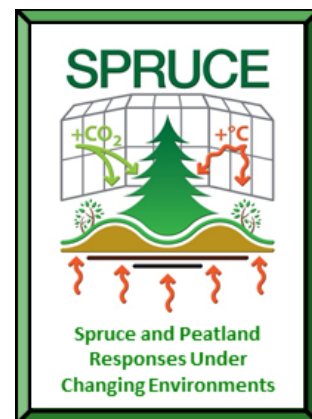


SPRUCE S1 Bog and SPRUCE Experiment Aerial Photographs

Summary:

This data set provides a record of the aerial photographs taken of the S1-Bog on the Marcell Experimental Forest and the SPRUCE experimental site within the S1-Bog.



- Oak Ridge National Laboratory contracted the acquisition of these photographs from Airways Aviation, Grand Rapids, Minnesota at various times during 2009, 2010, 2011, 2012, 2013, 2014 and 2015. The aerial photographs of the S1 Bog and SPRUCE experimental site were collected to capture seasonal conditions of the bog and surrounding upland areas, and to track progress of the SPRUCE infrastructure construction activities on and around the S1 Bog of the Marcell Experimental Forest.
- Eight historical aerial photographs of the S1 Bog covering a period from 1968 through 1978 are also included. Historical photos were provided by Steven Sebestyen of the USDA Forests Service Northern Research Station. The earliest photo covers pre-harvest conditions and photographs surrounding the sequential harvests of the S1-Bog in 1969 and 1974 with follow up photos through 1978.
- An even earlier photo of the S1-Bog, 1939-1940, was added in 2018 from the Itasca County GIS Viewer (<https://maps.co.itasca.mn.us/PublicApp/>).
- Beginning in November 2019, sets of images periodically collected by SPRUCE Staff using an unmanned aerial vehicle (UAV) have been added to this dataset. New UAV flights will continue as the project continues and new images will be added to this dataset.

Additional aerial photographs may be acquired and will be added to this data set.



Figure 1. Aerial photographs of the S1 Bog in 1968 and the April 16, 2015 view of emerging SPRUCE experiment infrastructure.

Data Citation:

Cite this data set as follows:

Hanson, P.J., M.B. Krassovski, and L.A. Hook. 2015. SPRUCE S1 Bog and SPRUCE Experiment Aerial Photographs. Oak Ridge National Laboratory, TES SFA, U.S. Department of Energy, Oak Ridge, Tennessee, U.S.A. <https://doi.org/10.3334/CDIAC/spruce.012> (list file name)

Please include the specific image file name(s) that contains the acquisition date and original ID number.

Data and Documentation Access

Get Data

For public access to SPRUCE data please visit the SPRUCE Web Site:
<https://mnspruce.ornl.gov/>

Description and Links to Supplemental Information

Marcell Experimental Forest Website: <https://www.nrs.fs.fed.us/ef/locations/mn/marcell/>

SPRUCE Project Website with project plans and additional information:
<https://mnspruce.ornl.gov/>

SPRUCE Data Policy - Sharing, Access, and Use Recommendations:
<https://mnspruce.ornl.gov/content/spruce-data-policies>

Related Data Sets:

Griffiths, N.A., L.A. Hook and P.J. Hanson. 2016. **SPRUCE S1 Bog and SPRUCE Experiment Location Survey Results, 2015**. Oak Ridge National Laboratory, TES SFA, U.S. Department of Energy, Oak Ridge, Tennessee, U.S.A.
<https://doi.org/10.3334/CDIAC/spruce.015>

SPRUCE Project Description

SPRUCE (Spruce and Peatland Responses Under Climatic and Environmental Change) is an experiment to assess the response of northern peatland ecosystems to increases in temperature and exposures to elevated atmospheric CO₂ concentrations. It is a key component of the Terrestrial Ecosystem Science Scientific Focus Area of ORNL's Climate Change Program,

focused on terrestrial ecosystems and the mechanisms that underlie their responses to climatic change. The experimental work is to be conducted in a *Picea mariana* [black spruce] – *Sphagnum* spp. bog forest in northern Minnesota, 40 km north of Grand Rapids, in the USDA Forest Service Marcell Experimental Forest (MEF). The site is located at the southern margin of the boreal forest. It is an ecosystem considered especially vulnerable to climate change, and anticipated to be near its tipping point with respect to climate change. Responses to warming and interactions with increased atmospheric CO₂ concentration are anticipated to have important feedbacks on the atmosphere and climate, because of the high carbon stocks harbored by peatlands.

Experimental work in the 8.1-ha S1 bog will be a climate change manipulation focusing on the combined responses to multiple levels of warming at ambient or elevated CO₂ (eCO₂) levels. The experiment provides a platform for testing mechanisms controlling the vulnerability of organisms, biogeochemical processes and ecosystems to climatic change (e.g., thresholds for organism decline or mortality, limitations to regeneration, biogeochemical limitations to productivity, the cycling and release of CO₂ and CH₄ to the atmosphere).

The manipulation will evaluate the response of the existing biological communities to a range of warming levels from ambient to +9°C, provided via large, modified open-top enclosures. All temperatures, ambient through the +9°C warming treatment, will also be conducted at eCO₂ (in the range of 800 to 900 ppm). Both direct and indirect effects of these experimental perturbations will be analyzed to develop and refine models needed for full Earth system analyses.

Marcell Experimental Forest

Stream flow, weather, and well data collection began on the Marcell Experimental Forest in 1960. This 1100-ha site has six calibrated watersheds, each consisting of a mineral soil upland and organic soil peatland; an intermittent or perennial stream drains each peatland and its larger watershed. Formally established in 1962, the Marcell contains two units on land owned by the USDA Forest Service, Chippewa National Forest, State of Minnesota, Itasca County, and a private individual. Previous and ongoing research addresses the ecology and hydrology of peatland. Research concerns typical upland/wetland watersheds in the Lake States, atmospheric chemistry, nutrient cycling, soil quality, tree-stand dynamics, and a variety of watershed treatments applied to upland or bogs to investigate impacts on water yield, peak stream flow, water quality and nutrient processing.

SPRUCES Sponsor

Research sponsored by the [Office of Biological and Environmental Research](#) within the [U.S. Department of Energy's Office of Science](#).

The SPRUCE experiment is a multi-year cooperative interaction among scientists of the [Oak Ridge National Laboratory](#) operated by UT-Battelle, LLC and the U.S. Forest Service, [Northern Research Station](#), [Marcell Experimental Forest](#).

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1. Data Set Overview:

This data set provides a record of the contracted aerial photographs taken of the S1-Bog on the Marcell Experimental Forest and the SPRUCE experimental site within the S1-Bog.

At various times during 2009, 2010, 2011, 2012, 2013, 2014 and 2015 aerial photographs of the S1-Bog and SPRUCE experimental site were collected under contract with Airways Aviation of Grand Rapids, Minnesota to capture seasonal conditions of the bog and surrounding upland areas, and to track progress of the construction required to install the SPRUCE experiment on the S1-Bog.

A number of historical aerial photographs of the S1-Bog were also provided by Steven Sebestyen of the USDA Forests Service Northern Research Station covering a period from 1968 through 1978. The earlier record covers a pre-harvest conditions and photographs surrounding the sequential harvest of the S1-Bog in 1969 and 1974 with follow up photos through 1978.

An even earlier photo of the S1-Bog, 1939-1940, was added in 2018 from the Itasca County GIS Viewer (<https://maps.co.itasca.mn.us/PublicApp/>).

Images collected by ORNL SPRUCE Staff beginning on November 20, 2019 were acquired using an unmanned aerial vehicle (UAV). UAV images will be added periodically.

2. Data Characteristics:

Images obtained during each ORNL contracted flight were saved as JPEG files (*.jpg). During each flight a large number of images were collected, but many missed the target area or were of insufficient quality to capture surface characteristics. This data set archives the best quality images for the S1-Bog, surrounding areas, and SPRUCE experimental locations within the S1-Bog.

Spatial Coverage

Photographic Targets on the S1 Watershed: Lat: 47.506345, Long: -93.452797

Photos requested for each flight:

1. An overall photograph of the watershed area.
2. Photos of individual segments of the watershed covering the entire length of the watershed (Figure 2). In some cases the segmented photos were combined into a single high-resolution composite view of the watershed. Most photographs were taken from a vertical/nadir position to maximize the potential to see individual tree canopies.

Notes:

- The trees in the experimental area are quite small.
 - Photos were requested to be acquired at 10-megapixel resolution or better to isolate and detail the vegetation and installed structures.
 - With the use of automated zoom features on the camera, individual photograph resolution varied.
3. In the later dates when SPRUCE infrastructure was installed, we requested oblique photographs of the experimental area for public relations and presentation purposes (Figure 3).

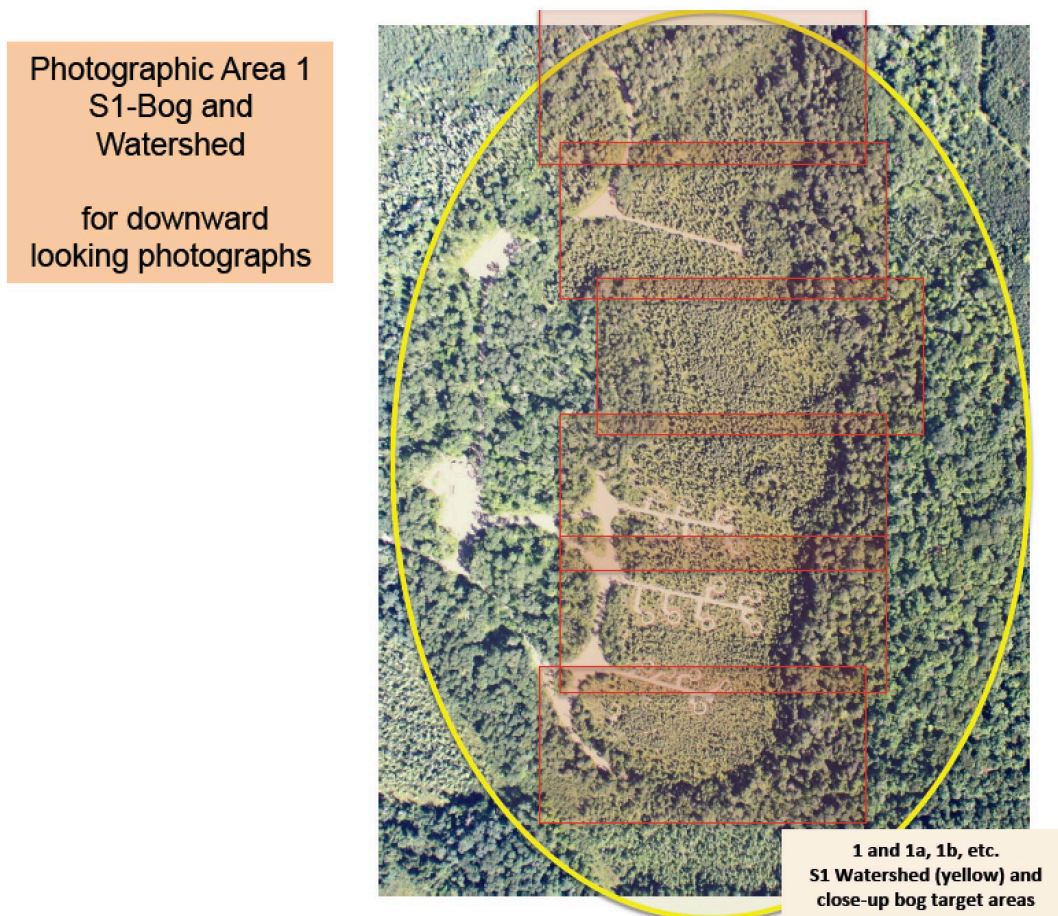


Figure 2. Requested photographs to be taken from a vertical position to maximize the potential to see individual tree canopies.

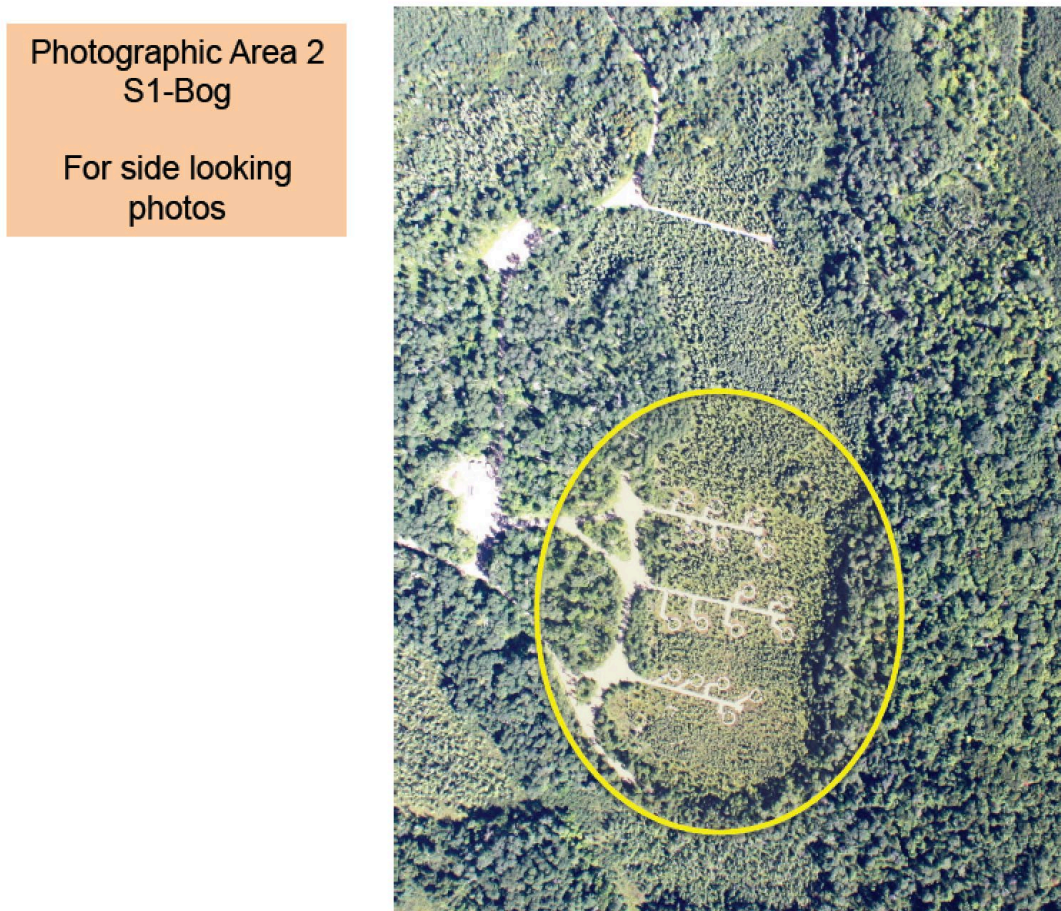
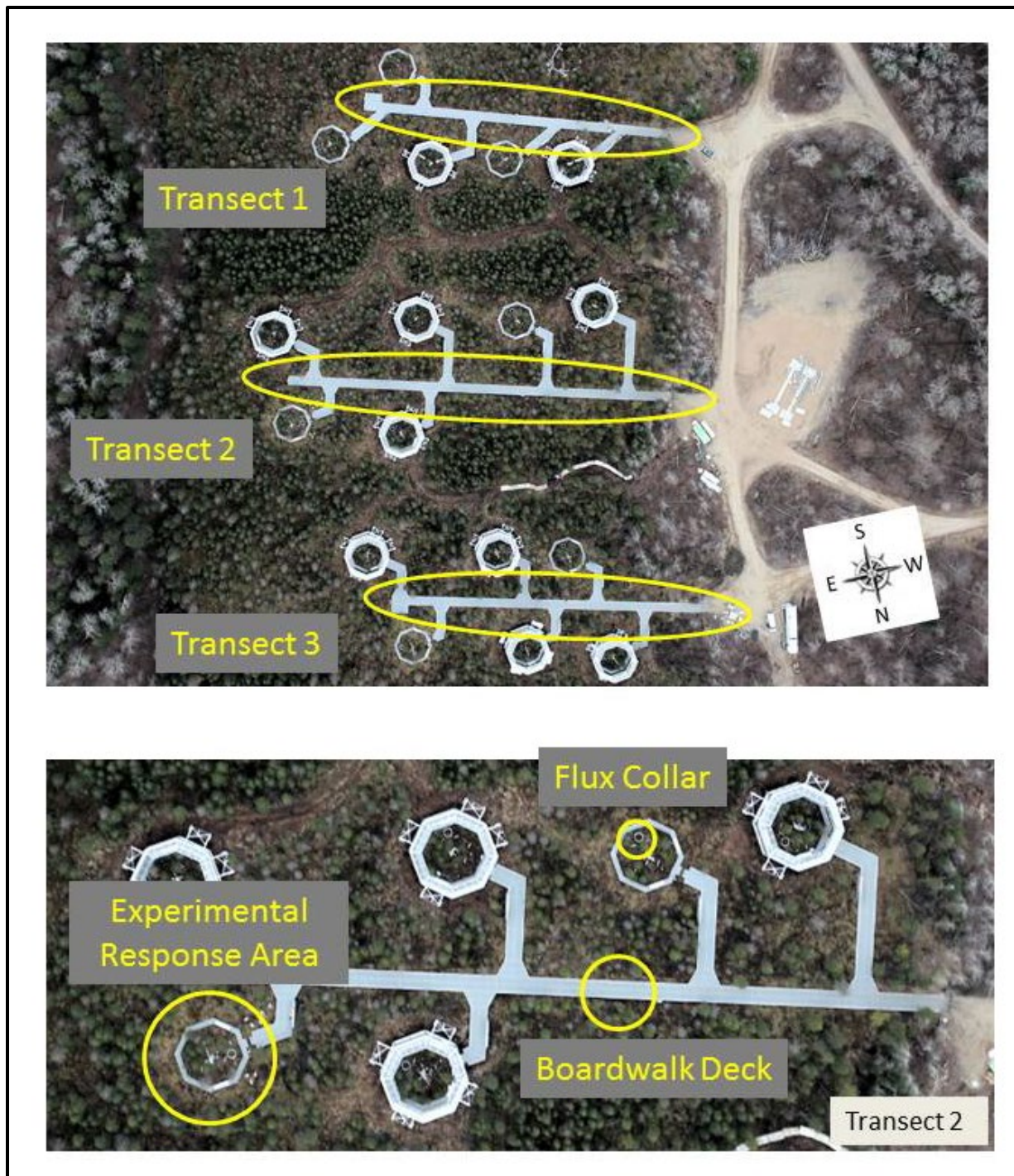


Figure 3. Oblique photographs were requested for the experimental area.

Spatial Resolution

With the use of automated zoom features on the camera, individual photograph resolution varied. Infrastructure features on the photos have known dimensions that facilitate scale comparisons.



Source photo: AP_2015.04.16_SPRUCE_IMG_6560.jpg

Dimensions of Infrastructure Features

Transect 1 length: 88 meters

Transect 2 length: 108 meters

Transect 3 length: 93 meters

Distance from Transect 1 to Transect 3: 144 meters

Flux Collar diameter: 1.3 meters

Boardwalk Deck width: 2.4 meters

Experimental Response Area inside diameter: ~9 meters

Temporal Coverage

Time period: Recent photographs were obtained on designated dates during a period from 10 AM to 2 PM Central Time. Slight overcast for these photos was ultimately considered an advantage, because it reduces and sometime eliminates shadows which can obscure surface detail.

Table 1. Archived aerial photographs by date, season, type, and number of each type.

Year	Month	Day	Season	S1-Bog Image	SPRUCE Site Image	Oblique Images
Itasca County GIS Viewer (https://maps.co.itasca.mn.us/PublicApp/)						
~1939-1940			Uncertain	1	0	0
Historical USDA FS Marcell Experimental Forest Images						
1968	Mar	18	Late Winter – Undisturbed Bog	0	0	2
1969	Mar	14	Late Winter – post strip cutting	0	0	1
1969	??	??	Summer	0	0	1
1972	??	??	Winter	0	0	1
1975	Aug	18	Summer – Color Infrared	1 Composite	0	1
1976	??	??	Summer	0	0	1
Aerial Photographs Acquired by Oak Ridge National Laboratory						
2009	Sep	29	Summer	1	0	2
2010	Mar	4	Winter	2	0	0
2010	Mar	22	Winter no snow	1 Composite	2	1
2010	Sep	1	Summer with sun	3	1	0
2010	Sep	9	Summer diffuse light	1	3	0

Year	Month	Day	Season	S1-Bog Image	SPRUCE Site Image	Oblique Images
2011	Oct	25	Late Autumn – Diffuse	1	3	0
2011	Nov	3	Late Autumn - Sun	2	2	0
2011	Dec	1	Winter sun	2	4	0
2012	Jan	30	Winter sun	3	1	0
2012	May	22	Spring	1	0	0
2012	Jun	22	Summer - sun	1	4	0
2012	Jul	23	Summer - sun	1	1	0
2012	Aug	20	Summer - sun	2	1	0
2012	Dec	12	Winter - Diffuse	0	4	3
2013	Jul	2	Summer - sun	2	0	3
2013	Sep	25	Late Summer - Diffuse	1	1	2
2014	Sep	2	Late Summer	1	1	1
2014	Sep	23	Autumn	1	1	2
2014	Nov	21	Early winter	1	1	3
2014	Dec	31	Winter	1	1	1
2015	Feb	25	Winter	0	1	1
2015	Apr	16	Late Winter – no snow	0	4	5
2015	Aug	5	Summer	0	2	4
Aerial Photographs Collected by SPRUCE Staff with UAV						
2019	Nov	20	SPRUCE Site Early Winter – little snow		4	4
2019	Nov	20	S1 Bog Transect 4 Early Winter – little snow		0	3
2019	Nov	21	SPRUCE Site Early Winter – some snow		2	2
2020	Jan	14	Cutaway Lake from North		0	1
2020	Jan	14	SPRUCE Winter Site Aerial		1	0
2020	Jan	14	SPRUCE Site from East		1	1
2020	Jan	14	SPRUCE Site from South		1	1
2020	Jan	14	SPRUCE Site from North		2	2
2020	Jan	14	SPRUCE Site from West		4	4
2020	Oct	2	SPRUCE Site		8	8
2020	Oct	2	SPRUCE Site Overhead		1	0
2020	Oct	4	SPRUCE Site		8	8

Additional aerial photographs may be acquired and will be added to this data set.

Data File Description

Photos are named according to the following syntax:

File name:

AP_2015.02.25_SPRUCE_IMG_6321.jpg or

AP_20191120_SPRUCE_UAV_0001.jpg

Where:

AP = aerial photograph

Acquisition date of photo = yyyy.mm.dd or yyymmdd

Target of photo: SPRUCE_IMG, S1Bog_Composite, SPRUCE Buildings, etc., or

UAV = photo collected from SPRUCE UAV, and

_XXXX = the original photograph identifier

User Notes:

- **Higher resolution images may be available for some images.**
- **UAV images were taken at an altitude of 300-350 feet above ground level.**
- **The UAV camera does not have zoom capabilities.**

Table 2. Archived aerial photographs by Source and FTP site directory location.

Source	FTP Directory Name	Number of Images
Itasca County GIS Viewer (https://maps.co.itasca.mn.us/PublicApp/)	Itasca_County_Historical	1
USDA FS Marcell Experimental Forest Images	Historical_Marcell_Experimental_Forest	8
Acquired by Oak Ridge National Laboratory	Acquired_by_ORNL	95
Collected by SPRUCE Staff with UAV	Collected_by_SPRUCE_UAV	36

Companion File Descriptions

None

3. Data Application and Derivation:

The aerial photographs of the S1 Bog and SPRUCE experimental site were collected to capture seasonal conditions of the bog and surrounding upland areas, and to track progress of the SPRUCE infrastructure construction activities on and around the S1 Bog of the Marcell Experimental Forest.

4. Quality Assessment:

These data are considered at **Quality Level 1**. During each flight a large number of images were collected, but many missed the target area or were of insufficient quality to capture surface characteristics. This data set archives the best quality images for the S1-Bog, surrounding areas, and SPRUCE experimental locations within the S1-Bog.

5. Data Acquisition Materials and Methods:

Site Description:

The site is the 8.1-ha S1 bog, a *Picea mariana* [black spruce] – Sphagnum spp. ombrotrophic bog forest in northern Minnesota, 40 km north of Grand Rapids, in the USDA Forest Service Marcell Experimental Forest (MEF). The S1 bog was harvested in successive strip cuts in 1969 and 1974 and the cut areas were allowed to naturally regenerate. The 1974 strips are characterized by medium density of 3-5 meter black spruce and larch trees with an open canopy. The 1969 harvest strips are characterized by a higher density of 3-5 meter black spruce and larch trees with a generally closed canopy.



Image acquired on November 20, 2019 looking North over the S1 Bog and SPRUCE Experiment Chambers. Collected by SPRUCE Staff using an unmanned aerial vehicle (UAV).

6. References:

Historical USDA FS Aerial Photographs

All USDA FS aerial images were supplied by Dr. Stephen Sebestyen of the USDA Forest Service, Northern Research Station, Grand Rapids, Minnesota. They were collected as a part of the long-term peatland watershed studies conducted on the Marcell Experimental Forest in the noted years.

7. Data Access:

For public access to SPRUCE data please visit the SPRUCE Web Site:

<https://mnspruce.ornl.gov/>

Contact for Data Access Information: <https://mnspruce.ornl.gov/contact>