ORNL/CDIAC-120

NDP-072

A Database of Woody Vegetation Responses to Elevated Atmospheric CO2

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A DATABASE OF WOODY VEGETATION RESPONSES TO ELEVATED ATMOSPHERIC CO_2

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CONTENTS

ABSTRACT

Curtis, P. S., R. M. Cushman, and A. L. Brenkert. 1999. *A Database of Woody Vegetation Responses to Elevated Atmospheric CO_2*. ORNL/CDIAC-120, NDP-072. Carbon Dioxide Information Analysis Center, U.S. Department of Energy, Oak Ridge National Laboratory, Oak Ridge, Tennessee, U.S.A.

To perform a statistically rigorous meta-analysis of research results on the response by woody vegetation to increased atmospheric CO_2 levels, a multiparameter database of responses was compiled. Eighty-four independent CO_2-enrichment studies, covering 65 species and 35 response parameters, met the necessary criteria for inclusion in the database: reporting mean response, sample size, and variance of the response (either as standard deviation or standard error). Data were retrieved from the published literature and unpublished reports.

This numeric data package contains a 29-field data set of CO_2-exposure experiment responses by woody plants (as both a flat ASCII file and a spreadsheet file), files listing the references to the CO_2-exposure experiments and specific comments relevant to the data in the data set, and this documentation file (which includes SAS®[1] and Fortran codes to read the ASCII data file).

The data files and this documentation are available without charge on a variety of media and via the Internet from the Carbon Dioxide Information Analysis Center (CDIAC).

NDP-072 is an enhancement of previously published CDIAC DB-1018, with additional quality control and documentation (and some corrections to the data, detailed herein).

Keywords: carbon dioxide, meta-analysis, vegetation

[1]SAS® is a registered trademark of the SAS Institute, Inc., Cary, North Carolina 27511.

1. BACKGROUND INFORMATION

To perform a statistically rigorous synthesis of research results on the response by vegetation to increased atmospheric CO_2 levels, a multiparameter database of woody-plant responses was compiled (Curtis 1996; Curtis and Wang 1998). Eighty-four independent CO_2-enrichment studies, covering 65 species (listed in Appendix A) and 35 response parameters, met the necessary criteria for inclusion in the database: reporting mean response, sample size, and variance of the response (either as standard deviation or standard error). Data were retrieved from the published literature and in a few instances from unpublished reports. Meta-analytical methods (Cooper and Hedges 1994; Gurevitch and Hedges 1993; Gurevitch et al. 1992) have been applied to part of this database (Curtis 1996; Curtis and Wang 1998).

Physiological "acclimation" or "downward regulation" of photosynthetic rates, stomatal conductance, dark respiration, and water-use efficiency of plants exposed to elevated CO_2 levels can be analyzed, keeping the following definitions in mind. "Acclimation" is in general defined as "diminishing enhancement of photosynthesis by elevated CO_2 with time" (Mousseau and Saugier 1992). "Downward regulation" can be defined as "the initial stimulation of enhanced photosynthesis and growth by atmospheric enrichment eroding with time" (Idso and Kimball 1992). The phenomenon is also called "downward acclimation" (Curtis and Teeri 1992): "following prolonged exposure to high CO_2, photosynthetic capacity measured at either elevated or ambient CO_2 partial pressure falls to below that of plants exposed only to ambient CO_2." When more than one elevated CO_2 treatment level was reported, only the elevated CO_2 level that was approximately twice the ambient level was included in the database. Only the longest lasting exposure experiment results on photosynthetic rates, stomatal conductance, dark respiration and water use efficiency are included, however, not multiple measurements over time from the same plant. And only responses of plants measured at elevated levels of CO_2 are included for evaluation of acclimatory responses. Durations of experimental exposures are always reported.

2. APPLICATIONS OF THE DATA

This database was produced to support a meta-analysis of the effects of elevated CO_2 on woody vegetation (Curtis 1996; Curtis and Wang 1998), and it was formatted accordingly. For other applications, the user should be aware that the data may be reported in more than one unit for a given variable (e.g., for dark respiration, the data are reported in units of mg/g/d, mmol/g/h, mmol/m^2/h, μmol/g/s, and μmol/m^2/s; and the experimental CO_2 concentrations are reported in units of cm^3/m^3, Pa, ppm, μbar, μl/l, and μmol/mol); this is not a problem for meta-analysis, but for other applications the user may need to convert the data to consistent units.

The effects of environmental factors (e.g., nutrient levels, light intensity, temperature), stress treatments (e.g., drought, heat, ozone, ultraviolet-B radiation), and the effects of experimental conditions (e.g., duration of CO_2 exposure, pot size, type of CO_2 exposure facility) on plant responses to elevated CO_2 levels can be explored with this database.

3. DATA LIMITATIONS AND RESTRICTIONS

In many papers, the data were reported graphically, rather than numerically. In such cases, the data values reported herein were digitized from the printed figures and may therefore be less accurate.

There might also have been some confusion because of the term "standard deviation." When a "standard deviation" was reported in a published paper, it was not generally possible to verify whether this value was a *sample* standard deviation or the standard deviation *of the mean*, which is sometimes used synonymously with standard error (i.e., standard error of the mean). Unfortunately, it was not possible to settle this issue definitively without personally contacting the authors of the published papers. In all cases, where not specified or known to be otherwise, a reported standard deviation was taken to be the sample standard deviation. If this was in error, then the standard deviation, standard error, and coefficient of variation reported in this database would all be incorrect.

In some cases an error bar in a figure or confidence interval in a table was not specified as standard deviation or standard error, in which case the data contributors had to make an assumption from the error bar or confidence interval and the sample size. Instances where data were obtained by personal communication with the authors, or where standard deviation or standard error was inferred from the published data, are documented in the comments.* files (included as Appendix C). Where it was not possible to determine whether the reported variability was standard deviation or standard error, it was assumed to be standard error, for the sake of conservatism.

In some cases (e.g., in long-term exposures), duration of the CO_2 exposure was approximated.

As noted in Sect. 2, various units may be used for the same parameter, so the user should apply caution in integrating observations from more than one paper. The units are reported in this database.

4. DATA CHECKS AND PROCESSING PERFORMED BY CDIAC

An important part of the data packaging process at CDIAC involves the quality assurance (QA) of data before distribution. To guarantee data of the highest possible quality, CDIAC performs extensive QA checks, examining the data for completeness, reasonableness, and accuracy, through close cooperation with the data contributor.

This database was originally published as CDIAC DB-1018, for which all entries in the data file were visually inspected for reasonableness and selected entries were spot-checked against the original publications. Additional quality-assurance and documentation was performed in the preparation of this numeric data package, and some data were corrected, as described herein.

The following describes the additional data checks that were performed in the preparation of this numeric data package and the resulting revisions to the database.

Using Excel, the spreadsheet included in the original database (db1018.xls) was converted to Lotus 1-2-3 format (ndp072.wk1). Headings were added to all columns.

Lists of entries for each field were generated, to identify possible spelling variants, typographical errors, or order-of-magnitude errors in the original literature or in the compilation and data entry of the database. In fact, some variant spellings of **GENUS**, **SPECIES**, and **P_UNIT** were identified and corrected for the sake of consistency.

The definition of parameter LFTNC was corrected, from "leaf N (TNC free weight basis)" to "leaf total nonstructural carbohydrate."

The internal consistency of the reported standard errors (s.e.), standard deviations (s.d.), and sample sizes (n) was checked by calculating s.d. from the s.e. and n in DB-1018 and comparing the resulting values of s.d. with the values in DB-1018; discrepancies were resolved by checking the original publications.

The ratio of elev/amb for X, SE, SD, and N was calculated; then all observations were ranked on the basis of each ratio to identify suspect values.

The following lists the changes that were made to the original database.

SOURCE: In entire spreadsheet, edited format of letters following T or F number to entirely lowercase.

OBS 39 & 40 (**PAP_NO** 150): Corrected **P_UNIT**, from $molH_2O/m^2/s$ to $mmolH_2O/m^2/s$.

OBS 142 (**PAP_NO** 340): Replaced existing value of **SD_AMB** (0.9798) with value calculated from **SE_AMB** & **N_AMB** (2.4495).

OBS 143 & 151 (**PAP_NO** 340): Corrected **P_UNIT**, from $0.01g/m^2$ to 10^2 g/g.

OBS 150 (**PAP_NO** 340): Replaced existing value of **SD_AMB** (3.9192) with value calculated from **SE_AMB** & **N_AMB** (1.9596).

OBS 191 (**PAP_NO** 505): Corrected **SOURCE**, from F2b to F2c.

OBS 191 (**PAP_NO** 505): Replaced existing values of **SD_AMB** (5.134) and **SD_ELEV** (7.7972) with values calculated from **SE** & **N** (**SD_AMB** = 10.268 and **SD_ELEV** = 3.487).

OBS 192 (**PAP_NO** 505): Replaced existing values of **SD_AMB** (5.367), **SD_ELEV** (5.747), **SE_AMB** (2.4), **SE_ELEV** (2.57), **N_AMB** (20), and **N_ELEV** (20) with values provided by author: **SD_AMB** (5.484), **SD_ELEV** (4.406), **SE_AMB** (2.452), **SE_ELEV** (1.970), **N_AMB** (5), and **N_ELEV** (5).

OBS 195 (**PAP_NO** 505): Corrected **P_UNIT**, from mgdvvt/cm^3 to mgdwt/cm^3.

OBS 210 & 211 (**PAP_NO** 506): Corrected **P_UNIT**, from umol/H_2O/m^2/s to mol/H_2O/m^2/s.

OBS 364 & 365 (**PAP_NO** 746): Corrected **SPECIES** name from tulipfera to tulipifera.

OBS 598-599, 606-607, and 612-613 (**PAP_NO** 2110): Existing values for means, standard error, and standard deviation multiplied by 100, based on personal communication from author, to correct for error in the published paper (in converting from % to mg/g, data were divided by 10 rather than multiplied by 10). Personal correspondence with author also confirmed that variance values given parenthetically in Table 2 were standard deviations; the tabulated data were corrected accordingly.

To search for possible confusion between standard error and standard deviation (see Sect. 3, **DATA LIMITATIONS AND RESTRICTIONS**), coefficients of variation **CV*** (after Sokal and Rohlf 1981) were calculated for each **PARAM** from each mean, standard deviation, and sample size. It was expected that, for any **PARAM**, an anomalously low coefficient of variation for a given observation might signal that a standard error was mislabeled as a standard deviation; but no such anomalies were obvious. The database was sorted by **PARAM**, then by **CV*_AMB** and **CV*_ELEV**, and inspected for jumps of greater than fourfold between adjacent observations. The following lists those adjacent observations that warranted further scrutiny, along with the results of the checks:

PARAM = BD

> **OBS** 396, **PAP_NO** 2004 (**CV*_AMB** = 35.5828): Contacted author and verified that "mean ± SD"actually referred to sample standard deviation rather than standard error of the mean.
>
> **OBS** 758, **PAP_NO** 2224 (**CV*_AMB** = 623.5): Verified tabulated value against publication.

PARAM = BGWT

OBS 380, **PAP_NO** 2003 (**CV*_AMB**=0) and **OBS** 378, **PAP_NO** 2003 (**CV*_AMB**=2.3864): Verified tabulated values against publication.

PARAM = LFC

OBS 599, **PAP_NO** 2110 (**CV*_AMB**=3.2753): Personal correspondence with author confirmed that variance values given parenthetically in Table 2 were standard deviations; the tabulated data were corrected accordingly.

OBS 490, **PAP_NO** 2043 (**CV*_AMB**=16.6223): Verified tabulated value against publication.

PARAM = LFNM

OBS 414, **PAP_NO** 2027 (**CV*_AMB**=0.4532) and **OBS** 251, **PAP_NO** 550 (**CV*_AMB**=2.3447): Verified tabulated values against publication.

PARAM = PN

OBS 513, **PAP_NO** 2045 (**CV*_AMB**=-99.0208): Verified tabulated value against publication.

OBS 638, **PAP_NO** 2120 (**CV*_AMB**=2.6460): Based on personal communication; did not verify.

PARAM = PN_AC

OBS 520, **PAP_NO** 2045 (**CV*_AMB**=-99.0208) and **OBS** 622, **PAP_NO** 2117 (**CV*_AMB**=4.6109): Verified tabulated values against publication.

PARAM = RD_AC

OBS 589, **PAP_NO** 2068 (**CV*_AMB**=96.7737) and **OBS** 162, **PAP_NO** 468 (**CV*_AMB**=1073.9583): Verified tabulated values against publication.

PARAM = INDLA

OBS 18, **PAP_NO** 44 (**CV*_ELEV**=10.1423) and **OBS** 17, **PAP_NO** 44 (**CV*_ELEV**=43.9153): Verified tabulated values against publication.

PARAM = LFC

OBS 599, **PAP_NO** 2110 (**CV*_ELEV**=1.9585): Personal correspondence with author confirmed that variance values given parenthetically in Table 2 were standard deviations; the tabulated data were corrected accordingly.

OBS 490, **PAP_NO** 2043 (**CV*_ELEV**=13.8699): Corrected **PARAM** to LFTNC.

PARAM = LFSTAR

OBS 151, **PAP_NO** 340 (**CV*_ELEV**=39.3519) and **OBS** 143, **PAP_NO** 340 (**CV*_ELEV**=554.3478): Verified tabulated values against publication.

PARAM = LFTNC

OBS 416, **PAP_NO** 2027 (**CV*_ELEV**=1.2777) and **OBS** 773, **PAP_NO** 2224 (**CV*_ELEV**=7.7891): Verified tabulated values against publication.

PARAM = RD_AC

OBS 589, **PAP_NO** 2068 (**CV*_ELEV**=11.2191) and **OBS** 588, **PAP_NO** 2068 (**CV*_ELEV**=129.3295): Verified tabulated values against publication.

PARAM = RGR

OBS 759, **PAP_NO** 2224 (**CV*_ELEV**=10.8333): Verified tabulated value against publication.

OBS 406 & 407, **PAP_NO** 2026 (**CV*_ELEV**=78.1250): The value for **X_ELEV** was corrected, from 0.0052 to 0.052, thereby lowering the calculated **CV*_ELEV** to a less anomalous 7.8125.

OBS 192, **PAP_NO** 505 (**CV*_ELEV**=105.7878): Tabulated data changed, as described earlier in this section, based on personal communication from author.

PARAM = TOTN

OBS 613, **PAP_NO** 2110 (**CV*_ELEV**=39.0833) - Personal correspondence with author confirmed that variance values given parenthetically in Table 2 were standard deviations; the tabulated data were corrected accordingly.

OBS 243, **PAP_NO** 521 (**CV*_ELEV**=177.7945) - Error bar not labeled as to SD or SE. Assumed by data contributor to be SE, based on size of the error bars and the sample size.

5. INSTRUCTIONS FOR OBTAINING THE DATA AND DOCUMENTATION

This database (NDP-072) is available free of charge from CDIAC. The files are available via the Internet, from CDIAC's World-Wide-Web site (**http://cdiac.esd.ornl.gov**), or from CDIAC's anonymous FTP (file transfer protocol) area (**cdiac.esd.ornl.gov**) as follows:

- FTP to cdiac.esd.ornl.gov (128.219.24.36).
- Enter "ftp" as the user id.
- Enter your electronic mail address as the password (e.g., fred@zulu.org).
- Change to the directory "pub/ndp072" (i.e., use the command "cd pub/ndp072").
- Set ftp to get ASCII files by using the ftp "ascii" command.
- Retrieve the ASCII database documentation file by using the ftp "get ndp072.txt" command.
- Retrieve the ASCII data files by using the ftp "mget *.dat" command.
- Set ftp to get binary files by using the ftp "binary" command.
- Retrieve the binary spreadsheet files by using the ftp "mget *.wk1" command.
- Exit the system by using the ftp "quit" command.

Uncompress files on computer, if obtained in compressed format.

For **non-Internet data acquisitions** (e.g., floppy diskette or 8-mm tape), or for additional information, contact:

User Services
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Note: After 1 November 1999, the area code 423 will be changed to 865.

6. REFERENCES

Cooper, H., and L. V. Hedges. 1994. *The Handbook of Research Synthesis*. Russell Sage Foundation, New York.

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7. LISTING OF FILES PROVIDED

The database consists of seven files (see Table 1), including this documentation file. The data file (ndp072.dat and ndp072.wk1), reference file (refs.dat and refs.wk1), and comment file (comments.dat and comments.wk1) are each formatted in two ways: as flat ASCII files and as binary spreadsheet files (in Lotus[2] 1-2-3 format, but readable by other spreadsheet programs).

The 29-field ndp072.dat and ndp072.wk1 files contain data (784 observations in all) relevant for CO_2-exposure meta-analysis for woody plants. The ndp072.dat file can be read into SAS® or Fortran programs, using the access codes provided in Sect. 11 of this numeric data package. The ndp072.dat file can also be converted into a spreadsheet file for processing, although it is simpler to use the ndp072.wk1 spreadsheet file provided in this numeric data package.

The refs.* files list the selected literature represented in the data files (84 references in all), and the comments.* files provide additional information about the studies, beyond what appears in the ndp072.* data files. The reference numbers in the refs.* and comments.* correspond to the paper numbers in the ndp072.* data files.

[2]Lotus 1-2-3 is a registered trademark of the Lotus Development Corporation, Cambridge, Massachusetts 02142

Table 1. Data files in the database

File number	File name	File size (kB)	File type	File description
1	**ndp072.txt**	81	ASCII text	Documentation file
2	**ndp072.dat**	185	ASCII text	Data file
3	**ndp072.wk1**	392	Binary spreadsheet	Data file
4	**refs.dat**	18	ASCII text	Reference file
5	**refs.wk1**	21	Binary spreadsheet	Reference file
6	**comments.dat**	24	ASCII text	Comment file
7	**comments.wk1**	25	Binary spreadsheet	Comment file

8. DESCRIPTION OF THE DOCUMENTATION FILE

ndp072.txt (File 1)

This file is an ASCII text equivalent to this document.

9. DESCRIPTION, FORMAT, AND PARTIAL LISTINGS OF THE ASCII DATA FILES

ndp072.dat (File 2)

Table 2 describes the format and contents of the ASCII data file **ndp072.dat** distributed with this numeric data package. This table also indicates the column in the corresponding spreadsheet file **ndp072.wk1** in which each variable is found.

Table 2. Contents and format of ndp072.dat (File 2)

Variable	Variable type	Variable width	Starting column	Ending column	Units	Spreadsheet column	Definition and comments
OBSNO	Numeric	3	1	3		A	Observation number
PAP_NO	Numeric	4	4	7	See below	B	Cited paper numbers
PARAM	Character	6	8	13	See below	C	Measured parameter
P_UNIT	Character	15	14	28		D	Unit for PARAM
GENUS	Character	13	29	41		E	Plant genus name
SPECIES	Character	25	42	66		F	Plant species name
DIV1	Character	5	67	71	See below	G	Functional division #1
DIV2	Character	5	72	76	See below	H	Functional division #2
AMB	Character	4	77	80	See CO2_UNIT	I	Ambient CO_2 treatment level
ELEV	Character	4	81	84	See CO2_UNIT	J	Elevated CO_2 treatment level
CO2_UNIT	Character	8	85	92	See below	K	Units for CO_2 exposure concentration
TIME	Numeric	4	93	96	Days	L	Maximum duration of CO_2 exposure
POT	Character	6	97	102	See below	M	Growing method
METHOD	Character	4	103	106	See below	N	CO_2-exposure facility
STOCK	Character	8	107	114	See below	O	Planting stock
XTRT	Character	6	115	120	See below	P	Interacting treatment
LEVEL	Character	7	121	127	See below	Q	Interacting treatment level

Table 2 (continued)

Variable	Variable type	Variable width	Starting column	Ending column	Units	Spreadsheet column	Definition and comments
QUANT	Character	24	128	151	See below	R	Quantity and unit associated with LEVEL
SOURCE	Character	6	152	157	See below	S	Figure, table, or page from which data were taken
X_AMB	Numeric	10	158	167	See P_UNIT	T	Mean response of plants grown in ambient CO_2
SE_AMB	Numeric	9	168	176	See P_UNIT	U	Standard error of X_AMB
SD_AMB	Numeric	10	177	186	See P_UNIT	V	Standard deviation of responses of plants grown in ambient CO_2
CV*_AMB	Numeric	9	187	195	%	W	Coefficient of variation of responses of plants grown in ambient CO_2
N_AMB	Numeric	3	196	198		X	Sample size of responses of plants grown in ambient CO_2
X_ELEV	Numeric	10	199	208	See P_UNIT	Y	Mean response of plants grown in elevated CO_2
SE_ELEV	Numeric	9	209	217	See P_UNIT	Z	Standard error of X_ELEV
SD_ELEV	Numeric	10	218	227	See P_UNIT	AA	Standard deviation of responses of plants grown in elevated CO_2

Table 2 (continued)

Variable	Variable type	Variable width	Starting column	Ending column	Units	Spreadsheet column	Definition and comments
CV*_ELEV	Numeric	9	228	236	%	AB	Coefficient of variation of responses of plants grown in elevated CO_2
N_ELEV	Numeric	3	237	239		AC	Sample size of responses of plants grown in elevated CO_2

Where:

For **PAP_NO**, a value < 2000 indicates abstracts in Strain and Cure (1994), and a value >2000 indicates more recent literature.

For **PARAM**, the following define the possible measured parameters:

plant parts

- AGWT: total aboveground weight
- BD: basal diameter
- BGWT: total belowground weight
- CRWT: coarse root weight
- FRWT: fine root weight
- HT: height
- LFWT: total leaf weight
- RGR: relative growth rate
- SEEDWT: reproductive biomass
- STWT: stem weight
- TOTWT: whole plant weight

leaf area components

- INDLA: maximum individual leaf area
- LAR: leaf area ratio (leaf area/unit mass of plant)
- MAXLA: maximum canopy leaf area
- SLA: specific leaf area (leaf area/unit mass of leaf)
- SLW: specific leaf weight (leaf mass/unit area of leaf)

gas-exchange parameters

GS: stomatal conductance of ambient plants measured under ambient CO_2 (**X_AMB**) and elevated plants measured under elevated CO_2 levels (**X_ELEV**)
GS_AC: stomatal conductance of ambient plants measured at elevated CO_2 (**X_AMB**) and elevated plants measured at elevated CO_2 levels (**X_ELEV**)
JMAX: maximum rate of electron transport
PIRC: rate of phosphate regeneration
PN: net CO_2 assimilation of ambient plants measured under ambient CO_2 (**X_AMB**) and elevated plants measured under elevated CO_2 levels (**X_ELEV**)
PN_AC: net CO_2 assimilation of ambient plants measured at elevated CO_2 (**X_AMB**) and elevated plants measured at elevated CO_2 levels (**X_ELEV**)
RD: dark respiration of ambient plants measured under ambient CO_2 (**X_AMB**) and elevated plants measured under elevated CO_2 levels (**X_ELEV**)
RD_AC: dark respiration of ambient plants measured at elevated CO_2 (**X_AMB**) and elevated plants measured at elevated CO_2 levels (**X_ELEV**)
VCMAX: maximum carboxylation rate of Rubisco
WUE: water use efficiency of ambient plants measured under ambient CO_2 (**X_AMB**) and elevated plants measured under elevated CO_2 levels (**X_ELEV**)
WUE_AC: water use efficiency of ambient plants measured at elevated CO_2 (**X_AMB**) and elevated plants measured at elevated CO_2 levels (**X_ELEV**)

biochemical constituents
LFC: leaf total C (unit mass basis)
LFNA: leaf N (unit area basis)
LFNM: leaf N (unit mass basis)
LFTNC: leaf total non-structural carbohydrate
LFP: leaf P (unit mass basis)
LFSTAR: leaf starch (unit mass basis)
LFSUG: leaf sugar (unit mass basis)
TOTN: total N (concentration)

The value of **PARAM** is linked to that shown for **P_UNIT** (parameter units), **X_AMB** (parameter value for plants grown under ambient CO_2 exposure conditions), and **X_ELEV** (parameter value for plants grown under elevated CO_2 exposure conditions).

All entries for **DIV1** are “WOODY” in this database.

Entries for **DIV2** are:
ANGIO: angiosperms
GYMNO: gymnosperms
N2FIX: nitrogen fixation by species in experiment

The values of **AMB** and **ELEV** are linked to that shown for **CO2_UNIT**.

Entries for **CO2_UNIT** are:

- Pa (Pascals)
- μbar (1 μbar = 0.1 Pa)
- ppm
- μl/l
- cm^3/m^3
- μmol/mol

For **POT**, a numeric entry signifies pot size (in liters) used during the major part of the experiment; the other entries are:

- GRND: plants rooted in the ground
- HYDRO: solution or aeroponic culture

Entries for **METHOD** are:

- BRANCH: branch chambers
- GC: indoor, controlled environment: growth chambers
- GH: sunlit greenhouses and chambers within greenhouses
- OTC: field-based open-top chambers
- SPAR: high-tech soil-plant-atmosphere chambers

Entries for **STOCK** are:

- BRANCH: branches exposed
- MATURE: mature plants exposed
- SAP: plants started from cuttings
- SEED: plants started from seeds

Entries for **XTRT** are:

- NONE: no treatment
- COMP: plant competition
- FERT+L: soil fertility and light
- FERT: soil fertility
- H2O: well-watered vs drought
- LIGHT: light treatment
- TEMP: temperature treatment
- OZONE: ozone exposure
- UVB: ultraviolet-B radiation exposure

The entries for **LEVEL** (which qualitatively describes the treatment level) are treatment-dependent and cannot be further categorized; this field is linked with **XTRT** (which characterizes the treatment type) and **QUANT** (which quantifies the treatment level).

For **XTRT** = NONE, COMP, or FERT+L, **LEVEL** = . (missing value) (see entry for corresponding paper in **comments.*** file)

For soil fertility treatment:
FERT - HI
LOW
CONTROL
missing (.) when treatment can not be clearly described (see entry for corresponding paper in **comments.*** file).

For H2O treatment:
DRT: drought
WW: well-watered

For LIGHT treatment:
HI
LOW

For TEMP treatment:
HI
LOW
CONTROL

For stress interactions:
OZONE
HI
LOW

UVB
HI
LOW

Entries for **QUANT**, which quantify the interacting treatment level, are treatment-dependent. The combination of quantity and unit is reported in this one field (see also the corresponding entry in **comments.*** file). The missing-value indicator for **QUANT** is a period (.).

Possible entry formats for **SOURCE** are:
F1a (Fig. 1a)
T1 (Table 1)
P235 (Page 235 of text)
1emeta (personal communication with authors)

Entries for **X_AMB**, **SE_AMB**, **SD_AMB**, **X_ELEV**, **SE_ELEV**, and **SD_ELEV** are linked to the units given for **P_UNIT**. The suffix "**AMB**" refers to measurements of plants grown under ambient CO_2 exposure conditions, and the suffix "**ELEV**" refers to measurements of plants grown under elevated CO_2 exposure conditions.

For **CV*_AMB** and **CV*_ELEV**, corrected (for small sample size) coefficient of variation was calculated according to Sokal and Rohlf (1981) as follows:

$$CV^* = (1 + 1/4N)(SD \times 100)/X$$

where SD = standard deviation, X = mean, and N = sample size.

First two data records:

```
  1  44PN    umolCO2/m2/s   ALNUS       RUBRA
WOODYN2FIX 350 650ul/l      46   0.5GC    SEED  FERT  HI
20mgN/l                T3      11.7700   0.6400    1.4311
12.7668  5  23.2000    4.6100   10.3083  46.6539  5
  2  44PN    umolCO2/m2/s   ALNUS       RUBRA
WOODYN2FIX 350 650ul/l      46   0.5GC    SEED  FERT  CONTROL.
                  T3      11.7000   1.1600    2.5938   23.2777  5
25.9000    1.4800    3.3094  13.4165  5
```

Last two data records:

```
7832224TOTWT g              POPULUS      TREMULOIDES
WOODYANGIO 385 642ul/l      60     6GC    SEED  NONE  .     .
                  F1      69.7000   2.1000    3.6373    5.6534  3
102.6000    3.6000    6.2354   6.5838  3
7842224LFSTAR%              POPULUS      TREMULOIDES
WOODYANGIO 385 642ul/l      60     6GC    SEED  NONE  .     .
                  F2       2.7600   0.1900    0.3291   12.9176  3
 8.5300    0.9300    1.6108  20.4576  3
```

refs.dat (File 4)

This ASCII file provides citations of papers included in the database. A full listing of the file is included as **APPENDIX B**.

comments.dat (File 6)

This ASCII file provides experimental details from papers included in the database. A full listing of the file is included as **APPENDIX C**.

10. DESCRIPTION AND FORMAT OF THE LOTUS 1-2-3 BINARY SPREADSHEET FILES

Three Lotus 1-2-3 binary spreadsheet files (files 3, 5, and 7) contain the same information as the corresponding *.dat ASCII files 2, 4, and 6.

ndp072.wk1 (File 3)

This Lotus 1-2-3 binary spreadsheet file corresponds to ASCII file **ndp072.dat (File 2)**. Table 2, which describes the contents and format of **ndp072.dat**, also indicates the column of **ndp072.wk1** in which each variable is found.

refs.wk1 (File 5)

This Lotus 1-2-3 binary spreadsheet file corresponds to ASCII file **refs.dat (File 4)**.

comments.wk1 (File 7)

This Lotus 1-2-3 binary spreadsheet file corresponds to ASCII file **comments.dat (File 6)**.

11. SAS® AND FORTRAN CODES TO ACCESS THE DATA

The following is SAS® code to read file **ndp072.dat**

```
*SAS data retrieval routine to read ndp072.dat;

data ndp072;
infile 'ndp072.dat';
input OBSNO 1-3 @4 PAP_NO 4. @8 PARAM $char6. P_UNIT $ 14-28 GENUS $ 29-41
      SPECIES $ 42-66 DIV1 $ 67-71 DIV2 $ 72-76 AMB $ 77-80 ELEV $ 81-84
      CO2_UNIT $ 85-92 TIME 93-96 POT $ 97-102 METHOD $ 103-106
      STOCK $ 107-114 XTRT $ 115-120 LEVEL $ 121-127 QUANT $ 128-151
      SOURCE $ 152-157 X_AMB 158-167 SE_AMB 168-176 SD_AMB 177-186
      CV_AMB 187-195 N_AMB 196-198 X_ELEV 199-208 SE_ELEV 209-217
      SD_ELEV 218-227 CV_ELEV 228-236 N_ELEV 237-239 ;

* In the above INPUT statement, the variables CV*_AMB and CV*_ELEV have
  been renamed CV_AMB and CV_ELEV, respectively.;

run;
```

The following is Fortran code to read file **ndp072.dat**

```
C *** Fortran program to read the file "ndp072.dat"
C
      INTEGER OBSNO, PAP_NO, N_AMB, N_ELEV, TIME
      DOUBLE PRECISION X_ELEV, SD_ELEV
      REAL X_AMB, SE_AMB, SD_AMB, CV_AMB, SE_ELEV, CV_ELEV
```

```
      CHARACTER PARAM*6, P_UNIT*15, GENUS*13, SPECIES*25, DIV1*5,
     + DIV2*5, AMB*4, ELEV*4, CO2_UNIT*8, POT*6, METHOD*4, STOCK*8,
     + XTRT*6, LEVEL*7, QUANT*24, SOURCE*6
C
      OPEN (UNIT=1, FILE='NDP072.DAT')
C
C     Note that the variables CV*_AMB and CV*_ELEV have
C     been renamed CV_AMB and CV_ELEV, respectively
C
   10 READ (1,100,END=99) OBSNO, PAP_NO, PARAM, P_UNIT, GENUS, SPECIES,
     + DIV1, DIV2, AMB, ELEV, CO2_UNIT, TIME, POT, METHOD, STOCK, XTRT,
     + LEVEL, QUANT, SOURCE, X_AMB, SE_AMB, SD_AMB,CV_AMB,N_AMB,X_ELEV,
     + SE_ELEV, SD_ELEV, CV_ELEV, N_ELEV
  100 FORMAT (I3,I4,A6,A15,A13,A25,2A5,2A4,A8,A4,A6,A4,A8,A6,A7,A24,
     + A6,F9.4,1X,F8.4,1X,2(F9.4,1X),I2,3(F9.4,1X),F8.4,1X,I2)
C
      GO TO 10
   99 CLOSE (UNIT=1)
      STOP
      END
```

APPENDIX A: SPECIES INCLUDED IN DATABASE

Acacia mangium
Acer pensylvanicum
Acer pseudoplatanus
Acer rubrum
Acer saccharinum
Acer saccharum
Alnus glutinosa
Alnus rubra
Betula alleghaniensis
Betula lenta
Betula papyrifera
Betula pendula
Betula populifolia
Betula pubescens
Brachychiton populneum
Castanea sativa
Cecropia obtusifolia
Cedrus atlantica
Citrus aurantium
Citrus sinensis
Eucalyptus microtheca
Eucalyptus polyanthemus
Eucalyptus tetrodonta
Fagus grandifolia
Fagus sylvatica
Ficus obtusifolia
Fraxinus americana
Garcinia mangostana
Gliricidia sepium
Lindera Benzoin
Liquidambar styraciflua
Liriodendron tulipifera
Malus domestica
Maranthes corymbosa
Myriocarpa longipes
Nothofagus fusca
Picea abies
Picea glauca
Picea mariana
Pinus banksiana
Pinus echinata
Pinus eldarica
Pinus nigra
Pinus ponderosa
Pinus radiata
Pinus strobus
Pinus sylvestris
Pinus taeda
Piper auritum
Poncirus trifoliata x *citrusparadisi*
Poncirus trifoliata x *citrussinensis*
Populus euramericana
Populus grandidentata
Populus interamericana
Populus tremuloides
Populus x *euramericana*
Pseudotsuga menziesii
Quercus alba
Quercus prinus
Quercus robur
Quercus rubra
Senna multijuga
Tabebuia rosea
Trichospermum mexicanum

APPENDIX B: FULL LISTING OF REFS.DAT (FILE 4)

The number at the beginning of each entry corresponds to **PAP_NO**, the cited paper number, as defined in Sect. 9.

44 Arnone, J.A., III, and J.C. Gordon. 1990. Effect of Nodulation, Nitrogen Fixation and CO2 Enrichment on the Physiology, Growth and Dry Mass Allocation of Seedlings of Alnus rubra Bong. New Phytologist 116:55-66.

2186 Bassow, S.L., K.D.M. McConnaughay, and F.A. Bazzaz. 1994. The Response of Temperate Tree Seedlings Grown in Elevated CO2 to Extreme Temperature Events. Ecological Applications 4(3):593-603.

2223 Bazzaz, F.A., and S.L. Miao. 1993. Successional Status, Seed Size,and Responses of Tree Seedlings to CO2, Light and Nutrients. Ecology 74(1):104-112.

2037 Bazzaz, F.A., S.L. Miao, and P.M. Wayne. 1993. CO2-induced Growth Enhancements of Co-occurring Tree Species Decline at Different Rates. Oecologia 96:478-482.

2217 Berryman, C.A., D. Eamus, and G.A. Duff. 1993. The Influence of CO2 Enrichment on Growth, Nutrient Content and Biomass Allocation of Maranthes corymbosa. Australian Journal of Botany 41:195-209.

112 Brown, K.R. 1991. Carbon Dioxide Enrichment Accelerates the Decline in Nutrient Status and Relative Growth Rate of Populus tremuloides Michx. Seedlings. Tree Physiology 8:161-173.

121 Bunce, J.A. 1992. Stomatal Conductance, Photosynthesis and Respiration of Temperate Deciduous Tree Seedlings Grown Outdoors at an Elevated Concentration of Carbon Dioxide. Plant, Cell and Environment 15:541-549.

2026 Callaway, R.M., E.H. DeLucia, E.M. Thomas, and W.H. Schlesinger. 1994. Compensatory Responses of CO2 Exchange and Biomass Allocation and their Effects on the Relative Growth Rate of Ponderosa Pine in Different CO2 and Temperature Regimes. Oecologia 98:159-166.

2043 Cipollini, M.L., B.G. Drake, and D. Whigham. 1993. Effects of ElevatedCO2 on Growth and Carbon/Nutrient Balance in the Deciduous Woody Shrub Lindera Benzoin (L.) Blume (Lauraceae). Oecologia 96:339-346.

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159 Couteaux, M.M., P. Bottner, H. Rouhier, and G. Billes. 1992. Atmospheric CO2 Increase and Plant Material Quality: Production, Nitrogen Allocation and Litter Decomposition of Sweet Chestnut. IN: Responses of Forest Ecosystems to Environmental Changes (A. Teller, P. Mathy, and J.N.R. Jeffers, eds.), Elsevier Applied Science, London, pp. 429-436.

168 Curtis, P.S., and J.A. Teeri. 1992. Seasonal Responses of Leaf Gas Exchange to Elevated Carbon Dioxide in Populus grandidentata. Canadian Journal of Forest Research 22:1320-1325.

2039 Curtis, P.S., C.S. Vogel, K.S. Pregitzer, D.R. Zak, and J.A. Teeri. 1995. Interacting Effects of Soil Fertility and Atmospheric CO2 on Leaf Area Growth and Carbon Gain Physiology in Populus x euramericana (Dode) Guinier. New Phytologist 129:253-263.

2129 Curtis, P.S., D.R. Zak, K.S. Pregitzer, and J.A. Teeri. 1994. Above- and Belowground Response of Populus grandidentata to Elevated Atmospheric CO2 and Soil N Availability. Plant and Soil 165:45-51.

184 Downton, W.J.S., W.J.R. Grant, and E.K. Chacko. 1990. Effect of Elevated Carbon Dioxide on the Photosynthesis and Early growth of Mangosteen (Garcinia mangostana L.). Scientia Horticulturae 44:215-225.

183 Downton, W.J.S., W.J.R. Grant, and B.R. Loveys. 1987. Carbon Dioxide Enrichment Increases Yield of Valencia Orange. Australian Journal of Plant Physiology 14:493-501.

2047 Eamus, D., C.A. Berryman, and G.A. Duff. 1993. Assimilation, Stomatal Conductance, Specific Leaf Area and Chlorophyll Responses to Elevated CO2 of Maranthes corymbosa a Tropical Rain Forest Species. Australian Journal of Plant Physiology 20:741-755.

2071 Eamus, D., C.A. Berryman, and G.A. Duff. 1995. The Impact of CO2 Enrichment on Water Relations in Maranthes corymbosa and Eucalyptus tetrodonta. Australian Journal of Botany 43:273-282.

2070 Eamus, D., G.A. Duff, and C.A. Berryman. 1995. Photosynthetic Responses to Temperature, Light, Flux-density, CO2 Concentration and Vapour Pressure Deficit in Eucalyptus tetrodonta Grown under CO2 Enrichment. Environmental Pollution 90:41-49.

208 El Kohen, A., J.-Y. Pontailler, and M. Mousseau. 1991. Effect of Doubling of Atmospheric CO2 Concentration on Dark Respiration in Aerial Parts of Young Chestnut Trees (Castanea sativa Mill.). Comptes Rendus des Sciences (Paris) t. 312, Serie III:477-481.

209 El Kohen, A., H. Rouhier, and M. Mousseau. 1992. Changes in Dry Weight and Nitrogen Partitioning Induced by Elevated CO2 Depends on Soil Nutrient Availability in Sweet Chestnut (Castanea sativa Mill.). Annales des Sciences Forestieres 49:83-90.

210 El Kohen, A., L. Venet, and M. Mousseau. 1993. Growth and Photosynthesis of Two Deciduous Forest Species at Elevated Carbon Dioxide. Functional Ecology 7:480-486.

221 Ferguson, J.J., W.T. Avigne, L.H. Allen, and K.E. Koch. 1986. Growth of CO2-enriched Sour Orange Seedlings Treated with Gibberellins/Cytokinins. Proceedings of the Florida State Horticultural Society 99:37-39.

222 Fetcher, N., C.H. Jaeger, B.R. Strain, and N. Sionit. 1988. Long-term Elevation of Atmospheric CO2 Concentration and the Carbon Exchange Rates of Saplings of Pinus taeda L. and Liquidambar styraciflua L. Tree Physiology 4:255-262.

2041 Garcia, R.L., S.B. Idso, G.W. Wall, and B.A. Kimball. 1994. Changes in net Photosynthesis and Growth of Pinus eldarica Seedlings in Response to Atmospheric CO2 Enrichment. Plant, Cell and Environment 17:971-978.

233 Gaudillere, J.-P., and M. Mousseau. 1989. Short Term Effect of CO2 Enrichment on Leaf Development and Gas Exchange of Young Poplars (Populus euramericana cv I 214). Acta Oecologica/Oecologia Plantarum 10:95-105.

2002 Gorissen, A., P.J. Kuikman, and H. van de Beek. 1995. Carbon Allocation and water Use in Juvenile Douglas Fir under Elevated CO2. New Phytologist 129:275-282.

2036 Grulke, N.E., J.L. Hom, and S.W. Roberts. 1993. Physiological Adjustment of two Full-sib Families of Ponderosa Pine to Elevated CO2. Tree Physiology 12:391-401.

2035 Gunderson, C.A., R.J. Norby, and S.D. Wullschleger. 1993. Foliar Gas Exchange Responses of two Deciduous Hardwoods during 3 Years of Growth in Elevated CO2: no Loss of Photosynthetic Enhancement. Plant, Cell and Environment 16:797-807.

290 Hollinger, D.Y. 1987. Gas Exchange and Dry Matter Allocation Responses to Elevation of Atmospheric CO2 Concentration in Seedlings of three Tree Species. Tree Physiology 3:193-202.

314 Idso, S.B., and B.A. Kimball. 1991. Downward Regulation of Photosynthesis and Growth at High CO2 Levels. Plant Physiology 96:990-992.

318 Idso, S.B., and B.A. Kimball. 1993. Effects of Atmospheric CO2 Enrichment on Net Photosynthesis and Dark Respiration Rates of Three AustralianTree Species. Journal of Plant Physiology 141:166-171.

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2123 Jarvis, P.G., H.S.J. Lee, and C.V.M. Barton. 1994. The Likely Impact of rising CO2 and Temperature on European Forests. Institute of Ecology and Resource Management, University of Edinburgh.

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340 Kaushal, P., J.M. Guehl, and G. Aussenac. 1989. Differential Growth Response to Atmospheric Carbon Dioxide Enrichment in Seedlings of Cedrus atlantica and Pinus nigra ssp. Laricio var. Corsicana. Canadian Journal of Forest Research 19:1351-1358.

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2120 Laboratorium Voor Plantecologie. 1992. Effect of Increased Atmospheric CO2 Concentration on Primary Productivity and Carbon Allocation in Typical Belgian Forest Ecosystems. Progress report 1992.

2028 Lavola, A., and R. Julkunen-Tiitto. 1994. The Effect of Elevated Carbon Dioxide and Fertilization on Primary and Secondary Metabolites in Birch, Betula pendula (Roth). Oecologia 99:315-321.

2165 Lewis, J.D., R.B. THomas, and B.R. Strain. 1994. Effect of Elevated CO2 on Mycorrhizal Colonization of Loblolly Pine (Pinus taeda L.) Seedlings. Plant and Soil 165:81-88.

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2065 Liu, S., and R.O. Teskey. 1995. Responses of Foliar Gas Exchange to Long-term Elevated CO2 Concentrations in Mature Loblolly Pine Trees. Tree Physiology 15:351-359.

2069 Marek, M.V., J. Kalina, and M. Matouskova. 1995. Response of Photosynthetic Carbon Assimilation of Norway Spruce Exposed to Long-term Elevation of CO2 Concentration. Photosynthetica 31:209-220.

2117 Mortensen, L.M. 1994. Effects of Carbon Dioxide Concentration on Assimilate Partitioning, Photosynthesis and Transpiration of Betula pendula Roth. and Picea abies (L.) Karst. Seedlings at two Temperatures. Acta Agriculturae Scandinavica, Section B, Soil and Plant Sciences 44:164-169.

2003 Mortensen, L.M. 1995. Effect of Carbon Dioxide Concentration on Biomass Production and Partitioning in (Betula pubescens Ehrh.) Seedlings at Different Ozone and Temperature Regimes. Environmental Pollution 87:337-343.

468 Mousseau, M. 1993. Effects of Elevated CO2 on Growth, Photosynthesis and Respiration of Sweet Chestnut (Castanea sativa Mill.). Vegetatio 104/105:413-419.

470 Mousseau, M., and H.Z. Enoch. 1989. Carbon Dioxide Enrichment Reduces Shoot Growth in Sweet Chestnut Seedlings (Castanea sativa Mill.). Plant, Cell and Environment 12:927-934.

502 Norby, R.J., C.A. Gunderson, S.D. Wullschleger, E.G. O'Neill, and M.K. McCracken. 1992. Productivity and Compensatory Responses of Yellow-poplar Trees in Elevated CO2. Nature 357:322-324.

505 Norby, R.J., and E.G. O'Neill. 1989. Growth Dynamics and Water Use of Seedlings of Quercus alba L. in CO2-enriched Atmospheres. New Phytologist 111:491-500.

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504 Norby, R.J., E.G. O'Neill, and R.J. Luxmoore. 1986. Effects of Atmospheric CO2 Enrichment on the Growth and Mineral Nutrition of Quercus alba Seedlings in Nutrient-poor Soil. Plant Physiology 82:83-89.

2131 Norby, R.J., Wullschleger, and C.A. Gunderson. 1996. Tree Responses to Elevated CO2 and Implications for Forests. IN: Carbon Dioxide and Terrestrial Ecosystems (G.W. Koch and H.A. Mooney, eds.), Academic Press, New York, pp.1-21.

510 O'Neill, E.G., R.J. Luxmoore, and R.J. Norby. 1987. Increases in Mycorrhizal Colonization and Seedling Growth in Pinus echinata and Quercus alba in an Enriched CO2 Atmosphere. Canadian Journal of Forest Research 17:878-883.

521 Overdieck, D. 1990. Effects of Elevated CO2-concentration Levels on Nutrient Contents of Herbaceous and Woody Plants. IN: The Greenhouse Effect and Primary Productivity in European Agro-ecosystems; 5-10 April 1990; Wageningen, The Netherlands (J. Goudriaan, H. van Keulen, and H.H. van Laar, eds.), Pudoc, Wageningen, pp. 31-37.

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2027 Pettersson, R., A.J.S. McDonald, and I. Stadenberg. 1993. Response of Small Birch Plants (Betula pendula Roth.) to Elevated CO2 and Nitrogen Supply. Plant, Cell and Environment 16:1115-1121.

553 Polle, A., T. Pfirrmann, S. Chakrabarti, and H. Rennenberg. 1993. The Effects of Enhanced Ozone and Enhanced Carbon Dioxide Concentrations on Biomass, Pigments and Antioxidative Enzymes in Spruce Seedlings. Plant, Cell and Environment 16:311-316.

2110 Pregitzer, K.S., D.R. Zak, P.S. Curtis, M.E. Kubiske, J.A. Teeri, and C.S. Vogel. 1995. Atmospheric CO2, Soil Nitrogen and Turnover of Fine Roots. New Phytologist 129(4):579-585.

582 Reekie, E.G., and F.A. Bazzaz. 1989. Competition and Patterns of Resource Use among Seedlings of Five Tropical Trees Grown at Ambient and Elevated CO2. Oecologia 79:212-222.

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2038 Roth, S.K., and R.L. Lindroth. 1994. Effects of CO2-mediated Changes in Paper Birch and White Pine Chemistry on Gypsy Moth Performance. Oecologia 98:133-138.

644 Sharkey, T.D., F. Loreto, and C.F. Delwiche. 1991. High Carbon Dioxide and Sun/Shade Effects on Isoprene Emission from Oak and Aspen Tree Leaves. Plant, Cell and Environment 14:333-338.

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666 Stewart, J.D., and J. Hoddinott. 1993. Photosynthetic Acclimation to Elevated Atmospheric Carbon Dioxide and UV Irradiation in Pinus banksiana. Physiologia Plantarum 88:493-500.

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676 Surano, K.A., P.F. Daley, J.L.J. Houpis, J.H. Shinn, J.A. Helms, R.J. Palassou, and M.P. Costella. 1986. Growth and Physiological Responses of Pinus ponderosa Dougl. ex P. Laws. to Long-term Elevated CO2 Concentration. Tree Physiology 2:243-259.

2005 Teskey, R.O. 1995. A Field Study of the Effects of Elevated CO2 on Carbon Assimilation, Stomatal Conductance and Leaf Branch Growth of Pinus taeda Trees. Plant, Cell and Environment 18:565-573.

682 Thomas, R.B., D.D. Richter, H. Ye, P.R. Heine, and B.R. Strain. 1991.Nitrogen Dynamics and Growth of Seedlings of an N-fixing Tree (Gliricidia sepium (Jacq.) Walp.) Exposed to Elevated Atmospheric Carbon Dioxide. Oecologia 88:415-421.

2044 Tissue, D.T., R.B. Thomas, and B.R. Strain. 1993. Long-term Effects of Elevated CO2 and Nutrients on Photosynthesis and Rubisco in Loblolly Pine Seedlings. Plant, Cell and Environment 16:859-865.

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2122 Vogel, C.S., and P.S. Curtis. 1995. Leaf Gas Exchange and Nitrogen Dynamics of N2-fixing, Field-grown Alnus glutinosa under Elevated Atmospheric CO2. Global Change Biology 1:55-61.

2068 Wang, K., S. Kellomaki, and K. Laitinen. 1995. Effects of Needle Age, Long-term Temperature and CO2 Treatments on the Photosynthesis of Scots Pine. Tree Physiology 15:211-218.

2152 Williams, R.S., D.E. Lincoln, and R.B. Thomas. 1994. Loblolly Pine Grown under Elevated CO2 Affects Early Instar Pine Sawfly Performance. Oecologia 98:64-71.

747 Wullschleger, S.D., and R.J. Norby. 1992. Respiratory Cost of Leaf Growth and Maintenance in White Oak Saplings Exposed to Atmospheric CO2 Enrichment. Canadian Journal of Forest Research 22:1717-1721.

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2004 Wullschleger, S.D., R.J. Norby, and P.J. Hanson. 1995. Growth and Maintenance Respiration in Stems of Quercus alba after Four Years of CO2 Enrichment. Physiologia Plantarum 93:47-54.

7J45 Wullschleger, S.D., R.J. Norby, and D.L. Hendrix. 1992. Carbon Exchange Rates, Chlorophyll Content, and Carbohydrate Status of Two Forest Tree Species Exposed to Carbon Dioxide Enrichment. Tree Physiology 10:21-31.

2048 Yakimchuk, R., and J. Hoddinott. 1994. The Influence of Ultraviolet-B Light and Carbon Dioxide Enrichment on the Growth and Physiology of Seedlings of Three Conifer Species. Canadian Journal of Forest Research 24:1-8.

756 Ziska, L.H., K.P. Hogan, A.P. Smith, and B.G. Drake. 1991. Growth and Photosynthetic Response of Nine Tropical Species with Long-term Exposure to Elevated Carbon Dioxide. Oecologia 86:383-389.

APPENDIX C: FULL LISTING OF COMMENTS.DAT (FILE 6)

The number at the beginning of each entry corresponds to **PAP_NO**, the cited paper number, as defined in Sect. 9.

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Listed are paper numbers, authors, CO2 exposure facility, light, temperature,
watering and nutrient conditions when available, location of experimental
set-up, and comments.  For the CO2 exposure facilities, watering regimes, and
locations the following distinctions were made:
CO2-exposure facilities:
      BRANCH - branch chambers
      GC     - indoor, controlled environment: growth chambers
      GH     - sunlit greenhouses and chambers within greenhouses
      OTC    - field-based open-top chambers
      SPAR   - high tech soil-plant-atmosphere chambers
Watering regime:
      WW     - well watered
      W      - watered
Locations:
      NA     - North America
      CA     - Central America
      AU     - Australia
      EU     - Europe

==============================================================================

44    Arnone, J.A., III, and J.C. Gordon, 1990
      GC
      Light: 400 umol/m2/s                Photoperiod: 16h
      Temperature: 26/20degC
      Watering regime: WW/drip            Humidity: 70%
      Nutrients: daily 1/4 strength Hoagland
      N Treatment: 0 vs 20 mg NH4NO3-N/l
      NA: North Carolina
      Root nodules from inocculation with Frankia cells

112   Brown, K.R., 1991
      GC
      Light: 400 umol/m2/s at canopy level      Photoperiod: 18h
      Temperature: 22/17degC
      Watering regime: WW 6 d/wk          Humidity: 45%
      Macronutrients 6d/wk; N Treatment: 0.155 vs 15.5 mM NH4NO3-N
      NA: Canada: Alberta
      SE estimated from confidence interval

121   Bunce, J.A., 1992
      GH
      Light: 27-49 mol/m2/d
      Temperature: 30-19degC
      Watering regime: WW 2e or 3e day
      fertile sandy loam+fertilizer/3 wks
      NA: Maryland
      SE and SD pers. comm.
```

150 Conroy, J.P., M. Kuppers, B. Kuppers, J. Virgona, and E.W.R. Barlow, 1988
GC
Light: 450 umol/m2/s at top of plants Photoperiod: 16h
Temperature: 25/18degC
Watering regime: daily water
nutrients added; P treatment: P levels at 4.4 vs 40 mg/pot
AU
P-deficient needles of 0.7-0.8 mgP/gdrywt or 1-1.5 mgP/gdrywt

159 Couteaux, M.M., P. Bottner, H. Rouhier, and G. Billes, 1992
GC
soil with micro flora, fauna and litter
EU: S France
Se assumed

168 Curtis, P.S., and J.A. Teeri, 1992
OTC
Temperature: local+1.5/1/2degC
Watering regime: Precip+W
available N: 2.7ug/g soil
NA: N-Michigan

183 Downton, W.J.S., W.J.R. Grant, and B.R. Loveys, 1987
GH
Light: 600-350 umol/m2/s: top of plants-pot level Photoperiod: 10h

Temperature: 25/18degC
Watering regime: WW Humidity: 60-90%
1/2 strength Hoagland 2*wk
AU
fruit dry wt

184 Downton, W.J.S., W.J.R. Grant, and E.K. Chacko, 1990
GC
Light: 450 umol/m2/s initially Photoperiod: 14-12h
Temperature: 30/22degC
Watering regime: WW daily Humidity: 50%
Oscomote each 3-4mo
AU

208 El Kohen, A., J.-Y. Pontailler, and M. Mousseau, 1991
OTC
EU: France

209 El Kohen, A., H. Rouhier, and M. Mousseau, 1992
GH
Watering regime: WW/drip
NPK Treatment: 0 NPK vs 0.82g N, 0.78gP, 0.4gK/month
EU: France

210 El Kohen, A., L. Venet, and M. Mousseau, 1993
GH
Temperature: local+-1.8degC
Watering regime: W daily
EU: France
N(#) Castanea from total # plants Castanea; from Fagus from F4

221 Ferguson, J.J., W.T. Avigne, L.H. Allen, and K.E. Koch, 1986
GH
Light: 85% from outside
Temperature: 31/23degC
Watering regime: WW
nutrients added: NPK 20:20:20; Peter's
NA: Florida
part of gibberellin and cytokinin treatment experiment

222 Fetcher, N., C.H. Jaeger, B.R. Strain, and N. Sionit, 1988
GH
Light: 1900 umol/m2/s for gas exchange measurements
Temperature controlled for 30yr average
NA: N Carolina
N(#) for stomatal conductance assumed same as for assimilation rate

233 Gaudillere, J.-P., and M. Mousseau, 1989
GC
Light: 250 umol/m2/s at top of canopy Photoperiod: 16h
Temperature: 22/15degC
Watering regime: WW Humidity: 50%
EU: France

290 Hollinger, D.Y., 1987
GC
Light: 700 umol/m2/s at top of canopy Photoperiod: 14h
Temperature: 20/10degC
Watering regime: WW Humidity: 70/90%
AU
SE of mass estimated

313 Idso, S.B., B.A. Kimball, and S.G. Allen, 1991
OTC
Watering regime: WW
nutrients added
NA: Arizona

314 Idso, S.B., and B.A. Kimball, 1991
OTC
Watering regime: WW
nutrients added
NA: Arizona
SD of mass estimated from area of F1

318 Idso, S.B., and B.A. Kimball, 1993
OTC
Watering regime: WW
nutrients added
NA: Arizona
Assimilation rate and N(#) estimated from F3

322 Idso, S.B., B.A. Kimball, and S.G. Allen, 1991
OTC
Watering regime: WW
nutrients added
NA: Arizona

340 Kaushal, P., J.M. Guehl, and G. Aussenac, 1989

GH
Light: 80% of natural outside light+160umol/m2/s at shoot level 6h/d
Temperature: local:10-23degC
Watering regime: WW Humidity: 80-90%
EU: France
SE/SD pers comm.

362 Koch, K.E., P. Jones, W.T. Avigne, and L.H. Allen Jr., 1986
GC
Light: 85% of incident light of outside
Temperature: 31/23degC
Watering regime: WW
nutrients added (Peter's)
NA: Florida
SE/SD pers comm

468 Mousseau, M., 1993
OTC
Temperature: 35-10/22-5degC
Watering regime: WW
nutrients added
EU: France
N(#) of mass assumed as in T1 pap 471

470 Mousseau, M., and H.Z. Enoch, 1989
OTC
Temperature: local+max4degC
Watering regime: WW/drip
nutrients added/yr
EU: France

502 Norby, R.J., C.A. Gunderson, S.D. Wullschleger, E.G. O'Neill, and M.K. McCracken, 1992
OTC
soils potentially NP deficient
NA: 35.9degN 84.4degW
note on drought and nutrient deficiency

503 Norby, R.J., E.G. O'Neill, W.G. Hood, and R.J. Luxmoore, 1987
GC
Light: 540 umol/m2/s Photoperiod: 14h
Temperature: 25/7degC
Watering regime: W Humidity: 65%
soils potentially NP deficient
NA: Tennessee
potential soil nutrient deficient

504 Norby, R.J., E.G. O'Neill, and R.J. Luxmoore, 1986
GC
Light: 660 umol/m2/s at top of canopy Photoperiod: 14h
Temperature: 25/15degC
Watering regime: WW/drip Humidity: 65%
soils potentially NP deficient
NA: Tennessee
SE/SD for F1,T1,T2: e-mail; soil potentially nutrient deficient

505 Norby, R.J., and E.G. O'Neill, 1989
GH

Light: 580 umol/m2/s Photoperiod: 14h
Temperature: 26/10degC
Watering regime: WW Humidity: 65/95%
NPK treatment: 0 NPK vs 5,1.5,1.9mg N,P,K/pot/wk
NA: Tennessee
SE/SD: e-mail

506 Norby, R.J., and E.G. O'Neill,1991
GC
Light: 600 umol/m2/s Photoperiod: 14h
Temperature: 26/12deg
Watering regime: WW Humidity: 70/90%
nutrients: 20.0.4.5,16.5 mg NPK+/wk ; later 2*wk
NA: Tennessee
N(#) from author

510 O'Neill, E.G., R.J. Luxmoore, and R.J. Norby, 1987
GC
Light: 450 umol/m2/s Photoperiod: 14h
Temperature: 26/10degC
Watering regime: WW
no nutrients added
NA: Tennessee

521 Overdieck, D., 1990
GC
Watering regime: W as precip
soils of average fertility
EU: Germany: 52degN 8degE

550 Pettersson, R., and A.J.S. McDonald, 1992
GC
Light: 600 umol/m2/s Photoperiod: 18h
Temperature: 20degC
hydroponics Humidity: 45%
nutrient solution
EU: Sweden
N(#) 2-5: pers comm for gas exchange; as T1 for other measures

553 Polle, A., T. Pfirrmann, S. Chakrabarti, and H. Rennenberg, 1993
GC
controlled as for local environment
Watering regime: WW:drip acidic mists
Ozone Treatment: 0.02 vs 0.08 cm3/m3: 24hrs/d like higher elevations
EU: Germany:Bavaria

582 Reekie, E.G., and F.A. Bazzaz, 1989
GH
Light: local with 1000-1200 umol/m2/s max levels
Temperature: local 30/27degC
Watering regime: WW
monthly Peter's fertilization(20:20:20)
Plant competition of tropical plants
NA: Massachusetts

596 Rochefort, L., and F.A. Bazzaz, 1992
GH
Light: 900 umol/m2/s clear days

Temperature: 28/20degC
Watering regime: WW Humidity: 73%
nutrients added each 2 weeks
NA: Massachusetts

644 Sharkey, T.D., F. Loreto, and C.F. Delwiche, 1991
GH
Light: 300-500 umol/m2/s (gas measurements at 900 umol/m2/s)
Photoperiod: 15h
Temperature: 25/20degC Humidity: 70%/85%
NA: Wisconsin
Partly a shading and isoprene emission experiment

655 Sionit, N., B.R. Strain, H. Hellmers, G.H. Riechers, and C.H. Jaeger, 1985
GH
Temperature: night temp controlled
Watering regime: WW/drip Humidity: 70%
nutrients (Hoagland 1/15 strength daily
NA: North Carolina

666 Stewart, J.D., and J. Hoddinott, 1993
GH
Light: 600 umol/m2/s as maximum Photoperiod: 18h
Temperature: 15-32degC (local)
Watering regime: WW:2*wk
nutrients 1/wk
UVB Treatment: 0.005-0.03 vs 0.25-0.90 W/m2
NA: Canada: Alberta

676 Surano, K.A., P.F. Daley, J.L.J. Houpis, J.H. Shinn, J.A. Helms, R.J. Palassou, and M.P. Costella, 1986
OTC
Light: 80-90% from outside
Temperature: local+upto5degC
Watering regime: WW:3*wk+ Humidity: down to 10%
nutrients added/month: NPK + 2.2,1.8,1.3 g/pot/month
NA: California

682 Thomas, R.B., D.D. Richter, H. Ye, P.R. Heine, and B.R. Strain, 1991i
GC
Light: 1000 umol/m2/s Photoperiod: 14h
Temperature: 29/23degC
Watering regime: WW Humidity: 70%
nutrients added daily with/without N
N Treatment: 0 vs 7.0 mM NH4NO3-N
NA: South Carolina
Seeds inocculated with Rhizobium

745 Wullschleger, S.D., R.J. Norby, and D.L. Hendrix, 1992
OTC
gas exchange measures at 1300 umol/m2/s
NA: 35.9degN 84.4degW
Precip 169 cm at study site compared to 139 cm as 30 yr average

746 Wullschleger, S.D., R.J. Norby, and C.A. Gunderson, 1992
OTC
NA: 35.9degN 84.4degW

747 Wullschleger, S.D., and R.J. Norby, 1992
OTC
NA: 35.9degN 84.4degW

756 Ziska, L.H., K.P. Hogan, A.P. Smith, and B.G. Drake, 1991
OTC
Light: 740 umol/m2/s average; 1200umol/m2/s max Photoperiod: 10h

Temperature: 36.5/21.2degC
Watering regime: WW 2*day Humidity: 60%/85%
nutrients added (Osmocote)
CA: 83.9degN 9.2degW
Values differ slightly from Table: pers comm

2002 Gorissen, A., P.J. Kuikman, and H. Van De Beek, 1995
GC
Light: 400 umol/m2/s Photoperiod: 16h
Temperature: 18/14degC
Watering regime: W Humidity: 70-80%
EU: 52.2degN 5.8degE

2003 Mortensen, L.M., 1995
GC
Light: 18 mol/m2/day for temp treatment
Light: 22 mol/m2/day for Ozone treatment Photoperiod: 24h
Temperature: 17.3degC=control
Watering regime: WW
nutrients added
2 Treatments: Ozone: 7 vs 62 nmol/mol for 8 hrs
Temperature: 15.3 vs 20 degC
EU: 60.8degN 11.5degE

2004 Wullschleger, S.D., R.J. Norby, and P.J. Hanson, 1995
OTC
NA: 35.9degN 84.4degW
Pisolithus tinctorius mycorrhizal inoculum; stem respiration

2005 Teskey, R.O., 1995
BRANCH
Light: 1200 umol/m2/s for gas exchange measurements
Watering regime: irrigated
NA: Georgia: 33.9degN 82.3degW

2026 Callaway, R.M., E.H. DeLucia, E.M. Thomas, and W.H. Schlesinger, 1994
GC
Light: 1000 umol/m2/s Photoperiod: 12h
Temperature Treatment: 25/10degC vs 30/25degC
Watering regime: WW Humidity: 45%i during day
nutrients 1/2 strength Hoagland
NA: Nevada

2027 Pettersson, R., A.J.S. McDonald, and I. Stadenberg, 1993
GC
Light: 600 umol/m2/s Photoperiod: 18h
Temperature: 20degC
Hydroponic Humidity: 50%
nutrient solution
N Treatment: 0.07 vs 0.15 molN/molN/d

EU: Sweden

2028 Lavola, A., and R. Julkunen-Tiitto, 1994
GH
Light: local -- 1137-175 umol/m2/s
Temperature: 22/15degC
NKP Treatment: 0 vs 500 kg/ha
EU: Finland

2032 Tschaplinski, T.J., R.J. Norby, and S.D. Wullschleger, 1993
GC
Light: 720 umol/m2/s Photoperiod: 14h
Temperature: 26/16degC
H2O Treatment: weekly vs biweekly watering Humidity: 85-90%
fertilized/month (Peter's NPK 20:20:20)
NA: Tennessee

2035 Gunderson, C.A., R.J. Norby, and S.D. Wullschleger, 1993
OTC
Light: 1100-2300 umol/m2/s for gas exchange measurements
Temperature: local
Watering regime: precip
NA: 35.9degN 84.4degW

2036 Grulke, N.E., J.L. Hom, and S.W. Roberts, 1993
GC
Light: 713 umol/m2/s at canopy height Photoperiod: 12hr later 14h
Temperature: 25/19degC
Watering regime: WW Humidity: 46-57%/81%
fertilized weekly
NA: California

2037 Bazzaz, F.A., S.L. Miao, and P.M. Wayne, 1993
GH
Light: 37% and 75 % of full sun
Temperature: 30/23degC
2 Treatments: Light: 37% and 75% of full sun
Fertilizer: 0.18 and 1.8 g Oscomote
NA: Massachusetts

2038 Roth, S.K., and R.L. Lindroth, 1994
GC
Light: 501 umol/m2/s Photoperiod: 15h
Temperature: 25/20degC
Watering regime: WW/drip Humidity: 70/85%
fertilized 1/2 strength Hoagland 2*per day
NA: Wisconsin

2039 Curtis, P.S., C.S. Vogel, K.S. Pregitzer, D.R. Zak, and J.A. Teeri, 1995
OTC
Light: gas exchange measures at 1800 umol/m2/s
Temperature: local
Watering regime: WW
Soil Treatment: 45 vs 346 ug N/g/d N mineralization in soils
64 vs 110 mg extractable PO4/kg soil
NA: N-Michigan

2041 Garcia, R.L., S.B. Idso, G.W. Wall, and B.A. Kimball, 1994

OTC
Watering regime: WW
fertilized
NA: Arizona

2042 Sullivan, J.H., and A.H. Teramura, 1994
GH
Light: ~80-85% of outdoors
Temperature: 27/23degC
Watering regime: WW/daily
fertilized 1/2 strength Hoagland
UVB Treatment: 8 hrs daily 8.8 vs 13.8 kJ/m2
NA: Maryland
SE for T1 SE for F1 (e-mail)

2043 Cipollini, M.L., B.G. Drake, and D. Whigham, 1993
OTC
Light: 10-100-occasionally 1000 umol/m2/min
NA: Maryland

2044 Tissue, D.T., R.B. Thomas, and B.R. Strain, 1993
OTC
Watering regime: precip
1/2 strength Hoagland 2*week
2 Treatments: High NP:7mol/m2 NH4NO3+1mol/m3 PO4;
low P:same N+0.2mol/m3P;
lowN:1mol/m3NH4NO3+1mol/m3PO4
NA: North Carolina
N(#) in T1 does not match text

2045 Johnsen, K.H., 1993
GC
Light: 450 umol/m2/s at bench height   Photoperiod: 19h
Temperature: 20/15degC
watering treatment   Humidity: 70/90%
treatment within 1/3 strength Ingestad
2 Treatments:
WW vs drought cycles (fertilized with 8 mL 300 ppmN: Ingestad);
Fertilization: 6 mL/wk then 12 mL after 71 days vs 12mL,
18 mL, 24 mL, 32 mL after day 1, 42, 71 and 104
NA: Canada: Ontario

2046 Reid, C.D., and B.R. Strain, 1994
GC
Light: 65 umol/m2/s   Photoperiod: 12h
Temperature: 19/15degC
Watering regime: WW daily
1/4 strength Hoagland
NA: North Carolina

2047 Eamus, D., C.A. Berryman, and G.A. Duff, 1993
OTC
Light: ambient   local
Temperature: local-up to 1.5degC
AU

2048 Yakimchuk, R., and J. Hoddinott, 1994
GC

Light: 150 umol/m2/s+2hrs 40 umol/m2/s   Photoperiod: 18h
Temperature: 20/18degC
Watering regime: WW   Humidity: 65%
fertilized weekly
Ozone treatment: 1.1 uW/cm2 vs 150 uW/cm2 8hrs/day
NA: Canada: Alberta
potsize: pers. com.

2065 Liu, S., and R.O. Teskey, 1995
BRANCH
Light: gas exchange at 1000-2000 umol/m2/s
Temperature: 16.5degC
Watering regime: W+precip
low to medium soil fertility
NA: 33.9degN 83.3degW
mature trees, low fertility site

2068 Wang, K., S. Kellomaki, and K. Laitinen, 1995
OTC
Temperature treatment: ambient vs hot=amb+2degC in summer,amb+5-20degC
Watering regime: W+precip
sandy soil
EU: 62.8degN 30.9degE
chamber around coniferous saplings; elevated CO2 only during daytime

2069 Marek, M.V., J. Kalina, and M. Matouskova, 1995
OTC
native   Coniferous
EU: 49.5degN 18.5degW
native   coniferous; elevated CO2 level is saturating level

2070 Eamus, D., G.A. Duff, and C.A. Berryman, 1995
SPAR
Light: 68% of full
Temperature: local minus upto 3degC
Watering regime: WW/drip
Osmocote in soils
AU

2071 Eamus, D., C.A. Berryman, and G.A. Duff, 1995
SPAR
Light: 66% of full
Temperature: local minus upto 3degC
Watering regime: WW 2*day
fertilized each 2 weeks
AU

2109 Johnson, D., D. Geisinger, R. Walker, J. Newman, J. Vose, K. Elliot, and T. Ball, 1994
OTC
Watering regime: WW
N treatment: 0 vs 20 g/m2/yr ammonium sulfate
NA: California
SE vs SD estimates F5; chamber description in Ball et al (1992)

2110 Pregitzer, K.S., D.R. Zak, P.S. Curtis, M.E. Kubiske, J.A. Teeri, and C.S. Vogel, 1995
OTC

Watering regime: WW
Soil treatment: 45 vs 348 ug N/g/d N mineralization in soils;
64 vs 110 mg extractable PO4/kg soil
NA: N-Michigan

2117 Mortensen, L.M., 1994
GC
Light treatment: 15 mol/m2/d then 22 mol/m2/d for birch,
21 mol/m2/d for spruce
Photoperiod: 24h
Temperature Treatment: 15.3 vs 20.0 degC
Watering regime: WW   600 vs 1000 Pa as wvpd at 15.3 vs 20degC
fertilized, see Mortensen, 1994
EU: Norway

2120 Laboratorium Voor Plantecologie   1992
GC
Light: 270umol/m2/s   Photoperiod: 16h
Temperature: 22/17.5degC
Watering regime: WW/drip   Humidity: 65%
fertilized at optimal levels
EU: Belgium

2121 Kubiske, M.E., and K.S. Pregitzer, 1994
OTC
Light Treatment: low and high; understory imitation
NA: N-Michigan

2122 Vogel, C.S., and P.S. Curtis, 1995
OTC
Temperature: local+2.6degC
fertilized with 4.5 g/m2 N
NA: 45.6degN 84.7degW
nodule inoculations

2123 Jarvis, P.G., H.S.J. Lee, and C.V.M. Barton, 1994
OTC
Light and temperature not reported for growth
EU: Scotland
N(#) pers comm for T2

2129 Curtis, P.S., D.R. Zak, K.S. Pregitzer, and J.A. Teeri,   1994
OTC
Temperature: local+3degC
Watering regime: precip+W
All rootboxes received 4.5 g/m2 N; similar to natural dry oak forest
NA: N-Michigan

2131 Norby, R.J., Wullschleger, and C.A. Gunderson, 1996
OTC
NA: Tennessee
Sample size and SD from pers comm.

2152 Williams, R.S., D.E. Lincolm, and R.B. Thomas, 1994
OTC
Watering regime: precip+W
modified Hoagland 7mmol NH4NO3+1mmolPO4 /wk
NA: North Carolina

2165 Lewis, J.D., R.B. Thomas, and B.R. Strain, 1994
GH
Temperature: 28/17 - 28/22degC
Watering regime: WW
1/2 strength Hoagland/wk; P Treatment: 0.083mM KH2PO4 vs 0.5mM KH2PO4:
P stress
NA: North Carolina
inocculation Pisolithus tinctorius vs not

2186 Bassow, S.L., K.D.M. McConnaughay, and F.A. Bazzaz, 1994
GH
Light: natural+supplement when light<500umol/m2/s i
Photoperiod local: 6-19h
Temperature: 28/22degC
Fertilizer Treatment: 0.12 vs 1.2 g Osmocote > N input of
40 vs 400 kg N/ha/yr; 3 mo after initial Osmocote
weekly 200 ml Peter's solution (20:20:20) at
0.042 v s 0.42 g/l/wk
NA: Massachusetts
N(#) F1: pers. comm

2217 Berryman, C.A., D. Eamus, and G.A. Duff, 1993
OTC
Light: 65% of full
Temperature: 29.7degC
Watering regime: WW:3*day
nutrients added; also 5 g low P Osmocote
AU

2223 Bazzaz, F.A., and S.L. Miao, 1993
GH
Light treatment: full gap light vs 37% thereof
Temperature: 27/20 > 30/23degC
Watering regime: WW
nutrient treatment: N equivalents of 40 vs 400 kg N/ha/yr i.e.
0.18 vs 1.8 g Osmocote/pot
NA: Massachusetts

2224 Lindroth, R.L., K.K. Kinney, and C.L. Platz, 1993
GH
Light: 490 mol/m2/s 70cm above pots Photoperiod: 15h
Temperature: 25/20degC
Watering regime: WW/drip Humidity: 70/80%
1/2 strength Hoagland
NA: Wisconsin
native mycorrhiza in soil