NPP Boreal Forest: Superior National Forest, USA, 1983-1984, R1

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Summary:

Revision Date: July 15, 2013

Summary:

This data set contains two files (.txt format). One file provides ground-based biophysical measurements and above-ground net primary productivity (ANPP) estimates for 31 black spruce (*Picea mariana*) and 30 quaking aspen (*Populus tremuloides*) stands in Superior National Forest (SNF) in northeastern Minnesota, U.S.A. (-92 W 48 N). The measurements were obtained during a 1983-1984 intensive field campaign. Non-destructive measurements were made in over 100 forest plots covering a 50 x 50 km area. Trees sacrificed for biomass and annual increment measurements were taken outside the plots. The second file provides climate data from nearby weather stations for the period 1976-1986.

The data set provides stand structural measurements (diameter at breast height, tree height, crown depth, and stem density), above-ground biomass, leaf area index, bark area index, and ANPP estimates. ANPP data are based on a combination of allometric relationships and annual tree-ring (radial) increments for the 5-year period 1979-1983.

In the spruce stands, above-ground biomass ranged from 700-15,100 g/m^2, LAI varied between 0.5-4.3, and ANPP ranged from 39-572 g/m^2/yr. In comparison, above-ground biomass among aspen stands ranged from 600-22,000 g/m^2, LAI varied between 1.3-4.0, and ANPP ranged from 213-1,199 g/m^2/yr.

The purpose of the SNF campaign was to investigate the ability of remote sensing to provide estimates of ecosystem biophysical properties. In addition to the results presented herein, satellite, aircraft, and helicopter observations and other ground measurements for the study sites are available from the ORNL DAAC Superior National Forest (SNF) Project web site [http://daac.ornl.gov/SNF/snf.shtml].

Revision Notes: Only the documentation for this data set has been modified. The data files have been checked for accuracy and are identical to those originally published in 1997.

Additional Documentation:

The Net Primary Productivity (NPP) data collection contains field measurements of biomass, estimated NPP, and climate data for terrestrial grassland, tropical forest, temperate forest, boreal forest, and tundra sites worldwide. Data were compiled from the published literature for intensively studied and well-documented individual field sites and from a number of previously compiled multi- -site, multi-biome data sets of georeferenced NPP estimates. The principal compilation effort (Olsen et al., 2001) was sponsored by the NASA Terrestrial Ecology Program. For more information, please visit the NPP web site at http://daac.ornl.gov/NPP/npp_home.html.

Data Citation:

Cite this data set as follows:

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1. Data Set Overview:

Project: Net Primary Productivity (NPP)

Productivity of a boreal forest was determined at 31 black spruce (*Picea mariana*) and 30 quaking (trembling) aspen (*Populus tremuloides*) plots in Superior National Forest (SNF) in northeastern Minnesota, U.S.A. (-92 W 48 N) at the southern edge of the North American boreal forest biome. The measurements were obtained during a 1983-1984 intensive field campaign sponsored by the National Aeronautics and Space Administration (NASA). Lowland black spruce and quaking aspen represent two very different ecophysiological functional types, the former being a slow-growing and long-lived tree and the latter a fast-growing and short-lived tree.

The purpose of the experiment was to investigate the ability of remote sensing to provide estimates of ecosystem biophysical properties, such as leaf area index (LAI), biomass, and above-ground net primary productivity (ANPP). This data set provides ground-based estimates of above-ground biomass, LAI, and ANPP. Additional ground measurements, plus the satellite, aircraft, and helicopter observations, for the study sites are available from the ORNL DAAC Superior National Forest (SNF) Project web site [http://daac.ornl.gov/SNF/snf.shtml]. The ORNL DAAC SNF Data Archive includes 37 data products.

Boreal forests were chosen for this project because of their relative taxonomic simplicity, their great extent (covering approximately 9 million km^2 in North America), and their potential sensitivity to climatic change. The study area in SNF included over 100 forest plots covering a 50 x 50 km area centered at approximately 48 degrees North latitude and 92 degrees West longitude in northeastern Minnesota. The SNF is mostly covered by boreal forest. Sites for biophysical measurements were chosen in areas where the cover type was uniform, pure spruce or aspen stands, but also included mixed stands.

At each site, five circular subplots of 16 m in diameter were sampled within a large plot of 60 m in diameter. Within the subplots, all woody stems over 2 m in height were tallied by species, diameter at breast height, and height. Within each subplot, coverage by vegetation type was determined for the canopy, subcanopy, and understory. Thirty-one (31) black spruce and 32 aspen trees from outside the plots were harvested and measured. Dimension analysis of these sampled trees was used to develop equations linking the convenience measurements taken at each site and the biophysical characteristics of interest, including LAI, biomass, and ANPP. Producutivity was estimated for each sacrificed tree from the average radial growth over 5 years measured from the segments cut from the boles and the terminal growth measured as the height increase of the tree. Allometric equations were used to find the height and radial increment as a function of crown height and diameter at breast height. An additional parameter of stem density was used for spruce stands. The models were used to project back for 5 years and determine biomass at that time. The average change in biomass per year over that 5-year time was used to determine ANPP. In the aspen sites, bark area and understory leaf area indexes were also calculated.

In the spruce stands, above-ground biomass ranged from 700-15,100 g/m^2, LAI varied between 0.5-4.3, and ANPP ranged from 39-572 $g/m^2/yr$. In comparison, above-ground biomass among aspen stands ranged from 600-22,000 g/m^2, LAI varied between 1.3-4.0, and ANPP ranged from 213-1,199 $g/m^2/yr$ (Hall et al., 1992; Olson et al., 2012a, b; Scurlock and Olson, 2012).

Climate data are provided for 1976-1986 from a weather station at International Falls, Minnesota (-93.217 W 44.883 N) about 130 km from Superior National Forest. Insolation data was measured by Donald Baker, Department of Soil Science, University of Minnesota, at Fall Lake Dam, Winton, Minnesota (-91.8 W 47.95 N) during the same time period.

2. Data Description:

This data set contains two files (.txt format). One file provides ground-based biophysical measurements (diameter at breast height, tree height, crown depth, stem density, above-ground biomass, leaf area index, and bark area index) and ANPP estimates from a 1983-1984 intensive field campaign in Superior National Forest (SNF) in northeastern Minnesota, U.S.A. The second file provides climate data from nearby weather stations for the period 1976-1986.

Spatial Coverage

Site: Superior National Forest, Minnesota, U.S.A.

Site Boundaries:(All latitude and longitude given in decimal degrees)

Site (Region)	Westernmost Longitude	Easternmost Longitude	Northernmost Latitude	Southernmost Latitude	Elevation (m)
Superior National Forest, Minnesota, U.S.A.	-92.506 W	-91.766 W	48.1697 N	47.9708 N	381-500

Site Information

The Superior National Forest (SNF) in northeastern Minnesota is near the southern limit of the North American boreal forest, and therefore may be particularly sensitive to climatic variability and change (Hall et al., 1992). The 40 km x 120 km study area overlaps the Boundary Waters Canoe Area Wilderness, north of the town of Ely, and adjoins Canada at Quetico Provincial Park, about 200 km west of Thunder Bay, Ontario. The SNF is primarily boreal forest with a wide range in site conditions, ages classes, successional stages, biomass, and vegetation productivity all under a similar climate.

While several dozen tree species occur in the SNF, only a few species dominate the landscape. Early successional stands on uplands are dominated by quaking aspen (*Populus tremuloides*), bigtooth aspen (*P. grandidentata*), or jack pine (*Pinus banksiana*). Jack pine, an evergreen conifer, generally dominates sites with shallow, dry soils, while the broadleaf deciduous aspens occur on mesic sites. Later in the succession, upland stands tend towards dominance by conifers: spruce (*Picea mariana* and *P. glauca*) and balsam fir (*Abies balsamea*). White and red pine (*P. strobus* and *P. resinosa*) are frequent and locally dominant, but constitute a small proportion of the total landscape cover. Extensive acidic peatlands often support sparse to dense stands of black spruce (*P. mariana*), mixed with open stands of tamarack (*Larix laricina*). Unforested areas occur on uplands in early succession or on rocky outcrops and in peatlands of perennially high water tables or extremely low nutrient availability.

Surficial geology of the area is a complex of granitic bedrock, glacial till, outwash deposits, alluvium, and lacustrine sediments. The area is classified as Great Lakes Boreal (modified Bailey ecoregion Continental needle-leaf taiga, #134). There is evidence of strong covariation among vegetation type, soil type, and disturbance history.

Thirty-two (32) quaking aspen and thirty-one (31) black spruce sites were studied. Study sites were chosen in areas where the cover type was uniform. The sites in which biophysical measurements were made were, as much as possible, pure stands of aspen or spruce. The dominant species in each stand constituted over 80 percent, and usually over 95 percent, of the total tree density and basal area. Aspen stands were selected to be evenly distributed over the full range of age and stem density for stands that were essentially pure aspen, of nearly complete canopy closure, and greater than 2 meters in height. Spruce stands ranged from very sparse stands on wet, nutrient-poor bog sites to dense, and closed stands on more productive peatlands. The sites were sampled to represent a variety of stand densities and leaf area indexes. Also, the sites needed to be accessible to the investigators.

Climate data in this data set are available from weather stations at International Falls, Minnesota (-93.217 W 44.883 N) and Fall Lake Dam, Winton, Minnesota (-91.8 W 47.95 N). The weather data are representative of the area.

Northern Minnesota has a humid continental climate with long cold winters, short cool summers, and precipitation scattered throughout the year. Continental climates characteristically have a great range in temperatures between the winter and summer. The average temperature is below freezing for 5 months of the year (November-March) and extreme cold is frequent in the winter. In the summer, hot periods occur with temperatures in the 90s (F). Although the summers are generally mild, midsummer frosts may also occur. Most of the precipitation falls during from May to September. Often the precipitation during this time of year comes as thunderstorms. These storms can be quite powerful, producing strong winds called downbursts, which may be very destructive in forests. In the winter, almost all of the precipitation falls comes as snow. Most of the snowfall occurs in the early months of the winter before the freezing of the lakes shuts off the major source of moisture to the atmosphere.

Spatial Resolution

The study area covered a 50 x 50 km area. Each study site was 60 m in diameter with five 16-m-diameter circular plots located within it for measurements of tree structural properties. A 2-m-diameter subplot was defined at the center of each plot to determine ground cover by plants under 1 m in height.

Temporal Coverage

Biophysical measurements were made using non-destructive and destructive methods during two field seasons in the summers of 1983 and 1984. ANPP data are based on a combination of allometric relationships from these measurements and annual tree-ring (radial) increments for the 5-year period 1979-1983. Climate data were recorded from 1976 through 1986.

Temporal Resolution

Biophysical measurements were made over two growing seasons. ANPP estimates are based on plant dry matter accumulation, expressed as g/m^2 (dry matter weight). Climate data are expressed as water equivalent of the total monthly precipitation amounts (mm), monthly averages of daily maximum, minimum, and average temperatures (C), and monthly averages of daily solar insolation (mega Joules/m^2). Annual climatic means are provided for the 1976-1986 period.

Data File Information

Table 1. Data files in this data set archive

FILE NAME	TEMPORAL COVERAGE	FILE CONTENTS

snf_npp.txt	1983/06/01-1984/09/30	Forest site characteristics, above-ground biomass, leaf area index, bark area index, and ANPP estimates for black spruce and quaking aspen stands in Superior National Forest, Minnesota
snf_cli.txt	1976/01/01-1986/12/31	Monthly and annual precipitation amount and mean average/maximum/minimum temperature data from weather station at International Falls, Minnesota near Superior National Forest. Also includes monthly and annual average solar insolation data measured at Fall Lake Dam, Winton, Minnesota

NPP Data. NPP estimates for the Superior National Forest site are provided in one file (.txt format). The variable values are delimited by semi-colons. The first 18 lines are metadata; data records begin on line 19. The values -0.999, -99, and -999.9 are used to denote missing values. All NPP units are in g/m^2/yr (dry matter weight).

Table 2. Column headings in NPP file

COLUMN HEADING	DEFINITION	UNITS	SOURCE*
SITE	Site where data were gathered (code refers to site identification)	Text	Code assigned by ORNL DAAC
VEG_TYPE	Dominant tree species on the site	Text	Table 2.2, Hall et al. (1992)
STAND_ID	Site (stand) number	Numeric	
LAT	Latitude, in decimal degrees	Numeric	Converted to decimal degrees by ORNL DAAC from degrees, minutes, seconds in Table 2.2, Hall et al. (1992)
LONG	Longitude, in decimal degrees	Numeric	
YEAR	Year in which data were collected	Numeric	Table 2.2, Hall et al. (1992)
TREE-HT	Canopy height	m	
NT	Number of trees on the site	Numeric	Tables 3.7 and 3.8, Hall et al. (1992)
AREA	Site area	m^2	
DBH	Average tree diameter at breast height	cm	
DBH_SD	Standard deviation of tree diameter at breast height		
DENSITY	Number of trees per square meter on the site	stems/m^2	
BASAL_F	Basal fraction (ratio of bole area to surface area)	ratio	
BMI	Biomass index	kg/m^2	
BMI_SD	Standard deviation of biomass index		
NPP	Estimated annual above-ground net primary production	g/m^2/year	
NPP_SD	Standard deviation of estimated NPP		
LAI	One-sided leaf area index	m^2/m^2	
LAI_SD	Standard deviation of one-sided leaf area index		
BAI	Bark area index defined as the entire surface area of the boles and branches		
BAI_SD	Standard deviation of bark area index		
LAI_SUB	Subcanopy leaf area index		
COMMENTS	Plot description	Text	Table 2.2, Hall et al. (1992)

Sample NPP Data Record

SITE; VEG_TYPE; STAND_ID; LAT; LONG; YEAR; TREE_HT; NT; AREA; DBH; DBH_SD; DENSITY; BASAL_F; BMI; BMI_SD; NPP; NPP_SD; LAI; LAI_SD; BAI; BAI_SD; LAI_SUB

snf ; spruce; 2; 48.1353; -92.306; 1984; 15; 176; 1005; 14.52; 4.43; 0.17507; 0.00317; 12.378; 0.830; 324.8; 41.2; 2.884; 0.340; -0.999; -0.999; -0.999
snf ; aspen; 3; 48.1319; -92.254; 1984; 24; 95; 1005; 15.22; 9.56; 0.09450; 0.00239; 13.705; 1.388; 563.0; -999.9; 2.524; 0.253; 1.286; 0.353; 0.201
snf ; spruce; 12; 48.0783; -91.960; 1984; 6; 165; 1005; 4.54; 2.11; 0.16413; 0.00032; 0.678; 0.127; 39.4; 12.3;

```
0.484; 0.181; -0.999; -0.999; -0.999 ...
```

Climate Data. The climate data for the Superior National Forest site are provided in one file (.txt format). The first 18 lines are metadata; data records begin on line 19. The variable values are delimited by semi-colons. The values -9999 and -99999 are used to denote missing values.

Sample Climate Data Record

```
Site;Temp;Parm; Jan; Feb; Mar; Apr; May; Jun; Jul; Aug; Sep; Oct; Nov; Dec; Year

SNF;mean;days; 28.5; 27.0; 30.5; 29.5; 25.5; 28.5; 28.6; 30.2; 28.0; 29.6; 27.0; 30.1; 29.4
SNF;mean;insl; 5504; 8090;12806;17076;19950;20290;20176;17025;12104; 7799; 4841; 3869; 12431
SNF;mean;prec; 16.3; 17.2; 26.9; 37.8; 65.1;110.7; 73.3; 64.9; 86.6; 47.2; 41.0; 17.0; 604.0
SNF;mean;tavg;-17.8;-12.2; -4.9; 4.9; 12.2; 15.9; 19.4; 17.5; 11.9; 5.2; -4.8;-14.7; 2.7
SNF;mean;tmax;-11.9; -6.7; 0.8; 11.1; 19.2; 22.2; 25.7; 23.7; 17.4; 10.1; -0.5; -9.4; 25.8
SNF;mean;tmin;-23.7;-17.8;-10.9; -1.6; 4.9; 9.3; 12.6; 10.9; 5.9; 0.0; -9.3;-20.0; -24.6
SNF;numb;insl; 10.0; 11.0; 11.0; 11.0; 11.0; 10.0; 11.0; 11.0; 10.0; 10.0; 11.0; 9.0; 6.0
SNF;numb;prec; 11.0; 11.0; 11.0; 11.0; 11.0; 11.0; 11.0; 11.0; 11.0; 11.0; 11.0; 11.0; 11.0
SNF;numb;tavg; 11.0; 11.0; 11.0; 11.0; 11.0; 11.0; 11.0; 11.0; 11.0; 11.0; 11.0; 11.0; 11.0
SNF;numb;tmax; 11.0; 11.0; 11.0; 11.0; 11.0; 11.0; 11.0; 11.0; 11.0; 11.0; 11.0; 11.0; 11.0
SNF;numb;tmin; 11.0; 11.0; 11.0; 11.0; 11.0; 11.0; 11.0; 11.0; 11.0; 11.0; 11.0; 11.0; 11.0
SNF;stdv;days; 6.1; 4.0; 1.8; 1.5; 10.8; 4.7; 6.6; 1.9; 6.3; 3.0; 5.4; 1.6; 1.2
SNF;stdv;insl; 813; 1221; 1579; 1407; 2786; 2602; 2081; 1586; 1342; 1494; 815; 750; 1224
SNF;stdv;prec; 8.0; 7.5; 16.6; 27.0; 53.1; 43.8; 42.2; 23.6; 41.3; 29.4; 24.5; 7.5; 107.1
SNF;stdv;tavg; 3.8; 3.6; 2.8; 1.9; 2.4; 1.5; 1.1; 2.1; 1.0; 1.7; 3.0; 4.1; 1.1
SNF;stdv;tmax; 3.5; 3.2; 2.4; 2.3; 3.0; 1.7; 1.4; 2.1; 1.3; 1.8; 2.7; 3.9; 1.4
SNF;stdv;tmin; 4.0; 4.0; 3.4; 1.6; 2.2; 1.5; 1.1; 2.2; 1.3; 1.8; 3.4; 4.3; 3.3
SNF;1976;days; 31.0; 29.0; 31.0; 30.0; 31.0; 30.0; 31.0; 28.0; 30.0; 31.0; 30.0; 30.0; 30.2
SNF;1976;insl; 5092; 8682;11719;18338;24380;22154;22962;19502;14104; 7849; 5443; 4598; 13735
SNF;1976;prec; 25.1; 11.7; 46.2; 25.9; 3.0;178.1;144.8; 47.0; 30.2; 21.3; 4.8; 15.0; 553.1
SNF;1976;tavg;-17.9; -9.7; -7.1; 6.2; 11.9; 18.2; 18.9; 18.4; 12.6; 2.0; -8.8;-19.5; 2.1
SNF;1976;tmax;-10.7; -3.3; -0.6; 12.5; 21.0; 24.8; 25.3; 24.9; 19.8; 6.9; -4.3;-13.3; 25.3
SNF;1976;tmin;-24.5;-16.1;-13.7; -0.5; 2.9; 11.1; 11.4; 10.5; 4.0; -3.2;-13.5;-25.8; -25.8â€¦

Where,
Temp (temporal) - specific year or long-term statistic:
  mean = mean based on all years
  numb = number of years
  stdv = standard deviation based on all years
Parm (parameter):
  days = number of days with solar insolation data
  insl = average solar insolation for month or year (mega Joules/m^2) measured with Yellow Springs solar cell
  prec = precipitation for month or year (mm)
  tavg = average temperature for month or year (C)
  tmax = maximum temperature for month or year (C)
  tmin = minimum temperature for month or year (C)
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3. Data Application and Derivation:

The accumulation of biomass, or NPP, is the net gain of carbon by photosynthesis that remains after plant respiration. While there are many fates for this carbon, annual above-ground NPP (ANPP) was estimated in this study using a combination of allometric relationships and annual tree-ring (radial) increments for the 5-year period 1979-1983. The allometric relationships derived from sample trees included foliar biomass, and thus the ANPP estimates include foliar production less growing-season litterfall.

The purpose of the experiment was to investigate the ability of remote sensing to provide estimates of biophysical properties of ecosystems, such as leaf area index (LAI), biomass, and ANPP. A key element of the experiment was the development of methodologies to measure forest stand characteristics to determine values of importance to both remote sensing and ecology. In addition to the results presented herein, satellite, aircraft, and helicopter observations and other ground measurements for the study sites are available from the ORNL DAAC Superior National Forest (SNF) Project web site [http://daac.ornl.gov/SNF/snf.shtml].

The biomass dynamics data for the Superior National Forest site are provided for comparison with models and estimation of NPP. Climate data are provided for use in driving ecosystem/NPP models.

4. Quality Assessment:

Biomass density and projected LAI were much more variable for spruce than for aspen. Spruce LAI and biomass density have a tight, nearly linear relationship. Stand attributes are often determined by site characteristics. Wet, ombrotrophic sites supported open, low-biomass, mixed-age stands. Spruce stands with LAI below about two and biomass densities below about 5 kg/m^2 appeared to be limited by site characteristics such as nutrient poverty and wetness. Stand quality improved with site richness until canopy closure brought on self thinning. Closed spruce canopies attained maximum LAI at around four, higher than aspen, perhaps because spruce is more shade tolerant (it was often observed growing beneath closed aspen stands in the study area). However, differences between maximum LAI for aspen and spruce also may be related to differences in the leaf distribution within the canopy.

Sources of Error

Information not available.

5. Data Acquisition Materials and Methods:

Non-Destructive Field Measurements. Study sites were chosen in uniform stands of aspen or spruce. The dominant species in each site constituted over 80 percent, and usually over 95 percent, of the total tree density and basal area. Aspen stands were chosen to represent the full range of age and stem density of essentially pure aspen, of nearly complete canopy closure, and of greater than 2 meters in height. Spruce stands ranged from very sparse stands on bog sites to dense closed stands on more productive peatlands.

In each stand a uniform site 60 m in diameter was laid out. Within this site, five circular plots, 16 m in diameter, were positioned. One plot was at the center of the site and four were tangent to the center plot, one each in the cardinal directions. In very dense stands, plot radii were decreased so that stem count for the five plots remained around 200 stems. Use of multiple plots within each site allowed estimation of the importance of spatial variation in stand parameters.

Within each plot, all woody stems greater than 2 m in height were recorded by species and relevant dimensions were measured. Diameter breast height (dbh) was measured directly. Height of the tree and height of the first live branch were determined by triangulation. The difference between these two heights was used as the depth of crown. The distances between trees and observer were such that no angle exceeded 65 degrees. Most plots were level and small slopes were ignored in calculating heights. Similar measurements were made for shrubs between 1 and 2 meters tall in the aspen sites.

For each plot, a 2-meter-diameter subplot was defined at the center of each plot. Within this subplot, the percent of ground coverage by plants under 1 meter in height was determined by species. Also, in each plot for the aspen sites, a visual estimation of the percent coverages of the canopy, subcanopy and understory vegetation was made.

Destructive Field Measurements. Dimension analysis of sampled trees was used to develop equations linking the convenience measurements taken at each site and the biophysical characteristics of interest (for example, LAI or biomass). To develop these relations, 32 aspen and 31 spruce trees were sacrificed from stands similar and near to the study sites. The trees were randomly sampled with stratification by diameter. Fifteen (15) mountain maple and 15 beaked hazelnut trees were also sampled and leaf areas were determined. These data were used to determine understory leaf area.

For each sampled tree, diameter at breast height, height to first live branch, and total height were measured before and after felling. Measurements of all branches included: height of attachment on bole, diameter, length to first secondary branch, and total length. Crowns were vertically stratified into three equal sections and six branches were randomly sampled from each stratum. For each sampled branch, all leaves and wood were weighed green and the current year's woody growth was measured. Leaf area was measured with a Licor leaf area meter from a sample of 200 leaves from each stratum; leaves were then dried and weighed. Subsamples from each sampled branch were dried and weighed.

Removal of green spruce needles from branches proved impractical, so needle-bearing parts of sampled branches were cut off, separated between current year and older classes, and dried. A sample of 21 needles each from the new and older growth were randomly selected from each canopy stratum. The sampled needles were photographed and green and dry weights were measured. Projected area was determined from the digitized photographs.

Boles were sectioned and weighed green. Four sections, 5 to 20 cm long, were cut from the base of the bole: halfway between the base and first live branch, just below the first live branch, halfway between the first and first live branch, just below the first live branch, and halfway between the first live branch.

Parameter Estimation from Sampled Trees. For each of the sacrificed trees, the total above-ground biomass was estimated as the sum of the branch and bole biomass. Branch biomass was estimated by finding the dry-to-green weight ratios for leaves, twigs, and wood and using the ratios to convert the green-to-dry weights for the sampled branches. A regression of branch biomass on branch dimensions was done independently for each tree and used to determine biomass for the unsampled branches. Total branch biomass was the sum of the estimated biomass of the sampled and unsampled branches. Bole biomass was estimated by finding the dry-to-green weight ratios for each section, converting the green weights, and summing. Total biomass = the sum of the branch and bole biomass.

Methods for estimating leaf area were parallel to those for estimating branch biomass. Leaf weights for unsampled branches were estimated using tree-specific, linear regressions on branch dimensions fit with data from sampled branches. For spruce, separate regressions were done for current-year and older needles. Measured and estimated foliage weights were summed within strata and, for spruce, within age class. The foliage weights were converted to leaf areas using ratios determined from sampled leaves, then totaled for trees.

Bark area in aspen was determined using similar techniques to those for leaf area. Sampled branches were divided into segments, each segment was assumed to be a cylinder and the surface area was calculated. Total branch surface area was the sum of the surface areas of the segments. A regression was developed to determine branch area for the unsampled branches. The sum of the estimated branch areas for the sampled and unsampled branches = the total bark area.

ANPP was estimated from the average radial growth over 5 years measured from the segments cut from the boles and the terminal growth measured as the height increase of the tree. Allometric equations were used to find the height and radial increment as a function of crown height and diameter at breast height. An additional parameter of stem density was used for spruces. The models were used to back project 5 years and determine biomass at that time. The change in biomass over that time was used to determine the productivity.

Measurements of the sacrificed trees were used to develop relationships between the biophysical parameters (biomass, leaf area index, bark area index, and ANPP) and the measurements made at each site (diameter at breast height, tree height, crown depth and stem density).

Climate. Weather data were compiled by the National Weather Service from the weather station at International Falls, Minnesota, about 130 km from the SNF, but the weather data are representative of the area. Climate records include monthly averages of daily temperature (minimum, maximum, and average) and water equivalent of the total monthly precipitation. Daily insolation data was measured nearby by Donald Baker, Department of Soil Science, University of Minnesota, at Fall Lake Dam, Winton, Minnesota using a Yellow Springs solar cell calibrated against an Eppley Pyranometer. The insolation data presented in the climate file are the monthly averages of the daily values.

6. Data Access:

This data set is available through the Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC).

Data Archive:

Web Site: http://daac.ornl.gov

Contact for Data Center Access Information:

E-mail: uso@daac.ornl.gov
Telephone: +1 (865) 241-3952

7. References:

Hall, F.G., K.F. Huemmrich, D.E. Strebel, S.J. Goetz, J.E. Nickeson, and K.D. Woods. 1992. Biophysical, Morphological, Canopy Optical Property, and Productivity Data From the Superior National Forest. NASA Technical Memorandum 104568. Goddard Space Flight Center, National Aeronautics and Space Administration. Greenbelt, Maryland, U.S.A.

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