief within catchments).
- Raised-dome bogs (precip. fed) or fens (groundwater fed).

RESEARCH THEMES

- 1960s - now:
Forest & peatland hydrology.
Properties of organic soils.
Water, energy, & solute budgets.
- 1970s - now:
Land management effects on soil, water, air, & forests.
Biogeochemistry.
Peatland methane production.
- 1980s - now:
Atmospheric deposition.
Mercury cycling.
- 1990s - now:
Net ecosystem C exchange.
- 2000s - now:
Climatic & environmental change.
Carbon cycling.
Source area dynamics.

ECOSYSTEM MONITORING

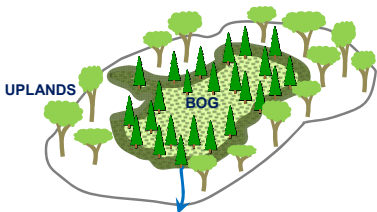
- 1960s - now:
Streamflow.
Water table elevation.
Air temp.
Precipitation.
Soil moisture.
Snow depth & water equivalents.
Frost depth.
Forest biomass.
Upland runoff.
- 1978 - now:
Stream water chem.
Atmospheric deposition.
- 1980s - now:
Static chambers for CO₂ + CH₄.
Soil temps.
- 2000s - now:
H₂O, CO₂, & CH₄ exchange with eddy covariance.
Net radiation & PAR.
Water isotopes are coming for all samples.
- Data from short-duration studies & recent monitoring.

EXPERIMENTATION

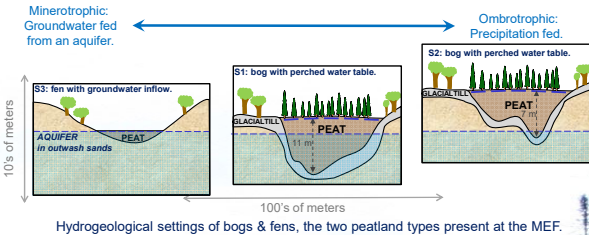
- 1967: S7 bog, drainage.
- 1968 - 1972: S8 bog, water manipulations.
- 1969 / 1974: S1 bog, stripcuts of black spruce.
- 1970 - 1972: S4 uplands, clearcut (aspen/birch harvest).
- 1972 - 1973: S3 fen, clearcut (*Picea* & *Larix*).
- 1980 - 1987: S6 uplands, clearcut (*Populus* / *Betula*) & forest conversion (to *Pinus* & *Picea*).
- 2001- 2009: S6 bog, sulfate deposition elevated.
- 2010: FACE log decomposition.
- 2012: S7 uplands, biomass harvest, with mercury isotope tracing.
- 2015 - now: S1 bog, SPRUCE warming & eCO₂.
- 2010s: snow removal & frost formation. Frost exclusion in peat.



Streamflow & water level monitoring in the S2 catchment.



Five of six research catchments have bogs, where uplands & central bogs drain to a perimeter lags that coalesce into zero-order streams.



Hydrogeological settings of bogs & fens, the two peatland types present at the MEF.

OTHER RESOURCES:

- Site & data managers.
- A research center with a prep lab, conference room, & lodging / kitchen.
- A chemistry laboratory for major ions, nutrients, metals, & water isotopes.

DATA AVAILABILITY:

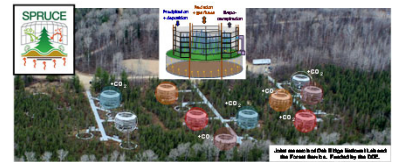
- We collaborate & share data.
- Some data are published @ the Forest Service Research Data Archive.

CURRENT CHALLENGES:

- Long-term funding & shrinking Federal allocations for research.
- A backlog of data to be published.
- Completing a transition from paper stripcharts to electronic sensors / logging.

THE FUTURE:

- More ecosystem manipulations.
- Collaboration & data synthesis.
- Have ideas? Join us!



SPRUCE, a peatland warming & eCO₂ experiment.



LEFT: The S2 bog (foreground), S6 bog (center left), & S3 fen (upper right) among the lakes & uplands of the northern Minnesota landscape. RIGHT: The S6 catchment after the 1980 upland harvest. BOTTOM: The S4 bog.