

# **LIBERTY - Leaf Incorporating Biochemistry Exhibiting Reflectance and Transmittance Yields**

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## **Installation and user instructions for Windows version of LIBERTY**

### **Introduction**

LIBERTY is a general purpose radiative transfer model for predicting the reflectance and transmittance spectra of a leaf, or stack of leaves in the visible and near infrared wavelengths (400 - 2500 nm). By treating a leaf as an aggregation of cells, with multiple radiation scattering between cells, output spectra is a function of three structural parameters and the combined absorption coefficients of leaf biochemicals. It is simple to use with the user being prompted for input values and the model output is written to an external file for use with graphing and spreadsheet packages as well as for coupling with vegetation canopy or ecosystem models. It is written in C which is a very flexible and portable language and, using external absorption coefficient files, has been successfully compiled for the following platforms: MS-DOS; SUN Microsystems Solaris; Silicon Graphics IRIX.

To compile, use the following command (note: this may vary between platforms - contact your system administrator if you are having problems): `cc liberty.c -lm`

No header or make files are required, all calls to external libraries and function definitions are made at the beginning of the file.

### **File list**

LIBERTY uses external data files. This allows the user to easily modify the existing absorption coefficients or provide new ones.

#### **The full source file list is:**

<b>File</b>	<b>Description</b>
LIBERTY.C	Program code
PIGMENT.DAT	Absorption coefficient of in-vivo chlorophylls and carotenoids
ALBINO.DAT	Absorption coefficient of dried albino leaf due to lignin (visible wavelengths)
WATER.DAT	Water absorption coefficient
LIGCELL.DAT	Combined absorption coefficient of lignin and cellulose
PROTEIN.DAT	Protein absorption coefficient

#### **Additional utility files:**

<b>File</b>	<b>Description</b>
PLOT.C	Plots LIBERTY output to display (MS-DOS with VGA/EGA display only)
EGAVGA.BGI	Graphics driver for plot program
LIBINV.C	Mathematical inversion of LIBERTY. By inputting a measured spectra, gives a global absorption output

Liberty generates an output file named LIBERTY.OUT which is a space delimited text file. When compiled, the full suite of files including executable and output files require less than 100 kbytes of disk storage.

The following inputs are required from the user:

Variable	Description	Typical values (and range)
Cell Diameter	Average leaf cell diameter (m-6)	40 (20 - 100)
Intercellular air space	Determinant for the amount of radiative flux passing between cells	0.045 (0.01 - 0.1)
Leaf thickness	Arbitrary value to determine single leaf reflectance and transmittance from infinite reflectance criteria	1.6 (1 - 10)
Baseline absorption	Wavelength independent absorption to compensate for changes in absolute reflectance	Fresh: 0.0006 Dry: 0.0004
Albino absorption	Absorption in the visible region due to lignin	2 (0 - 4)
Chlorophyll content	Chlorophyll (pigment) content ( $\text{mg.m}^{-2}$ )	200 (0 - 600)
Water content	Water content ( $\text{g.m}^{-2}$ )	100 (0 - 500)
Lignin and Cellulose content	Combined lignin and cellulose content ( $\text{g.m}^{-2}$ )	40 (10 - 80)
Nitrogen content	Nitrogen content( $\text{g.m}^{-2}$ )	1 (0.3 - 2.0)

### Model output

LIBERTY produces a space delimited text file, example as below:

```
W R refl trans
400 0.029629 0.029592 0.035535
405 0.030031 0.029991 0.036120
->...
2500 0.517565 0.414745 0.394991
```

The first column is the wavelength, second column is the predicted spectra for infinite reflectance as demonstrated by stacked leaves, and the third and fourth column is the predicted single leaf reflectance and transmittance spectra, respectively.

### Notes

LIBERTY has been developed specifically for conifer needles so you will find the facility to estimate single leaf reflectance and transmittance spectra from stacked needles particularly useful. However, the program is equally valid for any leaf species with a minor caveat; The in-vivo absorption coefficients used were determined from empirical work on various pine species so you may need to re-calibrate variable values for other vegetation types.

### Utilities

PLOT.C is a utility for plotting the liberty.out file to the screen. It displays all three spectra (infinite reflectance and single leaf reflectance and transmittance with their respective maximum reflectance values. This program requires the EGAVGA.BGI graphics driver included.

LIBINV.C performs a mathematical inversion of empirical spectra based upon the structural variables used in LIBERTY (forward prediction). The output file, LIBINV.OUT provides a global absorption coefficient which can facilitate determination of individual biochemical in-vivo absorption coefficients. The input file must be a space separated text file and can be of variable wavelength (for inverting airborne data, such as AVIRIS). An example specification is as follows:

401.00 0.080285  
403.23 0.078268  
405.9 0.072514

...

The output file, LIBINV.OUT provides a space separated text file of the wavelength, reflectance and global absorption values.

### **Reference**

Dawson, T.P., Curran, P.J. and Plummer, S.E. (1998), LIBERTY - Modelling the effects of leaf biochemistry on reflectance spectra, *Remote Sensing of Environment*, 65, 50-60.