Seedling Canopy Chemistry, 1992-1993 (ACCP)

Summary:

This data set describes the nitrogen and chlorophyll content of small, monospecific canopies formed from seedlings of Douglas-fir (*Pseudotsuga menziesii*) and bigleaf maple (*Acer macrophyllum*). The trees were provided different levels of fertilization in order to produce canopies with varying nitrogen and chlorophyll concentration. For the Douglas-fir, fertilization was provided during the dormant season, so there were no differences in growth or leaf area among canopies, and canopies were at a constant density with varying foliar chemistry. For the maple, seedlings were aggregated at various densities, producing a matrix of leaf area as well as chemistry variations. Before destructive analysis for foliar chemistry, canopy reflectance was measured under natural sunlight (see ACCP Seedling Canopy Reflectance Spectra Data).

Citation:

Cite this data set as follows (citation revised on September 30, 2002):

Yoder, B., and L. Johnson. 1999. Seedling Canopy Chemistry, 1992-1993 (ACCP). [Seedling Canopy Chemistry, 1992-1993 (Accelerated Canopy Chemistry Program)]. Data set. Available on-line [http://daac.ornl.gov] from Oak Ridge National Laboratory Distributed Active Archive Center, Oak Ridge, Tennessee, U.S.A. doi:10.3334/ORNLDAAC/422.

Table of Contents:

1. Data Set Overview:

Data Set Identification:

SEEDLING CANOPY CHEMISTRY, 1992-1993 (ACCP)

Data Set Introduction:

This data set describes the nitrogen and chlorophyll content of small, monospecific canopies formed from seedlings of Douglas-fir (*Pseudotsuga menziesii*) and bigleaf maple (*Acer macrophyllum*). The trees were provided different levels of fertilization in order to produce canopies with varying nitrogen and chlorophyll concentration. For the Douglas-fir, fertilization was provided during the dormant season, so there were no differences in growth or leaf area among canopies, and canopies were at a constant density with varying foliar chemistry. For the maple, seedlings were aggregated at various densities, producing a matrix of leaf area as well as chemistry variations. Before destructive analysis for foliar chemistry, canopy reflectance was measured under natural sunlight (see ACCP Seedling Canopy Spectra Data Set).

Objective/Purpose:

The experiments were designed to study the relationships between chemistry and spectral reflectance of canopies under very controlled conditions. In the case of the Douglas-fir, the purpose was to investigate the propagation of the reflectance signature from dried ground foliage to fresh foliage to whole canopies, where foliar chemistry varied and all other biophysical properties remained constant. In the case of the bigleaf maple, the purpose was to study the interactive effects of variable LAI and foliar chemistry on spectral reflectance of canopies. In both cases, the measurements were designed to minimize sources of spectral variation due to atmosphere, soils, etc. that are common in studies of natural vegetation.

Summary of Parameters:

Measurements were made to characterize the foliar biochemical and biophysical status of bigleaf maple and Douglas-fir seedlings

Discussion:

none (see References)

Related Data Sets:

Leaf Chemistry, 1992-1993 (ACCP) Site AVIRIS Images, 1992 (ACCP) Seedling Canopy Reflectance Spectra, 1992-1993 (ACCP)

2. Investigator(s):

Investigator(s) Name and Title:

Barbara Yoder, Assistant Professor of Forest Science (bigleaf maple) Lee Johnson, Sr. Research Scientist (Douglas-fir)

Title of Investigation:

Foliar chemistry of seedling canopies

Contact Information:

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3. Theory of Measurements:

Not applicable.

4. Equipment:

Sensor/Instrument Description:

Collection Environment:

Not applicable.

Source/Platform:

Not applicable.

Source/Platform Mission Objectives:

Not applicable.

Key Variables:

Leaf nitrogen and chlorophyll content.

Principles of Operation:

Not applicable.

Sensor/Instrument Measurement Geometry:

Not applicable.

Manufacturer of Sensor/Instrument:

Not applicable.

Calibration:

Not applicable.

Specifications:

Not applicable.

Tolerance:

Not applicable.

Frequency of Calibration:

Not applicable.

Other Calibration Information:

Not applicable.

5. Data Acquisition Methods:

The specific details of the subsampling and the analysis techniques differed for the two species, as described below. The data set "ACCP Leaf Chemistry" includes the results of chemical analyses on a unit leaf basis from these studies.

For the maple, samples for chlorophyll analysis were taken from fresh leaves within 1 week after spectral reflectance measurements. Ten trees were chosen from the 20-tree canopy according to a systematic design, and the topmost and third-from-top leaves were removed. Immediately thereafter, four small disks (total area 1.22 cm2) were excised from each leaf with a paper hole punch. The punched disks were placed in a vial containing 5 mL N,N-dimethylformamide, and the vials were covered with black cloth and maintained at 2 degrees C for 1 week. The absorbance of the resulting solution was measured at 664.5 and 647 nm with a Cary 14 Spectrophotometer. Chlorophyll concentration (per unit leaf area) was determined with the extinction coefficients of Inskeep and Bloom (1985). Then, the total area remaining in each sample leaf was determined with a LiCor 3100 leaf area meter. The tissue was then dried and weighted, and the specific leaf area (cm2 g-1) calculated. From the values for specific leaf area,

chlorophyll concentration was calculated on a mass basis. A canopy average value for leaf chlorophyll concentration was calculated from the simple mean of the sub-samples. Then, all foliage was harvested from all of the seedlings in each canopy. The foliage was dried and weighed, and canopy leaf area was calculated from the product of specific leaf area and total leaf mass. The dried foliage for the entire canopy was ground in a Wiley mill and mixed thoroughly. Subsamples were sent to the University of New Hampshire for total nitrogen analysis (See the description for the ACCP Leaf Chemistry Data Set for more details on N analysis). The whole-canopy content of both chlorophyll and nitrogen was calculated as the product of canopy leaf mass and average leaf concentration.

Douglas fir. Within 6 hours of spectral measurement, foliage samples were collected from each tree. Each tree was cut off at ground level and all needles were removed and immediately weighed. Total needle (minus buds and scales) wet weight was recorded and a subsample was dried to determine total dry weight and percent moisture. A second subsample of needles was weighed and specific leaf area was determined using a LiCor-3100 leaf area meter. Stem height and total stem dry weight were determined per tree, and the latter was added to total needle dry weight to calculate total aboveground biomass. Leaf area index was calculated by multiplying needle biomass by specific leaf area, and then dividing by the ground area of the planting pots. Foliage subsamples from each tree were dried, ground and analyzed for total nitrogen and total chlorophyll (a+b) by conventional laboratory methods. Total nitrogen was measured with an Alpkem continuous flow autoanalyzer after samples were digested in a block digestor using a sulfuric acid-mercuric oxide catalyst (Perstorp Analytical). To estimate the error of total nitrogen estimates obtained by this method, nine measurements were made of a standard pine reference material. The resulting coefficient of variation (CV) for the reference material (6.6%) was expected to be somewhat less than the CVs for the Douglas fir samples examined here. Chlorophyll was extracted in acetone buffered by CaCO3, and concentration was determined by standard spectrophotometric techniques. Percent moisture data were used to convert biochemical concentrations to mg constituent per gram oven-dried leaf weight. All laboratory work for Douglas-fir was performed at Ames Research Center.

6. Observations:

Data Notes:

Not applicable.

Field Notes:

Not applicable.

7. Data Description:

Spatial Characteristics:

Spatial Coverage:

NASA Ames Research Center. Latitude: 37.4015 Longitude: 122.0481

Spatial Coverage Map:

Not applicable.

Spatial Resolution:

Not applicable.

Projection:

Not applicable.

Grid Description:

Not applicable.

Temporal Characteristics:

Temporal Coverage:

Not applicable.

Temporal Coverage Map:

Not applicable.

Temporal Resolution:

Not applicable.

Data Characteristics:

Parameter/Variable Description:

Douglas Fir seedling leaf analysis results [Data file: df_can_chem.dat]
1.
variable=sampleid
definition=unique sample identifier that can be associated with individual leaf chemistry in related data set

2.
variable=fert
definition=fertilizer treatment level

code=1:
code=2:
code=3: highest level of treatment

3.
variable=colldate
definition=date field samples were collected
units=YYMMDD (format)
minimum= 921106
maximum= 921110

4.
variable=lab
definition=laboratory where analyses were performed
code=ames: NASA Ames Research Center

5.
variable=species
definition=coniferous and deciduous forest species collected
code=see companion file for LTER codes

6.
variable=TN
definition=total nitrogen
units= [mg][g^-1 dry weight]
minimum= 6.84
maximum= 33.48

7.
variable=chloroph
definition=chlorophyll
units= [mg][g^-1 dry weight]
minimum= 1.16
maximum= 6.96

8.
variable=water
definition= % fresh leaf weight
units= %
minimum= 37.7
maximum= 69.5

9.
variable=sp_lf_ar
definition=specific leaf area
units= [cm^2][g^-1 fresh weight]

minimum= 10.88
maximum= 36.08

Big Leaf Maple seedling leaf analysis results [Data file: map_can_chem.dat]
1.
variable=sampleid
definition=unique sample identifier that can be associated with individual leaf chemistry in related data set

2.
variable=fert
definition=fertilizer treatment level
code=1:
code=2:
code=3: highest level of treatment

3.
variable=colldate
definition=date field samples were collected
units=YYMMDD (format)
minimum= 930315
maximum= 930315

4.
variable=lab
definition=laboratory where analyses were performed
code=ames: NASA Ames Research Center

5.
variable=replicat
definition=replicate sample identifier number
units=unitless
minimum= 1
maximum= 3

6.
variable=tree_id
definition=tree identifier number
units=unitless
minimum= 1
maximum=17

7.
variable=leafpos
definition=identifies position of collected leaves on seedlings

code=1: topmost leaves
code=3: third-from-top leaves

8.
variable=species
definition=coniferous and deciduous forest species collected
code=see companion file for LTER codes

9.
variable=sp_lf_ar
definition=specific leaf area
units= [cm^2][g^-1 fresh weight]
minimum= 168
maximum= 395

10.
variable=nitrogen
definition=total nitrogen
units= [mg][g^-1 dry weight]
minimum= 9.5
maximum= 50.6

11.
variable=chloroph
definition=chlorophyll
units= [mg][g^-1 dry weight]
minimum= 2.9
maximum= 17.3

12.
variable=chl_ab_r
definition= chlorophyll-a / chlorophyll-b ratio
units= unitless
minimum= 2.555
maximum=4.977

Douglas Fir calculated canopy leaf nitrogen and chlorophyll content [Data file: df_can_calc.dat]
1.
variable=sampleid
definition=unique sample (canopy) identifier (syntax: DF= Douglas Fir and low, med, high=fertilizer treatment level)

2.
variable=TN
definition=average total nitrogen

units= [mg][g^-1 dry weight]
minimum= 13.63
maximum= 24.95

3.
variable=TN_std_d
definition=standard deviation total nitrogen
units= [mg][g^-1 dry weight]
minimum= 0.75
maximum= 0.84

4.
variable=chloroph
definition=average chlorophyll
units= [mg][g^-1 dry weight]
minimum= 3.11
maximum= 5.12

5.
variable=chloroph_std_d
definition=standard deviation chlorophyll
units= [mg][g^-1 dry weight]
minimum= 0.17
maximum= 0.21

Big Leaf Maple calculated canopy leaf nitrogen and chlorophyll content [Data file: map_can_calc.dat]
1.
variable=sampleid
definition=unique sample (canopy) identifier (syntax: MAP= Big Leaf Maple; low, med, high=fertilizer treatment level; full(f), half(h), and quarter(q)=quantity of seedlings used to construct canopy and determines LAI)

2.
variable=TN
definition=average total nitrogen
units= % dry weight
minimum= 1.62
maximum= 3.79

3.
variable=TN_std_d
definition=standard deviation total nitrogen
units= % dry weight]
minimum= 0.35
maximum= 0.77

4.
variable=chloroph_g
definition=average total chlorophyll
units= [mg][g^-1 dry weight]
minimum= 0.44
maximum= 1.26

5.
variable=chloroph_m2
definition=average total chlorophyll
units= [g][m^-2]
minimum= 0.2
maximum= 4.6

6.
variable=LAI
definition=leaf area index
units= unitless
minimum= 0.9
maximum= 10.8

Sample Data Record:

Douglas Fir seedling leaf analysis results [Data file: df_can_chem.dat]

sampleid,fert,colldate,lab,species,nitrogen,chloroph,water,sp_lf_ar
PSME_SC1,1,921106,ames,PSME,14.54,3.55,62.7,21.79
PSME_SC2,1,921106,ames,PSME,11.41,2.96,62,29.93

Big Leaf Maple seedling leaf analysis results [Data file: map_can_chem.dat]

sampleid,fert,colldate,lab,replicat,tree_id,leafpos,species,sp_lf_ar,nitrogen,chloroph,chl_ab_r
ACMA_SC11011,1,920315,ames,1,1,1,ACMA3,187,11.9,4.4,3.687
ACMA_SC11021,1,920315,ames,1,2,1,ACMA3,168,13.6,5.6,3.165

Douglas Fir calculated canopy leaf nitrogen and chlorophyll content [Data file: df_can_calc.dat]

sampleid,TN,TN_std_d,chloroph,chloroph_std_d
DF_low,13.63,0.78,3.11,0.21
DF_med,16.96,0.75,3.32,0.18
DF_high,24.95,0.84,5.12,0.17

Big Leaf Maple calculated canopy leaf nitrogen and chlorophyll content [Data file: map_can_calc.dat]

sampleid,TN,TN_std_d,chloroph_g,chloroph_m2,LAI
MAP_high_f,3.79,0.35,1.2,4.6,10.8
MAP_high_h,3.79,0.35,1.26,2.3,5.5
MAP_high_q,3.79,0.35,1.22,1.5,3.6

8. Data Organization:

Data Granularity:

Douglas fir and Big Leaf maple seedling canopy leaf nitrogen and chlorophyll content data are in separate data files as described in Section7.

A general description of data granularity as it applies to the IMS appears in the EOSDIS Glossary.

Data Format:

The data files are ASCII files. The first two lines are metadata. The first line contains the filename and the number of data records to follow. The second line
contains the comma delimited column headings. The data values are also comma delimited. Missing values are denoted by -999.

9. Data Manipulations:

Formulae:

Derivation Techniques and Algorithms:

Not applicable.

Data Processing Sequence:

Processing Steps:

Not applicable.

Processing Changes:

Not applicable.

Calculations:

Special Corrections/Adjustments:

Not applicable.

Calculated Variables:

Not applicable.

Graphs and Plots:

Not applicable.

10. Errors:

Sources of Error:

Quality Assessment:

Data Validation by Source:

Not applicable.

Confidence Level/Accuracy Judgment:

Not applicable.

Measurement Error for Parameters:

To estimate the error of total nitrogen estimates for Douglas-fir, nine TN measurements were made of a standard pine reference material of known concentration. The resulting coefficient of variation (CV) for the reference, 6.6%, was expected to be somewhat less than the CV for the Douglas fir samples examined here.

Additional Quality Assessments:

Not applicable.

Data Verification by Data Center:

Not applicable.

11. Notes:

Limitations of the Data:

...

Known Problems with the Data:

...

Usage Guidance:

...

Any Other Relevant Information about the Study:

...

12. Application of the Data Set:

These seedling data sets are intended for empirical and theoretical (radiative transfer model-based) analyses of the influence of plant canopy biochemical and biophysical status on canopy reflectance

13. Future Modifications and Plans:

No modifications to the data are planned. During the FY97-98 timeframe, a study is underway to use these experimental data sets to validate a coupled leaf- and canopy-level radiative transfer model.

14. Software:

Software Description:

Not applicable.

Software Access:

Not applicable.

15. Data Access:

Contact Information:

ORNL DAAC User Services
Oak Ridge National Laboratory

Telephone: (865) 241-3952
FAX: (865) 574-4665 Email: ornldaac@ornl.gov

Data Center Identification:

ORNL Distributed Active Archive Center
Oak Ridge National Laboratory
Telephone: (865) 241-3952
FAX: (865) 574-4665 Email: ornldaac@ornl.gov

Procedures for Obtaining Data:

Users may place requests by telephone, electronic mail, or FAX. Data is also available via the World Wide Web at http://daac.ornl.gov.

Data Center Status/Plans:

These data are available from the ORNL DAAC. Please contact the ORNL DAAC User Services Office for the most current information about these data.

16. Output Products and Availability:

Available via FTP or on CD-ROM. A complete listing of all data sets can be found on the World Wide Web at http://daac.ornl.gov.

17. References:

Dungan, J., L. Johnson, C. Billow, P. Matson, J. Mazzurco, J. Moen, and V. Vanderbilt. 1996. High spectral resolution reflectance of Douglas-fir grown under different fertilization treatments: Experimental design and treatment effects. Rem. Sens. of Environ. 55:217-228. Johnson, L. and C. Billow. 1996. Spectrometric estimation of total nitrogen concentration in Dougals-fir foliage. International Journal of Remote Sensing 17:489-500. Yoder, B. J., and R. E. Pettigrew-Crosby. 1995. Predicting nitrogen and chlorophyll content and concentrations from reflectance spectra (400-2500 nm) at leaf and canopy scales. Rem. Sens. Environ. 53:199-211.

18. Glossary of Terms:

Not applicable.

19. List of Acronyms:

URL

Uniform Resource Locator

ACCP

Accelerated Canopy Chemistry Program

TN

Total Nitrogen

20. Document Information:

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Document Review Date:

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Document Curator:

webmaster@daac.ornl.gov

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