AOP FLIGHT PLAN BOUNDARIES DESIGN

PREPARED BY	ORGANIZATION	DATE
John Musinsky	AOP	11/17/2017

APPROVALS	ORGANIZATION	APPROVAL DATE
Kate Thibault	SCI	05/16/2022

RELEASED BY	ORGANIZATION	RELEASE DATE
Tanisha Waters	CM	05/16/2022

See configuration management system for approval history.

The National Ecological Observatory Network is a project solely funded by the National Science Foundation and managed under cooperative agreement by Battelle. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

Change Record

REVISION	DATE	ECO #	DESCRIPTION OF CHANGE
A	07/28/2015	ECO-03045	Initial release
B	12/01/2017	ECO-05275	Minor updates for Payload 3 IOCR
C	05/16/2022	ECO-06821	• Updated NEON logo • Minor formatting updates

TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

1 DESCRIPTION

1.1 Purpose

The purpose of the Flight Plan Boundaries Design is to serve as reference source that describes the geographical areas that AOP plans to survey over NEON terrestrial and aquatic sites. This document depicts the flight boxes for NEON sites, and the underlying criteria, constraints and datasets used in their design. The document includes information on flight campaign schedules, flight conditions and issues of concern related to airborne surveys over NEON sites.

1.2 Scope

This document covers NEON core and gradient terrestrial and aquatic sites that have been formally designated and permitted by NEON's Permitting Department. The document demonstrates the method by which flight boundaries are designed; not all sites are presented here, but the general method and approach is valid for all sites.

2 RELATED DOCUMENTS AND ACRONYMS

2.1 Applicable Documents

Applicable documents contain information that shall be applied in the current document. Examples are higher level requirements documents, standards, rules and regulations.

AD [01]	NEON.DOC.001515	AOP Flight Season Management Plan
AD [02]	NEON.DOC.001557	AOP Flight Planning Standards and Configurations

2.2 Reference Documents

Reference documents contain information complementing, explaining, detailing, or otherwise supporting the information included in the current document.

RD [01]	NEON.DOC.000008	NEON Acronym List
RD [02]	NEON.DOC.000243	NEON Glossary of Terms
RD [03]	NEON.DOC.001981	Permitting for AOP Procedure

2.3 External References

ER [01]	FAA NOTAM Number FDC 0/8326: ("Temporary flight restrictions for Special Security Reasons") (http://tfr.faa.gov/save_pages/detail_0_8326.html)
ER [02]	Federal Aviation Administration. Aeronautical Information Manual. FAA, April 3, 2014

2.4 Acronyms

Acronym	Meaning
AGL	Altitude Above Ground Level
AOP	Airborne Observation Platform
ARTCC	Air Route Traffic Control Center
ASO	Airborne Sensor Operator
ATCT	Airport Traffic Control Tower
DAAC	Distributed Active Archive Center
EVI	Enhanced Vegetation Index
FAA	Federal Aviation Administration
MODIS	Moderate Resolution Imaging Spectroradiometer
MSAVI	Modified Soil Adjusted Vegetation Index
MSL	Altitude Above Mean Sea Level
NDVI	Normalized Difference Vegetation Index
TFR	Temporary Flight Restriction
TOS	NEON Terrestrial Observation System
TRACON	Terminal Radar Approach Control Facility
USDA-ARS	US Department of Agriculture-Agricultural Research Service
USFS	United States Forest Service

2.5 Airport ID's

Acronym	Meaning
KABY	Albany
KAFW	Fort Worth Alliance
KASH	Nashua
KBDU	Boulder Municipal Airport
KBDU	Boulder Municipal Airport
KBOS	Logan International Airport
KBZN	Gallatin Field
KEZF	Shannon
KFAT	Fresno
KFAT	Fresno
KFOE	Forbes Field
KISM	Kissimmee
KJMS	Jamestown Regional Airport
KLRU	Las Cruces
KPVU	Provo Municipal Airport
KRHI	Rhinelander-Oneida
KTCL	Tuscaloosa Regional Airport
KTRI	TriCities Regional Airport
KTTD	Portland
KTUS	Tuscon International Airport
POKE	Fairbanks
TJBQ	Rafael Hernandez
TOOL	Deadhorse

3 FLIGHT PLAN BOUNDARIES DESIGN

3.1 Background

The National Ecological Observatory Network (NEON) airborne observation platform (AOP) will collect co-registered high-resolution hyperspectral imagery, discrete and waveform LiDAR, and high-resolution digital photography from over 20 core and 27 gradient terrestrial sites, plus 20 core and 14 gradient aquatic sites spread across the continental United States, Puerto Rico, Alaska and Hawaii on as close to an annual basis as possible over the 30-year operational period of the observatory (Kampe 2010a). These airborne measurements and the data products derived from them will facilitate the scaling of field-based biological, physical and chemical measurements to regional and continental scales, enabling a better understanding of the relationships between climate variability and change, land use change and invasive species, and their ecological consequences in areas not directly sampled by the NEON facilities (Schimel, NEON Science Strategy: Enabling Continental Scale Ecological Forecasting 2011).

The AOP remote sensing system takes advantage of the strong synergy between imaging spectroscopy and small-footprint waveform-recording LiDAR to measure plant canopy biogeochemistry and habitat structure characteristics around NEON sites. Invasive plants can be detected both through their spectral properties and their structural properties. Pest and pathogen outbreaks, changes in competitive relations, responses to disturbances like wildfire, and many features of land use are readily observed and quantified using the powerful combination of biochemical and structural information provided by spectroscopy and waveform LiDAR (Kampe 2010b).

Successful up-scaling of both *in situ* and airborne measurements to continental scales requires a flight sampling design that: 1) covers the "area-of-influence" associated with cumulative eddy covariance flux tower observations and TOS field measurements; 2) captures landscape environmental representativeness and heterogeneity (i.e., ecological and topographic gradients); 3) is sensitive to temporal system variation (e.g., phenology); and 4) is flexible enough to respond to major disturbance events. Alignment of airborne campaigns – composed of two payloads for nominal science acquisitions and one payload for PI-driven science and rapid-response campaigns -- with other ground, airborne (e.g., AVIRIS) and satellite (e.g., Landsat, MODIS) collections will further facilitate scaling between sensors and data sources of varying spatial and spectral resolution and extent.

3.2 AOP Flight Operations Requirements

To complete the NEON mission, AOP must adhere to the following requirements related to data product development:

- The AOP operations period shall be 30 years or greater
- AOP shall perform aerial surveys of NEON terrestrial core and gradient sites once per year
- AOP shall perform aerial surveys of NEON aquatic sites once per year (as feasible)

- AOP shall perform aerial surveys of the NEON terrestrial sites during a period of time within 90% of their peak greenness
- AOP aerial surveys shall be conducted during a period approximately ± 2 hours about solar noon
- AOP aerial surveys shall be conducted during times where clouds are absent
- The AOP spectrometer ground sample distance (GSD) shall be 1 m or less
- The AOP instrument sampling of the survey areas shall be planned as contiguous or overlapping
- Co-registration between ground sample distances for the LiDAR, spectrometer, and digital camera shall be 0.3 m or less

3.3 Criteria for Defining Airborne Survey Boundaries that Support NEON Science

The definition of airborne survey boundaries for each NEON site follows a systematic flight planning protocol designed to produce consistent datasets at nominal 1m resolution from the NEON imaging spectrometer and waveform recording LiDAR while enabling AOP to survey 47 terrestrial sites and 34 aquatic sites annually during periods of 90% maximum foliage (peak greenness). The criteria used in the protocol defining airborne survey areas over each site should result in datasets with adequate spatial extent to support the needs of the NEON Field Instrument Unit (FIU), Field Sentinel Unit (FSU), Aquatics (AQU), and Data Products (DP) groups in data product development. The criteria will produce systematic "minimum size" datasets across sites and ecological gradients that enable robust statistical analysis for continental-scale modeling. Finally, the criteria promote data acquisition efficiency by assigning flight areas within the overall airborne survey boundary to either a high (Priority 1) or low (Priority 2) acquisition priority, providing flight sensor operators with greater flexibility in the event poor weather conditions prevent 100% data acquisition during an annual survey at a site.

3.3.1 Design Criteria for the Priority 1 Airborne Survey Area

A minimum airborne survey area of 10km x 10km will be flown over each terrestrial site (Requirement NEON.AOP.4.1024). This airborne survey area is initially centered over the NEON tower, but if necessary the survey area should be repositioned to capture the 90% cumulative eddy covariance flux and concentration footprint ("tower airshed") and the entire Terrestrial Observation System (TOS) sampling boundary (Requirements NEON.AOP.4.1028 and NEON.AOP.4.1029). Since a small percentage of airflow from outside of the tower airshed will interact with the tower sensors, it is important to be able to characterize the vegetation/land cover for these non-airshed areas with AOP observations; thus a minimum of 2km distance will be maintained between the tower and the edge of the airborne survey area (Requirement NEON.AOP.4.1027).

Where the 10km x 10km Priority 1 survey box can accommodate it, the survey area should also be repositioned to include the upstream watersheds of the TOS boundary[5] or the watershed of the aquatic site, and to capture ecologically relevant areas immediately adjacent to TOS boundary that either are important to acquire because of their potential impacts on the TOS sampling area, or because the predominant land cover patterns[1,2], climate patterns[6] or ecological gradients in these areas are relevant to domain-specific science themes and continental scaling. Repositioning the 10km x 10km survey box may not violate requirements NEON.AOP.4.1027, NEON.AOP.4.1028 or NEON.AOP.4.1029.

For larger sites with TOS boundaries that exceed the 10km x 10km minimum airborne survey area, the Priority 1 survey box is expanded so that AOP data are collected over the entire TOS field sampling area (Requirement NEON.AOP.4.1028).

3.3.2 Design Criteria for the Priority 2 Airborne Survey Area

In certain sites it is necessary to define a Priority 2 airborne survey area to capture ecologically relevant data outside the Priority 1 survey box. Assigning a Priority 2 (lower priority) to these areas provides greater flexibility in flight operations, accommodating periods when weather conditions prevent acquisition of an entire survey area. The Priority 2 survey area is usually an extension of the Priority 1 survey area, but may also include aquatic sites not co-located with the terrestrial site but within 1 hour flight time from the Priority 1 survey area. Priority 2 survey areas cover: 1) aquatic watershed areas that extend beyond the Priority 1 survey area boundary (Requirement NEON.AOP.4.1030); and 2) ecologically relevant areas immediately adjacent to TOS boundary that either are important to acquire because of their potential impacts on the Priority 1 area, or because the predominant land cover patterns, climate patterns, ecological gradients or topography in these areas are relevant to domain-specific science themes and continental scaling. This latter criteria is not supported by a NEON requirement, and therefore these areas are only included in airborne survey area boundary design where doing so has a minimal effect on flight time.

3.4 Constraints on Airborne Sampling of Terrestrial and Aquatic Sites

Scheduling of annual flight campaigns across all NEON sites with two AOP payloads is limited by the following constraints: 1) the start and end date of the flight window defined by 90% peak greenness for each site; 2) the estimated flight time required to fly the airborne survey flight plan for each NEON core and gradient site; 3) the number of additional contingency days allocated to compensate for potential cloud cover at each site; 4) the transit time between FBOs and sites, and the transit time among domains; and 4) the estimated amount of down-time due to aircraft maintenance, instrument failures and repair, and time-off for holidays and required rest periods for pilots and flight crew.

3.4.1 Peak Greenness

The NEON AOP flight schedule is constrained by the phenology of vegetation at each site. Nominal AOP science flights need to occur when the dominant vegetation species at a site are at or near peak foliage so that estimates of leaf area, foliar biomass, gas exchange, etc. are accurate and comparable over time (Requirement NEON.AOP.4.1031). Historical time-series of MODIS NDVI and EVI estimates from the Oak Ridge National Laboratory DAAC[3] have been used to determine when the vegetation at each NEON site is near the peak level of foliar growth, or "greenness". The actual flight window is calculated by including all days that have a mean NDVI (or in certain cases EVI or MSAVI) >90% of the mean maximum.

For each NEON terrestrial site, a fifteen-year historical time series (2001-2015) of 16-day MODIS NDVI and EVI composites over the approximate flight survey area was assembled. The 90% peak greenness values for each site were calculated by subtracting 10% of the difference between the minimum and maximum mean NDVI from the maximum mean NDVI value. Linear interpolation was then used to determine the exact Day of Year when the mean NDVI value of 90% peak greenness was reached. The average deviation from the mean onset date of 90% peak greenness was then calculated for the ten-year cumulative period. This average deviation was used to determine the variance in days around the mean onset date and gives some indication of the year-to-year variability in a site's dominant vegetation phenological response. A small average deviation (e.g., 7 days) indicates the phenology at a particular site is stable, and thus the mean onset date of peak greenness can reliably be used to determine the flight campaign start date; a large average deviation (e.g., 30 days) indicates the phenology is highly variable and greater flexibility should be used when scheduling the survey start flight survey date for that site.

3.4.2 Cloud Cover

AOP requires minimal cloud cover (cumulus and cirrus) for acquisition of spectroscopic data that can be atmospherically corrected to within acceptable error limits. From a scheduling perspective, cloud cover patterns are highly stochastic and difficult to forecast with certainty, particularly months ahead of a flight campaign. However, in many regions of the country there are coarse-scale seasonal patterns and trends that can be used to help determine the amount of flight contingency (additional flight hours/days) needed to successfully acquire cloud-free imagery during the period of peak greenness at each site. For this analysis, historical cloud fraction records[4] from nearby airport weather stations were combined with MODIS surface reflectance images over NEON sites to estimate the approximate number of additional flight contingency days that might be needed to complete the Priority 1 and Priority 2 airborne survey areas over each site between the hours of 9am-3pm local time (roughly the time of day during which surveys would occur).

3.4.3 Scheduled/Unscheduled Down-time

Scheduled down-time is estimated based on two factors: 1) pilot rotation/ASO rotation schedules, and 2) scheduled aircraft maintenance days. Pilot and crew rotation occurs every eight days (i.e., seven consecutive attempted flight days, followed by one pilot/crew rotation "down" day). Scheduled aircraft maintenance occurs after every 125 engine-hours (approximately). For the purposes of flight campaign scheduling, five aircraft maintenance days plus two payload cooling days are included in the schedule (seven days total) for each scheduled aircraft maintenance period. Unused scheduled maintenance days not required for actual maintenance are available for attempted flights in the domain where aircraft maintenance takes place.

4 AOP AIRBORNE SURVEY AREAS

4.1 Domain 01 – Harvard Forest

4.1.1 Site and Vegetation Characteristics

Harvard Forest is located in Petersham, Massachusetts near the Quabbin Reservoir. With an elevation of 1115 ft. (340m) MSL at the tower site, the terrain is moderately hilly and is nearly 95 % forested. Variability in relief, depth to bedrock and the local presence of a hardpan create a highly variable pattern of soil drainage. The vegetation is 80 year-old regenerating temperate forest typical of the Transition Hardwoods-White Pine-Hemlock region (Westveld 1956). Dominant species include red oak (*Quercus rubra*), red maple (*Acer rubrum*), black birch (*Betula lenta*), white pine (*Pinus strobus*) and hemlock (*Tsuga canadensis*). Drier soils areas may include white oak (*Quercus alba*), black oak (*Quercus velutina*) and shagbark hickory (*Carya ovata*), and moist but well-drained soil areas may include yellow birch (*Betula alleghaniensis*), beech (*Fagus grandifolia*), sugar maple (*Acer saccharum*), paper birch (*Betula papyrifera*) and white ash (*Fraxinus americana*). Mean canopy height is ~23 m.

4.1.2 Scientific Objectives and Airborne Survey Area Design Criteria

The Harvard Forest airborne survey area is primarily defined by the tower airshed and the Terrestrial Observation System (TOS) boundary (**Figure 4.1.1**). The TOS sampling area occupies approximately 49km^2, and the 90% cumulative eddy covariance flux tower airshed extends 4520m to the west of the tower. The east edge of the flight box is located a distance of 2km from the NEON tower. The north edge of the flight box is delimited by the northernmost boundary of the tower airshed. The west and south edges of the flight box are aligned with the western and southern edges of the TOS boundary. The 10x10km minimum flight area is contained within the boundary demarcated by these other features.

As a NEON core wildland site, the goal of the airborne survey area is to adequately capture the representative gradients, including vegetation/land uses (**Figure 4.1.3**) and climate (**Figure 4.1.7** and **Figure 4.1.8**) in the vicinity of the Harvard Forest site. The southeast corner of the flight box extends slightly beyond the TOS boundary to capture an expanding agricultural region similar to the northwest corner of the airborne survey area that is relevant for scaling. A single Priority 1 flight area was assigned to cover the entire site. The eastern border of the TOS watershed (**Figure 4.1.6**) was not included since it would require an additional 2.5 flight hours to survey. Given its small size, the southeast corner was not assigned to a Priority 2 flight area since any potential savings in flight duration would be lost due to the time involved in making additional turns.

4.1.3 Flight Conditions and Issues of Concern

Flight lines can be surveyed at a constant 1000m AGL (**Figure 4.1.2**). A cross-strip has been included that covers the NEON tower. Duration of the 90% peak greenness period is approximately 111 days (**Figure 4.1.4).** There are no special flight considerations or concerns associated with airborne surveys over Harvard Forest.

Table 4.1-1. Harvard Forest airborne survey area information

Site name	Harvard Forest (HARV)
NEON site type	Core
Latitude/longitude boundaries	Upper Left: 42°34'29.68"N, 72°16'56.30"W Upper Right: 42°34'29.25"N, 72° 8'53.93"W Lower Left: 42°22'57.70"N, 72°17'0.76"W Lower Right: 42°22'58.57"N, 72° 8'51.44"W
Flight survey area	234 km^2
Number of flight lines; flight line length; flight altitude (MSL)	28 lines plus 1 cross strip; 21 km average length; 3900’-4100’ MSL
Airspace class	Class E (FAA Sectional Aeronautical Raster Chart - New York (Edition 89) May 1, 2014)
Maximum terrain height	1371 ft. MSL
Mean canopy height	23 m
FBO transit distance/time (@135kts)	37.4 nm / 21 min to KASH (Nashua, NH)
Estimated survey flight duration	Priority 1 survey area: 5h 44m Priority 2 survey area: n/a
Mean start date peak greenness	May 26
Mean end date peak greenness	September 14
Average annual deviation from mean onset	6 days
Earliest onset date (2003-2012)	May 16
Percent of days with 0-10% cloud cover (9am-3pm) (Figure 4.1.5)	May 42% June 41% July 43% Aug 43% Sep 41%
Solar noon – local time (1st of month)	May 11:45 June 11:46 July 11:52 Aug 11:55 Sep 11:48
Domain headquarters and contact information	Cory Ritz Field Operations Manager Domain 1, NEON, Inc. 166 Boulder Drive, Suite 101, Fitchburg MA 01420 Office: (978)-627-4006 Cell: (207) 232-3869 critz@neoninc.org

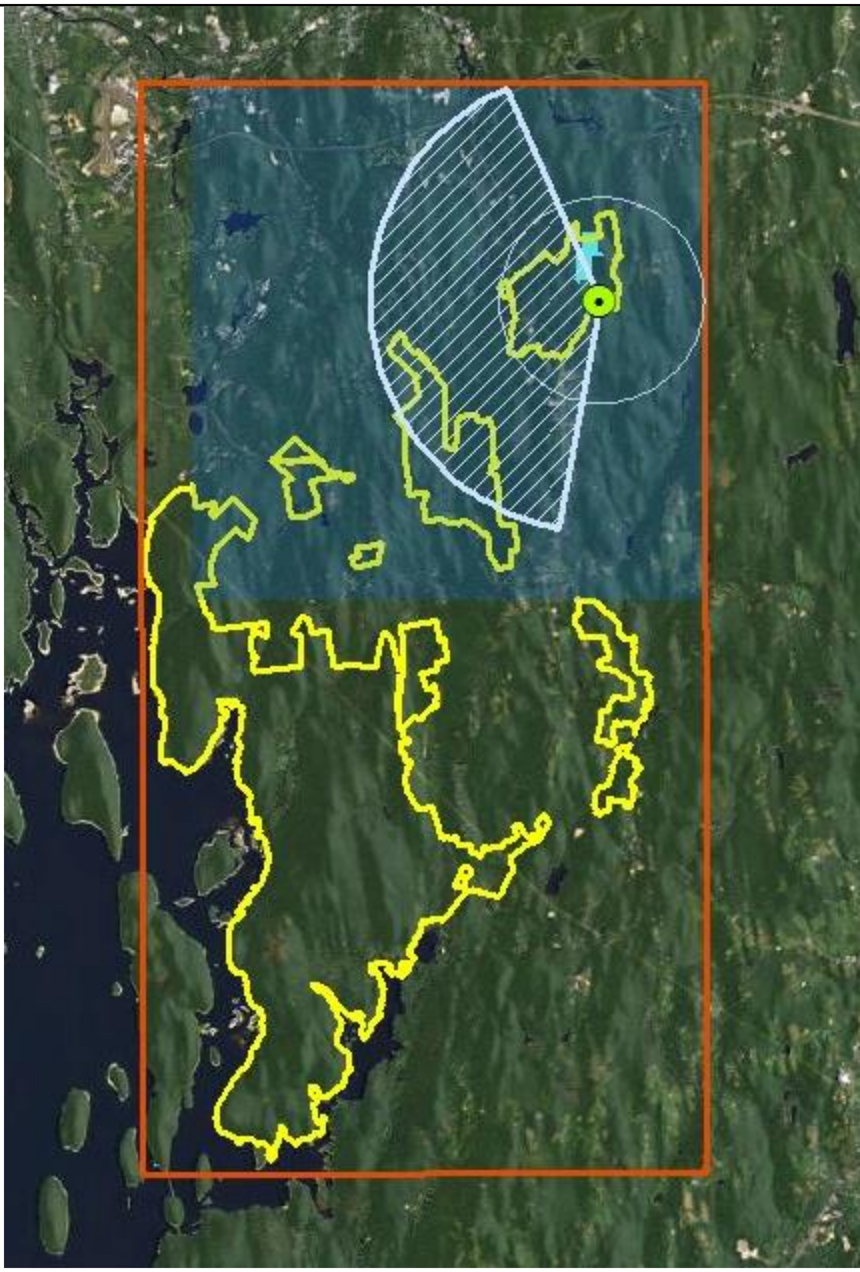


Figure 4.1.1. Harvard Forest Priority 1 airborne survey area (orange); Terrestrial Observation System sampling site boundary (yellow); cumulative eddy-covariance flux tower airshed (white); West Branch Bigelow Brook watershed (light blue); 2km radius buffer from tower (grey); 10x10km minimum area flight box (blue shaded square).

Figure 4.1.2. Flight lines over Harvard Forest at nominal 1000m AGL

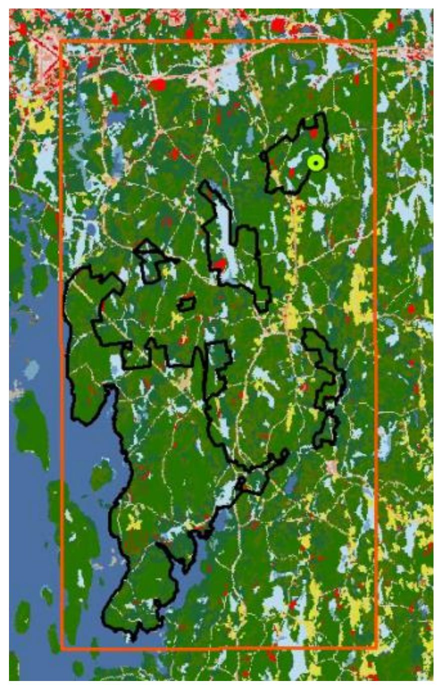


Figure 4.1.3. Land cover[1] and 2000-2012 forest cover change[2] (red)

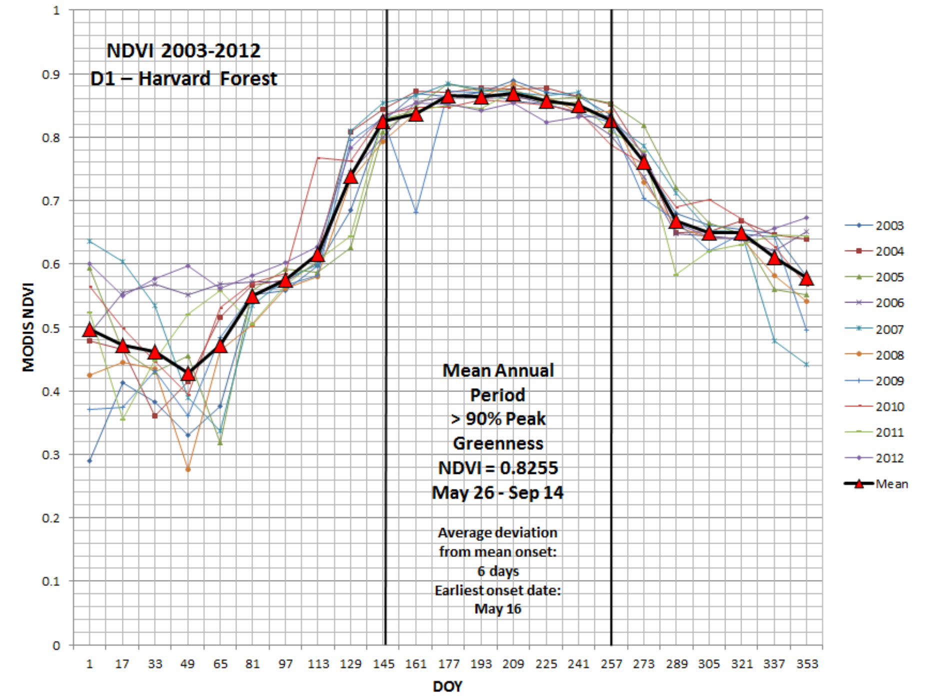


Figure 4.1.4. Phenology for Harvard Forest airborne survey area (2003-2012)[3]

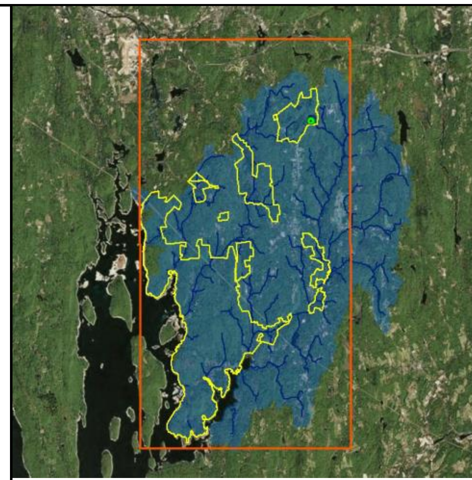


Figure 4.1.6. HARV watershed boundaries[5]

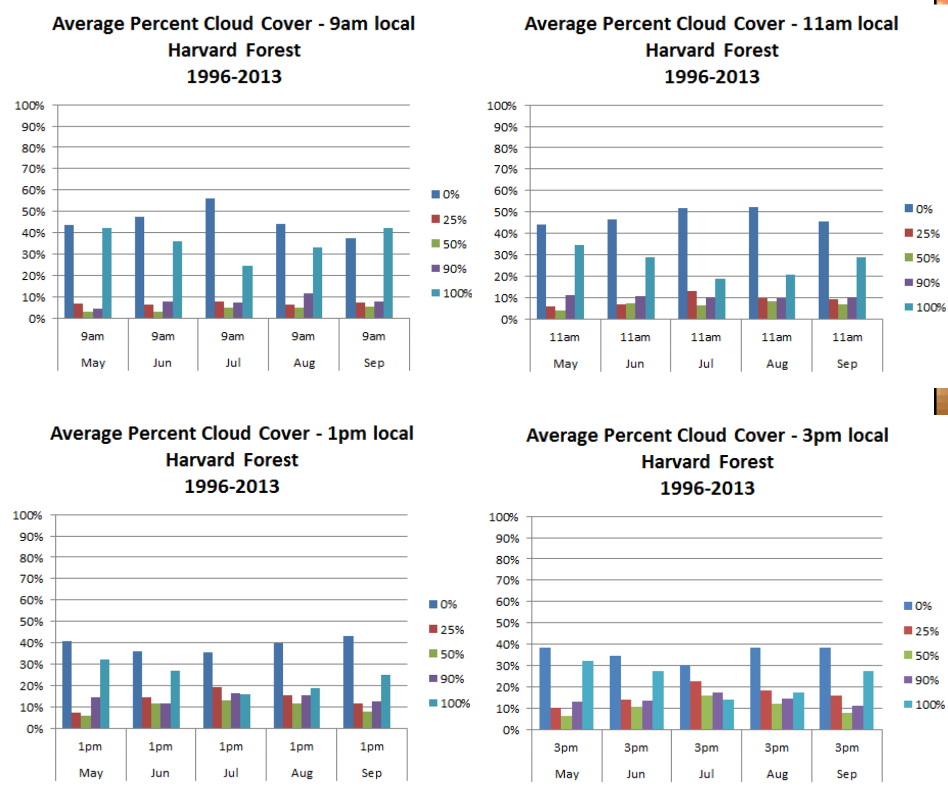


Figure 4.1.5. Cloud fractions per hour by month[4]

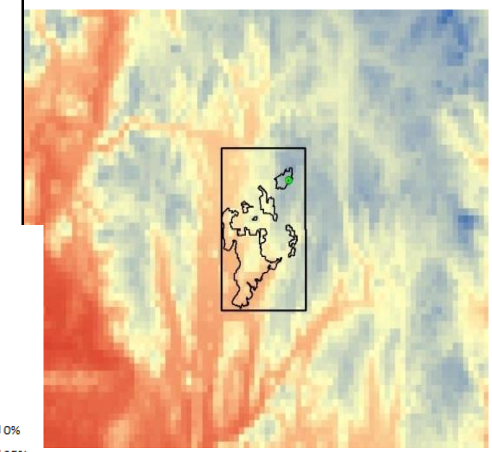


Figure 4.1.7. Average annual maximum temperature (1981-2010) (red=higher T°)[6]

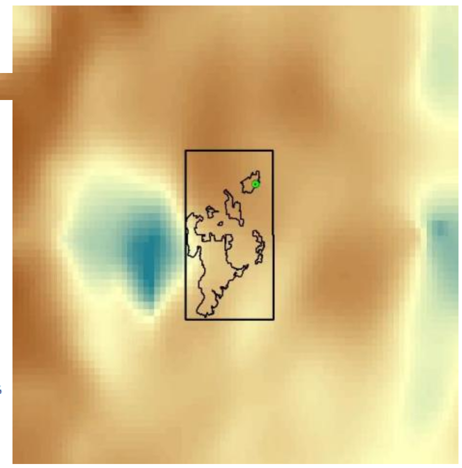


Figure 4.1.8. Average annual precipitation (1981-2010) (blue=higher PPT)[6]

4.2 Domain 01 – Bartlett Experimental Forest

4.2.1 Site and Vegetation Characteristics

The Bartlett Experimental Forest is located within the Saco Ranger District of the White Mountain National Forest near Bartlett, New Hampshire. It is managed by the Northern Research Station of the US Forest Service, and serves as a field laboratory for research on the ecology and management of northern hardwoods and associated ecosystems. Elevations at the Bartlett Forest range from 210m to 915m MSL. Temperatures vary from -35C in winter to 35C in the summer, and the average precipitation is 127cm, distributed fairly evenly throughout the year (USDA Forest Service 2014).

At 2,600 acres, Bartlett Forest contains areas of old-growth northern hardwoods dominated by beech (*Fagus grandifolia*), yellow birch (*Betula alleghaniensis*), sugar maple (*Acer saccharum*), and eastern hemlock (*Tsuga Canadensis*). Starting in the late 1800's the lower portion of the Bartlett Experimental Forest was logged or cleared for pasture; the upper slopes were progressively less impacted with increasing elevation. Previously cleared sites are dominated by even-aged groves of red maple (*Acer rubrum*), paper birch (*Betula papyrifera*), aspen (*Populus tremuloides)* and Eastern white pine (*Pinus strobus*), while red spruce (*Picea rubens*) occupies the highest elevations. Mean canopy height is ~19 m.

4.2.2 Scientific Objectives and Airborne Survey Area Design Criteria

The Bartlett Experimental Forest airborne survey area is constrained by its very close proximity to the Presidential Range Dry Wilderness Area, designated in 1975 and operated by the USFS (**Figure 4.2.1**). The Terrestrial Observation System (TOS) sampling area occupies approximately 23km^2, and the 90% cumulative eddy covariance flux and concentration airshed extends 3550m to the northwest of the tower. The USFS has given authorization for AOP surveys at Bartlett Forest under the condition that the aircraft avoids flying over any wilderness areas in the White Mountains region. The edge of the Presidential Range Dry Wilderness Area boundary is located only 0.17nm (312m) from the edge of the airshed, and 1.07nm (2000m) from the edge of the TOS boundary. Since the Twin Otter aircraft requires a minimum of 2 nautical miles distance from the end of one flight line to make a turn to the start of the next flight line, it is not possible to capture the entire flux tower airshed and TOS sampling area using N/S flight lines without flying over designated wilderness area. In order to capture the maximize TOS sampling boundary and airshed while avoiding the wilderness area airspace, placement of the Bartlett flight box was modified from the standard design configuration: the flight lines were changed from a standard north-south orientation to an east-west orientation, and the north edge of the 10x10km airborne survey area was repositioned so that the Twin Otter aircraft flying over the northernmost flight line will capture the complete width of the flight box while avoiding the southern tip of the Presidential Range Dry Wilderness Area (**Figure 4.2.2**). The flight box was also positioned so that it captures the expanding recreational ski area to northwest of Bartlett Forest, which may have long-term effects on NEON observations.

As a NEON Domain 1 gradient site, Bartlett Experimental Forest was selected to represent climate change impacts across the region (Keller 2008) (Schimel, NEON Science Strategy: Enabling Continental Scale Ecological Forecasting 2011). It appears that the flight box delimited by the standard airborne survey area design criteria adequately captures vegetation/land use types (**Figure 4.2.3**) and climate gradients (**Figure 4.2.7** and **Figure 4.2.8**) and in the vicinity of the White Mountains given the restrictions on air space over designated wilderness areas. Since the flight box is equal to the minimum 10x10km survey area, no Priority 2 flight area was defined for Bartlett Experimental Forest.

4.2.3 Flight Conditions and Issues of Concern

Duration of the 90% peak greenness period is approximately 109 days (**Figure 4.2.4**). The N/S oriented cross-strip is located in the eastern portion of the flight box and does not cover the NEON tower due to aircraft turn restrictions over wilderness areas (**Figure 4.2.2**).

Flight line altitudes have been adjusted to compensate for variations in mean elevation along-track so that the airborne remote sensing data are as close to nominal resolution as possible.

In addition to the Presidential Range Dry Wilderness Area, there are two other wilderness areas in the vicinity that must be avoided: the Pemigewassett Wilderness Area to the west and the Sandwich Wilderness Area to the south.

The White Mountains are characterized by steep mountain slopes and highly variable weather conditions. Given the rapid weather changes that can occur, pilots and flight crew must take extra care to avoid meteorological conditions that could damage exposed instruments or jeopardize safety.

Table 4.2-1. Bartlett Experimental Forest airborne survey area information

Site name	Bartlett Experimental Forest (BART)
NEON site type	Gradient
Latitude/longitude boundaries	Upper Left: 44° 5'1.73"N, 71°20'6.24"W Upper Right: 44° 4'55.84"N, 71°12'35.75"W Lower Left: 43°59'29.66"N, 71°20'5.25"W Lower Right: 43°59'18.06"N, 71°12'24.43"W
Flight survey area	100 km^2
Number of flight lines; flight line length; flight altitude (MSL)	35 lines plus 1 cross strip; 10 km average length; 3900’-5300’ MSL
Airspace class	Site within Alert Area and MOA airspace; transit crosses Class C airspace (FAA Sectional Aeronautical Raster Chart - New York (Edition 89) May 1, 2014)
Maximum terrain height	3214 ft. MSL
Mean canopy height	19 m
FBO transit distance/time (@135kts)	78.5 nm / 35 min to KASH (Nashua, NH)
Estimated flight duration	Priority 1 survey area: 4h 57m Priority 2 survey area: n/a
Mean start date peak greenness	May 26
Mean end date peak greenness	Sep 12
Average annual deviation from mean onset	6 days
Earliest onset date (2003-2012)	May 12
Percent of days with 0-10% cloud cover (9am-3pm) (Figure 4.2.5)	May 42% June 43% July 46% Aug 48% Sep 50%
Domain headquarters and contact information	Cory Ritz Field Operations Manager Domain 1 NEON, Inc. 166 Boulder Drive, Suite 101, Fitchburg MA 01420 Office: (978)-627-4006 Cell: (207) 232-3869 critz@neoninc.org

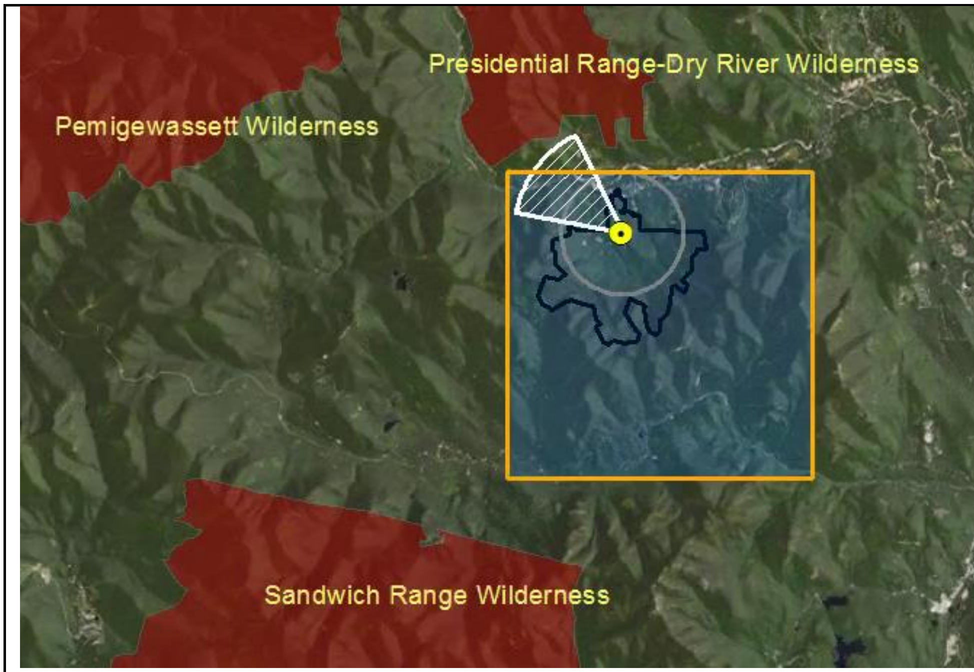


Figure 4.2.1. Bartlett Experimental Forest airborne survey area (orange); Terrestrial Observation System sampling site boundary (yellow); cumulative eddy-covariance flux tower airshed (white); 2km radius buffer from tower (grey); 10x10km minimum area flight box (blue shaded square); USFS designated wilderness areas[7] (red). No Priority 2 survey area required.

Figure 4.2.2. Flight lines over Bartlett Experimental Forest at nominal 1000m AGL

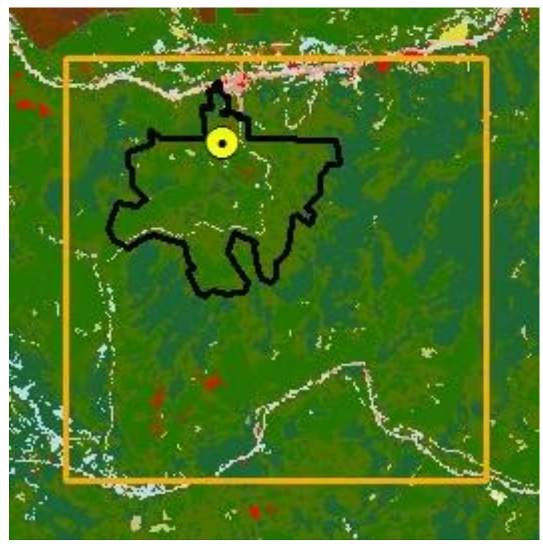


Figure 4.2.3. Land cover[1] and 2000-2012 forest cover change[2]

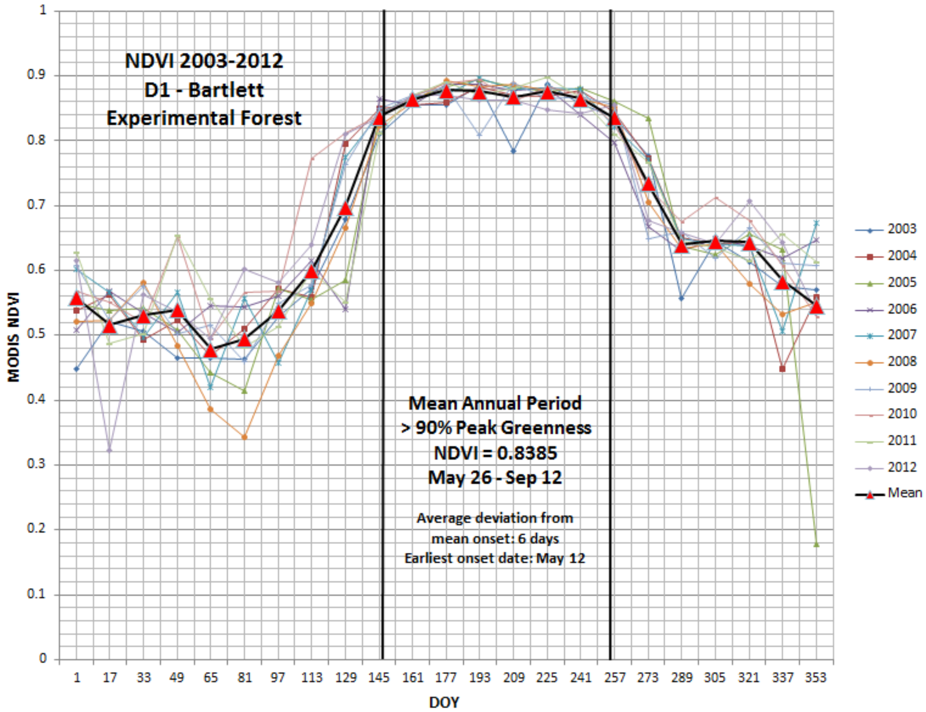


Figure 4.2.4. Phenology for Bartlett Experimental Forest airborne survey area (2003-2012)[3]

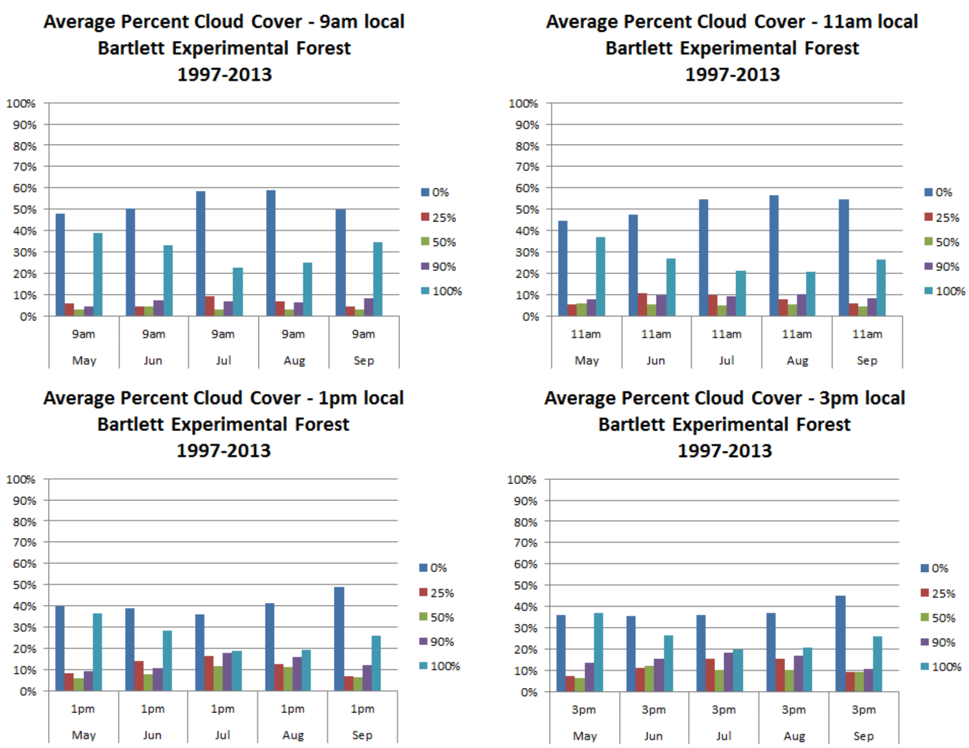


Figure 4.2.5. Cloud fractions per hour by month[4]

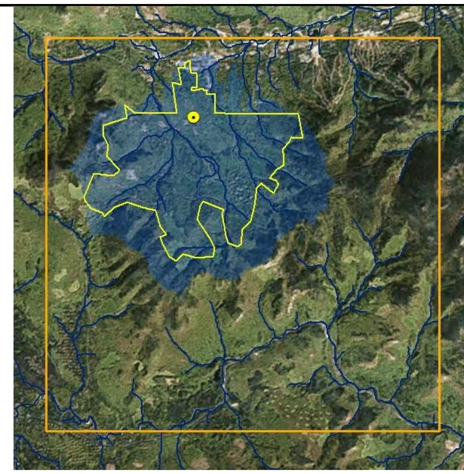


Figure 4.2.6. HARV watershed boundaries[5]

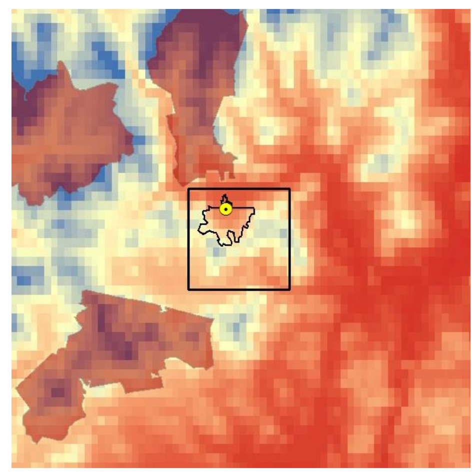


Figure 4.2.7. Average annual maximum temperature (1981-2010) (red=higher T°)[6]

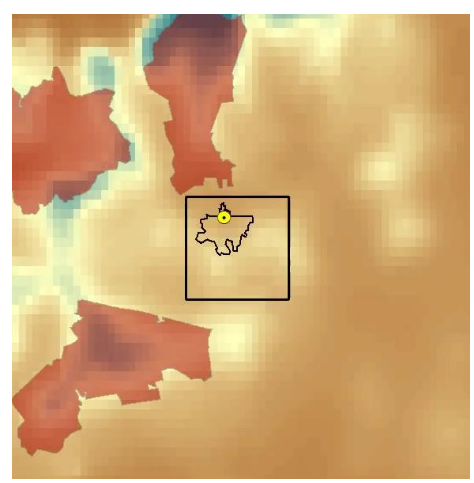


Figure 4.2.8. Average annual precipitation (1981-2010) (blue/yellow=higher PPT)[6]

4.3 Domain 02 – Smithsonian Conservation Biology Institute

4.3.1 Site and Vegetation Characteristics

The Smithsonian Conservation Biology Institute, which launched on January 25, 2010, serves as an umbrella for the Smithsonian's global effort to conserve species and train future generations of conservationists. The SCBI is headquartered in Front Royal, Virginia at the facility previously known as the National Zoo's Conservation and Research Center. The land on which the SCBI lies has a history dating back to 1909, when the United States Army leased forty-two farms in the area. The land was subsequently used for U.S. Army Remount Service depots providing pack animals to the military, and eventually expanded to include a canine training facility and detention barracks for 600 prisoners of war. In 1948, land ownership was transferring to the Department of Agriculture for redevelopment into a beef cattle research station. Until 1973, the Department of State leased part of the compound from USDA for use as an emergency relocation and communications site for more than 700 employees.

The NEON site is located on hilly terrain between 500-830ft MSL, at the intersection of three major physiographic provinces in the eastern US: the Blue Ridge, Ridge and Valley, and Piedmont provinces. The forest landscape on the property is fragmented into patches separated by agricultural fields. The closed forest is typical mature secondary eastern mixed deciduous forest, with a canopy dominated by tulip poplar (*Liriodendron tulipifera*), oak (*Quercus spp.*), black walnut (*Juglans nigra*), ash (*Fraxinus spp.*) and hickory (*Carya spp.*). Forest canopy height is ~35 m around tower site with lowest branches at ~7 m. Oak, ash and other tree species form upper understory with height ~ 8 m. The mid understory is composed of spicebush (*Lindera benzoin*), paw-paw (*Asimina triloba*), American hornbeam (*Carpinus caroliniana*), and witch hazel (*Hamamelis virginiana*) with mean height ~ 1.2 m. New ash seedlings and grasses form the understory at ground level with height ~ 0.3 m. The vegetation of the story at ground level is very dense on much of the forest floor.

4.3.2 Scientific Objectives and Airborne Survey Area Design Criteria

As a NEON core wildland site, the goal of the airborne survey area is to adequately cover the environmental gradients in the vicinity of the field sampling sites and flux tower for scaling purposes. The Terrestrial Observation System (TOS) sampling area occupies approximately 9.87km^2, and the 90% cumulative eddy covariance flux tower airsheds extends 2700m to the north and south of the tower (**Figure 4.3.1**). The 10km x 10km SCBI airborne survey area includes both north- and south-oriented tower airsheds as well as the entire TOS boundary. In order to capture the upstream boundaries of the primary watershed in which the SCBI is located (**Figure 4.3.6**), as well as a larger range of climate gradients (the interpolated historical precipitation pattern in particular, which shows a notable increase in rainfall over the northern edge of the Shenandoah Mountain range) (**Figure 4.3.7** and **Figure 4.3.8**), the airborne survey box is shifted off of center by 2075m south and 865m west. However, shifting of the box to the south is limited by the Shenandoah National Park (a USFS wilderness area); to maintain sufficient distance for airborne turns, a 2.25nm buffer was maintained between the southern edge of the flight box and the northern edge of the National Park. Note that shifting the flight box to the south does not significantly affect coverage of the Front Royal urban area within the AOP observation footprint (**Figure 4.3.3**). There does not appear to be any vegetation, land cover or climate feature that would be captured if the flight box were expanded, so a single Priority 1 is assigned to the 10km x 10km flight area.

4.3.3 Flight Conditions and Issues of Concern

Flight lines can be surveyed at the nominal 1000m AGL (**Figure 4.3.2**). A cross-strip has been included that covers the NEON tower. Duration of the 90% peak greenness period is approximately 111 days (**Figure 4.3.4**). Advanced flight planning is required for SCBI due to Temporary Flight Restrictions (TFR) under ER[01]. The USFS may have policies restricting flights over the Shenandoah National Park due to its popularity as a destination for recreation.

Table 4.3-1. Smithsonian Conservation Biology Institute airborne survey area information

Site name	Smithsonian Conservation Biology Institute (SCBI)
NEON site type	Core
Latitude/longitude boundaries	Upper Left: 38°55'8.98"N, 78°12'24.58"W Upper Right: 38°55'9.42"N, 78° 5'32.18"W Lower Left: 38°49'44.36"N, 78°12'25.16"W Lower Right: 38°49'45.02"N, 78° 5'31.33"W
Flight survey area	100 km^2
Number of flight lines; flight line length; flight altitude (MSL)	24 lines plus 1 cross strip; 10 km average length; 4400’-4700’ MSL
Airspace class	Edge of site overlaps Class C airspace; eastern edge of site located 12nm from Class B airspace. Washington, DC Metropolitan Area Special Flight Rules – Area/Flight Restricted Zone restrictions are in effect.
Maximum terrain height	836 ft. MSL
Mean canopy height	35 m
FBO transit distance/time (@135kts)	63 nm / 28 min from KEZF (Shannon Airport)
Estimated flight duration	Priority 1 survey area: 3h 43m Priority 2 survey area: n/a
Mean start date peak greenness	May 6
Mean end date peak greenness	Sep 22
Average annual deviation from mean onset	5 days
Earliest onset date (2003-2012)	Apr 18
Percent of days with 0-10% cloud cover (9am-3pm)	May 40% June 42% July 46% Aug 44% Sep 41%
Domain headquarters and contact information	Field Operations Manager Domain 2 NEON, Inc. 166 Boulder Drive, Suite 101, Fitchburg MA 01420 Office: (978)-627-4006 Cell: (207) 232-3869 critz@neoninc.org

Figure 4.3.1. Smithsonian Conservation Biology Institute airborne survey area (orange); Terrestrial Observation System sampling site boundary (yellow); cumulative eddy-covariance flux tower airshed (white); Posey Creek watershed (light blue); 2km radius buffer from tower (grey); 10x10km minimum area flight box (blue shaded square); USFS designated wilderness areas[7] (red). No Priority 2 survey area required.

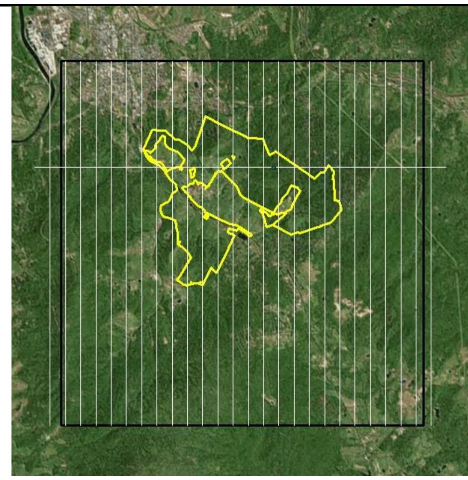


Figure 4.3.2. Flight lines over Smithsonian Conservation Biology Institute at nominal 1000m AGL

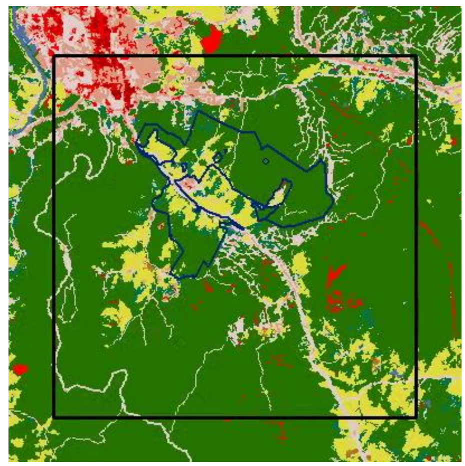


Figure 4.3.3. Land cover[1] and 2000-2012 forest cover change[2]

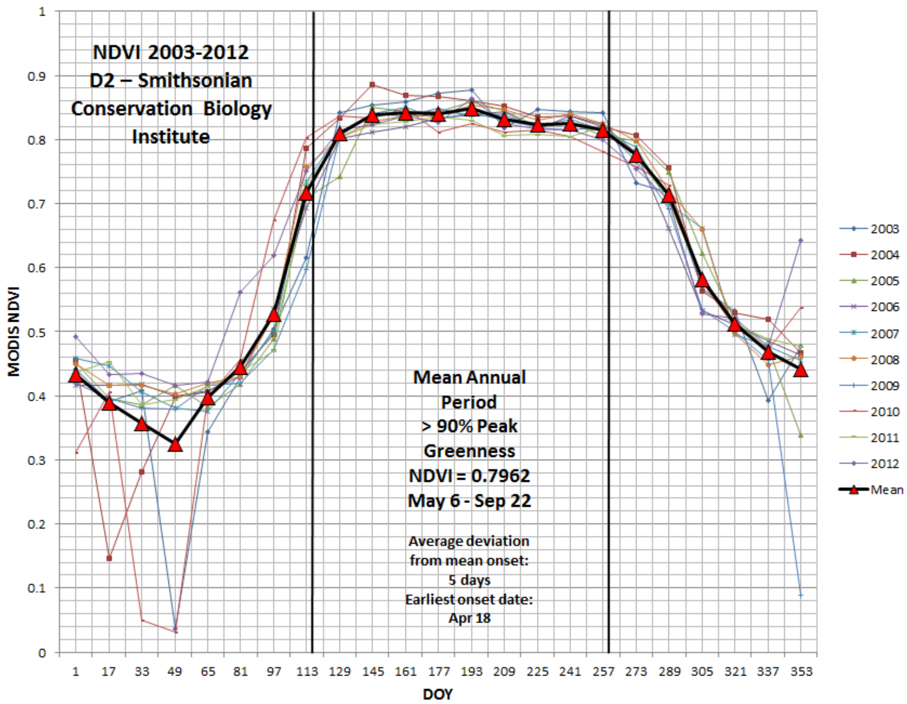


Figure 4.3.4. Phenology for the Smithsonian Conservation Biology Institute airborne survey area[3]

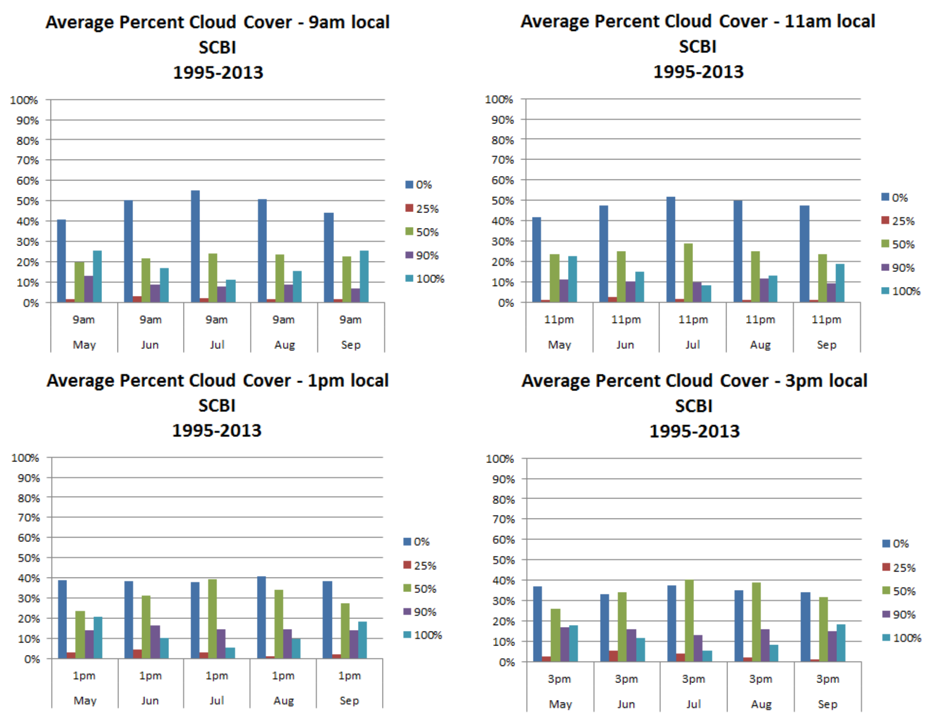


Figure 4.3.5. Cloud fractions per hour by month[4]

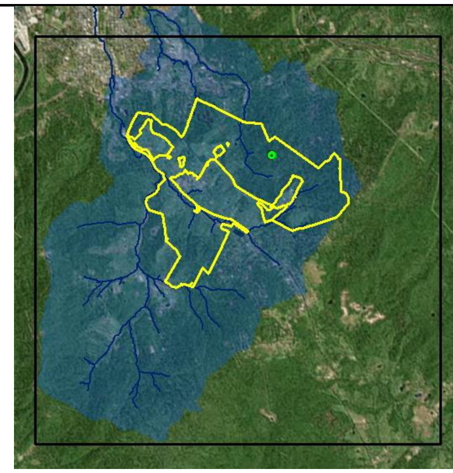


Figure 4.3.6. SCBI watershed boundaries[5]

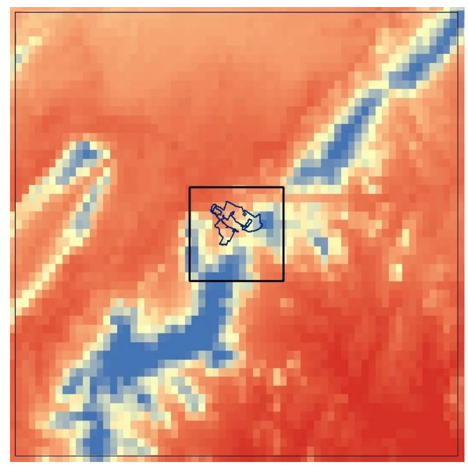


Figure 4.3.7. Average annual maximum temperature (1981-2010) (red=higher T°)[6]

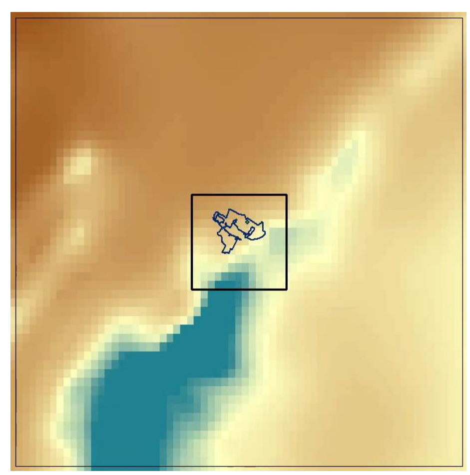


Figure 4.3.8. Average annual precipitation (1981-2010) (blue=higher PPT)[6]

4.4 Domain 02 – Smithsonian Environmental Research Center

4.4.1 Site and Vegetation Characteristics

The Smithsonian Environmental Research Center (SERC) is a 2,800-acre (11 km^2) environmental research and educational facility operated by the Smithsonian Institution located in Edgewater, MD on the Rhode and West Rivers. The center's focus of study is on the ecosystems of coastal zones, particularly in the Chesapeake Bay wetlands. The SERC conducts research on a wide variety of topics that include terrestrial, atmospheric, and estuarine environmental research within the disciplines of botany, ecology, environmental education, biology, chemistry, mathematics, microbiology, physics, and zoology.

The representative ecosystem at SERC is a hardwood deciduous forest dominated by tulip popular (*Liriodendron tulipifera*), oak (*Quercus spp.*) and ash (*Fraxinus spp.*). Selective logging occurs at the north end of the property. The majority of the forest is well preserved for research use: mean canopy height around the NEON tower site is ~38m, with the lowest branches at 10m above ground level. Oak recruitments form the upper understory, which varies from 3m to 15m in height without obvious strata. Seedlings and sapling of ash and oak form the lower understory with heights between 0.5-1.5 m. Ferns and new recruitment of ash and oak form ground vegetation. Grass and forest floor annuals are not common at this site.

4.4.2 Scientific Objectives and Airborne Survey Area Design Criteria

The Terrestrial Observation System (TOS) sampling area occupies approximately 10.27km^2, and the 90% cumulative eddy covariance flux tower airshed extends 2920m to the west of the tower (**Figure 4.4.1**). The 10km x 10km SERC airborne survey area includes the west-oriented tower airshed and the entire TOS boundary. The survey area was shifted 385m to the west to accommodate the western edge of the watershed encompassing the SERC TOS boundary (**Figure 4.4.6**). The placement of this flight box straddles the east-west temperature gradient (**Figure 4.4.7**) but does not capture the regional variability in precipitation (**Figure 4.4.8**); however, the flight area required to adequately capture this gradient is not feasible given that it would triple the flight time required. There does not appear to be any vegetation or land cover feature that would be captured if the flight box were expanded (**Figure 4.4.3**), so a single Priority 1 is assigned to the 10km x 10km flight area (**Figure 4.4.2**).

4.4.3 Flight Conditions and Issues of Concern

Flight lines can be surveyed at the nominal 1000m AGL. A cross-strip has been included that covers the NEON tower. Duration of the 90% peak greenness period is approximately 136 days (**Figure 4.4.4**). Advanced flight planning is required for SERC due to Temporary Flight Restrictions (TFR) under ER[01].

Table 4.4-1. Smithsonian Environmental Research Center airborne survey area information

Site name	Smithsonian Environmental Research Center (SERC)
NEON site type	Gradient
Latitude/longitude boundaries	Upper Left: 38°56'6.03"N, 76°37'15.72"W Upper Right: 38°56'5.90"N, 76°30'21.30"W Lower Left: 38°50'42.13"N, 76°37'15.85"W Lower Right: 38°50'42.20"N, 76°30'21.54"W
Flight survey area	100 km^2
Number of flight lines; flight line length; flight altitude (MSL)	24 lines plus 1 cross strip; 10 km average length; 4400'-4700' MSL
Airspace class	Site within Class C airspace; eastern edge of site located 12nm from Class B airspace. Washington, DC Metropolitan Area Special Flight Rules – Area/Flight Restricted Zone restrictions are in effect.
Maximum terrain height	241 ft. MSL
Mean canopy height	38 m
FBO transit distance/time (@135kts)	71 nm / 32 min from KEZF (Shannon)
Estimated flight duration	Priority 1 survey area: 3h 43m Priority 2 survey area: n/a
Mean start date peak greenness	May 12
Mean end date peak greenness	Sep 25
Average annual deviation from mean onset	22 days
Earliest onset date (2003-2012)	Apr 19
Percent of days with 0-10% cloud cover (9am-3pm)	May 55% June 53% July 62% Aug 56% Sep 53%
Domain headquarters and contact information	Field Operations Manager Domain 2 NEON, Inc. 166 Boulder Drive, Suite 101, Fitchburg MA 01420 Office: (978)-627-4006 Cell: (207) 232-3869 critz@neoninc.org

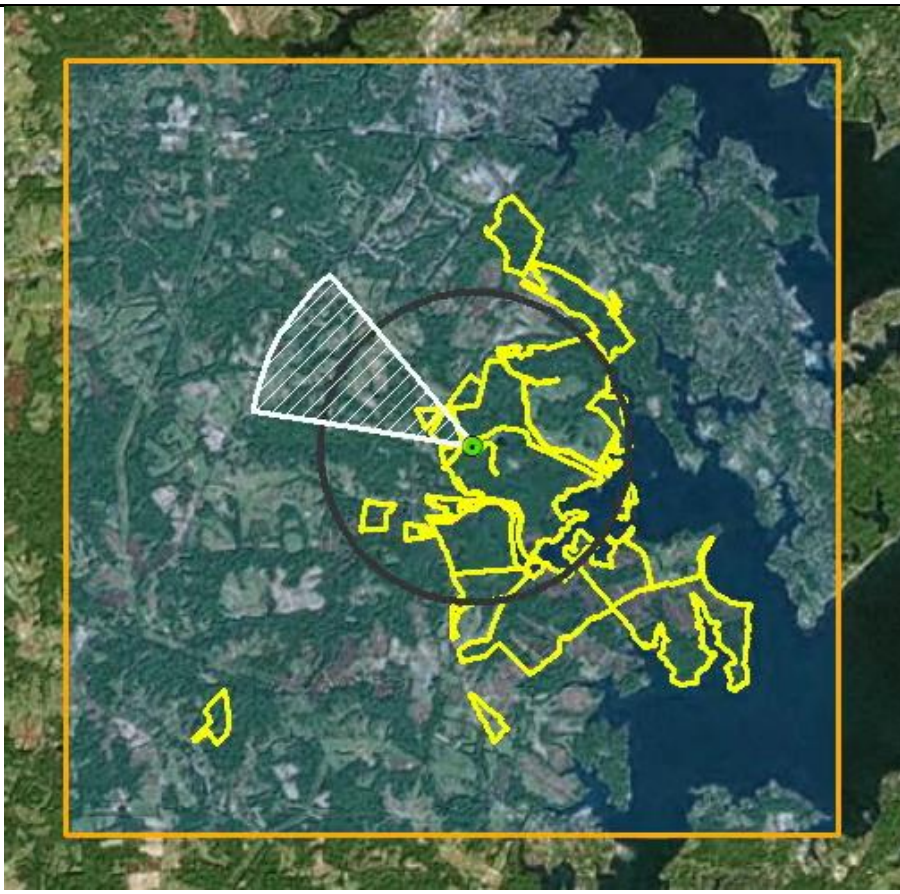


Figure 4.4.1. Smithsonian Ecological Research Center airborne survey area (orange); Terrestrial Observation System sampling site boundary (yellow); cumulative eddy-covariance flux tower airshed (white); 2km radius buffer from tower (grey); 10x10km minimum area flight box (blue shaded square). No Priority 2 survey area required.

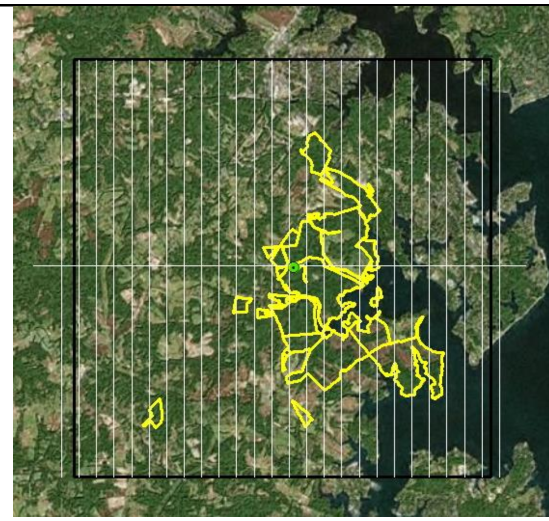


Figure 4.4.2. Flight lines over Smithsonian Ecological Research Center at nominal 1000m AGL

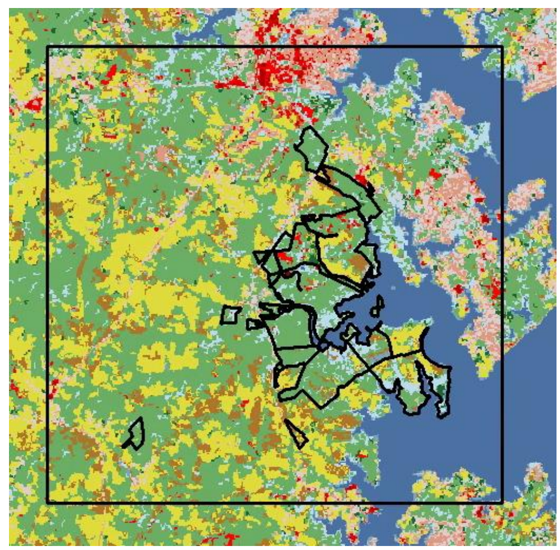


Figure 4.4.3. Land cover[1] and 2000-2012 forest cover change[2]

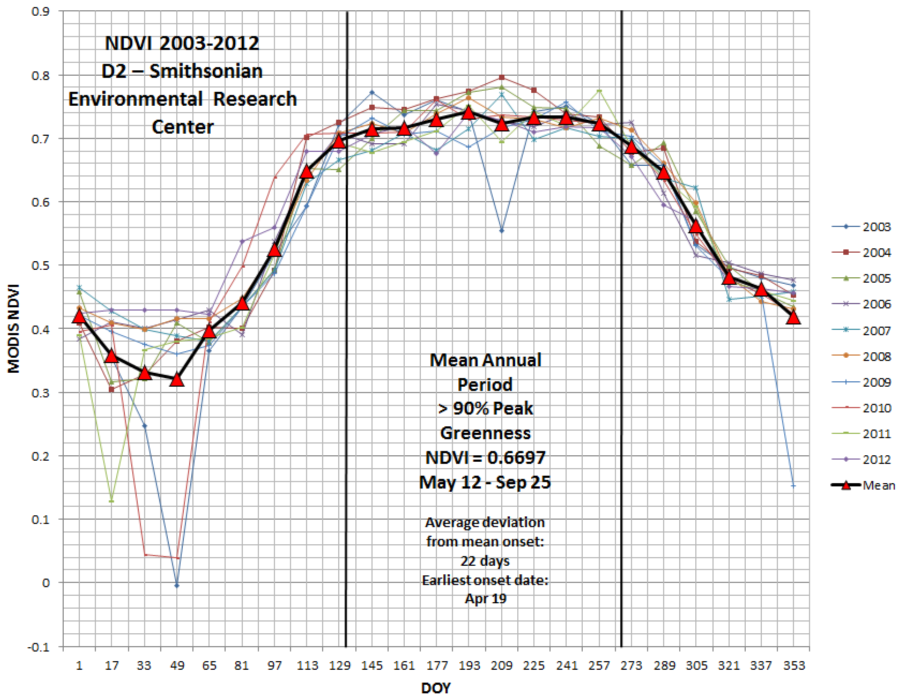


Figure 4.4.4. Phenology for the Smithsonian Ecological Research Center airborne survey area[3]

Figure 4.4.5. Cloud fractions per hour by month[4]

Figure 4.4.6. SERC watershed boundary[5]

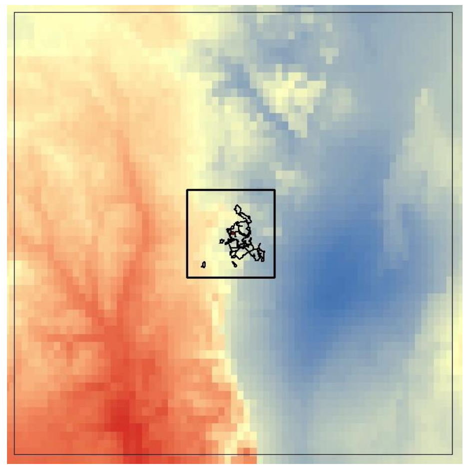


Figure 4.4.7. Average annual maximum temperature (1981-2010) (red=higher T°)[6]

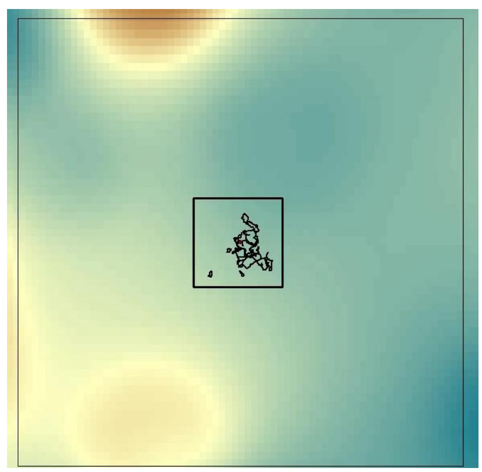


Figure 4.4.8. Average annual precipitation (1981-2010) (blue=higher PPT)[6]

4.5 Domain 3 – Ordway-Swisher Biological Station

4.5.1 Site and Vegetation Characteristics

The Ordway-Swisher Biological Station (OSBS) supports long-term ecological research and the conservation of unique wetland and upland ecosystems through management and education. Originally named the Katharine Ordway Preserve-Carl Swisher Memorial Sanctuary and renamed the Ordway-Swisher Biological Station in 2006, the preserve was established in the 1930's and expanded through a combination of donations and land purchases by The Nature Conservancy and the University of Florida-Gainesville (UF IFAS Research: Ordway-Swisher Biological Station 2014). OSBS occupies a relatively flat landscape mosaic of wetlands and uplands covering more than 9,300 acres with twelve natural plant communities and five altered landscapes, including sandhills, xeric hammock, upland mixed forest, swamps, marshes, clastic upland lakes, sandhill upland lakes, and marsh lakes. More than 516 documented species of plants, 284 vertebrates and 713 invertebrates inhabit the preserve, including a number of state and federally listed species. Archeological sites indicate a long history of human presence, and land use practices since the mid-19th century, such as mixed farming and intensive logging of longleaf pine (*Pinus palustrus*), have had a major impact on OSBS (Eisenberg 1995). More recent land use practices have included cattle ranching, and wildfires and prescribed burning have had a major influence on plant community ecology. Longleaf pine, historically the dominant forest ecosystem in the region, is maintained by fire and has a relatively open structure and mean canopy height of 10-25 m.

4.5.2 Scientific Objectives and Airborne Survey Area Design Criteria

One of the major research focuses of Ordway-Swisher Biological Station is the study of forest management practices and conservation on the longleaf pine ecosystem. The OSBS Terrestrial Observation System (TOS) sampling area associated with the tower and airshed occupies approximately 36.8km^{2,} and includes the entire 90% cumulative eddy covariance flux tower airshed (**Figure 4.5.1**). The 10km x 10km baseline flight survey boundary centered on the tower was shifted 529m to the east in order to capture the entire TOS boundary. Watershed boundaries for the Barco Lake and Suggs Lake NEON aquatic sites were the main drivers used to expand the Priority 1 flight box and to assign two Priority 2 flight boxes to the plan (**Figure 4.5.6**). In order to efficiently cover the northern and southern extent of the watershed, flight lines 5-12 in the Priority 1 flight box based on the 10km x 10km minimum survey area were extended to the north by 2552m, and flight lines 9-16 were extended to the south by 3416m (**Figure 4.5.2**). Assigning these flight line extensions to a separate Priority 2 flight plan would have significantly increased overall flight duration due to the additional time that would be required to conduct a duplicate set of turns. Watershed areas to the east and the west of the Priority 1 flight box were included in the Priority 2 flight box (**Figure 4.5.2**). The Priority 1 and 2 survey areas adequately capture the range of plant communities and land use change dynamics in and around OSBS (**Figure 4.5.3**). The site straddles a transition zone between cooler areas to the north and hotter areas to the south (**Figure 4.5.7**), so modifications to the survey boundary were not made to accommodate climate variability.

4.5.3 Flight Conditions and Issues of Concern

Flight lines can be surveyed at the nominal 1000m AGL. Two cross-strips have been included: the cross-strip for the Priority 1 flight box intersects the NEON tower, and the cross-strip for the Priority 2 flight boxes is oriented to cross both areas in a single pass. Duration of the 90% peak greenness period is very short at approximately 35 days (**Figure 4.5.4**). Historical cloud cover data from Orlando International Airport show that 34-39% of days are cloud-free during a typical August and September time period as compared with the January-March average of 51-57% of days cloud-free (**Figure 4.5.5**). August and September also fall within hurricane season, which may add significant risk to deployment during the late summer months. Since OSBS shows relatively high NDVI during the entire calendar year (the dominant longleaf pine vegetation is evergreen), it is recommended to move the flight deployment to the January-March time period when cloud-free days are more frequent and the likelihood of hurricanes is low.

Prescribed burning is actively practiced at OSBS, mainly in the spring, as part of restoration and management efforts to return oak-dominated areas that emerged when fire activity was suppressed to native longleaf pine habitat, on which many native threatened or endangered species depend. Prescribed burning is a major concern for AOP due to the smoke and haze this produces since these may interfere with spectroscopic returns. Coordination with field operations personnel on a daily basis for the purpose of suspending prescribed burning in OSBS before flights are initiated is highly recommended.

OSBS falls within Class G airspace. However, caution is advised since the western boundary of the flight box is located 5nm east of Class D airspace (KGNV Gainesville), and the southeast boundary of the flight box is located 3.8nm northwest of Palatka 2 MOA restricted airspace (FAA Sectional Aeronautical Raster Chart - Cheyenne (Edition 90) July 24, 2014).

Table 4.5-1. Ordway-Swisher Biological Station airborne survey area information

Site name	Ordway-Swisher Biological Station (OSBS)
NEON site type	Core plus Aquatics
Latitude/longitude boundaries	Upper Left: 29°45'35.99"N, 82° 5'14.45"W Upper Right: 29°45'25.83"N, 81°54'49.69"W Lower Left: 29°36'47.15"N, 82° 5'1.90"W Lower Right: 29°36'55.18"N, 81°54'50.67"W
Flight survey area	Priority 1: 129 km^2 Priority 2: 38 km^2
Number of flight lines; flight line length; flight altitude (MSL)	Priority 1: 26 lines plus 1 cross strip; 13.5 km average length; 3400' MSL Priority 2: 15 lines plus 1 cross strip; 7.2 km average length; 3400' MSL
Airspace class	Class G; west boundary of flight box is 5nm east of Class D airspace (KGNV Gainesville); southeast boundary of flight box is 3.8nm northwest of Palatka 2 MOA (FAA Sectional Aeronautical Raster Chart - Jacksonville (Edition 94) Aug 21, 2014).
Maximum terrain height	223 ft. MSL
Mean canopy height	23 m
FBO transit distance/time (@135kts)	93 nm / 42 min from KISM (Kissimmee)
Estimated flight duration	Priority 1 survey area: 4h 13m Priority 2 survey area: 2h 53m
Mean start date peak greenness	Aug 10
Mean end date peak greenness	Sep 24
Average annual deviation from mean onset	24 days
Earliest onset date (2003-2012)	Jun 9
Percent of days with 0-10% cloud cover (9am-3pm)	Jan 57% Feb 50% Mar 54% Aug 39% Sep 34%
Domain headquarters and contact information	Robert Nelson National Ecological Observatory Network (NEON, Inc.) Field Operations Manager-Southeast 4579 N.W. 6th Street, Unit B-2 Gainesville, FL 32609 Phone: 352-505-2001 Cell: 407-908-6555 rnelson@neoninc.org

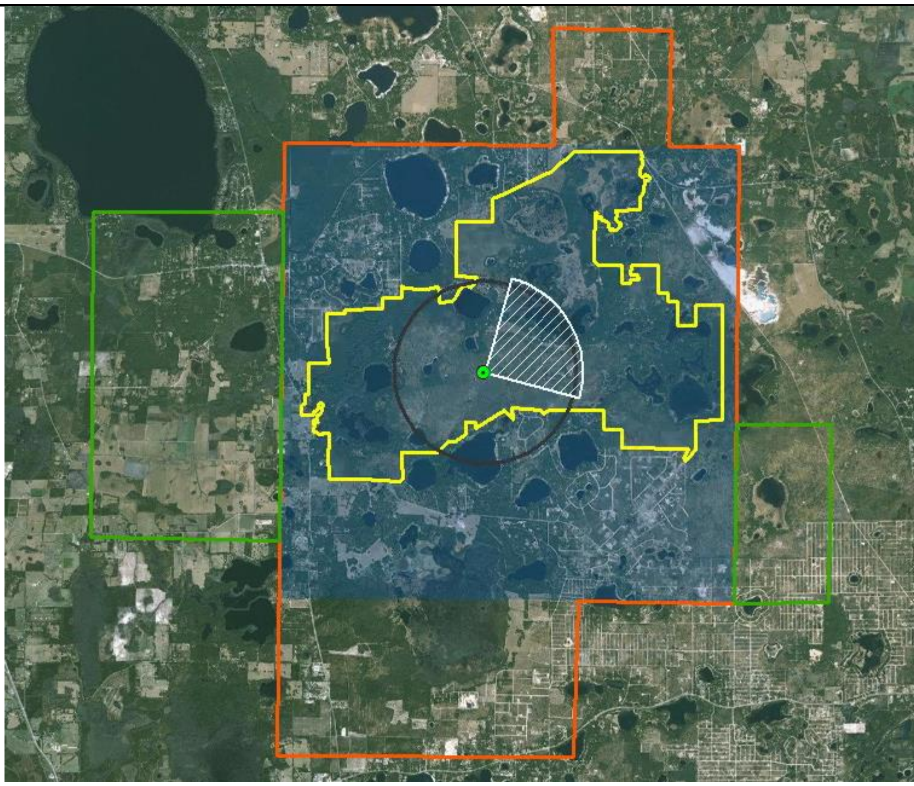


Figure 4.5.1. Ordway-Swisher Biological Station priority 1 airborne survey area (orange); OSBS priority 2 survey area (green); OSBS Terrestrial Observation System sampling site boundary (yellow); cumulative eddy-covariance flux tower airshed (white); 2km radius buffer from tower (grey); 10x10km minimum area flight box (blue shaded square).

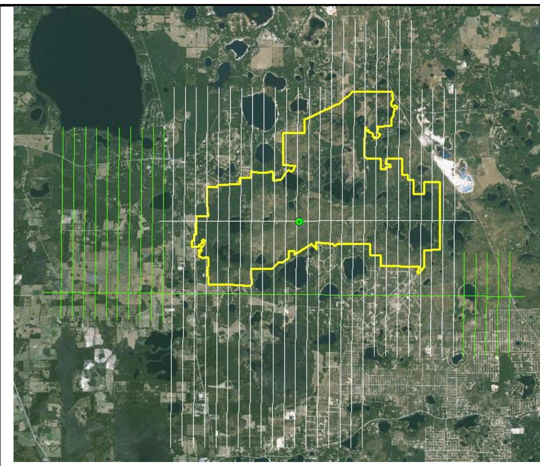


Figure 4.5.2. Priority 1 flight lines (white) and priority 2 flight lines (green) over Ordway-Swisher Biological Station at nominal 1000m AGL.

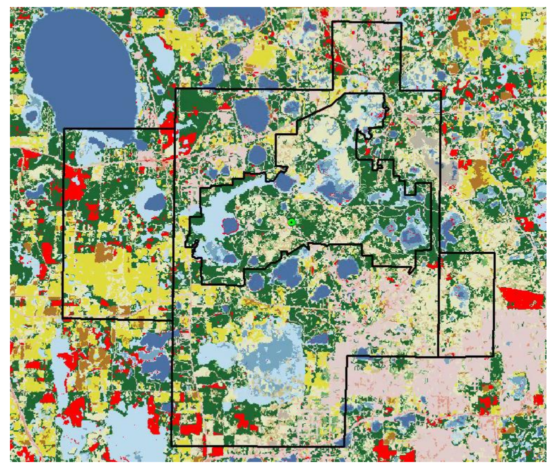


Figure 4.5.3. Land cover[1] and 2000-2012 forest cover change[2] (red)

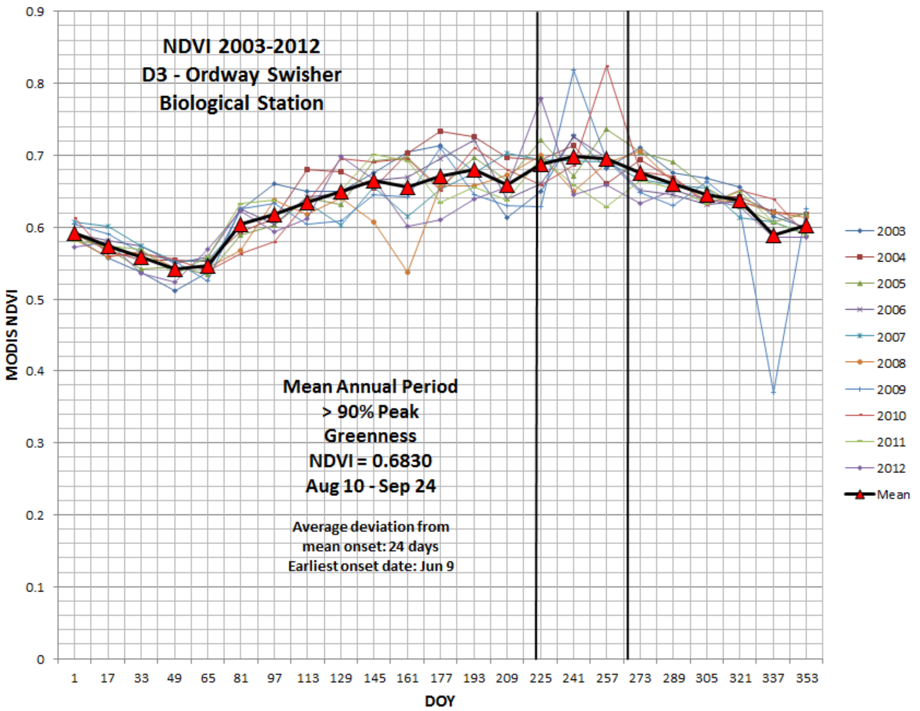


Figure 4.5.4. Phenology for the Ordway-Swisher Biological Station airborne survey area[3]

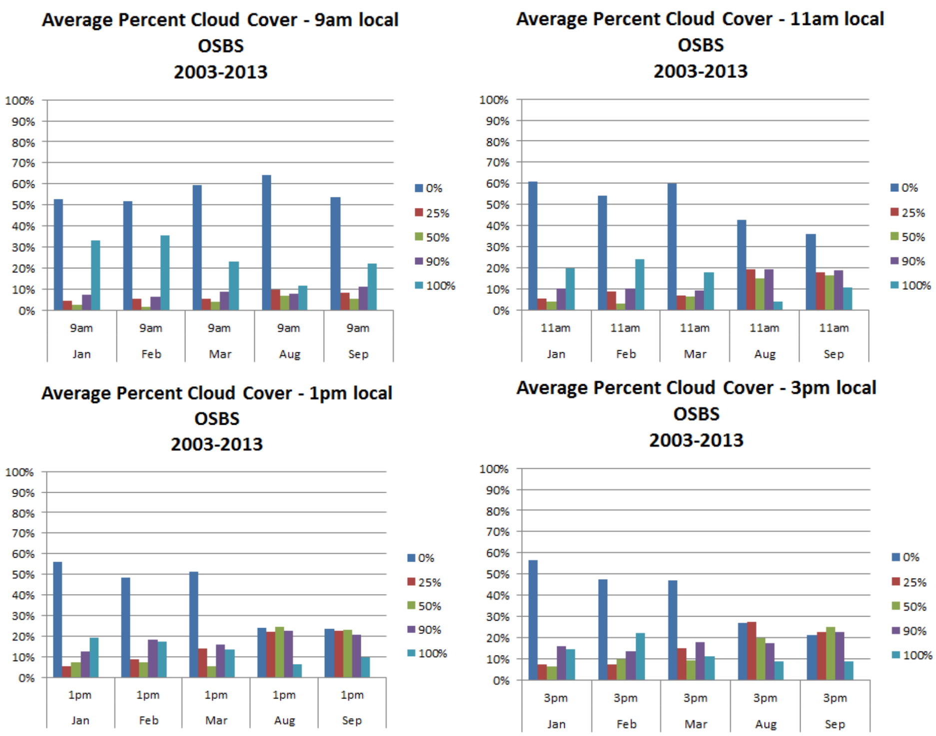


Figure 4.5.5. Cloud fractions per hour by month[4]

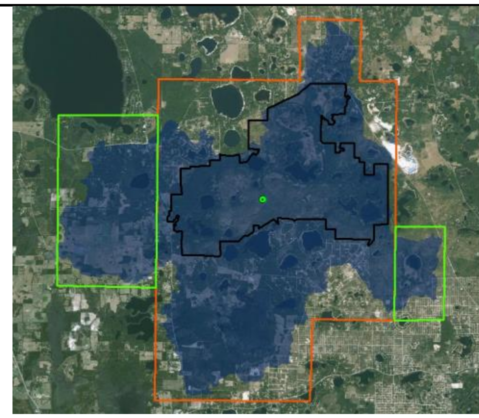


Figure 4.5.6. Watershed boundaries for Barco Lake and Suggs Lake[5] within OSBS

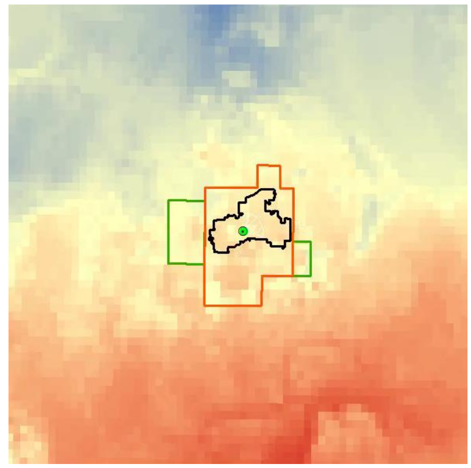


Figure 4.5.7. Average annual maximum temperature (1981-2010) (red=higher T°)[6]

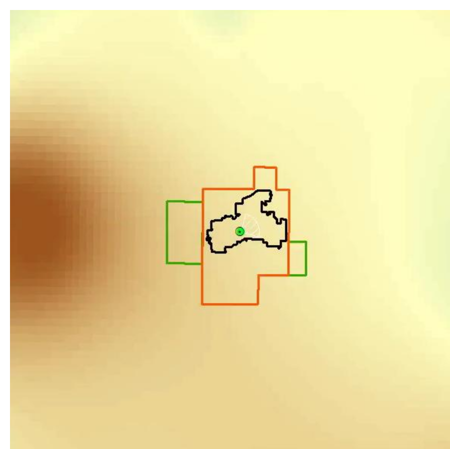


Figure 4.5.8. Average monthly precipitation (1981-2010) (yellow=higher PPT)[6]

4.6 Domain 3 – Disney Wilderness Preserve

4.6.1 Site and Vegetation Characteristics

The Disney Wilderness Preserve is located south of Orlando in Osceola and Polk counties and covers 12,000 acres at the head of the Greater Everglades watershed. The original 8,500 acre cattle ranch was purchased as a mitigation site for wetland disturbance by the Walt Disney World Corporation and the Greater Orlando Aviation Authority in early 1990s, and was transferred to The Nature Conservancy for hydrological/vegetation restoration and management (Drake 2000). The Disney Wilderness Preserve is composed of patches of wetlands in a matrix of xeric upland and savanna-like vegetation communities. Dominant vegetation types within the preserve include Pine Flatwoods, Southern Coastal Plain Non-riverine Cypress Dome, and Florida Dry Prairie (Abrahamson and Hartnett 1990). The landscape is seasonally wet and flooded, and the terrestrial vegetation is historically a fire-dominated system that is maintained with controlled burns. Mean canopy height in the forest is between 10 m and 25 m, while in the prairie mean canopy height is between 0.5 m and 1 m.

4.6.2 Scientific Objectives and Airborne Survey Area Design Criteria

Scientific objectives of the NEON site at Disney Wilderness Preserve include understanding ecological dynamics and impact of management practices on the longleaf pine ecosystem. The DSNY Terrestrial Observation System (TOS) sampling area occupies approximately 49km^2, and the 90% cumulative eddy covariance flux tower airshed extends 1580m to the east of the tower (Figure 4.6.1). The 10km x 10km baseline flight survey boundary centered on the tower was shifted 2543m to the south and 710m to the west to cover the northern part of the TOS boundary, capturing the range of different land uses surrounding the site while minimizing inclusion of water bodies within the flight boundary and maintaining the northern edge of the survey boundary outside of the 2km minimum distance to the tower (**Figure 4.6.3**). The survey boundary was expanded 6610m to the south to cover the remaining extent of the TOS boundary.

The DSNY TOS boundary delineates an area with a higher elevation than those to the east and west, which means streams flow from DSNY to lands outside of the reserve (**Figure 4.6.6**). Watershed boundaries were therefore not used as criteria to delineate the flight box. The site is located in a spatially homogenous area in terms of mean annual temperature and precipitation; adjusting the location or size of the flight box to capture the cooler/drier or warmer/wetter climatologies to the north or south, respectively, would not be feasible given the distances involved (**Figure 4.6.7** and **Figure 4.6.8**).

4.6.3 Flight Conditions and Issues of Concern

Flight lines can be surveyed at the nominal 1000m AGL. A cross-strip has been included that covers the NEON tower. Duration of the 90% peak greenness period is very short at approximately 34 days (**Figure 4.6.4).** However, historical cloud cover data from Orlando International Airport show that only 1-4% of days are cloud-free during a typical August and September time period (**Figure 4.6.5**). August and

September also fall within hurricane season, which adds significant risk to deployment during the late summer months. Since DSNY shows relatively high NDVI during the entire calendar year (the dominant longleaf pine vegetation is evergreen), it is recommended to move the flight deployment to the January-March time period when cloud-free days are much more frequent and the likelihood of hurricanes is low.

Prescribed burning is actively practiced at DSNY, mainly in the spring, as part of restoration and management efforts to return oak-dominated areas that emerged when fire activity was suppressed to native longleaf pine habitat, on which many native threatened or endangered species depend. Prescribed burning is a major concern for AOP due to the smoke and haze this produces since these may interfere with spectroscopic returns. Coordination with field operations personnel on a daily basis for the purpose of suspending prescribed burning in DSNY before flights are initiated is highly recommended.

DSNY falls within Orlando International Airport's Class B airspace, which requires special consideration by the pilots and advance notice provided to the ARTCC, ATCT and TRACON responsible for managing the airspace at KMCO (RD[03]).

Table 4.6-1. Disney Wilderness Preserve airborne survey area information

Site name	Disney Wilderness Preserve (DSNY)
NEON site type	Gradient
Latitude/longitude boundaries	Upper Left: 28° 8'59.10"N, 81°29'52.59"W Upper Right: 28° 9'0.37"N, 81°21'56.06"W Lower Left: 28° 1'32.75"N, 81°29'50.04"W Lower Right: 28° 1'38.00"N, 81°21'56.36"W
Flight survey area	Priority 1: 138 km^2
Number of flight lines; flight line length; flight altitude (MSL)	Priority 1: 30 lines plus 1 cross strip; 11.2 km average length; 3350' MSL
Airspace class	Class G; west boundary of flight box is 5nm east of Class D airspace (KGNV Gainesville); southeast boundary of flight box is 3.8nm northwest of Palatka 2 MOA (FAA Sectional Aeronautical Raster Chart - Jacksonville (Edition 94) Aug 21, 2014).
Maximum terrain height	122 ft. MSL
Mean canopy height	25 m
FBO transit distance/time (@135kts)	14nm nm / 6 min from KISM (Kissimmee)
Estimated flight duration	Priority 1 survey area: 4h 13m Priority 2 survey area: 2h 53m
Mean start date peak greenness	Aug 25
Mean end date peak greenness	Sep 28
Average annual deviation from mean onset	34 days
Earliest onset date (2003-2012)	Jun 4
Percent of days with 0-10% cloud cover (9am-3pm)	Jan 13% Feb 13% Mar 14% Aug 1% Sep 4%
Domain headquarters and contact information	Robert Nelson National Ecological Observatory Network (NEON, Inc.) Field Operations Manager-Southeast 4579 N.W. 6th Street, Unit B-2 Gainesville, FL 32609 Phone: 352-505-2001 Cell: 407-908-6555 rnelson@neoninc.org

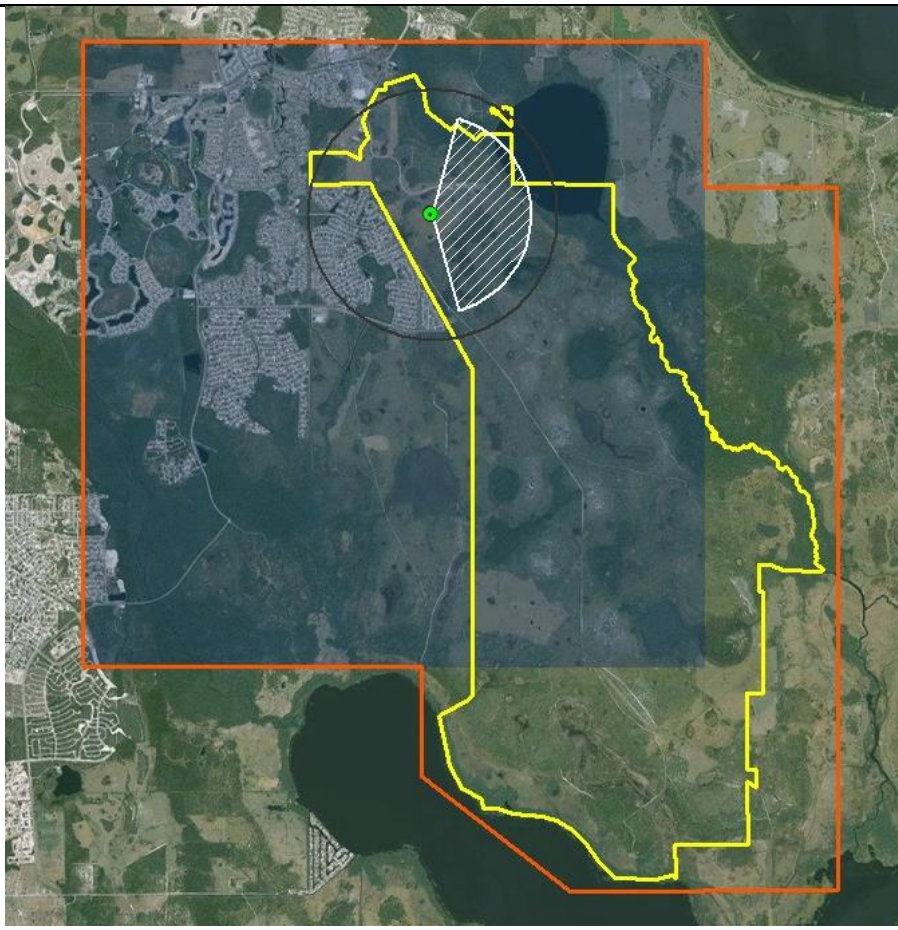


Figure 4.6.1. Disney Wilderness Preserve (DSNY) Priority 1 airborne survey area (orange); DSNY Terrestrial Observation System sampling site boundary (yellow); cumulative eddy-covariance flux tower airshed (white); 2km radius buffer from tower (grey); 10x10km minimum area flight box (blue shaded square).

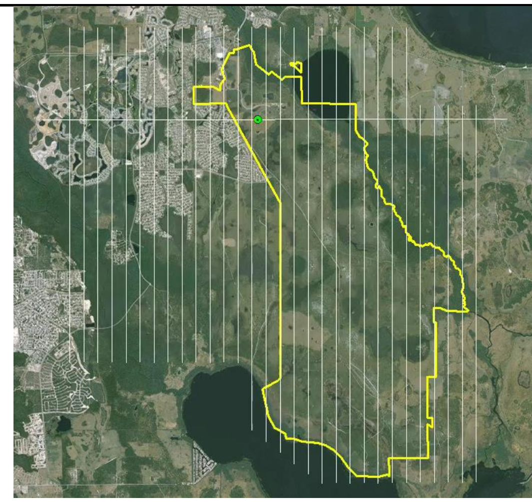


Figure 4.6.2. Flight lines over Disney Wilderness Preserve at nominal 1000m AGL.

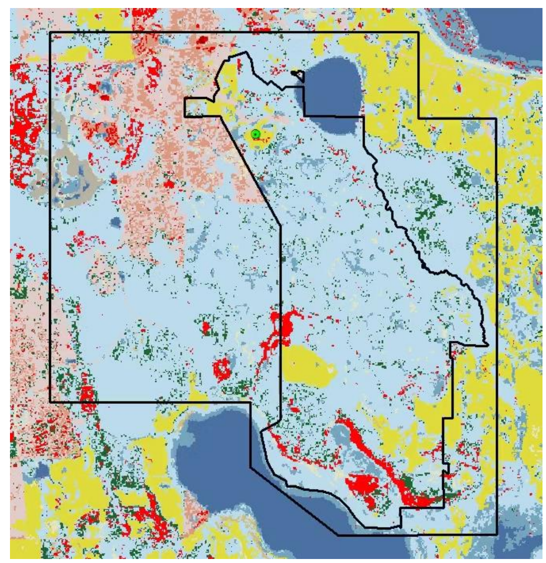


Figure 4.6.3. Land cover[1] and 2000-2012 forest cover change[2] (red)

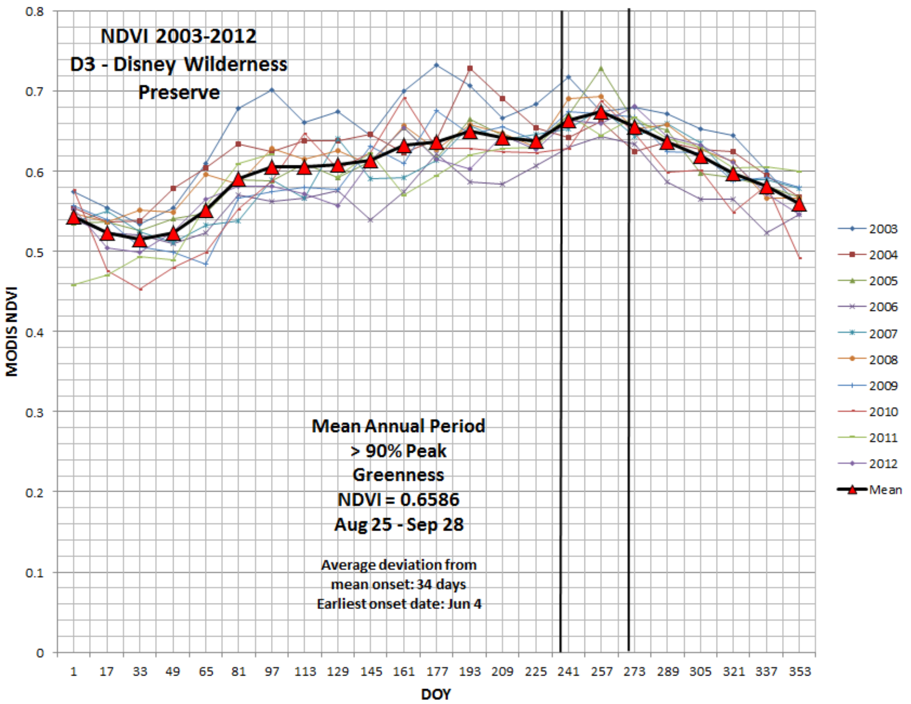


Figure 4.6.4. Phenology for the Disney Wilderness Preserve airborne survey area[3]

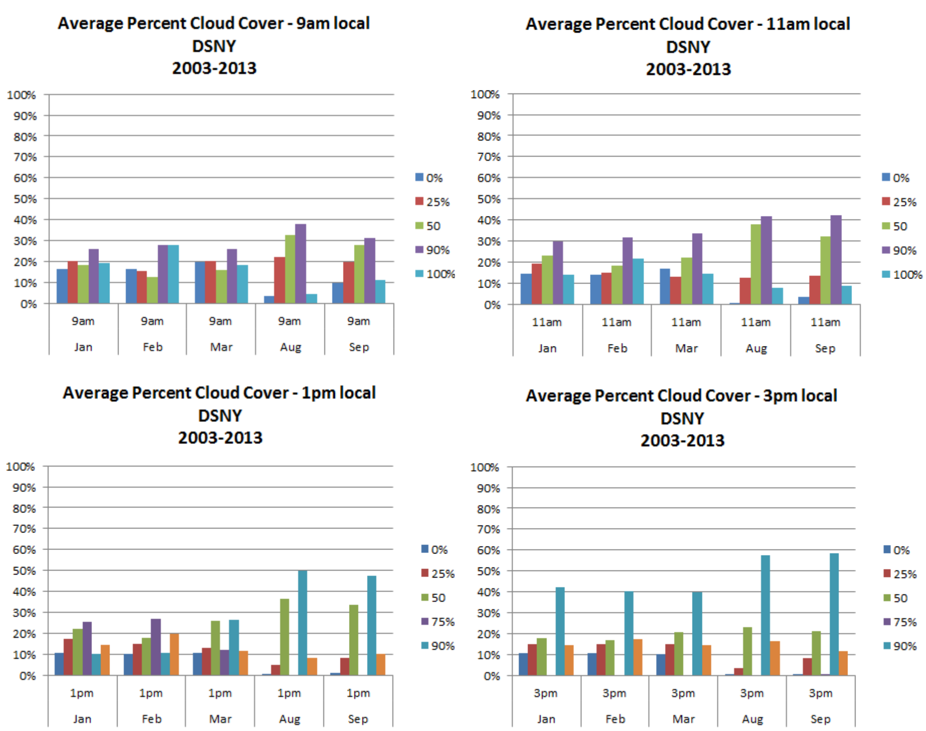


Figure 4.6.5. Cloud fractions per hour by month[4]

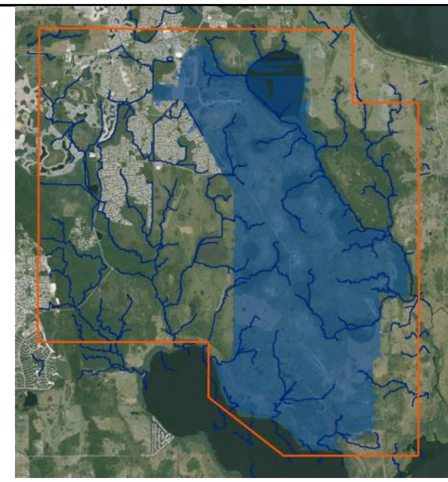


Figure 4.6.6. Watershed boundaries[5] of DSNY

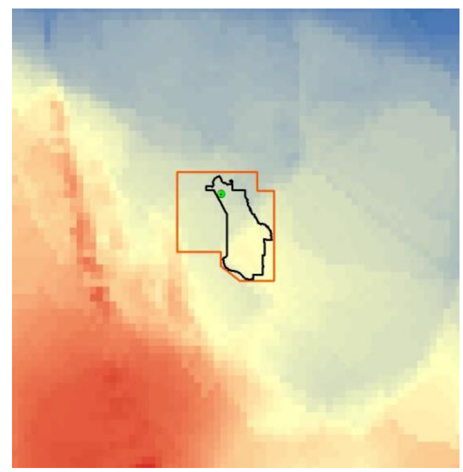


Figure 4.6.7. Average annual maximum temperature (1981-2010) (red=higher T°)[6]

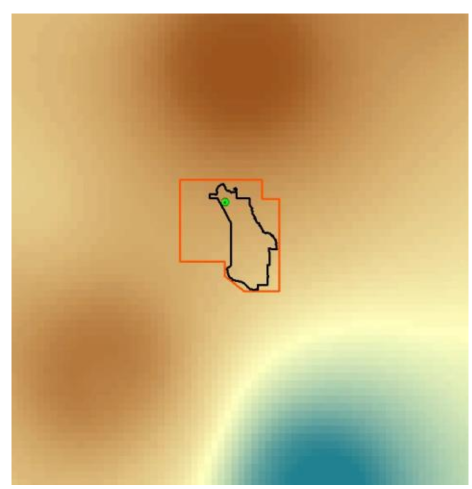


Figure 4.6.8. Average monthly precipitation (1981-2010) (blue=higher PPT)[6]

4.7 Domain 3 – Jones Ecological Research Center at Ichauway

4.7.1 Site and Vegetation Characteristics

The Jones Ecological Research Center at Ichauway is a 29,000 acre property located in southwestern Georgia that was established in the 1920's by Robert Woodruff as an eastern bobwhite quail (*Colinus virginianus*) hunting plantation. Ichauway is divided into management zones that accommodate the conservation, research, and education goals of the Center, which include conserving biological diversity while maintaining sustainable practices and patterns of land use that support wildlife and forest management (Ecological Communities of Ichauway 2014). The property is surrounded by large-scale agriculture, and is dominated by longleaf pine-wiregrass forests ranging from xeric sandhills to seasonally wet flatwoods, with slash pine (*Pinus elliottii*), riparian hardwood forests, shrub-scrub uplands and cypress-gum ponds scattered throughout (Palik and Pederson 1996). Much of the longleaf pine ecosystem is annually maintained with controlled burns. Mean canopy height is between 10 m and 25 m. More than 1,100 vascular plant species and over 280 vertebrate species have been documented in Ichauway.

4.7.2 Scientific Objectives and Airborne Survey Area Design Criteria

Scientific objectives of the NEON site at Jones Ecological Research Center (JERC) include understanding ecological dynamics and impact of management practices on the longleaf pine ecosystem. The JERC Terrestrial Observation System (TOS) sampling area occupies approximately 13.3km^2, and the 90% cumulative eddy covariance flux tower airshed extends 3420m to the northeast of the tower (**Figure 4.7.1**). The 10km x 10km baseline flight survey boundary centered on the tower was shifted 992m to the north and 354m to the west to accommodate the JERC property boundary (pers. comm. with JERC science team 3/14/2014).

The watershed boundary extent for the Ichawaynochaway Creek NEON aquatic site was the main driver used to expand the Priority 1 flight box and to assign two Priority 2 flight boxes to the plan (**Figure 4.7.6).** (The complete watershed (2756 km^2) upstream of the TOS boundary and aquatic site was not used due to its extensive size.) In order to efficiently cover the northern extent of the watershed included within the JERC property boundary, all flight lines in the Priority 1 flight box based on the 10km x 10km minimum survey area were extended to the north by 8676m (**Figure 4.7.2**). Assigning these flight line extensions to a separate Priority 2 flight plan would have significantly increased overall flight duration due to the additional time that would be required to conduct a duplicate set of turns. Watershed areas to the east and the west of the Priority 1 flight box were included in the Priority 2 flight box. The Priority 1 and 2 survey areas adequately capture the range of plant communities and land use change dynamics in and around the JERC TOS area (**Figure 4.7.3**). The flight survey area captures some of the range in temperature across the broader landscape (**Figure 4.7.7**), but does not adequately include wetter areas to the south of the site (**Figure 4.7.8**).

4.7.3 Flight Conditions and Issues of Concern

Flight lines can be surveyed at the nominal 1000m AGL. Two cross-strips were included, one that covers the NEON tower and the second that crosses the Priority 2 flight areas. Duration of the 90% peak greenness period is short at approximately 51 days (**Figure 4.7.4**). Historical cloud cover data from Albany Airport (KABY) show that only 31-44% of days are cloud-free during a typical August and September time period, while 52-54% of days are cloud-free from January-March (Figure **4.7.5**). August and September also fall within hurricane season, which adds significant risk to deployment during the late summer months. Since JERC shows relatively high NDVI during the entire calendar year (the dominant longleaf pine vegetation is evergreen), it is recommended to move the flight deployment to the January-March time period when cloud-free days are more frequent and the likelihood of hurricanes is low.

Prescribed burning is actively practiced at JERC, mainly in the spring, as part of restoration and management efforts to return oak-dominated areas that emerged when fire activity was suppressed to native longleaf pine habitat, on which many native threatened or endangered species depend. Prescribed burning is a major concern for AOP due to the smoke and haze this produces since these may interfere with spectroscopic returns. Coordination with field operations personnel on a daily basis for the purpose of suspending prescribed burning in JERC before flights are initiated is highly recommended.

OSBS falls within Class G airspace. The east side of the Priority 1 flight survey box is located 2.4 nm from the west edge of the Class E airspace of the Camilla-Mitchell airport (KCXU).

Table 4.7-1. Jones Ecological Research Center airborne survey area information

Site name	Jones Ecological Research Center (JERC)
NEON site type	Gradient
Latitude/longitude boundaries	Upper Left: 31°19'34.31"N, 84°34'11.86"W Upper Right: 31°19'30.62"N, 84°24'30.24"W Lower Left: 31° 9'25.14"N, 84°34'6.41"W Lower Right: 31° 9'30.26"N, 84°24'37.20"W
Flight survey area	Priority 1: 186.4 km^2 Priority 2: 43.3 km^2
Number of flight lines; flight line length; flight altitude (MSL)	Priority 1: 25 lines plus 1 cross strip; 18.7 km average length; 3450' MSL Priority 2: 12 lines plus 1 cross strip; 8.6 km average length; 3450' MSL
Airspace class	Class G airspace. The east side of the Priority 1 flight survey box is located 2.4 nm from the west edge of the Class E airspace of the Camilla-Mitchell airport (KCXU). (FAA Sectional Aeronautical Raster Chart - Jacksonville (Edition 94) Aug 21, 2014)
Maximum terrain height	245 ft. MSL
Mean canopy height	10-25 m
FBO transit distance/time (@135kts)	25 nm / 11 min from KABY (Albany)
Estimated flight duration	Priority 1 survey area: 4h 47m Priority 2 survey area: 1h 56m
Mean start date peak greenness	Jul 17
Mean end date peak greenness	Sep 5
Average annual deviation from mean onset	9 days
Earliest onset date (2003-2012)	Jul 10
Percent of days with 0-10% cloud cover (9am-3pm)	Jan 54% Feb 52% Mar 54% Aug 31% Sep 44%
Domain headquarters and contact information	Robert Nelson National Ecological Observatory Network (NEON, Inc.) Field Operations Manager-Southeast 4579 N.W. 6th Street, Unit B-2 Gainesville, FL 32609 Phone: 352-505-2001 Cell: 407-908-6555 rnelson@neoninc.org

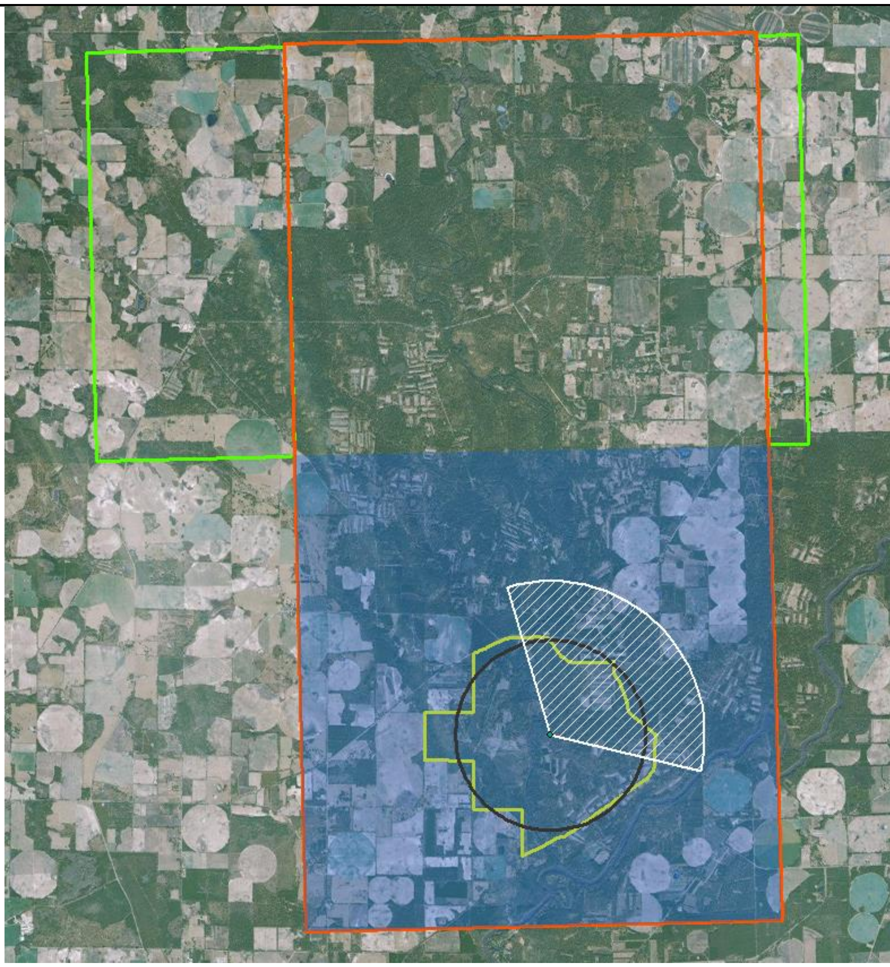


Figure 4.7.1. Jones Ecological Research Center (JERC) Priority 1 airborne survey area (orange); JERC priority 2 survey area (green); JERC Terrestrial Observation System sampling site boundary (yellow); cumulative eddy-covariance flux tower airshed (white); 2km radius buffer from tower (grey); 10x10km minimum area flight box (blue shaded square).

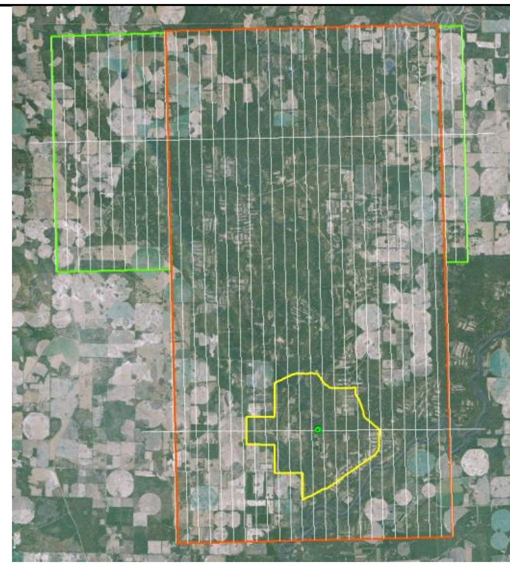


Figure 4.7.2. Flight lines over Jones Ecological Research Center at nominal 1000m AGL.

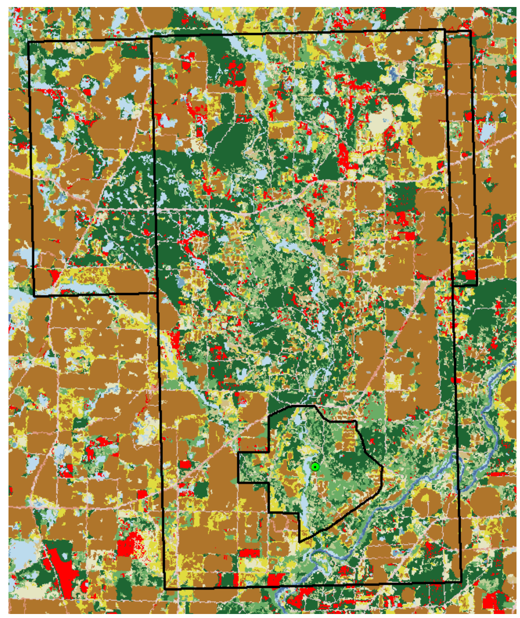


Figure 4.7.3. Land cover[1] and 2000-2012 forest cover change[2] (red)

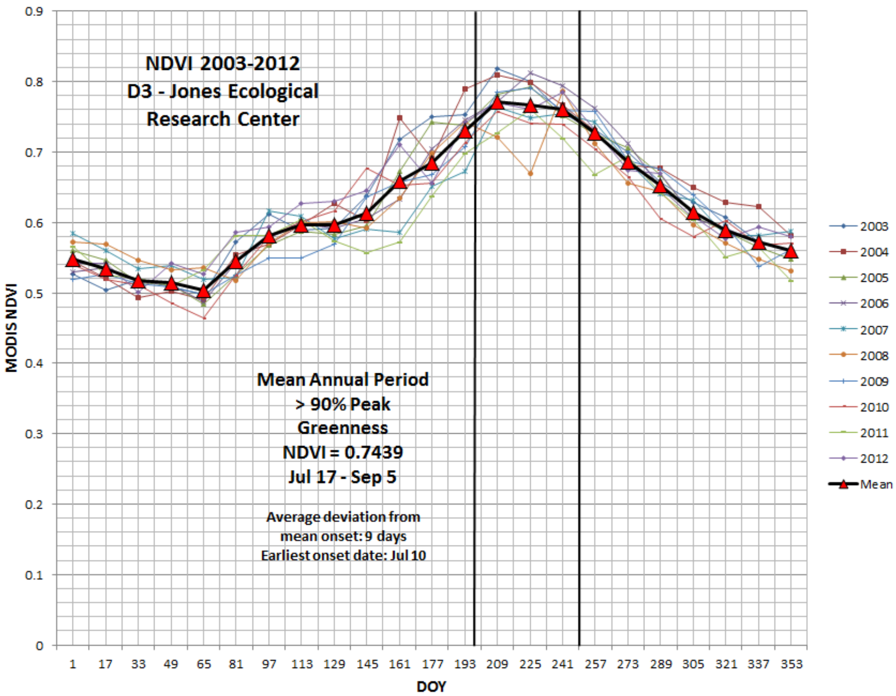


Figure 4.7.4. Phenology for the Jones Ecological Research Center airborne survey area[3]

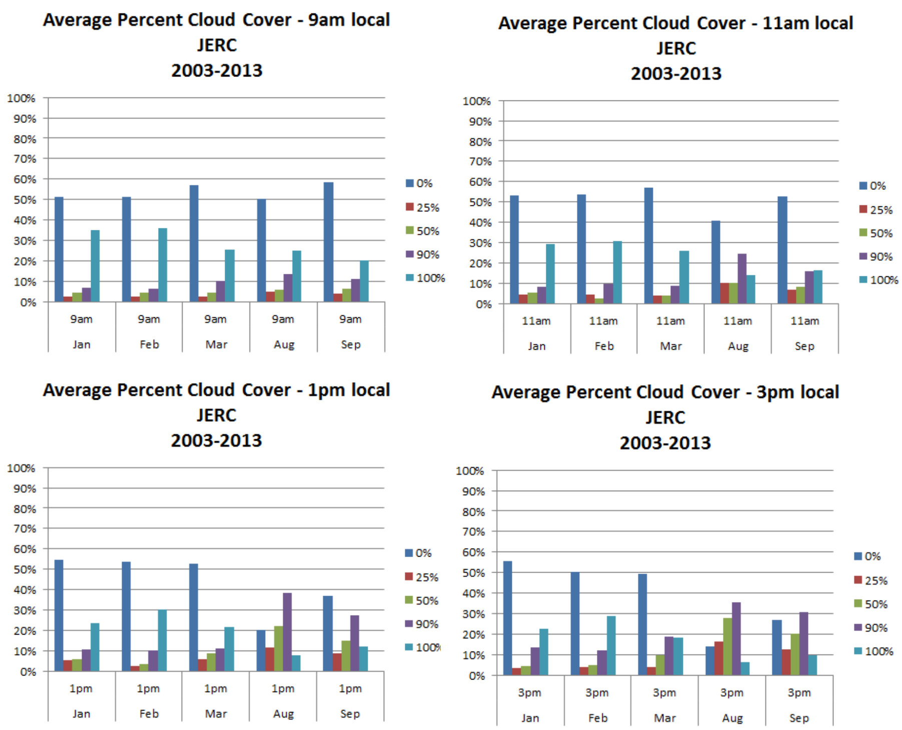


Figure 4.7.5. Cloud fractions per hour by month[4]

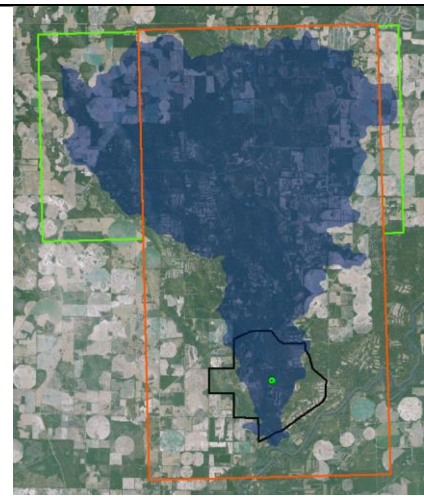


Figure 4.7.6. Watershed boundary[8] of JERC and Ichawaynochaway Creek aquatic site

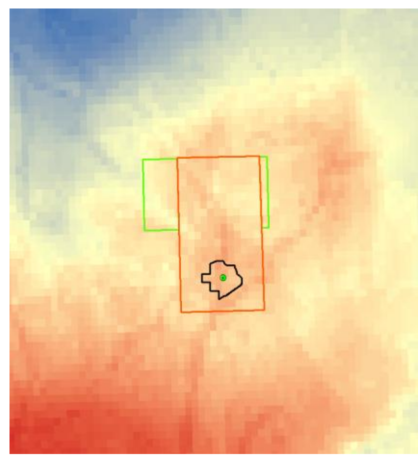


Figure 4.7.7. Average annual maximum temperature (1981-2010) (red=higher T°)[6]

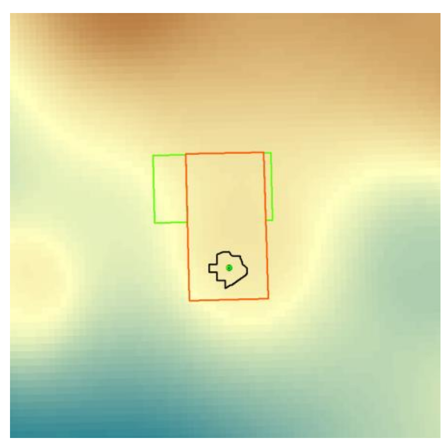


Figure 4.7.8. Average monthly precipitation (1981-2010) (blue=higher PPT)[6]

4.8 Domain 10 – Central Plains Ecological Range

4.8.1 Site and Vegetation Characteristics

The Central Plains Ecological Range (CPER) is a 15,500 acre (62.7 km^2) research station owned and managed by the US Department of Agriculture-Agricultural Research Service (USDA-ARS). In the 1930's, farms and ranches throughout the western Great Plains were abandoned due to drought and poor land management practices, contributing to what is commonly known as the “dust-bowl”. The U.S. Forest Service requested that CPER be established to study improved management practices on fragile grasslands. The Agricultural Act of 1953 transferred administration of CPER to the USDA-ARS, and grazing research initiated in the 1930's is still being conducted to study the long-term impacts of livestock on rangeland resources. CPER is a part of the Long-Term Ecological Research (LTER) Program, and Colorado State University and the Natural Resources Ecology Laboratory have active research projects at the site.

The CPER ecosystem is characterized by flat to slightly hilly topography (1587-1721m) dominated by C4 native shortgrass steppe vegetation with a variety of other plant communities (e.g., floodplain shrubland and salt meadow) also present. Blue grama (*Bouteloua gracilis*) contributes 60-80% percent of plant cover, biomass, and net primary productivity. Other important plants include buffalo grass (*Buchloe dactyloides*), prickly pear cactus (*Opuntia polyacantha*), rabbitbrush (*Chrysothamnus nauseosa*) and saltbush (*Atriplex canescens*). The climate regime is characterized by low precipitation, periodic droughts, and a high degree of interannual and interseasonal climatic variability. This is evident in the pattern of phenological variability observed in **Figure 4.8.4**. The biotic communities of the shortgrass steppe ecosystem are adapted to extended periods of drought; species such as blue grama and prickly-pear cactus, large herbivores (cattle), and burrowing animals like the black-tailed prairie dog (*Cynomys ludovicianus*) play important roles in ecosystem functioning (e.g., nutrient cycling, seed dispersal).

4.8.2 Scientific Objectives and Airborne Survey Area Design Criteria

As the NEON Domain 10 core site, CPER was selected to assess the impacts of dust transported by prevailing westerly winds from land use practices in Domains 13 and 15 onto the Front Range and Great Plains; and the impacts of reactive nitrogen generated by agriculture and transportation in Domain 10 that is transported upslope by night-time westerly winds towards domains 13 and 15 (Schimel 2011). Both dust and nitrogen have major effects on biogeochemistry and ecohydrology, and the influence productivity and biodiversity health.

The Terrestrial Observation System (TOS) sampling area occupies approximately 10km^2, and the 90% cumulative eddy covariance flux tower airshed extends 1140m to the east of the tower (**Figure 4.8.1**). The 10km x 10km Priority 1 airborne survey area (**Figure 4.8.2**) includes the east-oriented tower airshed and the entire TOS boundary. The baseline survey boundary centered on the tower was shifted 1660m to the north and 1290m to the east to encompass the entire CPER TOS boundary. Vegetation cover in CPER is highly representative of the natural vegetation across the region. No obvious land use change is apparent in the study area, and there does not appear to be any new vegetation or land cover feature that would be captured if the flight box were expanded (**Figure 4.8.3**). While the impact of dust deposition on ecohydrology is a primary concern, the survey boundary was not expanded to cover the large network of watersheds upstream of the CPER TOS boundary due to their extensive size (**Figure 4.8.6**). CPER and the associated flight box are located within a drier, hotter area than the plateau to the north (**Figure 4.8.7**, **Figure 4.8.8**) but since the primary focus of CPER is on dust and nitrogen deposition and transport, moderate spatial variability in climate does not in itself justify expanding the flight box to include the upland area given that it would more than double flight times.

4.8.3 Flight Conditions and Issues of Concern

Flight lines can be surveyed at the nominal 1000m AGL. A cross-strip has been included that covers the NEON tower. Duration of the 90% peak greenness period is approximately 45 days (**Figure 4.8.4**). The narrow peak greenness window and large average annual deviation from the mean onset date of 90% peak greenness mean that each year's phenology pattern should be carefully tracked so that the flight survey start date can be adjusted accordingly. Aside from an intensive glider activity advisory 8 nm to the west of the flight box, there are no special flight navigation considerations or concerns associated with airborne surveys over CPER.

Table 4.8-1. Central Plains Ecological Range

Site name	Central Plains Ecological Range (CPER)
NEON site type	Core
Latitude/longitude boundaries	Upper Left: 40° 52' 23.29"N, 104° 49' 15.28"W Upper Right: 40° 52' 23.29"N, 104° 39' 19.52"W Lower Left: 40° 46' 48.43"N, 104° 49' 15.28"W Lower Right: 40° 46' 48.43"N, 104° 39' 19.52"W
Flight survey area	100 km^2
Number of flight lines; flight line length; flight altitude (MSL)	27 lines plus 1 cross strip; 10 km average length; 8650'-8750' MSL
Airspace class	Class G (FAA Sectional Aeronautical Raster Chart - Cheyenne (Edition 90) July 24, 2014)
Maximum terrain height	5645 ft. MSL
Mean canopy height	n/a
FBO transit distance/time (@135kts)	50.1nm / 27 min from KBDU Boulder Municipal Airport
Estimated flight duration	Priority 1 survey area: 3h 43m Priority 2 survey area: n/a
Mean start date peak greenness	May 22
Mean end date peak greenness	Jul 6
Average annual deviation from mean onset	30 days
Earliest onset date (2003-2012)	May 20
Percent of days with 0-10% cloud cover (9am-3pm)	May 53% June 65% July 70% Aug 72% Sep 70%
Domain headquarters and contact information	Tracey Baldwin Manager Field Operations NEON, Inc. 1685 38th St., Ste. 100 Boulder, CO 80301 Office: (720) 836-2462 tbaldwin@neoninc.org

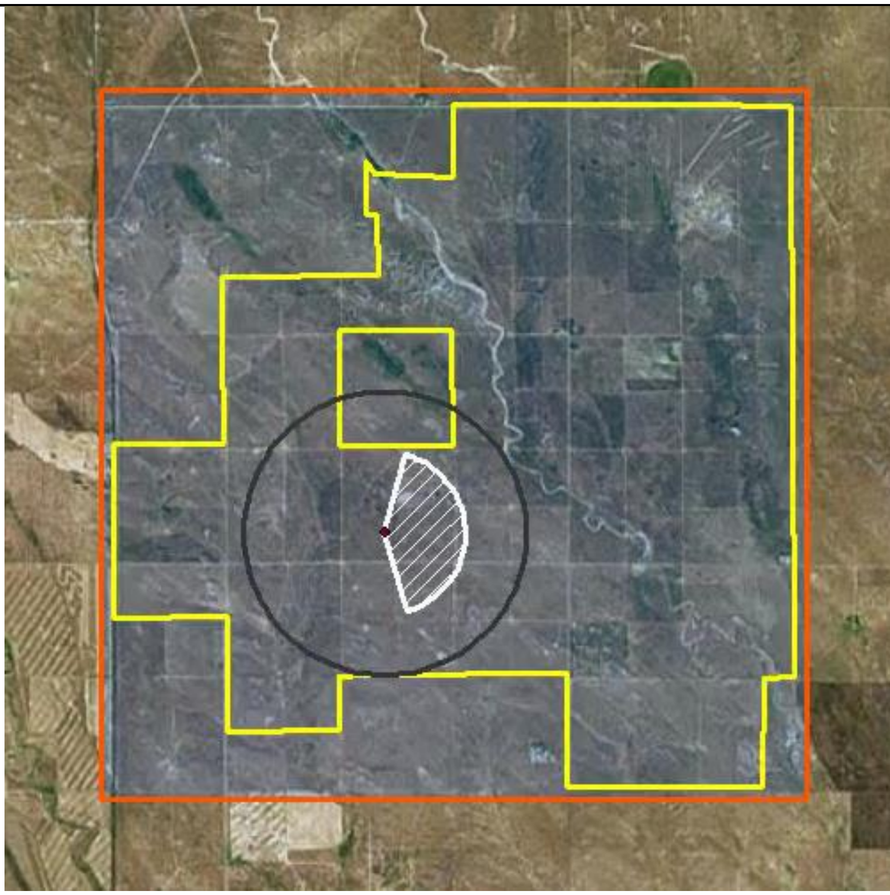


Figure 4.8.1. Central Plains Ecological Range airborne survey area (orange); Terrestrial Observation System sampling site boundary (yellow); cumulative eddy-covariance flux tower airshed (white); 2km radius buffer from tower (grey); 10x10km minimum area flight box (blue shaded square). No Priority 2 survey area required.

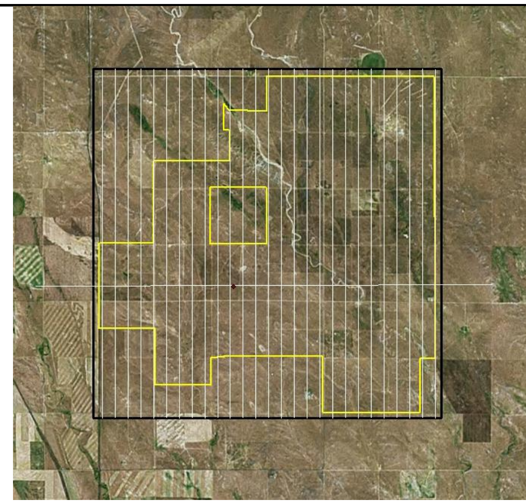


Figure 4.8.2. Flight lines over Central Plains Ecological Range at nominal 1000m AGL

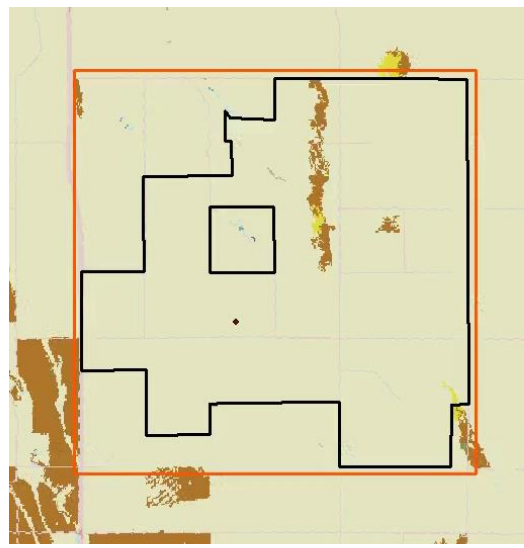


Figure 4.8.3. Land cover[1] and 2000-2012 forest cover change[2]

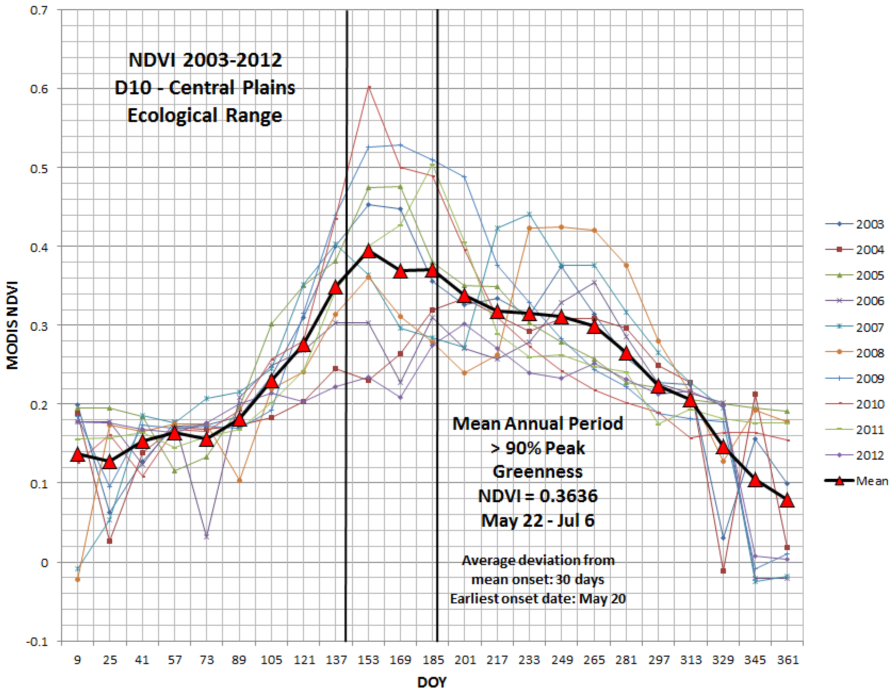


Figure 4.8.4. Phenology for the Central Plains Ecological Range airborne survey area[3]

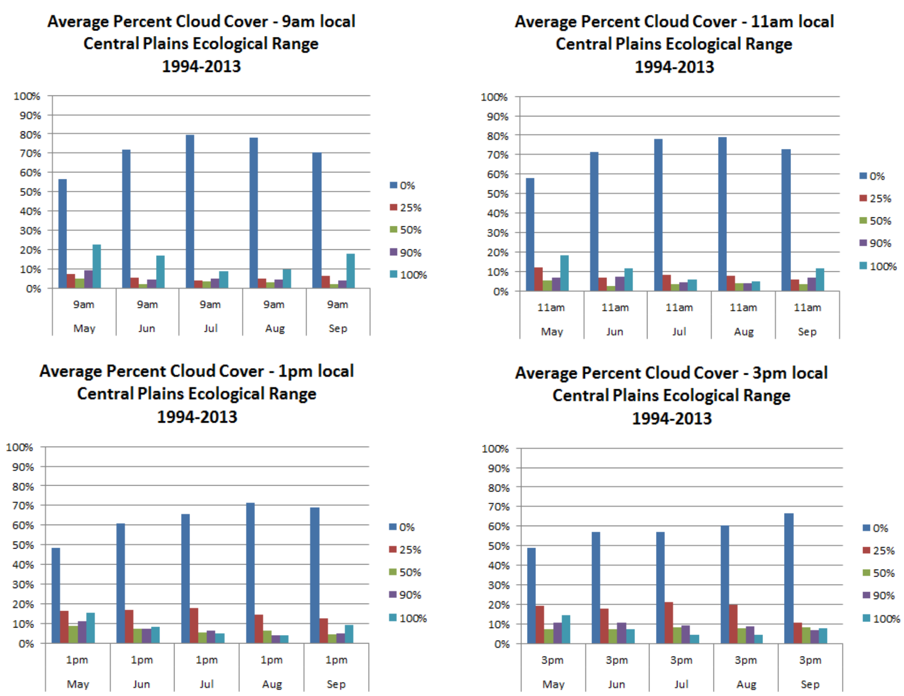


Figure 4.8.5. Cloud fractions per hour by month[4]

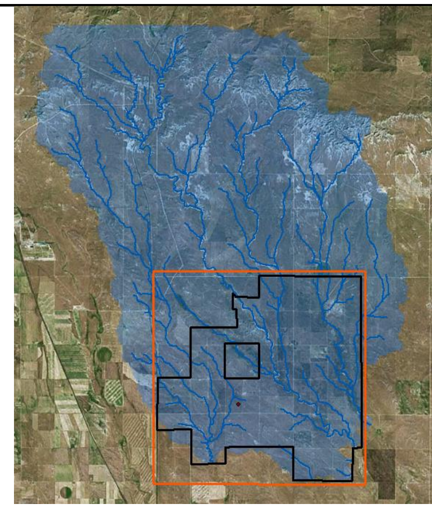


Figure 4.8.6. CPER watershed boundary extending 15km upstream of CPER[5]

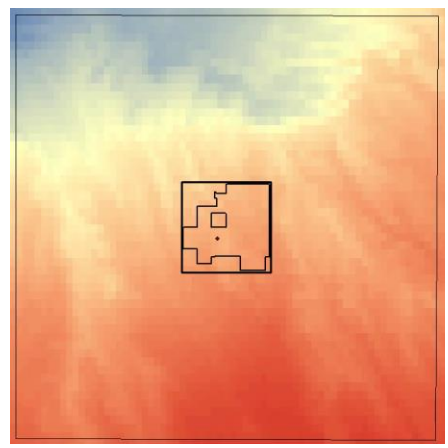


Figure 4.8.7. Average annual maximum temperature (1981-2010) (red=higher T°)[6]

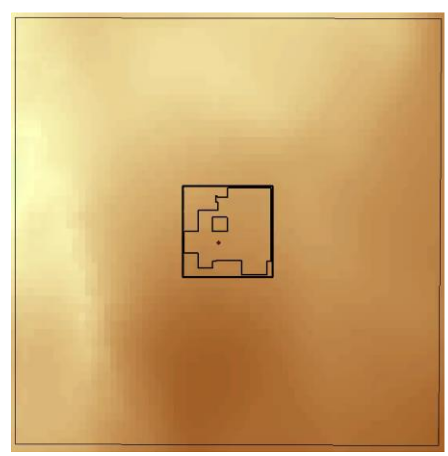


Figure 4.8.8. Average monthly precipitation (1981-2010) (yellow=higher PPT)[6]

4.9 Domain 10 – North Sterling Agricultural Site

4.9.1 Site and Vegetation Characteristics

The North Sterling gradient agricultural site (STER) is located near Sterling, CO at an elevation ranging from 1341-1425m. It is at the edge of a non-tilled experimental field that is used for the long-term sustainable Dryland Agroecosystems Project (DAP), which was initiated in 1985 at three sites in eastern Colorado to evaluate the effects of cropping intensity on production, water use efficiency, and selected soil chemical and physical properties. The DAP site was chosen because of the three representative soils present in the area. Prior to establishment of the no-till cropping systems the site had been under conventional tillage since 1910. The primary crop was winter wheat grown in a wheat-fallow rotation.

Cropping systems under no-till management were initiated in 1985. These systems included: winter wheat (*Triticum aestivum L.*), winter wheat-maize (*Zea mays L.*), winter wheat-maize-proso millet (*Panicum miliaceum L.*), continuous cropping (maize, sorghum, winter wheat, forage millet, and sunflower) and perennial grass. The systems represent a gradient of cropping intensity (crops divided by years in the rotation). Grass stands were established in the spring of 1986 and contain a mixture of perennial species including both warm and cool season grasses.

4.9.2 Scientific Objectives and Airborne Survey Area Design Criteria

As a NEON Domain 10 gradient site, STER was primarily selected to assess the impacts of climate change on agriculture, and also to evaluate both the impacts of dust transported by prevailing westerly winds from land use practices in Domains 13 and 15 onto the Front Range and Great Plains, and associated impacts of reactive nitrogen generated by agriculture and transportation in Domain 10 transported upslope by night-time westerly winds towards domains 13 and 15 (Schimel 2011). Both dust and nitrogen have major effects on biogeochemistry and ecohydrology, and the influence productivity and biodiversity health.

The Terrestrial Observation System (TOS) sampling area occupies approximately 5km^2, divided into two plots covering the 1km^2 primary agricultural site and an adjoining 4km^2 area dedicated to farming (**Figure 4.9.1**). The 90% cumulative eddy covariance flux tower airshed extends 780m to the west of the tower. The 10km x 10km STER airborne survey box includes the tower airshed and the entire TOS boundary. The baseline airborne survey area centered on the tower was shifted 2646m to the north and 1482m to the west to cover the entire watershed of the TOS boundary (**Figure 4.9.6**). STER is located in an area characterized by a relatively homogenous temperature and precipitation regime (**Figure 4.9.7** and **Figure 4.9.8**); the drier, warmer area to the west of STER is not used for agriculture and therefore beyond the scope of the primary science goal for the site. A single Priority 1 is assigned to the 10km x 10km flight area (**Figure 4.9.2**).

4.9.3 Flight Conditions and Issues of Concern

Flight lines can be surveyed at the nominal 1000m AGL. A cross-strip has been included that covers the NEON tower. Duration of the 90% peak greenness period is approximately 114 days (**Figure 4.9.4**). The large average annual deviation from the mean onset date of 90% peak greenness means that each year's phenology pattern should be carefully tracked so that the flight survey start date can be adjusted accordingly. There are no special flight considerations or concerns associated with airborne surveys over STER.

Table 4.9-1. North Sterling Agricultural Site

Site name	North Sterling Agricultural Site (STER)
NEON site type	Gradient
Latitude/longitude boundaries	Upper Left: 40°31'27.32"N, 103° 6'24.51"W Upper Right: 40°31'29.16"N, 102°58'48.38"W Lower Left: 40°26'5.83"N, 103° 6'24.95"W Lower Right: 40°26'7.14"N, 102°58'49.59"W
Flight survey area	100 km^2
Number of flight lines; flight line length; flight altitude (MSL)	24 lines plus 1 cross strip; 10 km average length; 7800’-7850’ MSL
Airspace class	Class G abutting Class E and overlapping V169 airway to the west (FAA Sectional Aeronautical Raster Chart - Cheyenne (Edition 90) July 24, 2014)
Maximum terrain height	4677 ft. MSL
Mean canopy height	n/a
FBO transit distance/time (@135kts)	103 nm / 46 min from KBDU Boulder Municipal Airport
Estimated flight duration	Priority 1 survey area: 3h 43m Priority 2 survey area: n/a
Mean start date peak greenness	May 2
Mean end date peak greenness	Aug 25
Average annual deviation from mean onset	44 days
Earliest onset date (2003-2012)	Apr 1
Percent of days with 0-10% cloud cover (9am-3pm)	May 54% June 66% July 73% Aug 73% Sep 69%
Domain headquarters and contact information	Tracey Baldwin Manager Field Operations NEON, Inc. 1685 38th St., Ste. 100 Boulder, CO 80301 Office: (720) 836-2462 tbaldwin@neoninc.org

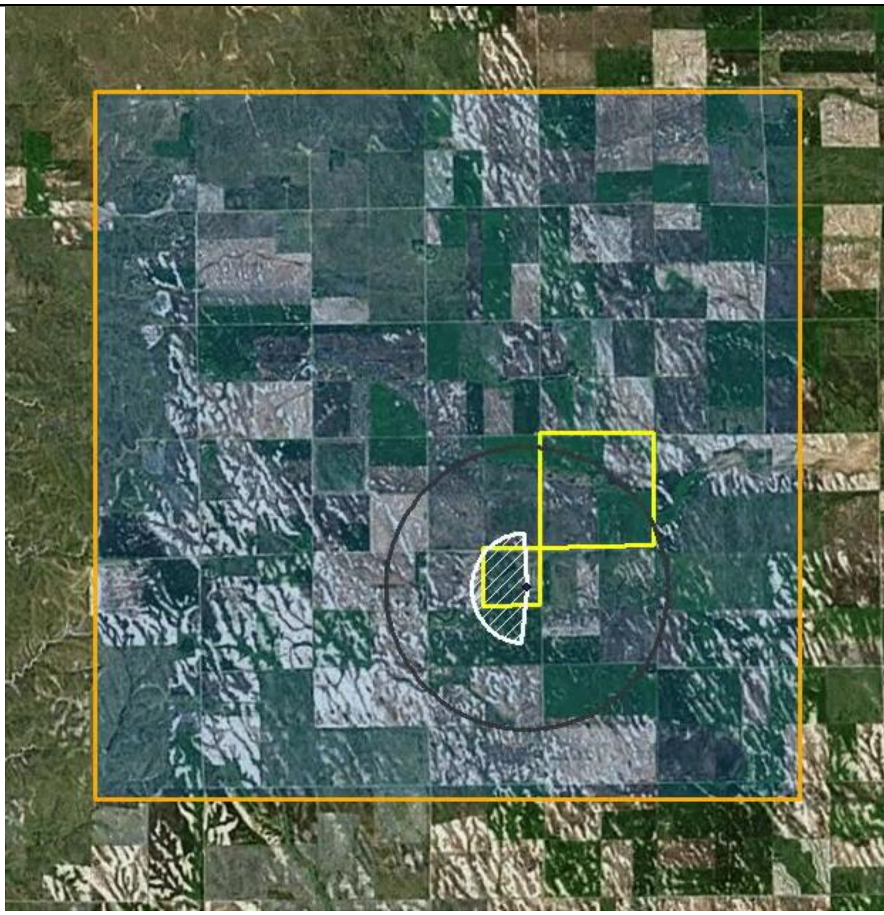


Figure 4.9.1. North Sterling Agricultural Site airborne survey area (orange); Terrestrial Observation System sampling site boundary (yellow); cumulative eddy-covariance flux tower airshed (white); 2km radius buffer from tower (grey); 10x10km minimum area flight box (blue shaded square). No Priority 2 survey area required.

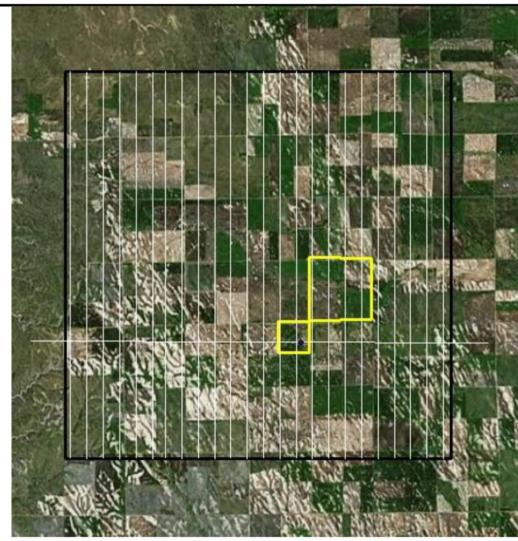


Figure 4.9.2. Flight lines over Central Plains Ecological Range at nominal 1000m AGL

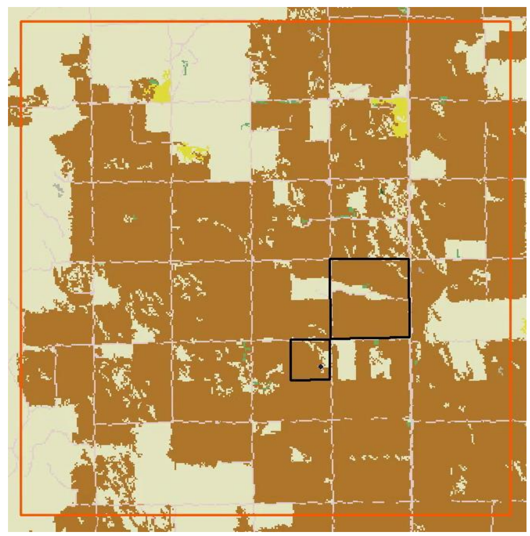


Figure 4.9.3. Land cover[1] and 2000-2012 forest cover change[2]

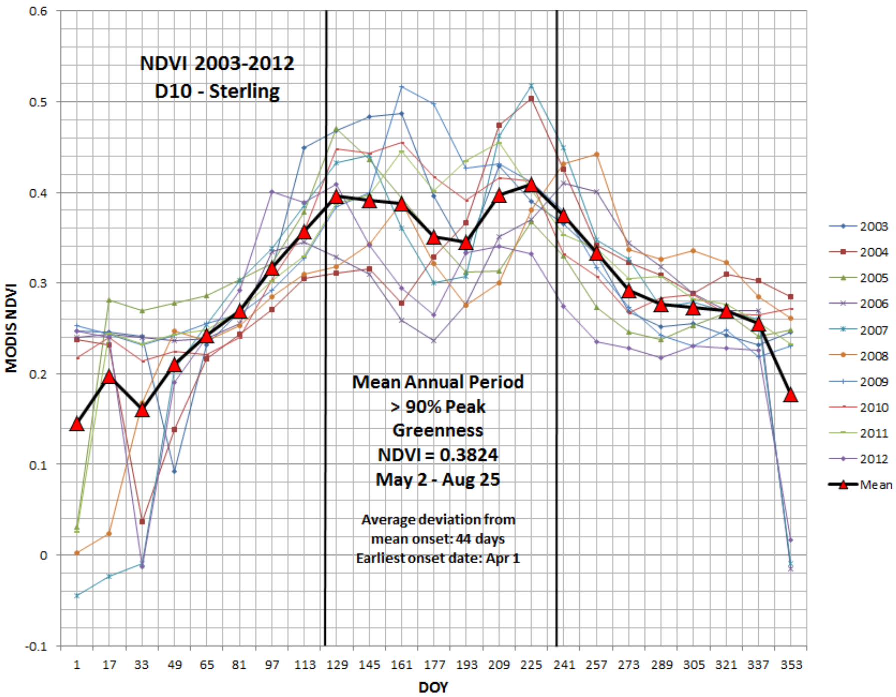


Figure 4.9.4. Phenology for the North Sterling Agricultural Site airborne survey area[3]

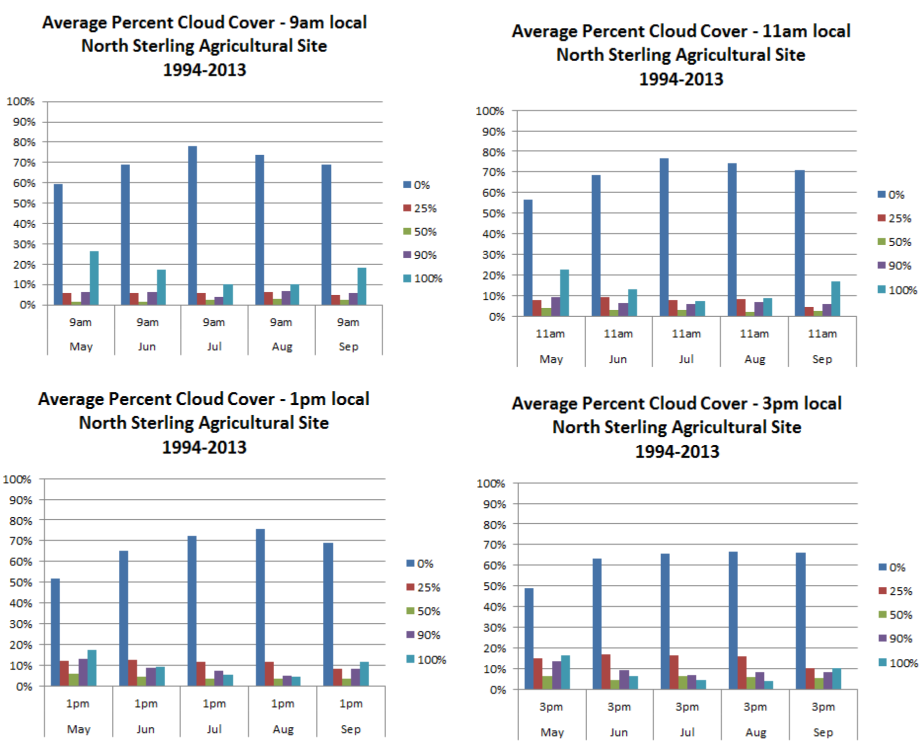


Figure 4.9.5. Cloud fractions per hour by month[4]

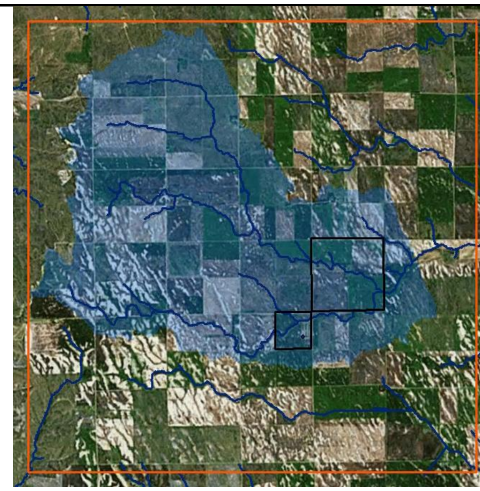


Figure 4.9.6. STER TOS watershed boundary[5]

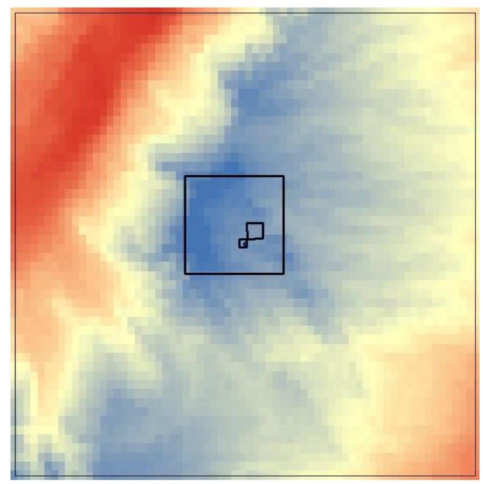


Figure 4.9.7. Average annual maximum temperature (1981-2010) (red=higher T°)[6]

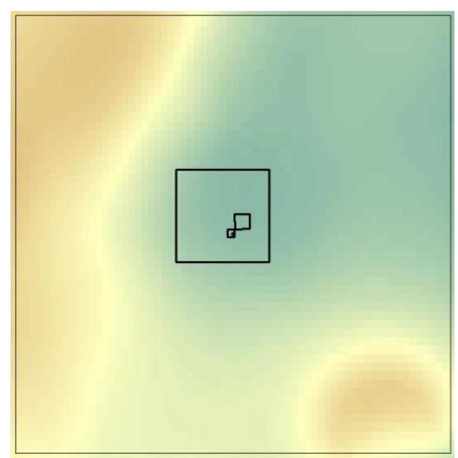


Figure 4.9.8. Average monthly precipitation (1981-2010) (yellow=higher PPT)[6]

5 FLIGHT CAMPAIGN SCHEDULING

5.1 Estimated Flight Hours per Site

Domain	Site Name	Flight Box Dim_X (km)	Flight Box Dim_Y (km)	Flight time @ 4 min. turns (hrs)	Neares t FBO	Distan ce to FBO (nm)	RT Flight Time to/fro m FBO (min)	Flight time on-site w/ 4 min turns (hrs)	Exceed s 4.5 hrs?	Multiple Flight Time Est. (hrs)	Minimum flight time per site	Minimum Days (1 day = 4.5 hrs flight time)	Percent of days with 0-10% cloud cover (avg 9am-3pm)	Cloud contin gency factor	Total est. days per site with contin gency
1	HARV	10.2	21.0	5.73	Nashua (I	39	35	6.31		6.89	8.85	2	43%	2.3	5
1	BART	10.0	10.0	4.50	Nashua (I	77	68	5.64		6.78	8.71	2	43%	2.3	5
	HOPB	3.5	5.6	1.20	Nashua (I	42	37	1.82		1.82	2.36	1	41%	2.4	3
2	SCBI	10.0	10.0	4.00	Charlotte	48	43	4.71		5.42	6.99	2	42%	2.4	5
2	SERC	10.0	10.0	3.42	Charlotte	107	95	5.00		6.59	8.13	2	53%	1.9	4
2	BLAN	13.0	10.0	4.25	Charlotte	58	52	5.11		5.97	7.70	2	42%	2.4	5
3b	OSBS	16.2	16.0	4.22	Kissimme	88	78	5.52		6.82	9.08	2	34%	2.9	6
3b	DSNY	12.0	13.5	4.50	Kissimme	14	12	4.71		4.91	6.54	2	34%	2.9	6
3a	JERC	10.0	10.0	4.78	Thomasv	44	39	5.44		6.09	7.91	2	40%	2.5	5
	GUAN	11.5	11.0	4.50	Rafael He	35	31	5.02		5.54	7.75	2	20%	5.0	10
	CUPE / GUIL	6.6	5.5	2.28	Rafael He	27	24	2.68		2.68	3.76	1	20%	5.0	5
	LAJA	10.0	10.0	3.50	Rafael He	28	25	3.91		3.91	5.48	1	20%	5.0	5
5	UNDE	11.3	13.0	4.17	Rhinelanc	37	33	4.71		5.26	6.86	2	39%	2.5	6
5	STEI-CHEQ	10.0	10.0	1.92	Rhinelanc	29	26	2.35		2.35	3.05	1	40%	2.5	3
5	STEI/TREE	10.0	11.4	3.42	Rhinelanc	10	9	3.56		3.56	4.63	1	40%	2.5	3
	LIRO	2.0	2.0	0.67	Rhinelanc	24	21	1.02		1.02	1.34	1	37%	2.7	3
6	KONZ/KONA	14.0	11.0	5.75	Forbes Fi	44	39	6.40		7.05	8.78	2	51%	2.0	6
6	UKFS	10.0	10.0	3.58	Forbes Fi	23	20	3.92		3.92	4.77	1	57%	1.8	2
	MCDI	7.5	5.5	2.08	Forbes Fi	40	36	2.68		2.68	3.25	1	57%	1.8	2
7	ORNL	22.0	16.0	7.67	Asheville	98	87	9.12		10.57	14.08	3	34%	3.0	9
2	MLBS	10.0	10.0	4.75	Charlotte	110	98	6.38		8.01	10.67	2	34%	3.0	6
7	GRSM	36.0	20.0	35.00	Asheville	57	51	35.84		41.76	41.76	10	18%	5.6	17
8	TALL	10.0	12.5	3.75	Birmingh:	51	45	4.51		5.26	6.81	2	41%	2.4	5
8	DELA	10.0	10.0	3.43	Birmingh:	81	72	4.63		5.83	7.50	2	43%	2.3	5
8	LENO	10.0	13.5	4.13	Birmingh:	127	113	6.01		7.90	10.15	2	43%	2.3	5
9	WOOD	10.0	10.0	7.75	Bismark I	72	64	8.82		9.88	12.01	3	57%	1.8	6
9	DCFS	10.0	10.0	0.00	Bismark I	0	0	0.00		0.00	0.00	0	57%	1.8	0
9	NOGP	10.0	10.0	3.33	Bismark I	7	6	3.44		3.44	4.18	1	57%	1.8	2
10a	CPER	10.0	10.0	3.87	Boulder N	53	47	4.65		5.44	6.36	2	66%	1.5	4
10b	STER	10.0	10.0	3.57	Boulder N	104	92	5.11		6.65	7.55	2	73%	1.4	3
	ARIK	5.0	10.0	5.17	Boulder N	129	115	7.08		8.99	10.47	2	67%	1.5	3
10b	RMNP	10.0	10.0	6.25	Boulder N	35	31	6.77		7.29	8.53	2	66%	1.5	4
11	CLBJ	11.5	11.5	3.67	Wichita F.	60	53	4.56		5.44	6.78	2	51%	2.0	4
	PRIN	11.0	10.0	2.88	Wichita F.	60	53	3.77		3.77	4.70	1	51%	2.0	2
	BLUE	6.0	5.0	3.02	Wichita F.	97	86	4.45		4.45	5.48	1	54%	1.9	2
11	OAES	14.0	15.0	7.15	Wichita F.	90	80	8.48		9.82	12.07	3	54%	1.9	6
12	YELL	14.0	15.8	10.33	Gallatin F	59	52	11.21		12.96	16.91	3	39%	2.6	8
13	NIWO	10.0	10.0	6.17	Boulder N	26	23	6.55		6.94	9.95	2	13%	7.7	16
13	MOAB	10.0	10.0	3.67	Boulder N	228	203	7.04		10.42	11.46	3	80%	1.3	4
	WLOU	4.4	4.1	1.42	Boulder N	35	31	1.94		1.94	2.10	1	83%	1.2	2
14	SRER	22.5	22.4	12.82	El Paso Ir	235	209	16.30		23.26	27.56	6	63%	1.6	10
14	JORN	10.0	17.7	3.88	El Paso Ir	55	49	4.70		5.51	6.48	2	65%	1.5	4
15	ONAQ	14.7	10.0	5.60	Salt Lake	43	38	6.24		6.87	8.90	2	41%	2.4	5
	REDB	2.0	5.0	1.97	Salt Lake	9	8	2.10		2.10	2.72	1	41%	2.4	3
16	WREF	10.0	19.0	9.70	Hillsboro	45	40	10.37		11.03	16.25	3	37%	2.7	9
16	ABBY	10.0	10.0	5.58	Hillsboro	30	27	6.03		6.47	9.53	2	37%	2.7	6
17a	SJER	10.0	10.0	3.83	Fresno	21	19	4.14		4.14	5.62	1	29%	3.4	4
17b	SOAP	10.0	10.0	8.88	Fresno	28	25	9.30		9.71	12.29	3	47%	2.1	7
17b	TEAK	16.0	14.0	7.22	Fresno	41	36	7.82		8.43	10.67	2	47%	2.1	5
18	TOOL	23.7	24.5	7.98	Deadhors	100	89	9.46		12.43	17.15	3	24%	4.2	10
18	BARO	13.7	11.7	6.25	Deadhors	176	156	8.86		11.46	16.05	3	20%	5.0	10
	OKSR	7.8	14.5	5.50	Deadhors	100	89	6.98		8.46	11.68	2	24%	4.2	9
19	DEJU	10.0	13.1	5.43	Fairbanks	81	72	6.63		7.83	11.16	2	15%	6.7	7
19	BONA	10.0	10.0	6.48	Fairbanks	22	20	6.81		7.13	10.16	2	15%	6.7	7
19	HEAL	10.0	10.0	4.28	Fairbanks	69	61	5.31		6.33	9.02	2	15%	6.7	7
	OLAA	10.0	10.0	3.50	Honolulu	198	176	6.43		9.37	13.58	3	10%	10.0	30

5.2 Example of Deployment Schedule with Multiple Payloads

Payload	Domain	Core Site	FBO Name	Departure FBO	Destination FBO	FBO-FBO Transit Distance (nm)	FBO-FBO Transit Hrs @ 135 kts	Cooling Days	FBO-FBO Transit Days	Transit Days + cooling (rounded up)	Domain Latest Start Peak Greenness	Domain Earliest End Peak Greeness	Domain Flight Days	No Fly Days (flight days/8)	Days per Domain	Start Julian Day	End Julian Day	Domain Surveys Start Date	Domain Surveys End Date	Cummulative Flight Hours
1		BLDR	Boulder M	KGJT	KBDU	163	1.2	0	0.2	1	n/a	n/a	0	0	0	65	65	5-Mar	5-Mar	1.21
1		BLDR	Boulder M	KBDU	KFAT	710	5.26	0	0.9	1	n/a	n/a	14	0	14	66	79	6-Mar	19-Mar	65.47
1	17	SJER	Fresno	KFAT	KTYS	1724	12.77	2	4.1	5	12-Feb	4-Apr	4	1	5	81	85	21-Mar	25-Mar	83.40
1	7	GRSM	McGhee T	KTYS	KSPS	723	5.36	0	0.9	1	19-May	23-Sep	17	3	20	91	110	31-Mar	19-Apr	126.72
1	11	CLBJ	Wichita Fa	KSPS	KBHM	587	4.35	0	0.7	1	21-Apr	2-May	10	2	12	119	130	28-Apr	9-May	152.71
1	8	TALL	Birmingha	KBHM	KTYS	192	1.42	0	0.2	1	29-Apr	11-Sep	15	2	17	132	148	11-May	27-May	179.05
1	7	ORNL	McGhee T	KTYS	KFOE	588	4.36	0	0.7	1	19-May	6-Sep	6	1	7	150	156	29-May	4-Jun	194.97
1	6	KONZ	Forbes Fiel	KFOE	KBIS	520	3.85	0	0.6	1	22-May	4-Sep	8	1	9	158	166	6-Jun	14-Jun	210.98
1	9	WOOD	Bismark M	KBIS	KBZN	437	3.24	0	0.5	1	9-Jun	10-Aug	12	2	14	168	181	16-Jun	29-Jun	233.81
1	12	YELL	Gallatin Fie	KBZN	KBDU	432	3.20	0	0.5	1	9-Jun	26-Jul	7	1	8	183	190	1-Jul	8-Jul	250.19
1	10b	STER	Boulder M	IKBDU	KHEF	1286	9.53	2	3.6	4	3-May	21-Aug	3	1	4	194	197	12-Jul	15-Jul	267.38
1	2	SCBI	Manassas	KHEF	KASH	366	2.71	0	0.5	1	25-May	9-Sep	19	3	22	202	223	20-Jul	10-Aug	302.04
1	1	HARV	Nashua	KASH	KRHI	792	5.87	0	1.0	1	27-May	15-Sep	11	2	13	225	237	12-Aug	24-Aug	326.48
1	5	UNDE	Rhinelande	KRHI	KTVI	921	6.82	0	1.1	2	30-May	11-Sep	12	2	14	239	252	26-Aug	8-Sep	350.31
1	3a	JERC	Thomasvill	KTVI	KISM	202	1.50	0	0.2	1	21-Aug	28-Sep	5	1	6	255	260	11-Sep	16-Sep	361.67
1	3b	OSBS	Kissimmee	KISM	KTYS	469	3.47	0	0.6	1	21-Aug	28-Sep	9	2	11	262	272	18-Sep	28-Sep	382.10
1	7	GRSM	McGhee T	KTYS	KBDU	1037	7.68	0	1.3	2	19-May	23-Sep	17	3	20	281	300	7-Oct	26-Oct	427.74
		BLDR	Boulder M	KBDU	KGJT	163	1.21	0	0.2	1	n/a	n/a	7	1	8	303	310	29-Oct	5-Nov	443.95
			Subtotal			11312	83.79	4	18.0	27			176	28.00	204	240				443.95
2		BLDR	Boulder M	KGJT	KBDU	163	1.21	0	0.2	1	n/a	n/a	0	0	0	124	124	3-May	3-May	1.21
2		BLDR	Boulder M	KBDU	KBDU	0	0.00	0	0.0	0	n/a	n/a	17	0	17	125	141	4-May	20-May	30.21
2	10a	CPER	Boulder M	IKBDU	KSLC	312	2.31	0	0.4	1	23-May	5-Jul	7	1	8	142	149	21-May	28-May	41.97
2	15	ONAQ	Salt Lake C	KSLC	KHIO	559	4.14	0	0.7	1	20-Apr	21-Jun	6	1	7	151	157	30-May	5-Jun	58.85
2	16	WREF	Hillsboro A	KHIO	KFAT	546	4.04	0	0.7	1	7-Jun	17-Jul	11	2	13	159	171	7-Jun	19-Jun	78.34
2	17	SOAP	Fresno	KFAT	PASC	2209	16.36	2	4.7	5	22-Jun	10-Jul	8	1	9	180	188	28-Jun	6-Jul	109.02
2	18	TOOL	Deadhorse	PASC	PAFA	324	2.40	0	0.4	1	3-Jul	9-Aug	15	2	17	194	210	12-Jul	28-Jul	147.39
2	19	BONA	Fairbanks	PAFA	KELP	2500	18.52	2	5.1	6	9-Jun	16-Aug	15	2	17	212	228	30-Jul	15-Aug	190.10
2	14	SRER	El Paso Int	KELP	KBDU	496	3.67	0	0.6	1	11-Aug	9-Sep	11	2	13	235	247	22-Aug	3-Sep	225.45
2	13	NIWO	Boulder M	KBDU	KBDU	0	0.00	0	0.0	0	1-Jul	1-Sep	15	2	17	256	272	12-Sep	28-Sep	244.37
2		BLDR	Boulder M	KBDU	KGJT	163	1.21	0	0.2	1	n/a	n/a	7	1	8	273	280	29-Sep	6-Oct	260.57
			Subtotal			7272	53.87	4	13.0	18			112	14	126	153				260.57
														Total days		393		Total engine hrs		704.52
											Orange donotes domains where deployments have been truncated due to limited payload availability in 2017									
											Yellow denotes domains with sites flown outside of peak greenness due to limited payload availability in 2017									

John Musinsky: Includes 34 hrs training/ASO recertification and 25 hrs calibration flights (with RRV)

John Musinsky: P1 install: 1 day
Cooling: 2 days
Shakeout flight: 1 day
Recert of ASOs: 2 days
Campaign calibration flights: 3 days
Contingency: 5 days

John Musinsky: GRSM Fire Scar - Includes ASO training

John Musinsky: Maximum 5 day maintenance break plus 2 day cooling (7 days total) - minimum is 3 days down time

John Musinsky: 1 day maintenance break plus 2 day cooling (3 days total)

John Musinsky: Assumes MLBS flown from Domain 2 (KHEF)

John Musinsky: Maximum 5 day maintenance break plus 2 day cooling (7 days total) - minimum is 3 days down time

John Musinsky: Includes 15 hours for calibration flights

John Musinsky: P2 install: 1 day
Cooling: 2 days
Shakeout flight: 1 day
Campaign calibration flights: 3 days
Additional ASO training: 4 days
Contingency: 6 days

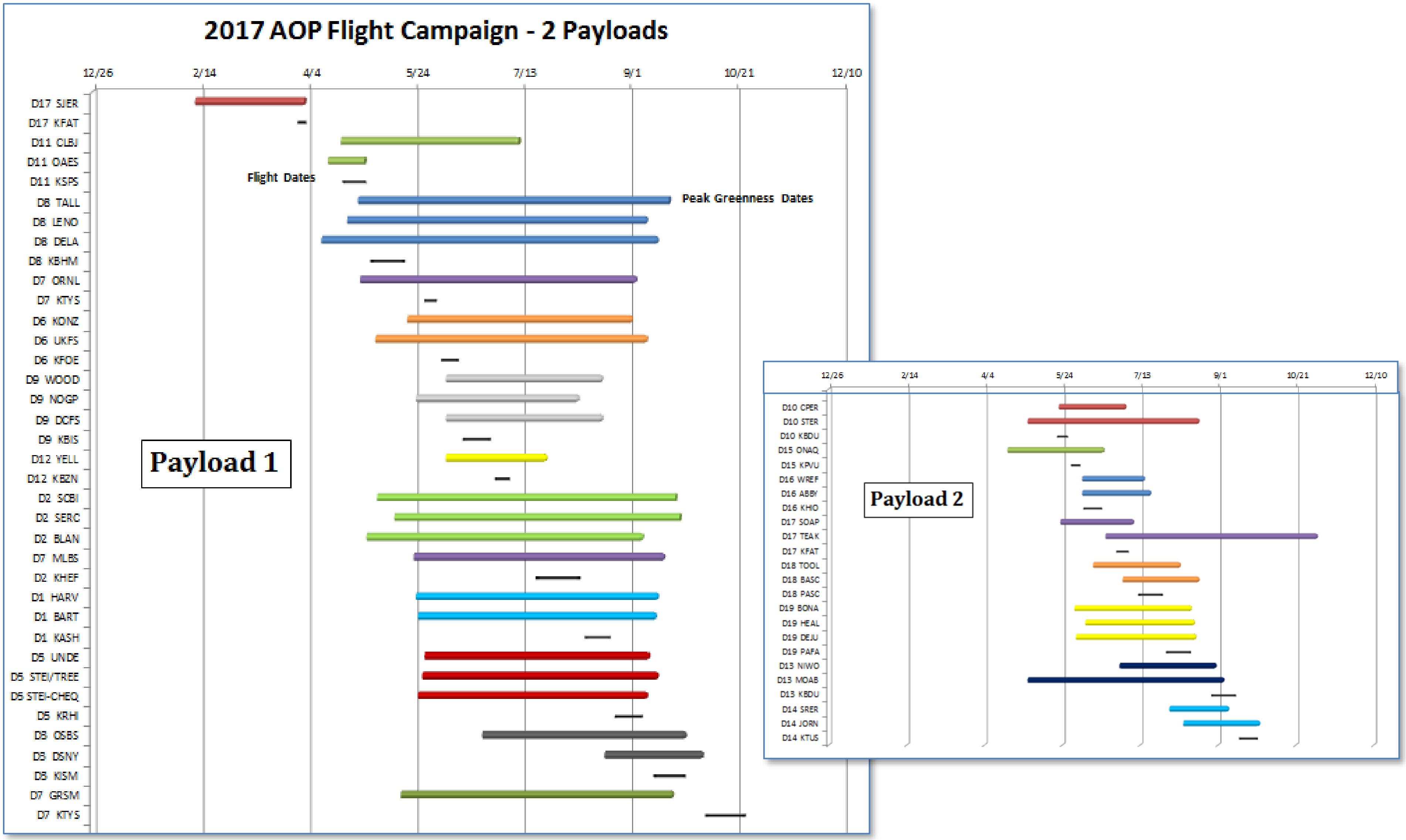
John Musinsky: Includes 4 hours additional ASO training and 25 hrs for calibration flights (with RRV)

John Musinsky: Maximum 5 day maintenance break plus 2 day cooling (7 days total) - minimum is 3 days down time

John Musinsky: Maximum 5 day maintenance break plus 2 day cooling (7 days total) - minimum is 3 days down time

John Musinsky: Includes 15 hours for calibration flights

5.3 Example of AOP Flight Campaign Deployments with Peak Greenness per Site – 2 Payloads



6 DATA SOURCES

[1]Fry, J., Xian, G., Jin, S., Dewitz, J., Homer, C., Yang, L., Barnes, C., Herold, N., and Wickham, J., "Completion of the 2006 National Land Cover Database for the Conterminous United States," PE&RS 77, no. 9 (2011):858-864.

[2]Hansen, M. C. , P. V. Potapov, R. Moore, M. Hancher, S. A. Turubanova, A. Tyukavina, D. Thau, S. V. Stehman, S. J. Goetz, T. R. Loveland, A. Kommareddy, A. Egorov, L. Chini, C. O. Justice, and J. R. G. Townshend, "High-Resolution Global Maps of 21st-Century Forest Cover Change," Science 342, no. 6160 (2013): 850-853.

[3]Oak Ridge National Laboratory Distributed Active Archive Center (ORNL DAAC). 2012. MODIS subsetted land products, Collection 5. Available on-line [http://daac.ornl.gov/MODIS/modis.html] from ORNL DAAC, Oak Ridge, Tennessee, U.S.A. Accessed November 2013.

[4]Weather Source, accessed May 2014, http://weathersource.com.

[5]NEON AOP. Modeled from 1/3 arc second USGS National Elevation Dataset DEM using ArcHydro, 2014.

[6]PRISM Climate Group, Oregon State University, created February 2013, http://prism.oregonstate.edu.

[7]United States Forest Service, Automated Lands Program (ALP), Land Status Record System Data (LSRS), http://svinetfc4.fs.fed.us/vector/lsrs.php.

7 BIBLIOGRAPHY

May 1, 2014. *FAA Sectional Aeronautical Raster Chart - New York (Edition 89).*

Abrahamson, W.G, and D.C. Hartnett. 1990. "Pine flatwoods and dry prairie." In *Ecosystems of Florida*, by Myers R.L. and J.J. Ewel (eds.), 103-149. Orlando: University of Central Florida Press.

Bowers, M.A. 1997. "University of Virginia's Blandy Experimental Farm." *Bulletin of the Ecological Society of America* 78 (3): 218-219.

Drake, J.B. and J.F. Weishampel. 2000. "Multifractal analysis of canopy height measures in a longleaf pine savanna." *Forest Ecology and Management* 128: 121-127.

2014. *Ecological Communities of Ichauway.* http://www.jonesctr.org/about_us/ecological_communities.html.

Eisenberg, J. F. and R. Franz. 1995. "Natural History of the Katharine Ordway Preserve-Swisher Memorial Sanctuary, Putnam County, Florida." *Bulletin of the Florida Museum of Natural History* 38: 260 pp.

Kampe, T.U., B. R. Johnson, M. Kuester, and M. Keller. 2010. "NEON: the first continental-scale ecological observatory with airborne remote sensing of vegetation canopy biochemistry and structure." *Journal of Applied Remote Sensing* 4, 043510. doi:doi: 10.1117/1.3361375.

Kampe, T.U., G.P. Asner, R.O. Green, M. Eastwood, B.R. Johnson, and M. Kuester. 2010. "Advances in airborne remote sensing of ecosystem processes and properties – Toward high-quality measurements at a global scale." *Proc. SPIE.* doi:doi:10.1117/12,859455.

Keller, M., D. S. Schimel, W. W. Hargrove, and F. M. Hoffman. 2008. "A continental strategy for the National Ecological Observatory Network." *Frontiers in Ecology and the Environment* 6 (5): 282-284. doi:[doi: 10.1890/1540-9295(2008)6[282:ACSFTN]2.0.CO;2].

Palik, B. J., and N. Pederson. 1996. "Overstory mortality and canopy disturbances in longleaf pine ecosystems." *Canadian Journal of Forest Research* 26: 2035-2047.

PRISM Climate Group, Oregon State University. 2013. February . http://prism.oregonstate.edu.

Schimel, D.S., M. Keller, S. Berukoff, B. Kao, H. Loescher, H. Powell, T. Kampe, D. Moore, W. Gram. 2011. *NEON Science Strategy: Enabling Continental Scale Ecological Forecasting.* Boulder, CO: NEON, Inc. http://www.neoninc.org/sites/default/files/NEON_Strategy_2011u2.pdf.

Schimel, D.S., M. Keller, S. Berukoff, B. Kao, H. Loescher, H. Powell, T. Kampe, D. Moore, W. Gram. 2011. *NEON Science Strategy: Enabling Continental Scale Ecological Forecasting.* Boulder, CO: NEON, Inc. http://www.neoninc.org/sites/default/files/NEON_Strategy_2011u2.pdf.

2014. *UF IFAS Research: Ordway-Swisher Biological Station.* http://ordway-swisher.ufl.edu.

USDA Forest Service, Northern Research Station. 2014. *Ecology and Management of Northern forests: Bartlett Experimental Forest.* http://www.fs.fed.us/ne/durham/4155/bartlett.htm.

Westveld, M., et al. 1956. "Natural forest vegetation zones of New England ." *Journal of Forestry* 54(5): 332-338.