Calculating GHG (CO_2) Benefits of Trees with New ARB Methods

December 9, 2016

Kelaine Ravdin
Urban Ecos, LLC
kelaine@urban-ecos.com

california urban forests council
invest from the ground up
Growing Trees Make Great Neighborhoods

Urban Ecos

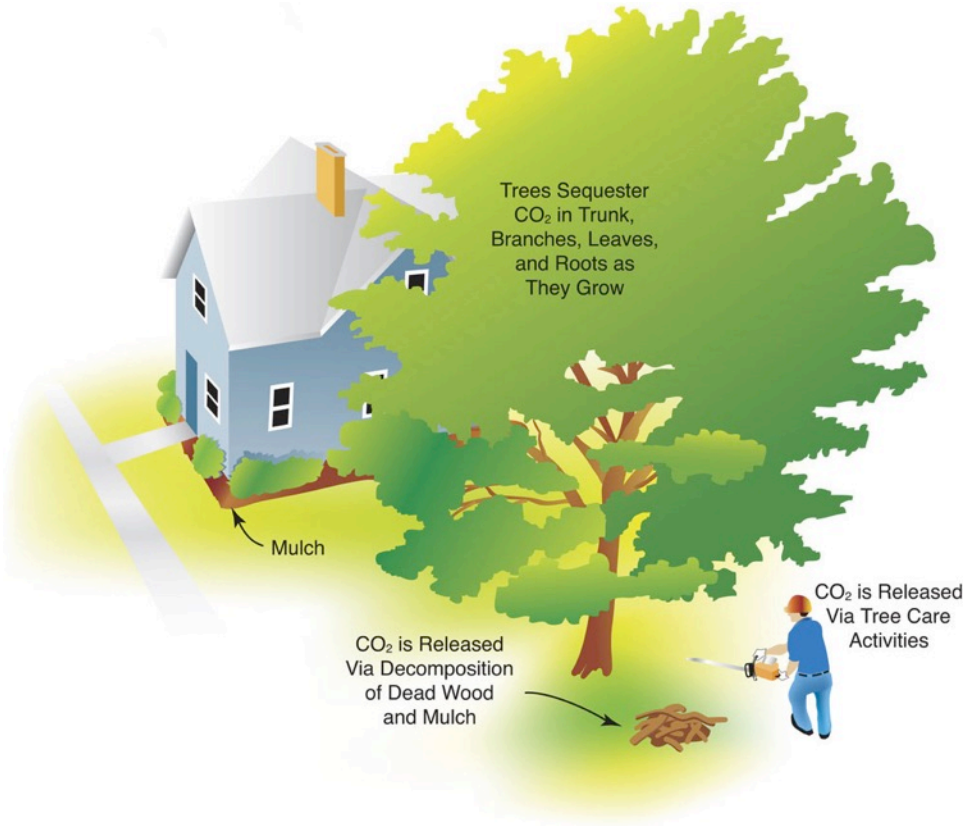
Agenda

1. Overview of how trees provide GHG benefits
2. Tools you need to do the new calculations
3. Walk through a few examples
4. Questions

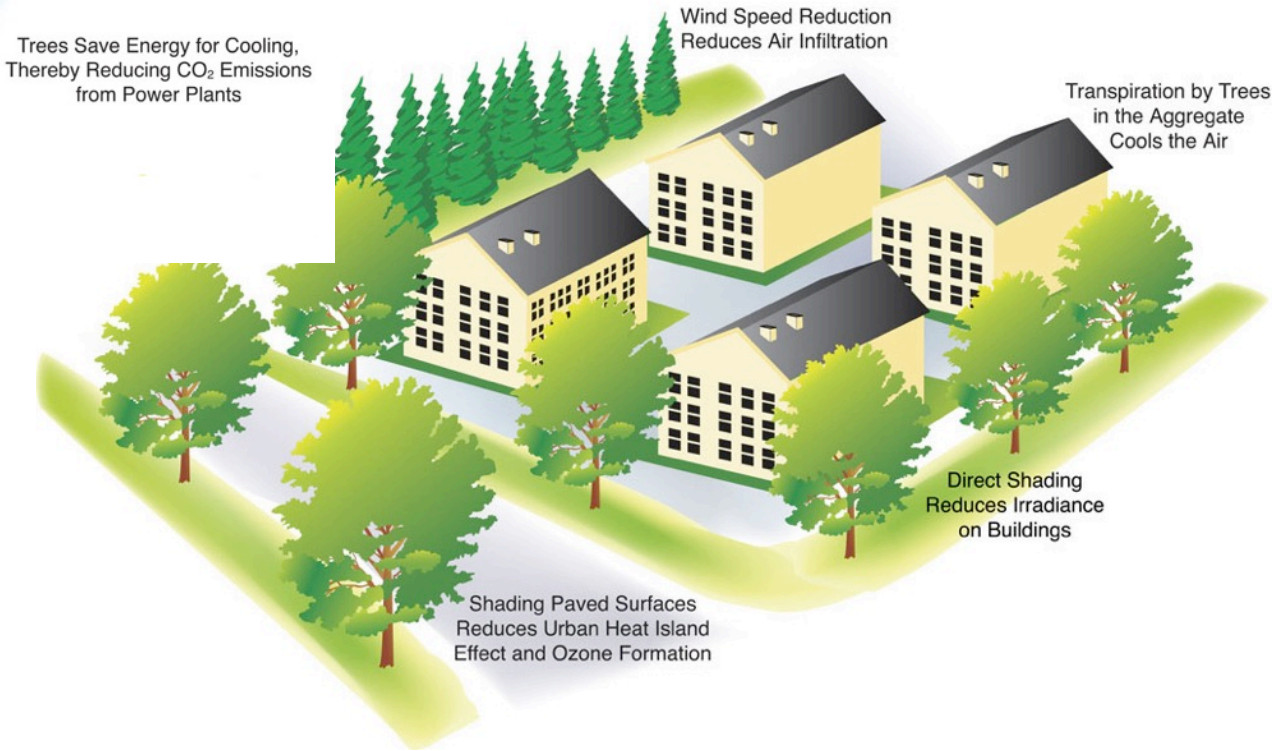
Trees and greenhouse gas benefits: storage (sequestration)

****Carbon sequestration** =
annual amount of carbon dioxide absorbed by the tree

Carbon storage =
total amount of carbon dioxide sequestered by tree *to date***

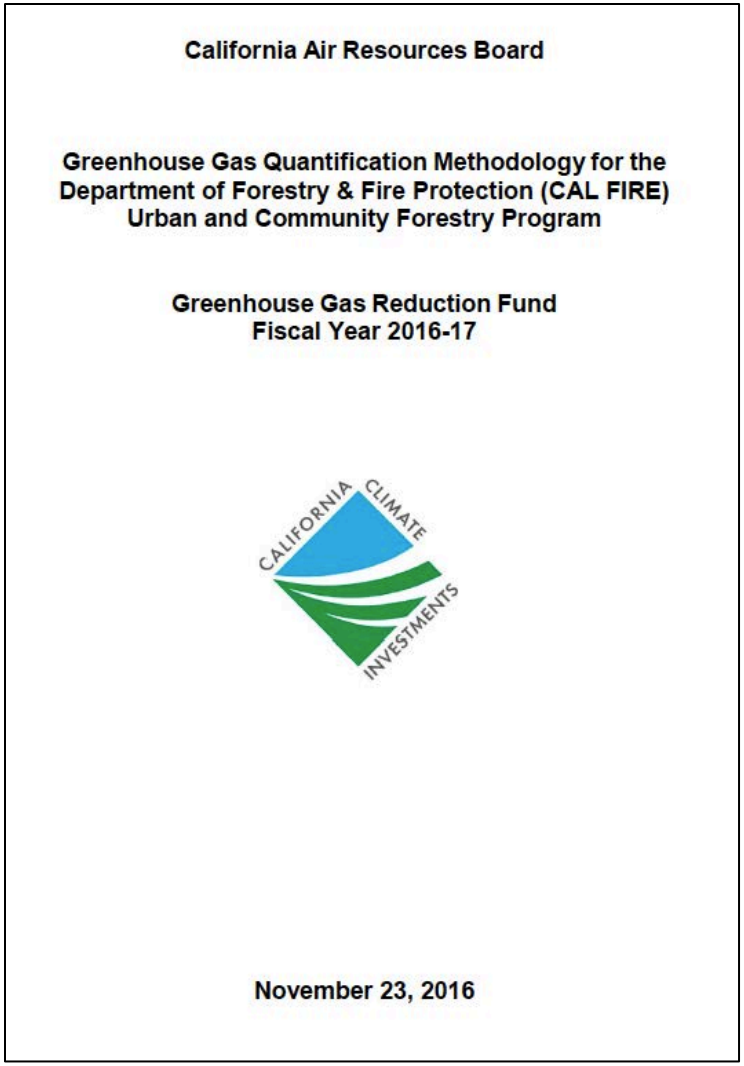


Trees and greenhouse gas benefits: avoided emissions from reduced energy use



Avoided emissions are presented *on an annual basis*.

New methodology



California Air Resources Board

Greenhouse Gas Quantification Methodology for the Department of Forestry & Fire Protection (CAL FIRE) Urban and Community Forestry Program

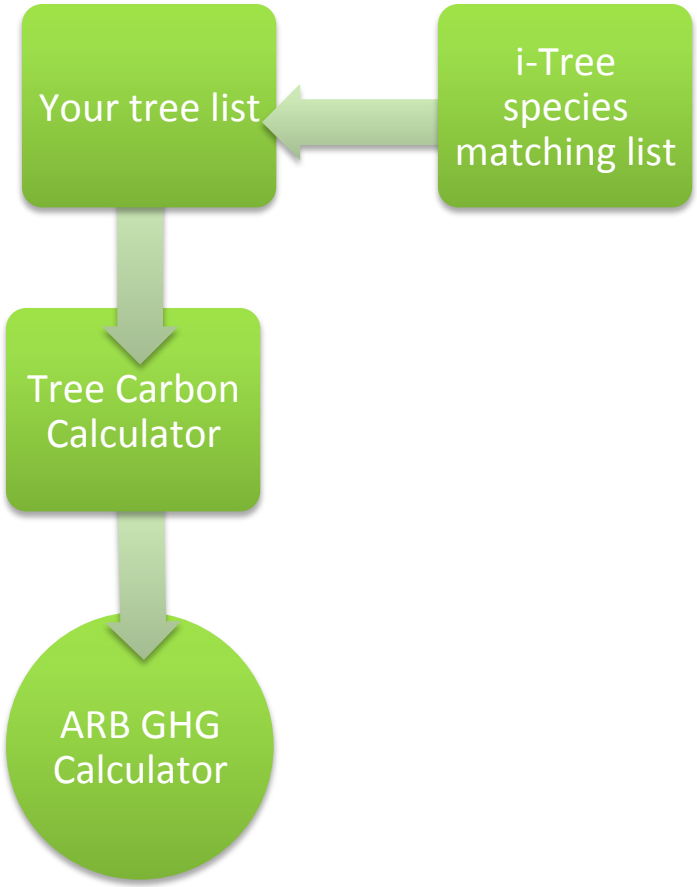
Greenhouse Gas Reduction Fund
Fiscal Year 2016-17

November 23, 2016

https://www.arb.ca.gov/cc/capandtrade/auctionproceeds/quantification.htm

Two methods

Method #1

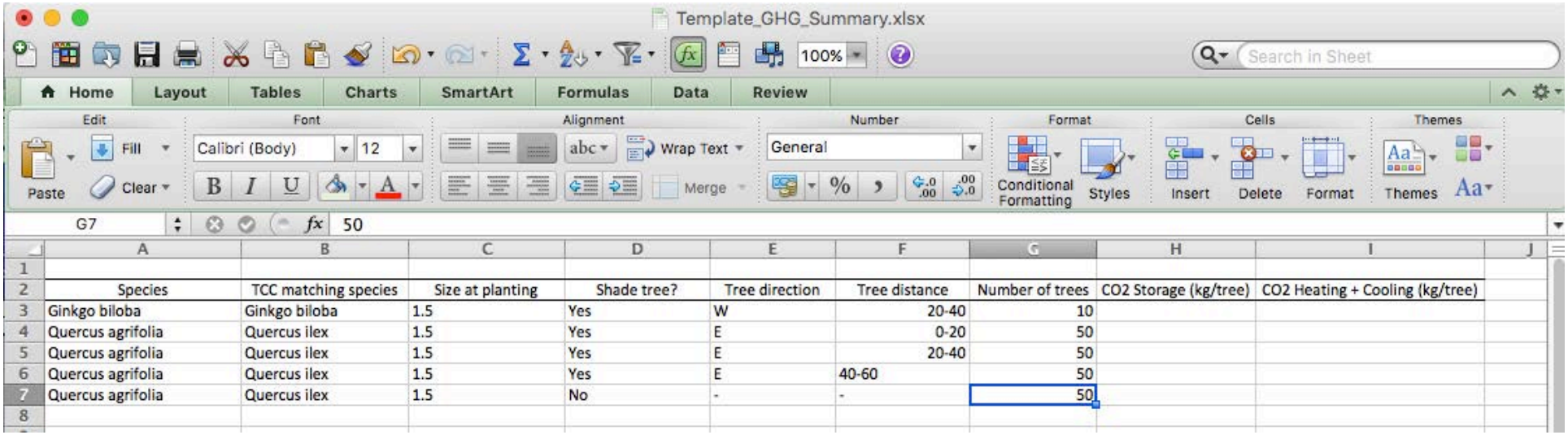


Method #2

To Get Started

1. List of your trees
2. Tree Carbon Calculator: www.fire.ca.gov/resource_mgt/downloads/TREES_WC.zip
3. i-Tree Streets Species Matching List: http://www.itreetools.org/streets/resources/Streets Species Codes.xls
4. New ARB GHG Calculator https://www.arb.ca.gov/cc/capandtrade/auctionproceeds/quantification.htm

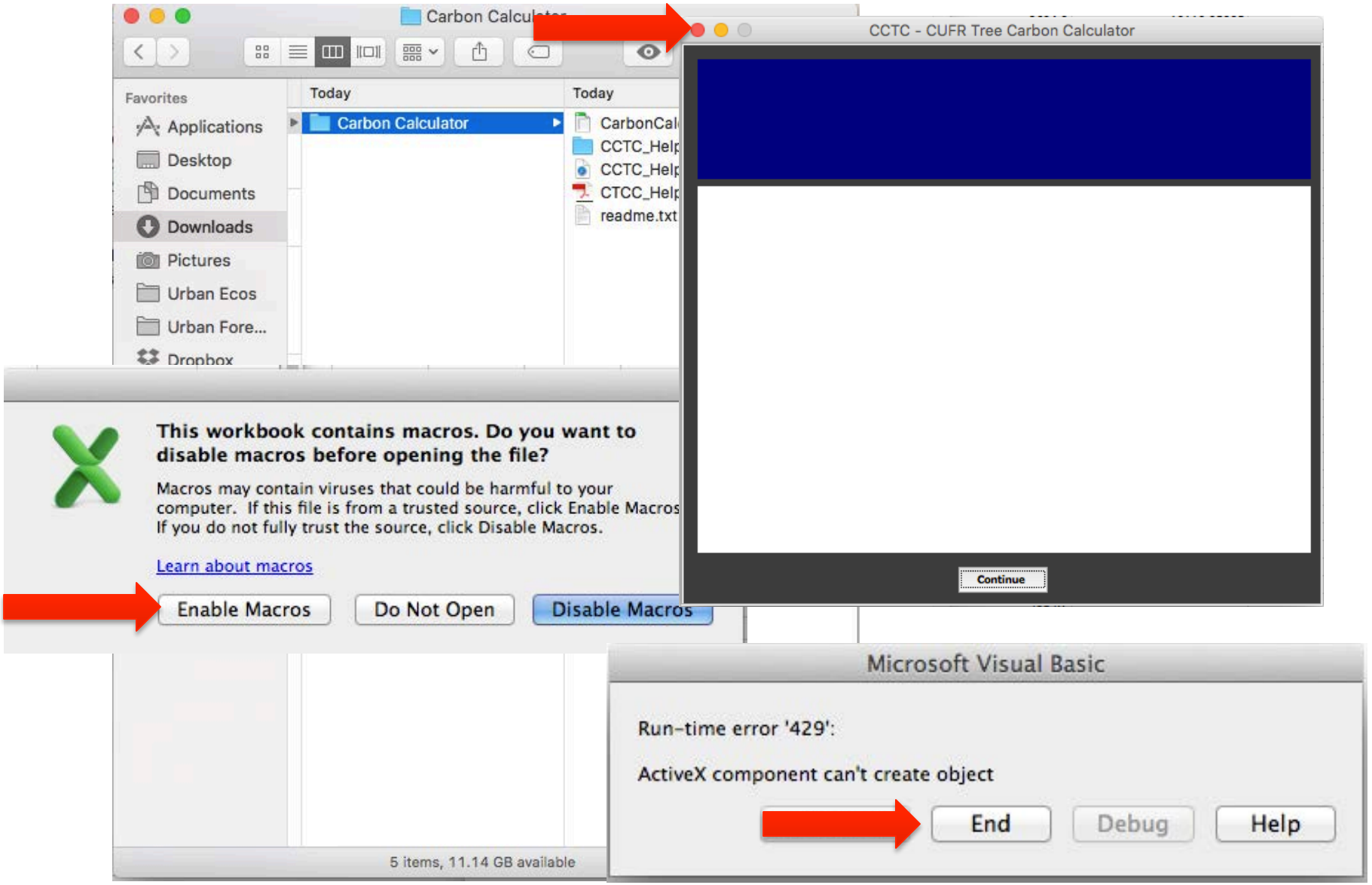
Tree list

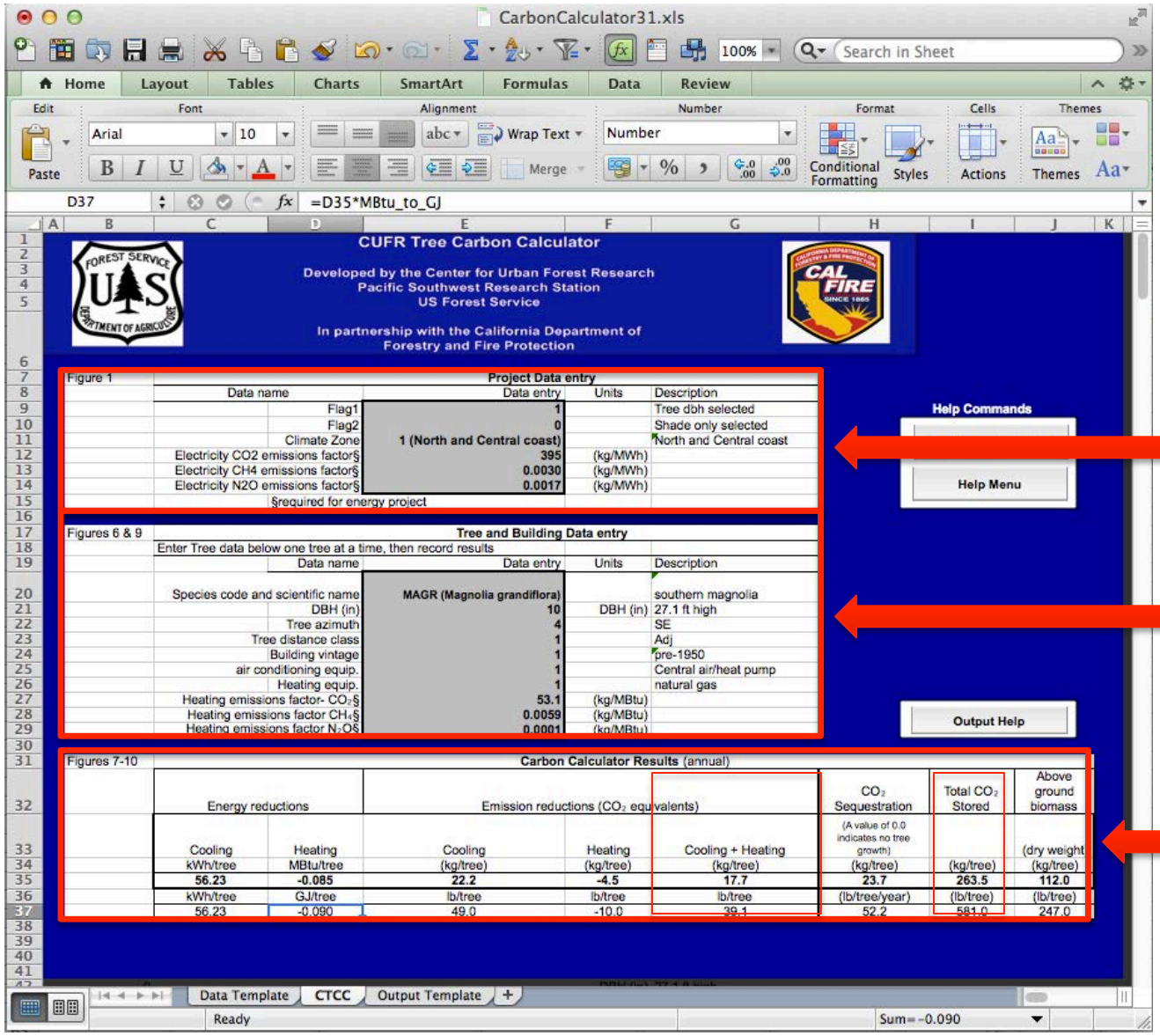


	A	B	C	D	E	F	G	H	I
1									
2	Species	TCC matching species	Size at planting	Shade tree?	Tree direction	Tree distance	Number of trees	CO2 Storage (kg/tree)	CO2 Heating + Cooling (kg/tree)
3	Ginkgo biloba	Ginkgo biloba	1.5	Yes	W	20-40	10		
4	Quercus agrifolia	Quercus ilex	1.5	Yes	E	0-20	50		
5	Quercus agrifolia	Quercus ilex	1.5	Yes	E	20-40	50		
6	Quercus agrifolia	Quercus ilex	1.5	Yes	E	40-60	50		
7	Quercus agrifolia	Quercus ilex	1.5	No	-	-	50		
8									

***TCC matching species:** Match your species to the closest option in the CTCC.
Shade tree?: Is the tree within 60' to the west, southwest, south, southeast, or east a building with heating/cooling?
Tree direction: The tree is to the [W, SW, S, SE, E] of the building (shade trees only).
Tree distance: Distance from tree to building: 0-20', 20-40', 40-60'
Number of trees: Trees with these characteristics (species, size, distance, direction)

Tree Carbon Calculator





Three major components

Project inputs

Tree inputs

Outputs

Project inputs: DBH vs age

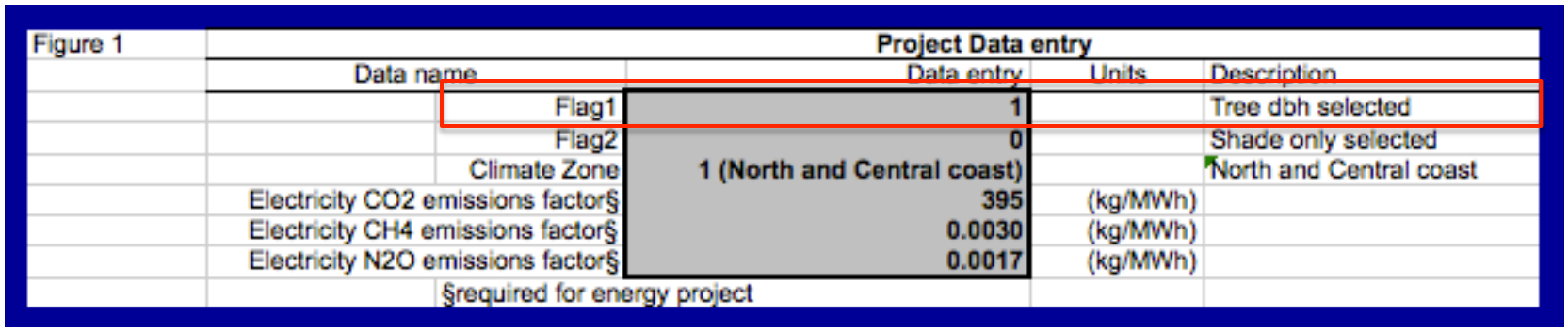


Figure 1	Project Data entry			
	Data name	Data entry	Units	Description
	Flag1	1		Tree dbh selected
	Flag2	0		Shade only selected
	Climate Zone	1 (North and Central coast)		North and Central coast
	Electricity CO2 emissions factor§	395	(kg/MWh)	
	Electricity CH4 emissions factor§	0.0030	(kg/MWh)	
	Electricity N2O emissions factor§	0.0017	(kg/MWh)	
	§required for energy project			

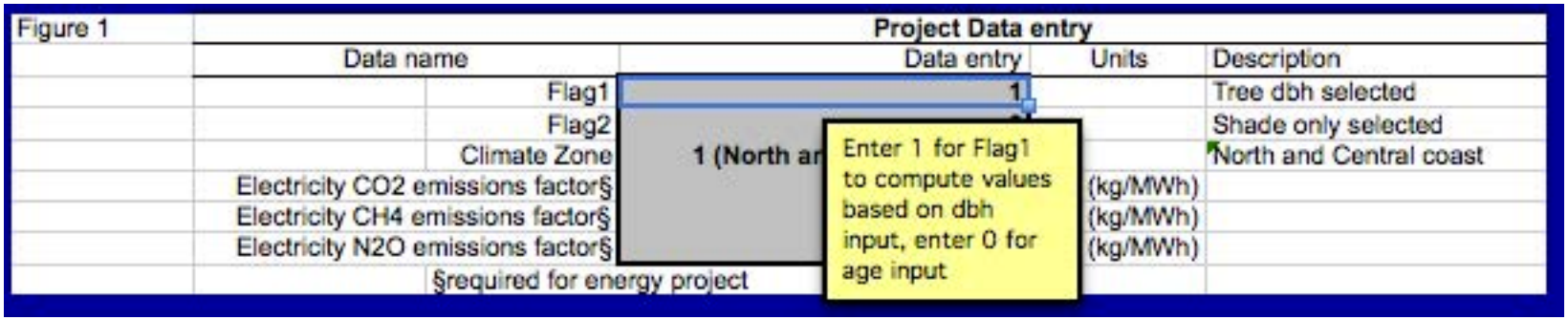


Figure 1	Project Data entry			
	Data name	Data entry	Units	Description
	Flag1	1		Tree dbh selected
	Flag2			Shade only selected
	Climate Zone	1 (North ar		North and Central coast
	Electricity CO2 emissions factor§		(kg/MWh)	
	Electricity CH4 emissions factor§		(kg/MWh)	
	Electricity N2O emissions factor§		(kg/MWh)	
	§required for energy project			

Enter 1 for Flag1 to compute values based on dbh input, enter 0 for age input

HINT: Enter 0 to use age

Project inputs: shade vs climate

Figure 1	Project Data entry			
	Data name	Data entry	Units	Description
	Flag1	1		Tree dbh selected
	Flag2	0		Shade only selected
	Climate Zone	1 (North and Central coast)		North and Central coast
	Electricity CO2 emissions factor§	395	(kg/MWh)	
	Electricity CH4 emissions factor§	0.0030	(kg/MWh)	
	Electricity N2O emissions factor§	0.0017	(kg/MWh)	
	§required for energy project			

Figure 1	Project Data entry			
	Data name	Data entry	Units	Description
	Flag1	0		Tree age selected
	Flag2	0		Shade only selected
	Climate Zone	1 (North a		North and Central coast
	Electricity CO2 emissions factor§		g/MWh)	
	Electricity CH4 emissions factor§		g/MWh)	
	Electricity N2O emissions factor§		g/MWh)	
	§required for energy project			
Figures 6 & 9	T		ntry	

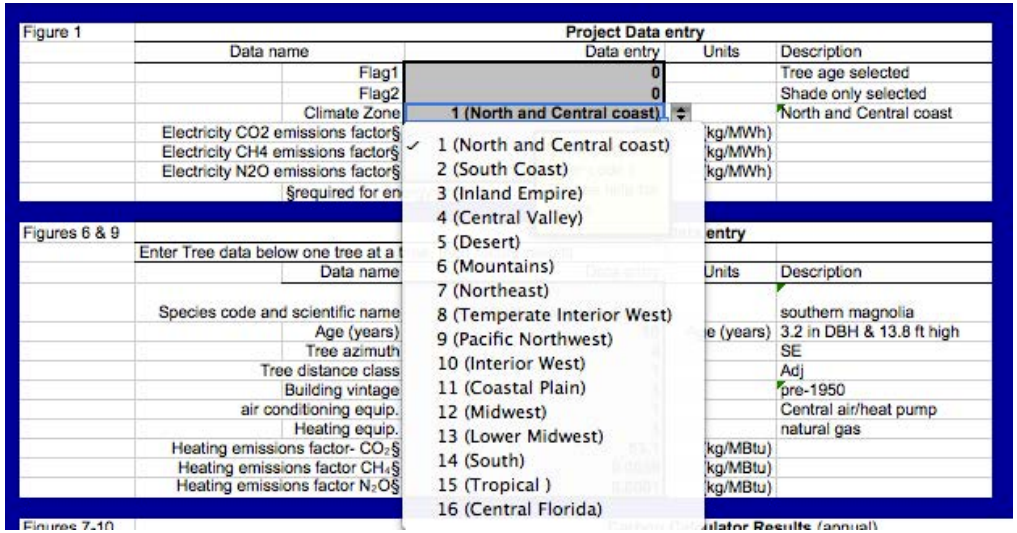
Enter 1 for Flag2 to compute values based on shade and climate effects, enter 0 for shade effects only

**Trees have direct effects on energy use when a tree shades a building (shade effects). When *very large* numbers of trees are planted, they can also have an effect on a city's climate (climate effects). Very few projects will have climate effects. **

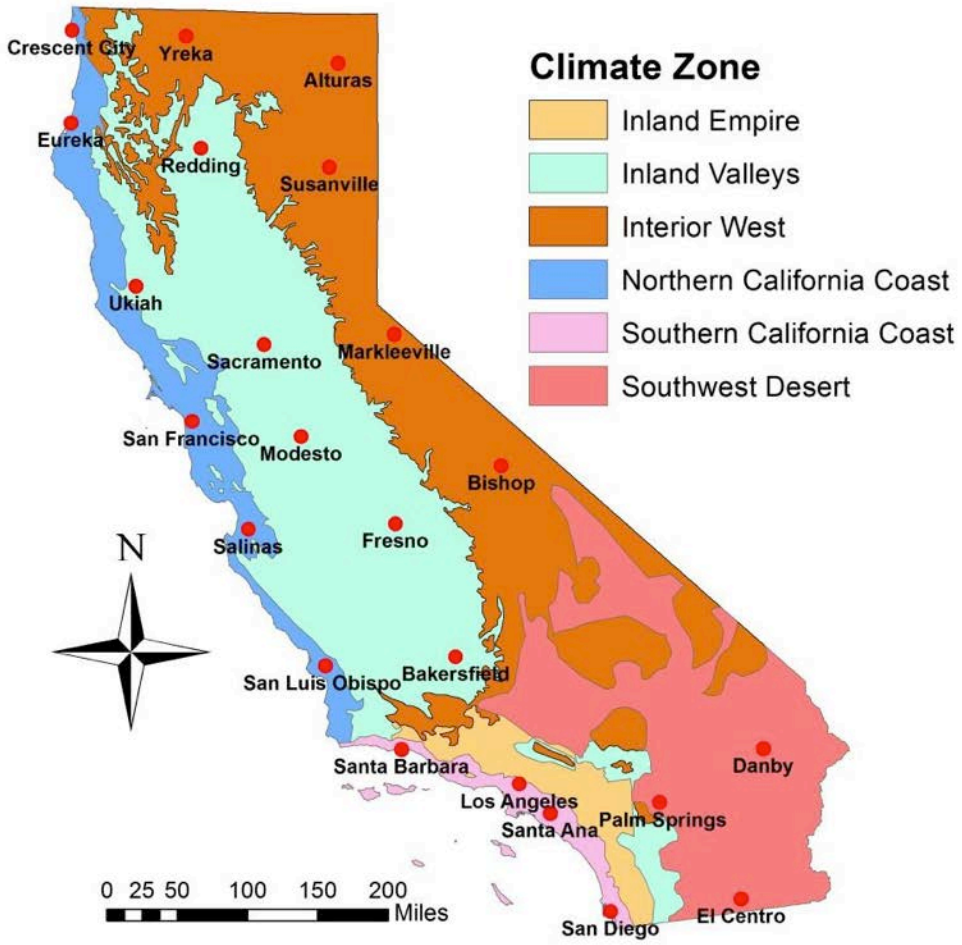
HINT: Enter 0 to use shade only

Project inputs: climate zone

Figure 1	Project Data entry			
Data name		Data entry	Units	Description
	Flag1	1		Tree dbh selected
	Flag2	0		Shade only selected
	Climate Zone	1 (North and Central coast)		North and Central coast
Electricity CO2 emissions factor§		395	(kg/MWh)	
Electricity CH4 emissions factor§		0.0030	(kg/MWh)	
Electricity N2O emissions factor§		0.0017	(kg/MWh)	
§required for energy project				

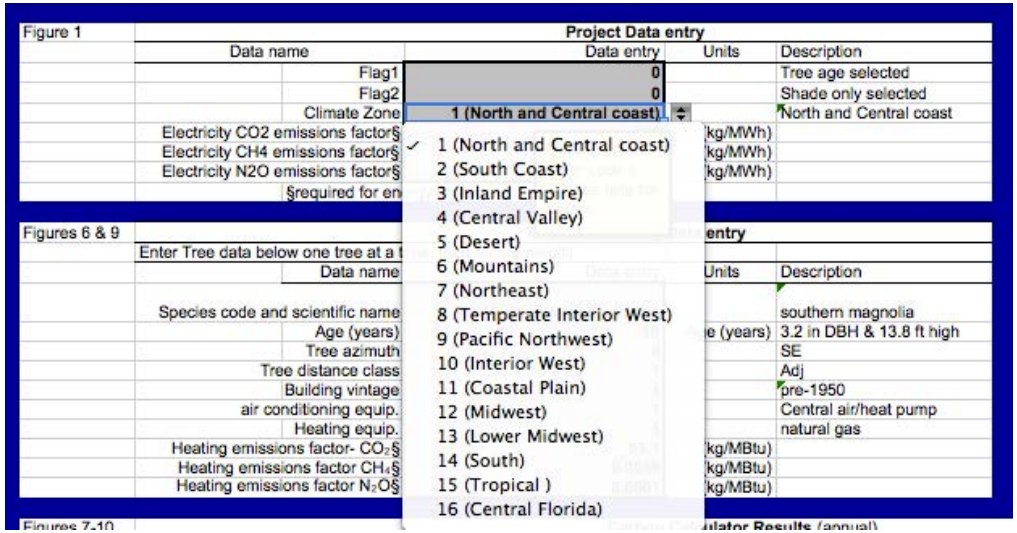


Climate zones



Project inputs: climate zone

Figure 1	Project Data entry			
	Data name	Data entry	Units	Description
	Flag1	1		Tree dbh selected
	Flag2	0		Shade only selected
	Climate Zone	1 (North and Central coast)		North and Central coast
	Electricity CO2 emissions factor§	395	(kg/MWh)	
	Electricity CH4 emissions factor§	0.0030	(kg/MWh)	
	Electricity N2O emissions factor§	0.0017	(kg/MWh)	
	§required for energy project			



HINT: choose your project's climate zone

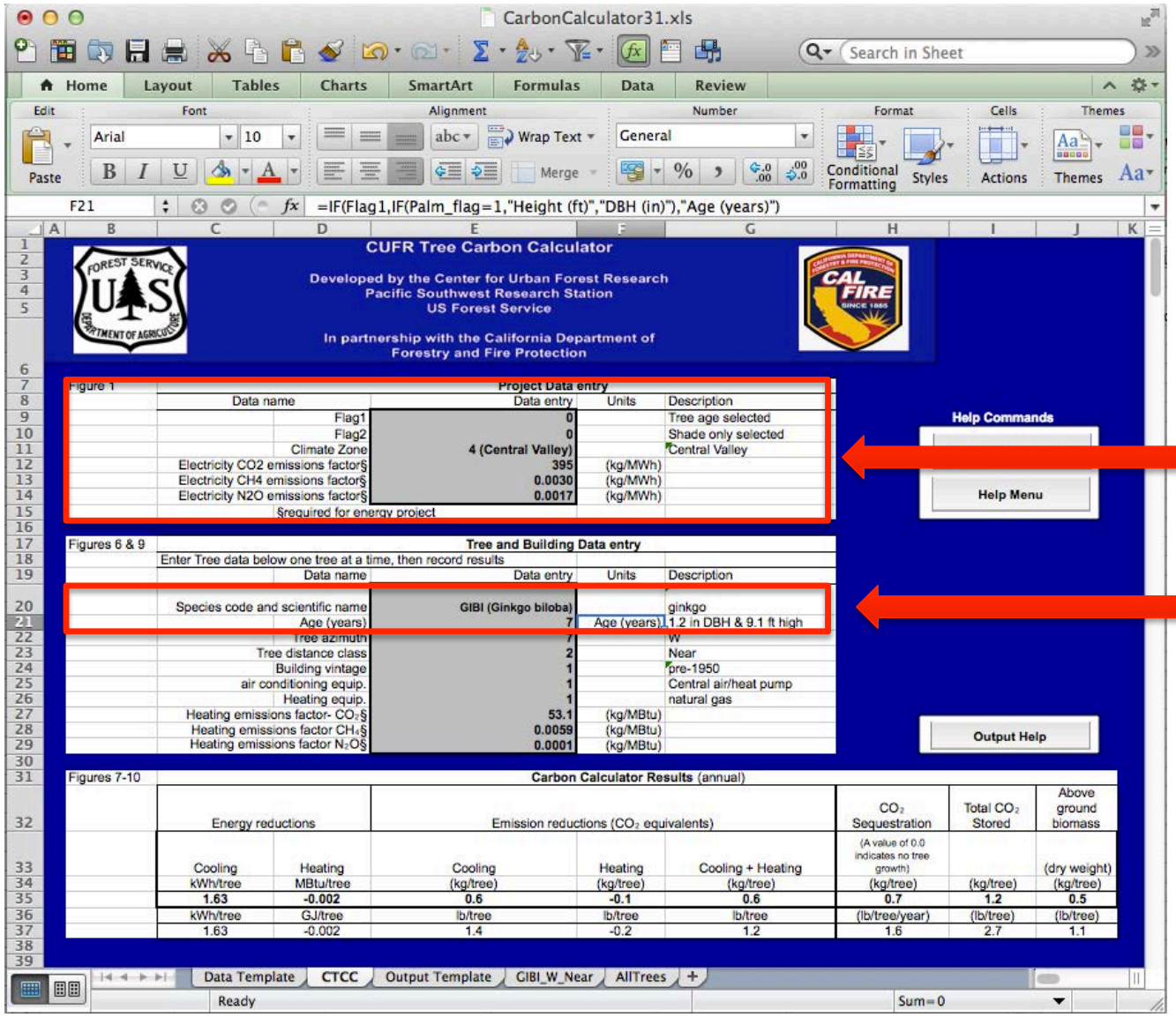
Project inputs: emissions factors

Figure 1	Project Data entry			
	Data name	Data entry	Units	Description
	Flag1	1		Tree dbh selected
	Flag2	0		Shade only selected
	Climate Zone	1 (North and Central coast)		North and Central coast
	Electricity CO2 emissions factor§	395	(kg/MWh)	
	Electricity CH4 emissions factor§	0.0030	(kg/MWh)	
	Electricity N2O emissions factor§	0.0017	(kg/MWh)	
	§required for energy project			

Emissions factors are regionally based and reflect the source of a region's energy (coal, nuclear, hydro, etc.). They indicate how many kg of CO2 are emitted for each MWh of electricity produced. Coal, e.g., has a very high emissions factor. Nuclear and hydro, e.g., are essentially zero.

HINT: Enter 303 for CO2, and 0 for the others

Calculating CO_2 storage

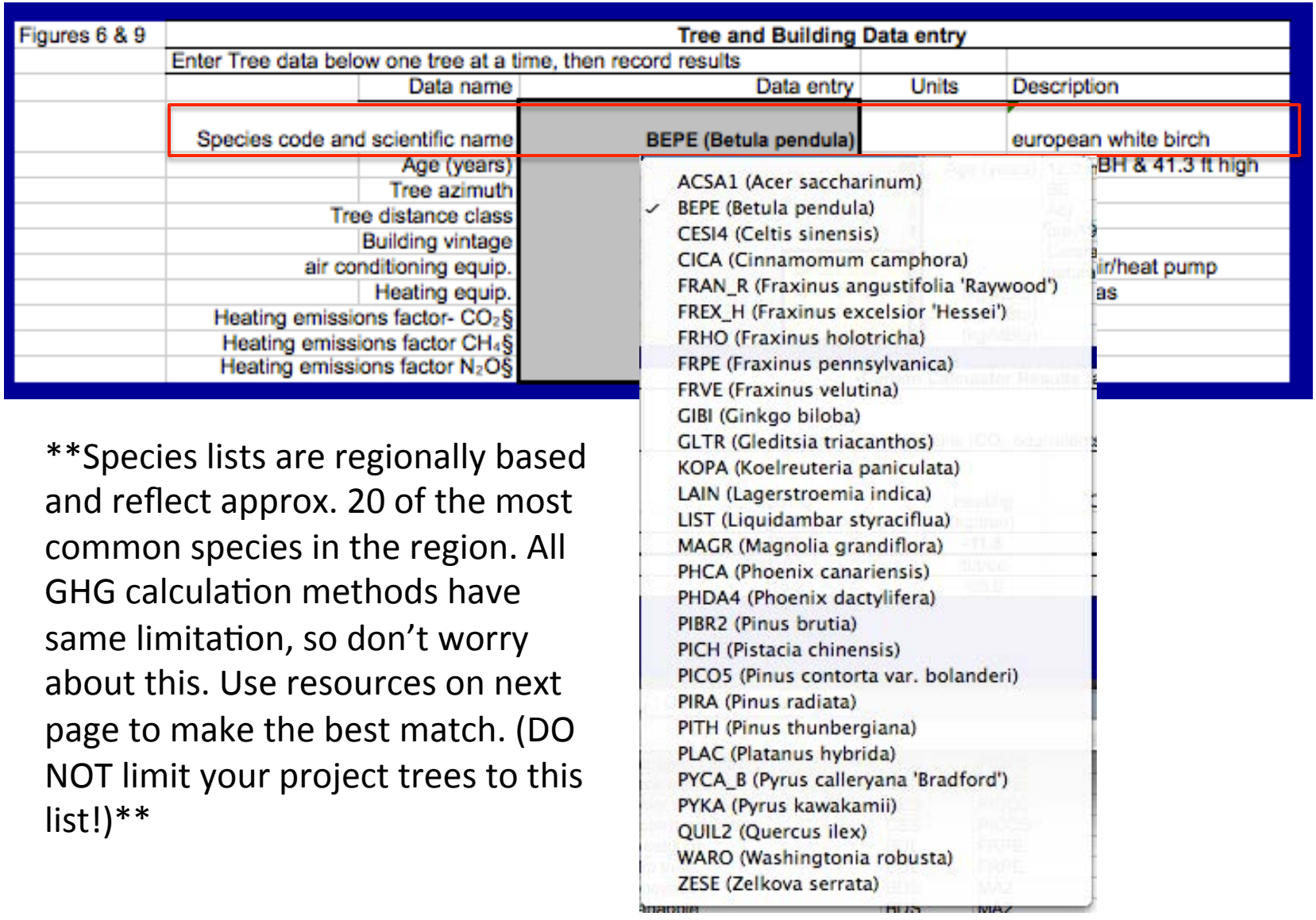


Project inputs

CO_2 storage inputs

Only two inputs needed for calculating CO_2 storage benefits: species and age.

CO_2 storage tree inputs: species



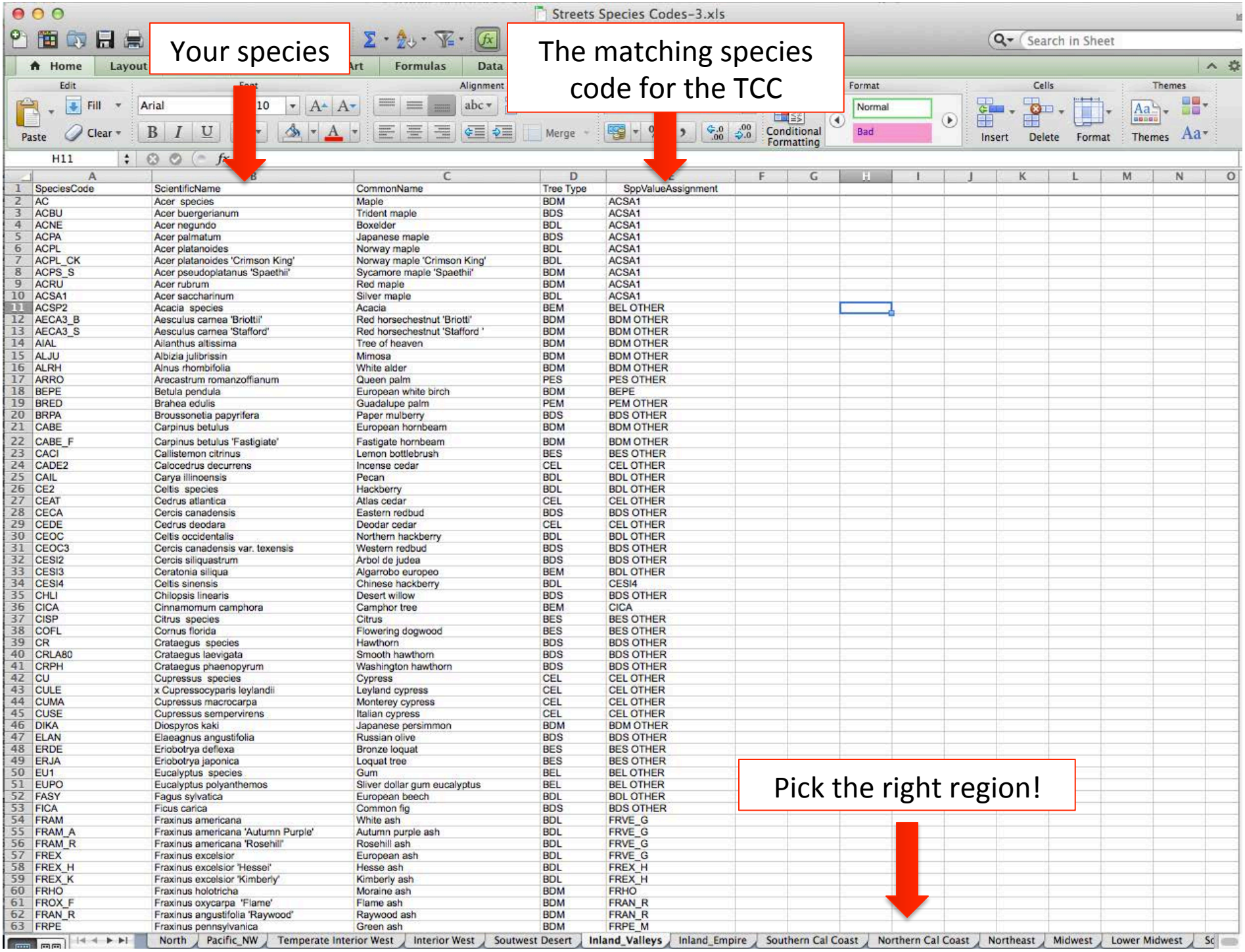
Figures 6 & 9	Tree and Building Data entry			
	Enter Tree data below one tree at a time, then record results			
	Data name	Data entry	Units	Description
	Species code and scientific name	BEPE (Betula pendula)		european white birch
	Age (years)			BH & 41.3 ft high
	Tree azimuth			
	Tree distance class			
	Building vintage			
	air conditioning equip.			ir/heat pump
	Heating equip.			as
	Heating emissions factor- CO_2§			
	Heating emissions factor CH_4§			
	Heating emissions factor N_2O§			

ACSA1 (Acer saccharinum)
✓ BEPE (Betula pendula)
CESI4 (Celtis sinensis)
CICA (Cinnamomum camphora)
FRAN_R (Fraxinus angustifolia 'Raywood')
FREX_H (Fraxinus excelsior 'Hessei')
FRHO (Fraxinus holotricha)
FRPE (Fraxinus pennsylvanica)
FRVE (Fraxinus velutina)
GIBI (Ginkgo biloba)
GLTR (Gleditsia triacanthos)
KOPA (Koelreuteria paniculata)
LAIN (Lagerstroemia indica)
LIST (Liquidambar styraciflua)
MAGR (Magnolia grandiflora)
PHCA (Phoenix canariensis)
PHDA4 (Phoenix dactylifera)
PIBR2 (Pinus brutia)
PICH (Pistacia chinensis)
PICO5 (Pinus contorta var. bolanderi)
PIRA (Pinus radiata)
PITH (Pinus thunbergiana)
PLAC (Platanus hybrida)
PYCA_B (Pyrus calleryana 'Bradford')
PYKA (Pyrus kawakamii)
QUIL2 (Quercus ilex)
WARO (Washingtonia robusta)
ZESE (Zelkova serrata)

Species lists are regionally based and reflect approx. 20 of the most common species in the region. All GHG calculation methods have same limitation, so don't worry about this. Use resources on next page to make the best match. (DO NOT limit your project trees to this list!)

Species matching

1. Download the species matching lists from iTree Streets: www.itreetools.org/streets/resources/Streets%20Species%20Codes.xls


Streets Species Codes-3.xls
Your species
The matching species code for the TCC
Pick the right region!
Search in Sheet
Home
Layout
Formulas
Data
Edit
Font
Alignment
Format
Cells
Themes
Paste
Fill
Clear
Arial
10
Merge
Conditional Formatting
Normal
Bad
Insert
Delete
Format
Themes
H11
SpeciesCode
ScientificName
CommonName
Tree Type
SppValueAssignment
AC Acer species Maple BDM ACSA1
ACBU Acer buergerianum Trident maple BDS ACSA1
ACNE Acer negundo Boxelder BDL ACSA1
ACPA Acer palmatum Japanese maple BDS ACSA1
ACPL Acer platanoides Norway maple BDL ACSA1
ACPL_CK Acer platanoides 'Crimson King' Norway maple 'Crimson King' BDL ACSA1
ACPS_S Acer pseudoplatanus 'Spaethii' Sycamore maple 'Spaethii' BDM ACSA1
ACRU Acer rubrum Red maple BDM ACSA1
ACSA1 Acer saccharinum Silver maple BDL ACSA1
ACSP2 Acacia species Acacia BEM BEL OTHER
AECA3_B Aesculus carnea 'Briottii' Red horsechestnut 'Briotti' BDM BDM OTHER
AECA3_S Aesculus carnea 'Stafford' Red horsechestnut 'Stafford ' BDM BDM OTHER
AIAL Ailanthus altissima Tree of heaven BDM BDM OTHER
ALJU Albizia julibrissin Mimosa BDM BDM OTHER
ALRH Alnus rhombifolia White alder BDM BDM OTHER
ARRO Arecastrum romanzoffianum Queen palm PES PES OTHER
BEPE Betula pendula European white birch BDM BEPE
BRED Brahea edulis Guadalupe palm PEM PEM OTHER
BRPA Broussonetia papyrifera Paper mulberry BDS BDS OTHER
CABE Carpinus betulus European hornbeam BDM BDM OTHER
CABE_F Carpinus betulus 'Fastigiate' Fastigate hornbeam BDM BDM OTHER
CACI Callistemon citrinus Lemon bottlebrush BES BES OTHER
CADE2 Calocedrus decurrens Incense cedar CEL CEL OTHER
CAIL Carya illinoensis Pecan BDL BDL OTHER
CE2 Celtis species Hackberry BDL BDL OTHER
CEAT Cedrus atlantica Atlas cedar CEL CEL OTHER
CECA Cercis canadensis Eastern redbud BDS BDS OTHER
CEDE Cedrus deodara Deodar cedar CEL CEL OTHER
CEOC Celtis occidentalis Northern hackberry BDL BDL OTHER
CEOC3 Cercis canadensis var. texensis Western redbud BDS BDS OTHER
CESI2 Cercis siliquastrum Arbol de judea BDS BDS OTHER
CESI3 Ceratonia siliqua Algarrobo europeo BEM BDL OTHER
CESI4 Celtis sinensis Chinese hackberry BDL CESI4
CHLI Chilopsis linearis Desert willow BDS BDS OTHER
CICA Cinnamomum camphora Camphor tree BEM CICA
CISP Citrus species Citrus BES BES OTHER
COFL Cornus florida Flowering dogwood BES BES OTHER
CR Crataegus species Hawthorn BDS BDS OTHER
CRLA80 Crataegus laevigata Smooth hawthorn BDS BDS OTHER
CRPH Crataegus phaenopyrum Washington hawthorn BDS BDS OTHER
CU Cupressus species Cypress CEL CEL OTHER
CULE x Cupressocyparis leylandii Leyland cypress CEL CEL OTHER
CUMA Cupressus macrocarpa Monterey cypress CEL CEL OTHER
CUSE Cupressus sempervirens Italian cypress CEL CEL OTHER
DIKA Diospyros kaki Japanese persimmon BDM BDM OTHER
ELAN Elaeagnus angustifolia Russian olive BDS BDS OTHER
ERDE Eriobotrya deflexa Bronze loquat BES BES OTHER
ERJA Eriobotrya japonica Loquat tree BES BES OTHER
EU1 Eucalyptus species Gum BEL BEL OTHER
EUPO Eucalyptus polyanthemos Sliver dollar gum eucalyptus BEL BEL OTHER
FASY Fagus sylvatica European beech BDL BDL OTHER
FICA Ficus carica Common fig BDS BDS OTHER
FRAM Fraxinus americana White ash BDL FRVE_G
FRAM_A Fraxinus americana 'Autumn Purple' Autumn purple ash BDL FRVE_G
FRAM_R Fraxinus americana 'Rosehill' Rosehill ash BDL FRVE_G
FREX Fraxinus excelsior European ash BDL FRVE_G
FREX_H Fraxinus excelsior 'Hessei' Hesse ash BDL FREX_H
FREX_K Fraxinus excelsior 'Kimberly' Kimberly ash BDL FREX_H
FRHO Fraxinus holotricha Moraine ash BDM FRHO
FROX_F Fraxinus oxycarpa 'Flame' Flame ash BDM FRAN_R
FRAN_R Fraxinus angustifolia 'Raywood' Raywood ash BDM FRAN_R
FRPE Fraxinus pennsylvanica Green ash BDM FRPE_M
North
Pacific_NW
Temperate Interior West
Interior West
Soutwest Desert
Inland_Valleys
Inland_Empire
Southern Cal Coast
Northern Cal Coast
Northeast
Midwest
Lower Midwest

Species matching with iTree lists

SpeciesCode	ScientificName	CommonName	Tree Type	SppValueAssignment
SOHUCF	Sorbus hupehensis var coral fire	Mountain ash 'Coral Fire'	BDS	BDS OTHER
SOHUCQ	Sorbus hupehensis var columbia queen	Mountain ash 'Columbia Queen'	BDS	BDS OTHER
SOJA	Sophora japonica	Japanese pagoda tree	BDM	PICH
TADI	Taxodium distichum	Baldcypress	BDL	CEL OTHER
TI	Tilia species	Basswood	BDM	BDM OTHER
TRFO	Trachycarpus fortunei	Windmill palm	PEM	PEM OTHER
TRLA	Tristaniopsis laurina	Water gum; kanooka	BES	BES OTHER
TRLA_E	Tristania laurina 'Elegans'	Water gum 'Elegans'	BES	BES OTHER
TRSE6	Triadica sebifera	Tallowtree	BDM	BDM OTHER
ULPA	Ulmus parvifolia	Chinese elm	BDL	ZESE
ULS	Ulmus species	Elm	BDL	ZESE
UMCA	Umbellularia californica	California laurel	BEL	BEL OTHER
WAFI	Washingtonia filifera	California palm	CES	PES OTHER
WARO	Washingtonia robusta	Mexican fan palm	PES	WARO
ZESE	Zelkova serrata	Japanese zelkova	BDM	ZESE
ZESE_V	Zelkova serrata 'Village Green'	Japanese zelkova 'Village Green'	BDM	ZESE
BDL OTHER	Broadleaf Deciduous Large	Broadleaf Deciduous Large	BDL	CESI4
BDM OTHER	Broadleaf Deciduous Medium	Broadleaf Deciduous Medium	BDM	PYCA_B
BDS OTHER	Broadleaf Deciduous Small	Broadleaf Deciduous Small	BDS	LAIN
BEL OTHER	Broadleaf Evergreen Large	Broadleaf Evergreen Large	BEL	QUIL2
BEM OTHER	Broadleaf Evergreen Medium	Broadleaf Evergreen Medium	BEM	CICA
BES OTHER	Broadleaf Evergreen Small	Broadleaf Evergreen Small	BES	PYKA
CEL OTHER	Conifer Evergreen Large	Conifer Evergreen Large	CEL	PIRA
CEM OTHER	Conifer Evergreen Medium	Conifer Evergreen Medium	CEM	PIBR2
CES OTHER	Conifer Evergreen Small	Conifer Evergreen Small	CES	PICO5
PEL OTHER	Palm Evergreen Large	Palm Evergreen Large	PEL	PHCA
PEM OTHER	Palm Evergreen Medium	Palm Evergreen Medium	PEM	PHDA4
PES OTHER	Palm Evergreen Small	Palm Evergreen Small	PES	WARO

Example 1: You plan to plant *Ulmus parvifolia*. The species code for the matching species is ZESE. We can use the species code directly in the TCC or look up ZESE in the far left column to see that ZESE = *Zelkova serrata*.

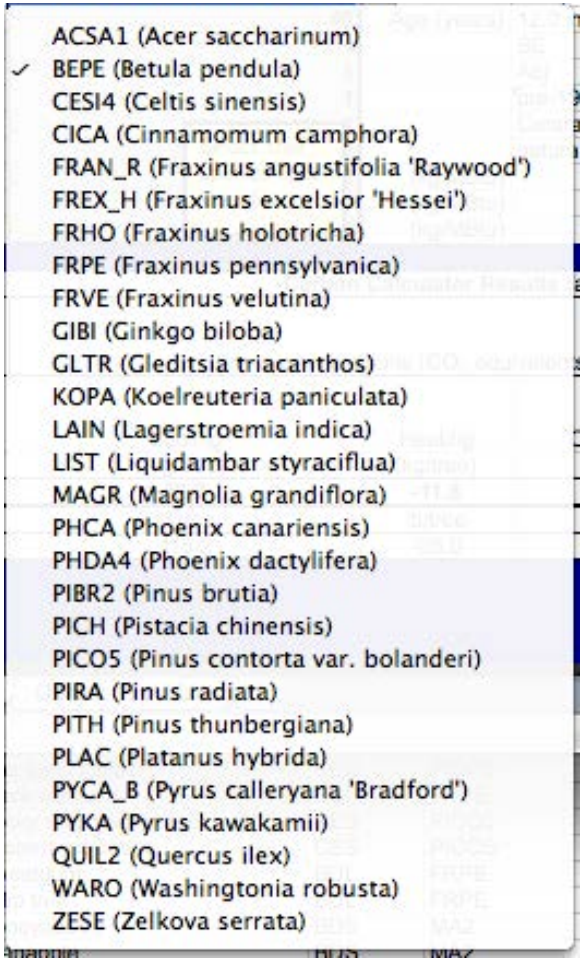
Species matching with iTree lists

SpeciesCode	ScientificName	CommonName	Tree Type	SppValueAssignment
SOHUCF	Sorbus hupehensis var coral fire	Mountain ash 'Coral Fire'	BDS	BDS OTHER
SOHUCQ	Sorbus hupehensis var columbia queen	Mountain ash 'Columbia Queen'	BDS	BDS OTHER
SOJA	Sophora japonica	Japanese pagoda tree	BDM	[illegible]H
TADI	Taxodium distichum	Baldcypress	BDL	[illegible]EL OTHER
TI	Tilia species	Basswood	[illegible]	BDM OTHER
TRFO	Trachycarpus fortunei	Windmill palm	PEM	PEM OTHER
TRLA	Tristaniopsis laurina	Water gum; kanooka	BES	BES OTHER
TRLA_E	Tristania laurina 'Elegans'	Water gum 'Elega[illegible]'	BES	BES OTHER
TRSE6	Triadica sebifera	Tallowtree	BDM	BDM OTHER
ULPA	Ulmus parvifolia	Ch[illegible]im	BDL	ZESE
ULS	Ulmus species	[illegible]	BDL	ZESE
UMCA	Umbellularia californica	California laurel	BEL	BEL OTHER
WAFI	Washingtonia filifera	California palm	CES	PES OTHER
WARO	Washingtonia ro[illegible]	Mexican fan palm	PES	WARO
ZESE	Zelkova [illegible]	Japanese zelkova	BDM	ZESE
ZESE_V	Z[illegible] serrata 'Village Green'	Japanese zelkova 'Village Green'	BDM	ZESE
BDL OTHER	Broadleaf Deciduous Large	Broadleaf Deciduous Large	BDL	CESI4
BDM OTHER	Broadleaf Deciduous Medium	Broadleaf Deciduous Medium	BDM	PYCA_B
BDS OTHER	Broadleaf Deciduous Small	Broadleaf Deciduous Small	BDS	LAIN
BEL OTHER	Broadleaf Evergreen Large	Broadleaf Evergreen Large	BEL	QUIL2
BEM OTHER	Broadleaf Evergreen Medium	Broadleaf Evergreen Medium	BEM	CICA
BES OTHER	Broadleaf Evergreen Small	Broadleaf Evergreen Small	BES	PYKA
CEL OTHER	Conifer Evergreen Large	Conifer Evergreen Large	CEL	PIRA
CEM OTHER	Conifer Evergreen Medium	Conifer Evergreen Medium	CEM	PIBR2
CES OTHER	Conifer Evergreen Small	Conifer Evergreen Small	CES	PICO5
PEL OTHER	Palm Evergreen Large	Palm Evergreen Large	PEL	PHCA
PEM OTHER	Palm Evergreen Medium	Palm Evergreen Medium	PEM	PHDA4
PES OTHER	Palm Evergreen Small	Palm Evergreen Small	PES	WARO

Example 2: You plan to plant *Sorbus hupehensis*. The species code for the matching species is BDS OTHER. But that's not in the TCC! It stands for Broadleaf Deciduous Small Other. Look in the far left column for the species that represents BDS OTHER. For this region it is LAIN = Lagerstroemia indica. Use that in the TCC or look for something more appropriate.

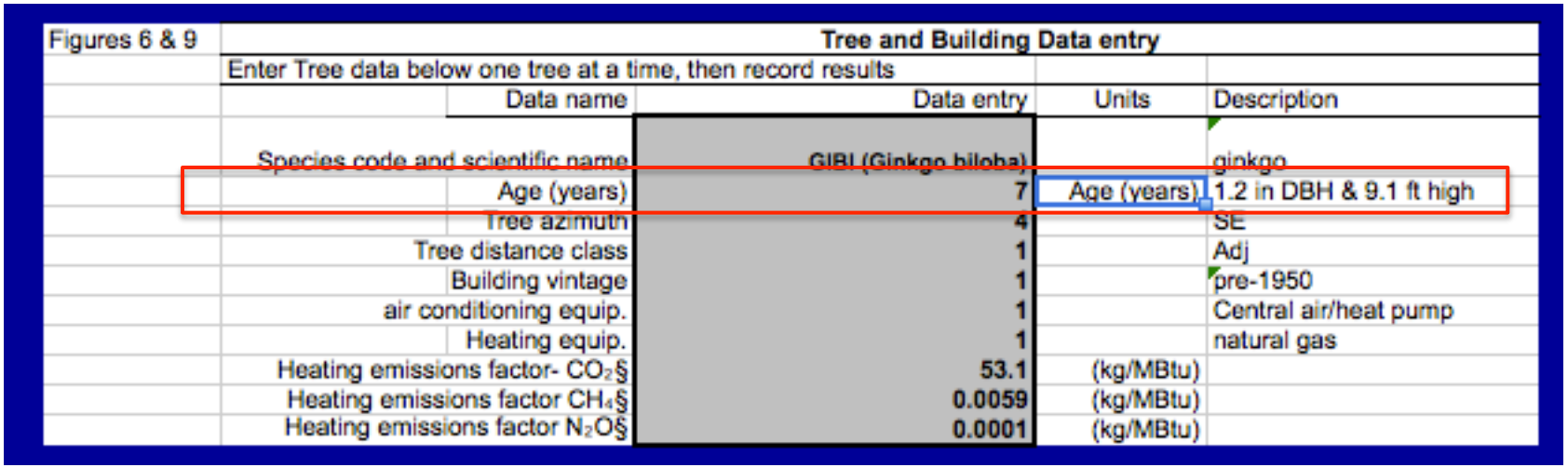
Species matching

1. Download the species matching lists from iTree Streets: www.itreetools.org/streets/resources/Streets%20Species%20Codes.xls
2. Look for species of same genus.
   Ex: *Quercus lobata* => QUIL2
3. Look for species of same family.
   Ex: *Malus domestica* => PYCA_B
4. But still consider mature size and growth. Ex: If you were planting Japanese maple, it would be better to match with another small species than to match with silver maple.
5. Choose species with similar type (broadleaf, conifer), mature size, and leaf habit (deciduous vs evergreen)
   Ex: *Eucalyptus globulus* => QUIL2



HINT: choose the species *most* like yours

CO_2 storage tree inputs: age

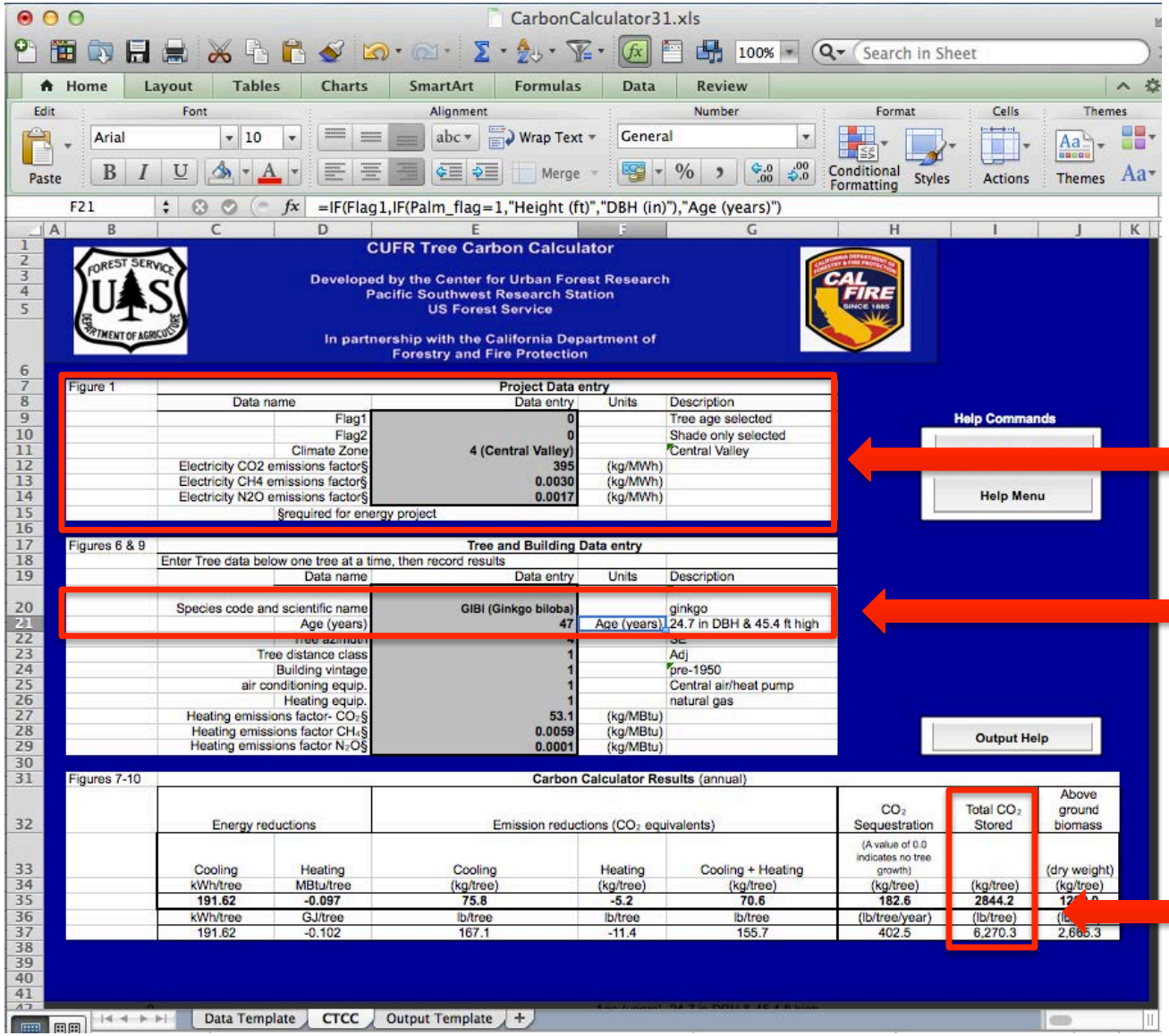


Figures 6 & 9	Tree and Building Data entry			
	Enter Tree data below one tree at a time, then record results			
	Data name	Data entry	Units	Description
	Species code and scientific name	GIBI (Ginkgo biloba)		ginkgo
	Age (years)	7	Age (years)	1.2 in DBH & 9.1 ft high
	Tree azimuth	4		SE
	Tree distance class	1		Adj
	Building vintage	1		pre-1950
	air conditioning equip.	1		Central air/heat pump
	Heating equip.	1		natural gas
	Heating emissions factor- CO_2§	53.1	(kg/MBtu)	
	Heating emissions factor CH_4§	0.0059	(kg/MBtu)	
	Heating emissions factor N_2O§	0.0001	(kg/MBtu)	

**Step 1: Start with age = 1 and go up one year at a time until DBH matches approximate planting size (probably 1-1.5 inch dbh).
Step 2: Add 37-39 years to that number to reflect remaining project lifespan.
Step 3: Enter that number in the age box.
Ex: Slow growing ginkgo reaches 1.2 in dbh at 7 years (i.e., when we plant a 15 gallon ginkgo, it's already 7 years old). We'll enter 46 in age box to reflect age of tree 40 years after planting.**

HINT: enter age of tree 40 years after project start

Calculating CO_2 storage



Project inputs

Storage inputs

Storage output

The value in the "Total CO_2 Stored" box is the PROJECT TOTAL, i.e., the amount of CO_2 stored in the tree over the project lifetime.

CO_2 storage output

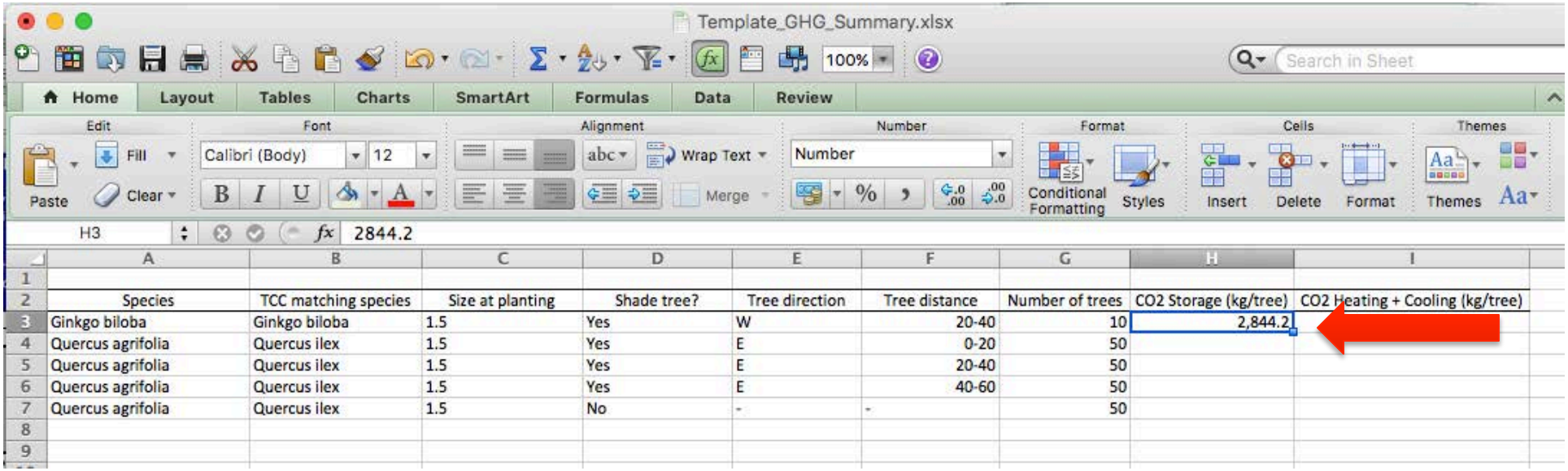
CO_2 Sequestration	Total CO_2 Stored	Above ground biomass
(A value of 0.0 indicates no tree growth)		(dry weight)
(kg/tree)	(kg/tree)	(kg/tree)
182.6	**2844.2**	**1209.0**
(lb/tree/year)	(lb/tree)	(lb/tree)
402.5	6,270.3	2,665.3

Annual sequestration

Total storage for project lifetime

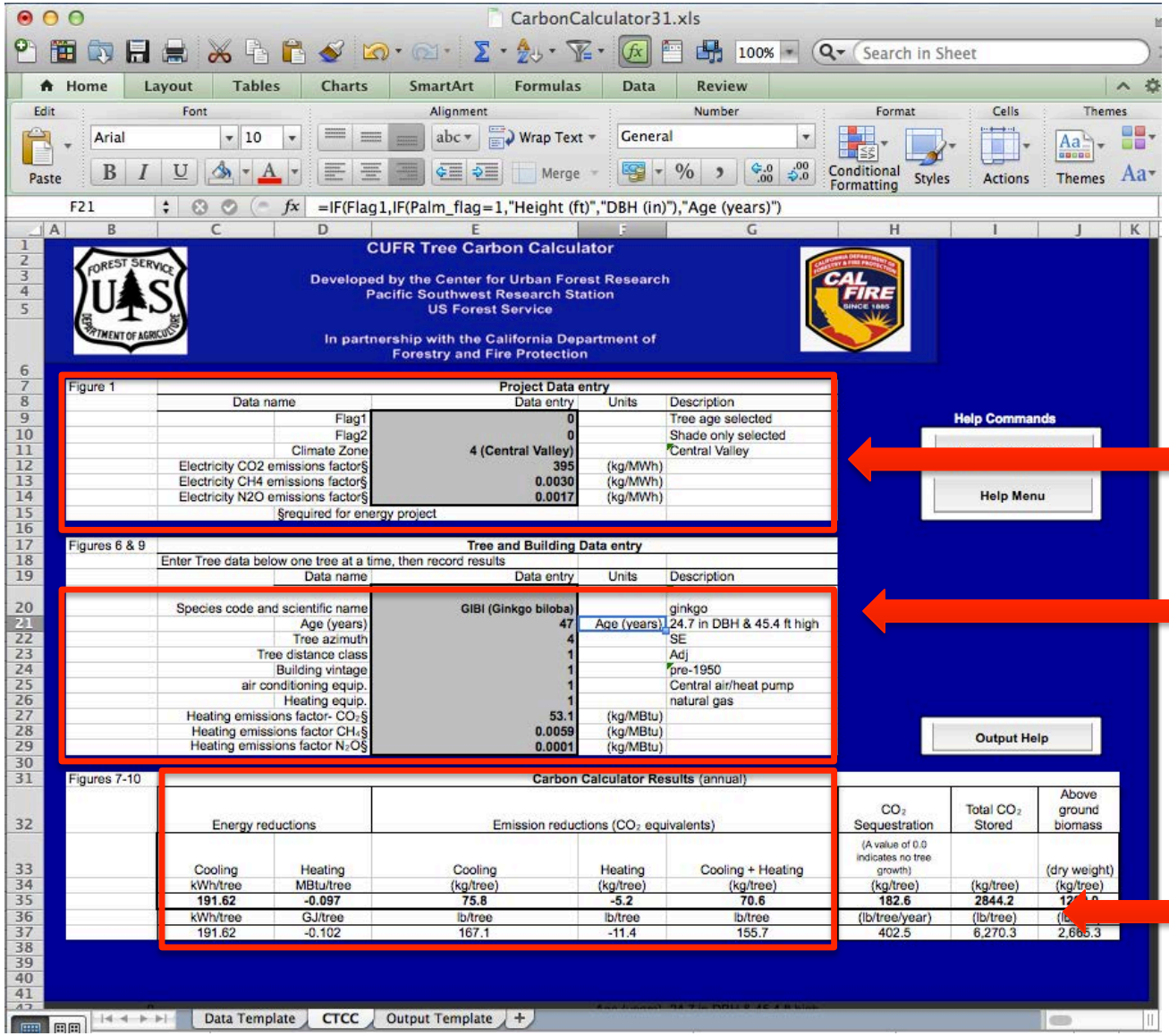
HINT: record Total CO_2 Stored in kg

Enter CO2 storage in tree list



	A	B	C	D	E	F	G	H	I
1									
2	Species	TCC matching species	Size at planting	Shade tree?	Tree direction	Tree distance	Number of trees	CO2 Storage (kg/tree)	CO2 Heating + Cooling (kg/tree)
3	Ginkgo biloba	Ginkgo biloba	1.5	Yes	W	20-40	10	2,844.2	
4	Quercus agrifolia	Quercus ilex	1.5	Yes	E	0-20	50		
5	Quercus agrifolia	Quercus ilex	1.5	Yes	E	20-40	50		
6	Quercus agrifolia	Quercus ilex	1.5	Yes	E	40-60	50		
7	Quercus agrifolia	Quercus ilex	1.5	No	-	-	50		
8									
9									

Calculating avoided CO_2



Project inputs

Avoided CO_2 and energy conservation inputs

Avoided CO_2 and energy conservation outputs

Avoided CO_2 tree inputs: species and *age at end of project*

Figures 6 & 9	Tree and Building Data entry			
	Enter Tree data below one tree at a time, then record results			
	Data name	Data entry	Units	Description
	Species code and scientific name	GIBI (Ginkgo biloba)		ginkgo
	Age (years)	47	Age (years)	24.7 in DBH & 45.4 ft high
	Tree azimuth	7		W
	Tree distance class	2		Near
	Building vintage	1		pre-1950
	air conditioning equip.	1		Central air/heat pump
	Heating equip.	1		natural gas
	Heating emissions factor- CO_2§	53.1	(kg/MBtu)	
	Heating emissions factor CH_4§	0.0059	(kg/MBtu)	
	Heating emissions factor N_2O§	0.0001	(kg/MBtu)	

HINT: Remain the same as for storage

Avoided CO_2 tree inputs: azimuth

Figures 6 & 9

Tree and Building Data entry

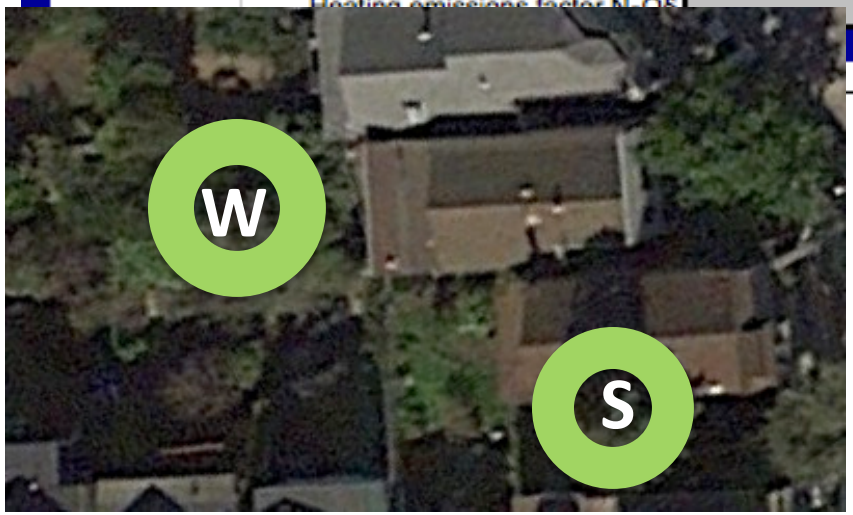
Enter Tree data below one tree at a time, then record results

Data name	Data entry	Units	Description
Species code and scientific name	GIBI (Ginkgo biloba)		ginkgo
Age (years)	7	Age (years)	1.2 in DBH & 9.1 ft high
Tree azimuth	7		W
Tree distance class	2		Near
Building vintage	1		pre-1950
air conditioning equip.			Central air/heat pump
Heating equip.			natural gas
Heating emissions factor- CO_2§			
Heating emissions factor CH_4§			

1 = N
2 = NE
3 = E
4 = SE
5 = S
6 = SW
7 = W
8 = NW

sults (annual)

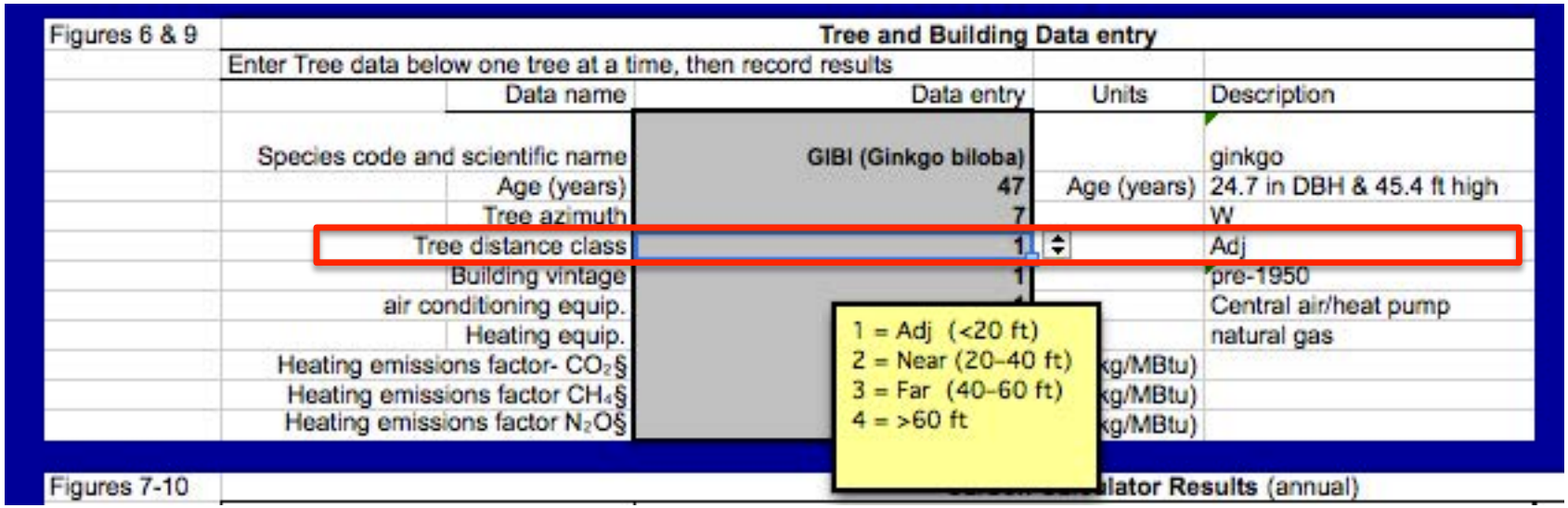
Emission reductions (CO_2 equivalents)



Shade benefits rarely accrue to trees on the N or NE sides. If your trees will be there, don't waste your time with these calculations!

HINT: Ask yourself: "The tree is to the _____ of the building.

Avoided CO_2 tree inputs: distance



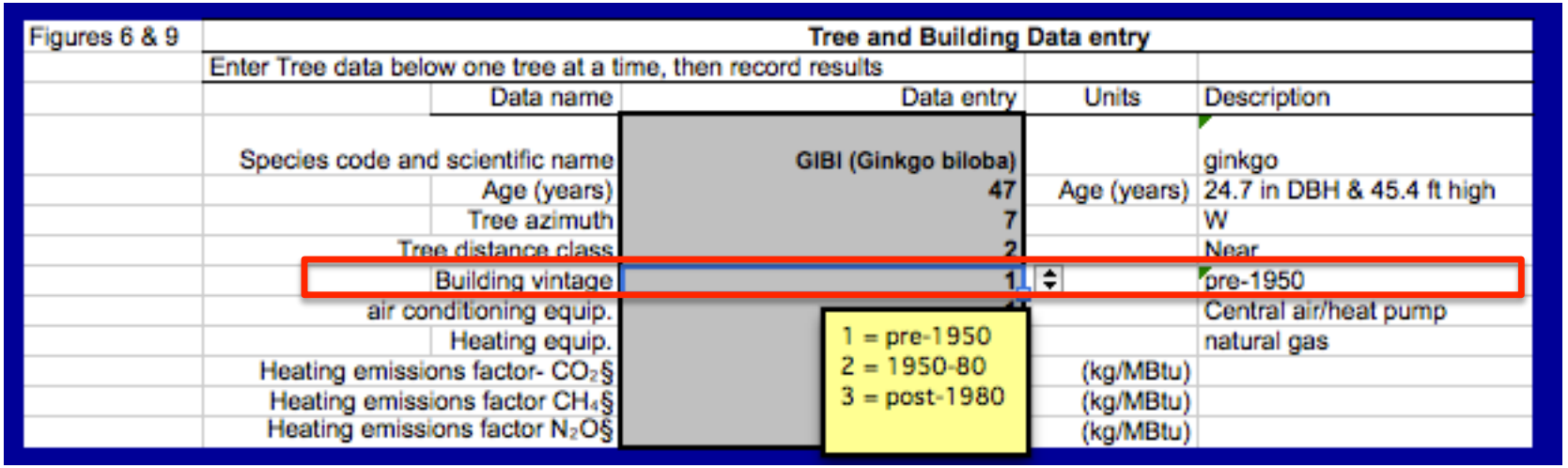
Figures 6 & 9	Tree and Building Data entry			
	Enter Tree data below one tree at a time, then record results			
	Data name	Data entry	Units	Description
	Species code and scientific name	GIBI (Ginkgo biloba)		ginkgo
	Age (years)	47	Age (years)	24.7 in DBH & 45.4 ft high
	Tree azimuth	7		W
	Tree distance class	1		Adj
	Building vintage	1		pre-1950
	air conditioning equip.			Central air/heat pump
	Heating equip.			natural gas
	Heating emissions factor- CO_2§		kg/MBtu)	
	Heating emissions factor CH_4§		kg/MBtu)	
	Heating emissions factor N_2O§		kg/MBtu)	
Figures 7-10				lator Results (annual)

1 = Adj (<20 ft)
2 = Near (20–40 ft)
3 = Far (40–60 ft)
4 = >60 ft

Shade benefits only accrue to trees in categories 1-3.

HINT: How far is the tree from the building?

Avoided CO_2 tree inputs: bldg vintage



Figures 6 & 9	Tree and Building Data entry			
	Enter Tree data below one tree at a time, then record results			
	Data name	Data entry	Units	Description
	Species code and scientific name	GIBI (Ginkgo biloba)		ginkgo
	Age (years)	47	Age (years)	24.7 in DBH & 45.4 ft high
	Tree azimuth	7		W
	Tree distance class	2		Near
	Building vintage	1		pre-1950
	air conditioning equip.			Central air/heat pump
	Heating equip.			natural gas
	Heating emissions factor- CO_2§		(kg/MBtu)	
	Heating emissions factor CH_4§		(kg/MBtu)	
	Heating emissions factor N_2O§		(kg/MBtu)	

1 = pre-1950
2 = 1950-80
3 = post-1980

HINT: How old is the typical building in your project area?

Avoided CO_2 tree inputs: equipment

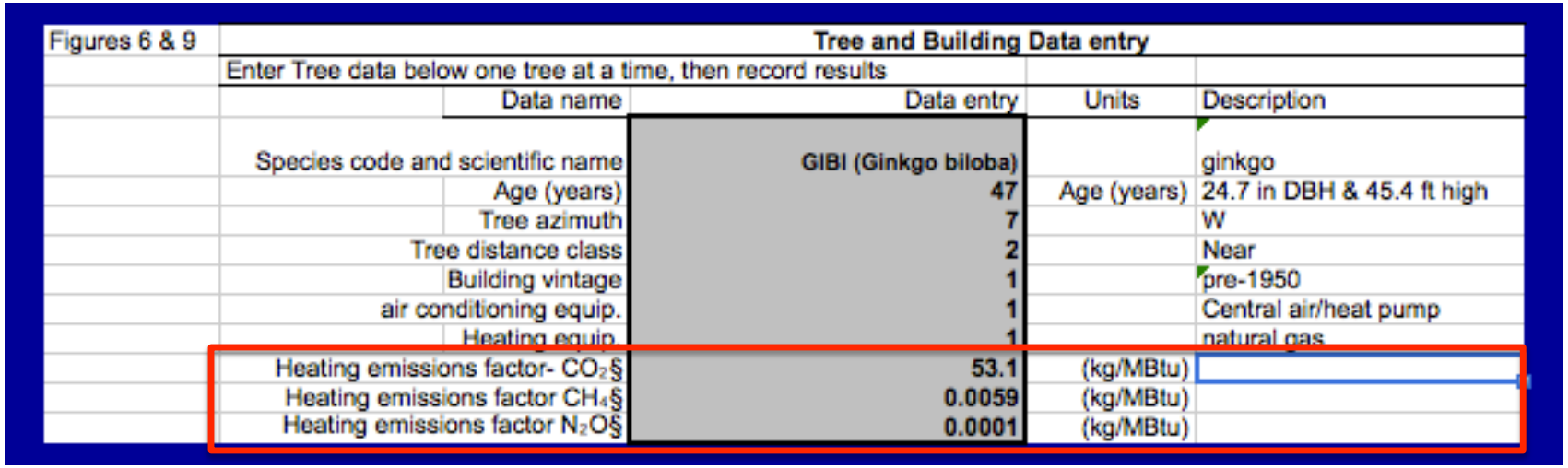
Figures 6 & 9	Tree and Building Data entry			
	Enter Tree data below one tree at a time, then record results			
	Data name	Data entry	Units	Description
	Species code and scientific name	GIBI (Ginkgo biloba)		ginkgo
	Age (years)	47	Age (years)	24.7 in DBH & 45.4 ft high
	Tree azimuth	7		W
	Tree distance class	2		Near
	Building vintage	1		pre-1950
	air conditioning equip.	1		Central air/heat pump
	Heating equip.	1		natural gas
	Heating emissions factor- CO_2§	53.1	(kg/MBtu)	
	Heating emissions factor CH_4§	0.0059	(kg/MBtu)	
	Heating emissions factor N_2O§	0.0001	(kg/MBtu)	

1 = Central air/heat pump
2 = Evaporative cooler
3 = Wall/window unit
0 = None

1 = Natural gas
2 = Heat pump
3 = Electric resistance
4 = Oil/other fossil
0 = None

HINT: Leave as defaults

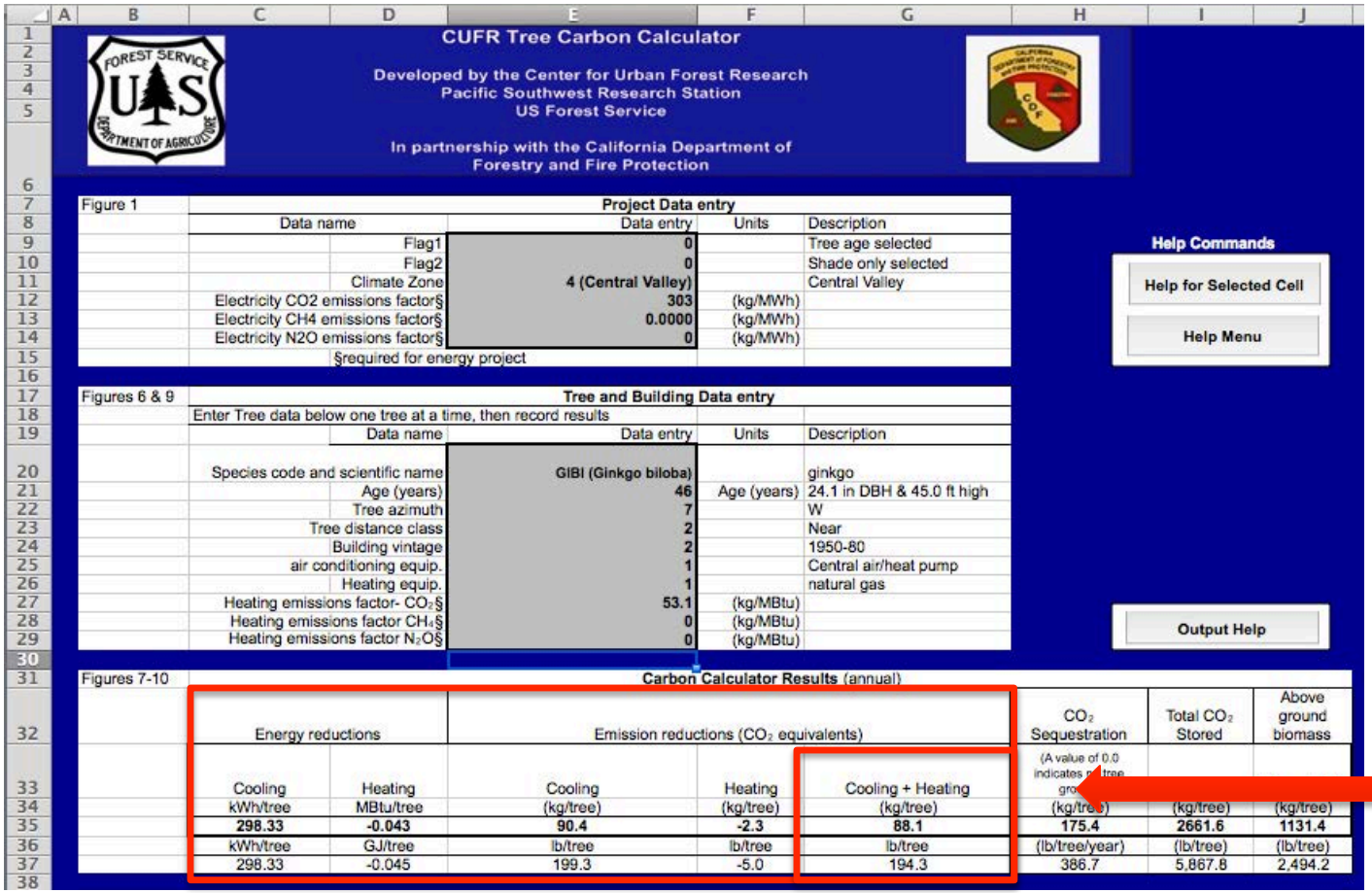
Avoided CO_2 tree inputs: heating emissions



Figures 6 & 9	Tree and Building Data entry			
	Enter Tree data below one tree at a time, then record results			
	Data name	Data entry	Units	Description
	Species code and scientific name	GIBI (Ginkgo biloba)		ginkgo
	Age (years)	47	Age (years)	24.7 in DBH & 45.4 ft high
	Tree azimuth	7		W
	Tree distance class	2		Near
	Building vintage	1		pre-1950
	air conditioning equip.	1		Central air/heat pump
	Heating equip.	1		natural gas
	Heating emissions factor- CO_2§	53.1	(kg/MBtu)	
	Heating emissions factor CH_4§	0.0059	(kg/MBtu)	
	Heating emissions factor N_2O§	0.0001	(kg/MBtu)	

Leave the default value for Heating emissions factor-CO2 = 53.1. Set the other two to 0.

HINT: 1st = 53.1, other two = 0



CUFR Tree Carbon Calculator

Developed by the Center for Urban Forest Research
Pacific Southwest Research Station
US Forest Service

In partnership with the California Department of Forestry and Fire Protection

Figure 1 — **Project Data entry**

Data name	Data entry	Units	Description
Flag1	0		Tree age selected
Flag2	0		Shade only selected
Climate Zone	4 (Central Valley)		Central Valley
Electricity CO2 emissions factor§	303	(kg/MWh)	
Electricity CH4 emissions factor§	0.0000	(kg/MWh)	
Electricity N2O emissions factor§	0	(kg/MWh)	

§required for energy project

Help Commands: Help for Selected Cell; Help Menu

Figures 6 & 9 — **Tree and Building Data entry**

Enter Tree data below one tree at a time, then record results

Data name	Data entry	Units	Description
Species code and scientific name	GIBI (Ginkgo biloba)		ginkgo
Age (years)	46	Age (years)	24.1 in DBH & 45.0 ft high
Tree azimuth	7		W
Tree distance class	2		Near
Building vintage	2		1950-80
air conditioning equip.	1		Central air/heat pump
Heating equip.	1		natural gas
Heating emissions factor- CO_2§	53.1	(kg/MBtu)	
Heating emissions factor CH_4§	0	(kg/MBtu)	
Heating emissions factor N_2O§	0	(kg/MBtu)	

Output Help

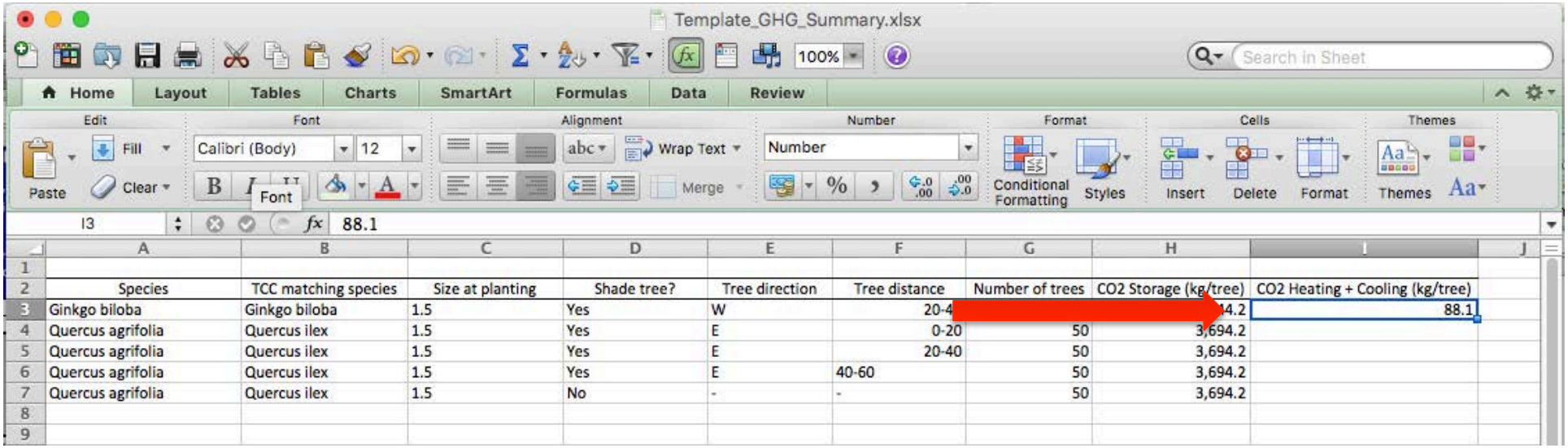
Figures 7-10 — **Carbon Calculator Results** (annual)

Energy reductions		Emission reductions (CO_2 equivalents)			CO_2 Sequestration	Total CO_2 Stored	Above ground biomass
Cooling	Heating	Cooling	Heating	Cooling + Heating	(A value of 0.0 indicates no tree gro		
kWh/tree	MBtu/tree	(kg/tree)	(kg/tree)	(kg/tree)	(kg/tree)	(kg/tree)	(kg/tree)
298.33	**-0.043**	**90.4**	**-2.3**	**88.1**	**175.4**	**2661.6**	**1131.4**
kWh/tree	GJ/tree	lb/tree	lb/tree	lb/tree	(lb/tree/year)	(lb/tree)	(lb/tree)
298.33	-0.045	199.3	-5.0	194.3	386.7	5,867.8	2,494.2

Calculating avoided CO_2 and energy conserved

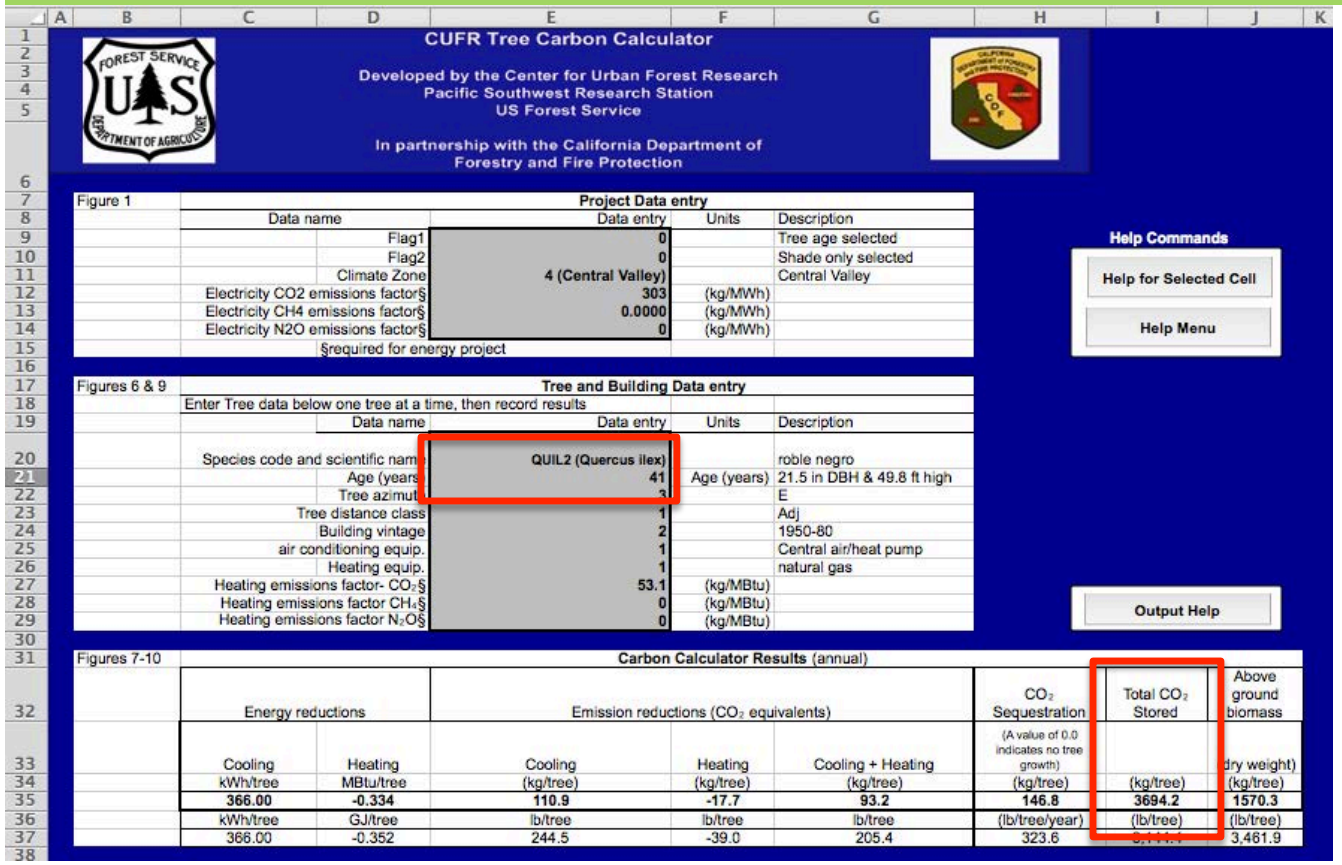
Avoided CO_2 and energy conservation outputs

Enter CO2 Heating + Cooling in tree list



	A	B	C	D	E	F	G	H	I	J
1										
2	Species	TCC matching species	Size at planting	Shade tree?	Tree direction	Tree distance	Number of trees	CO2 Storage (kg/tree)	CO2 Heating + Cooling (kg/tree)	
3	Ginkgo biloba	Ginkgo biloba	1.5	Yes	W	20-4		4.2	88.1	
4	Quercus agrifolia	Quercus ilex	1.5	Yes	E	0-20	50	3,694.2		
5	Quercus agrifolia	Quercus ilex	1.5	Yes	E	20-40	50	3,694.2		
6	Quercus agrifolia	Quercus ilex	1.5	Yes	E	40-60	50	3,694.2		
7	Quercus agrifolia	Quercus ilex	1.5	No	-	-	50	3,694.2		
8										
9										

Next tree list entry



CUFR Tree Carbon Calculator

Developed by the Center for Urban Forest Research
Pacific Southwest Research Station
US Forest Service

In partnership with the California Department of Forestry and Fire Protection

Figure 1 — **Project Data entry**

Data name	Data entry	Units	Description
Flag1	0		Tree age selected
Flag2	0		Shade only selected
Climate Zone	4 (Central Valley)		Central Valley
Electricity CO_2 emissions factor§	303	(kg/MWh)	
Electricity CH_4 emissions factor§	0.0000	(kg/MWh)	
Electricity N_2O emissions factor§	0	(kg/MWh)	

§required for energy project

Help Commands: Help for Selected Cell; Help Menu

Figures 6 & 9 — **Tree and Building Data entry**

Enter Tree data below one tree at a time, then record results

Data name	Data entry	Units	Description
Species code and scientific nam	QUIL2 (Quercus ilex)		roble negro
Age (years	41	Age (years)	21.5 in DBH & 49.8 ft high
Tree azimut	3		E
Tree distance class	1		Adj
Building vintage	2		1950-80
air conditioning equip.	1		Central air/heat pump
Heating equip.	1		natural gas
Heating emissions factor- CO_2§	53.1	(kg/MBtu)	
Heating emissions factor CH_4§	0	(kg/MBtu)	
Heating emissions factor N_2O§	0	(kg/MBtu)	

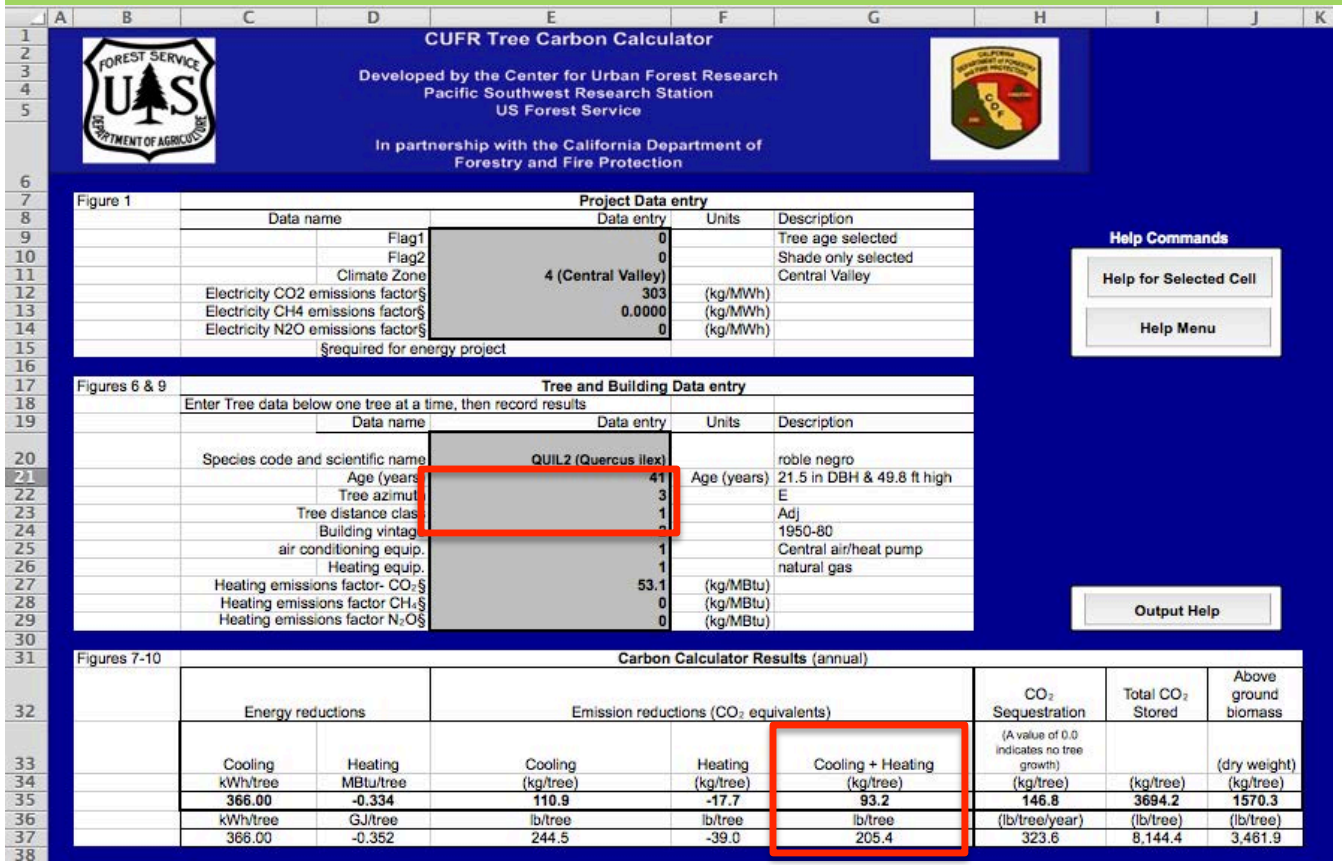
Output Help

Figures 7-10 — **Carbon Calculator Results** (annual)

Energy reductions		Emission reductions (CO_2 equivalents)			CO_2 Sequestration	Total CO_2 Stored	Above ground biomass
Cooling	Heating	Cooling	Heating	Cooling + Heating	(A value of 0.0 indicates no tree growth)		dry weight)
kWh/tree	MBtu/tree	(kg/tree)	(kg/tree)	(kg/tree)	(kg/tree)	(kg/tree)	(kg/tree)
366.00	**-0.334**	**110.9**	**-17.7**	**93.2**	**146.8**	**3694.2**	**1570.3**
kWh/tree	GJ/tree	lb/tree	lb/tree	lb/tree	(lb/tree/year)	(lb/tree)	(lb/tree)
366.00	-0.352	244.5	-39.0	205.4	323.6	[illegible]	3,461.9

Species	TCC matching species	Size at planting	Shade tree?	Tree direction	Tree distance	Number of trees	CO2 Storage (kg/tree)	CO2 Heating + Cooling (kg/tree)
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	10	[illegible]	88.1
Quercus agrifolia	Quercus ilex	1.5	Yes	E	0-20	50	3,694.2	
Quercus agrifolia	Quercus ilex	1.5	Yes	E	20-40	50	3,694.2	
Quercus agrifolia	Quercus ilex	1.5	Yes	E	40-60	50	3,694.2	
Quercus agrifolia	Quercus ilex	1.5	No	-	-	50	3,694.2	

Next tree list entry, cont.



CUFR Tree Carbon Calculator

Developed by the Center for Urban Forest Research
Pacific Southwest Research Station
US Forest Service

In partnership with the California Department of Forestry and Fire Protection

Figure 1 — **Project Data entry**

Data name	Data entry	Units	Description
Flag1	0		Tree age selected
Flag2	0		Shade only selected
Climate Zone	4 (Central Valley)		Central Valley
Electricity CO_2 emissions factor§	303	(kg/MWh)	
Electricity CH_4 emissions factor§	0.0000	(kg/MWh)	
Electricity N_2O emissions factor§	0	(kg/MWh)	

§required for energy project

Help Commands: Help for Selected Cell; Help Menu

Figures 6 & 9 — **Tree and Building Data entry**

Enter Tree data below one tree at a time, then record results

Data name	Data entry	Units	Description
Species code and scientific name	QUIL2 (Quercus ilex)		roble negro
Age (years	41	Age (years)	21.5 in DBH & 49.8 ft high
Tree azimut	3		E
Tree distance clas	1		Adj
Building vintag			1950-80
air conditioning equip.	1		Central air/heat pump
Heating equip.	1		natural gas
Heating emissions factor- CO_2§	53.1	(kg/MBtu)	
Heating emissions factor CH_4§	0	(kg/MBtu)	
Heating emissions factor N_2O§	0	(kg/MBtu)	

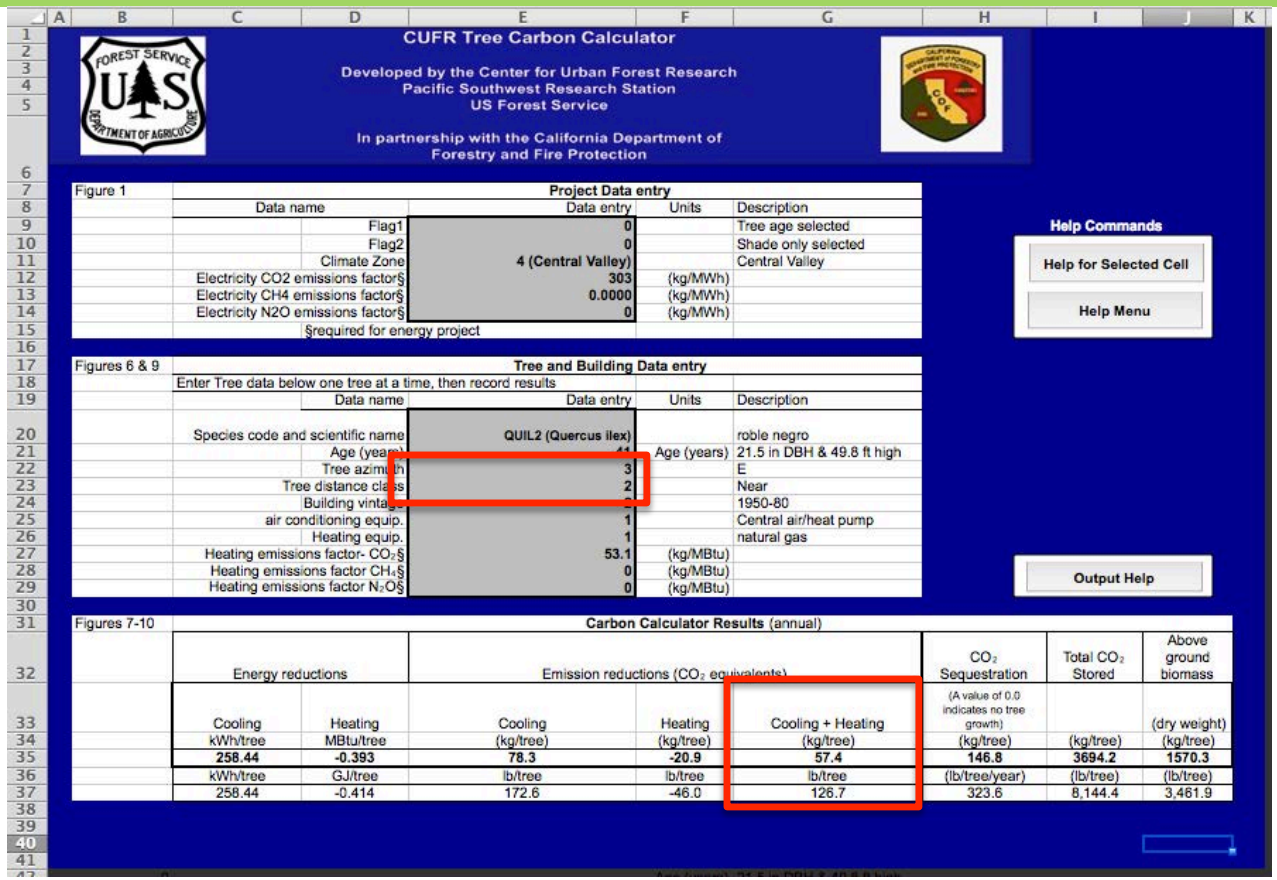
Output Help

Figures 7-10 — **Carbon Calculator Results** (annual)

Energy reductions		Emission reductions (CO_2 equivalents)			CO_2 Sequestration	Total CO_2 Stored	Above ground biomass
Cooling	Heating	Cooling	Heating	Cooling + Heating	(A value of 0.0 indicates no tree growth)		(dry weight)
kWh/tree	MBtu/tree	(kg/tree)	(kg/tree)	(kg/tree)	(kg/tree)	(kg/tree)	(kg/tree)
366.00	**-0.334**	**110.9**	**-17.7**	**93.2**	**146.8**	**3694.2**	**1570.3**
kWh/tree	GJ/tree	lb/tree	lb/tree	lb/tree	(lb/tree/year)	(lb/tree)	(lb/tree)
366.00	-0.352	244.5	-39.0	205.4	323.6	8,144.4	3,461.9

	A	B	C	D	E	F	G	H	I
2	Species	TCC matching species	Size at planting	Shade tree?	Tree direction	Tree distance	Number of trees	CO2 Storage (kg/tree)	CO2 Heating + Cooling (kg/tree)
3	Ginkgo biloba	Ginkgo biloba	1.5	Yes	W	20-40	10	2,844.2	88.1
4	Quercus agrifolia	Quercus ilex	1.5	Yes	E	0-20	50	3,694.2	93.2
5	Quercus agrifolia	Quercus ilex	1.5	Yes	E	20-40	50	3,694.2	
6	Quercus agrifolia	Quercus ilex	1.5	Yes	E	40-60	50	3,694.2	
7	Quercus agrifolia	Quercus ilex	1.5	No	-	-	50	3,694.2	

3rd template entry



CUFR Tree Carbon Calculator

Developed by the Center for Urban Forest Research
Pacific Southwest Research Station
US Forest Service

In partnership with the California Department of Forestry and Fire Protection

Figure 1 — **Project Data entry**

Data name	Data entry	Units	Description
Flag1	0		Tree age selected
Flag2	0		Shade only selected
Climate Zone	4 (Central Valley)		Central Valley
Electricity CO2 emissions factor§	303	(kg/MWh)	
Electricity CH4 emissions factor§	0.0000	(kg/MWh)	
Electricity N2O emissions factor§	0	(kg/MWh)	

§required for energy project

Help Commands: Help for Selected Cell; Help Menu

Figures 6 & 9 — **Tree and Building Data entry**

Enter Tree data below one tree at a time, then record results

Data name	Data entry	Units	Description
Species code and scientific name	QUIL2 (Quercus ilex)		roble negro
Age (years)	41	Age (years)	21.5 in DBH & 49.8 ft high
Tree azimuth	3		E
Tree distance class	2		Near
Building vintage	2		1950-80
air conditioning equip.	1		Central air/heat pump
Heating equip.	1		natural gas
Heating emissions factor- CO_2§	53.1	(kg/MBtu)	
Heating emissions factor CH_4§	0	(kg/MBtu)	
Heating emissions factor N_2O§	0	(kg/MBtu)	

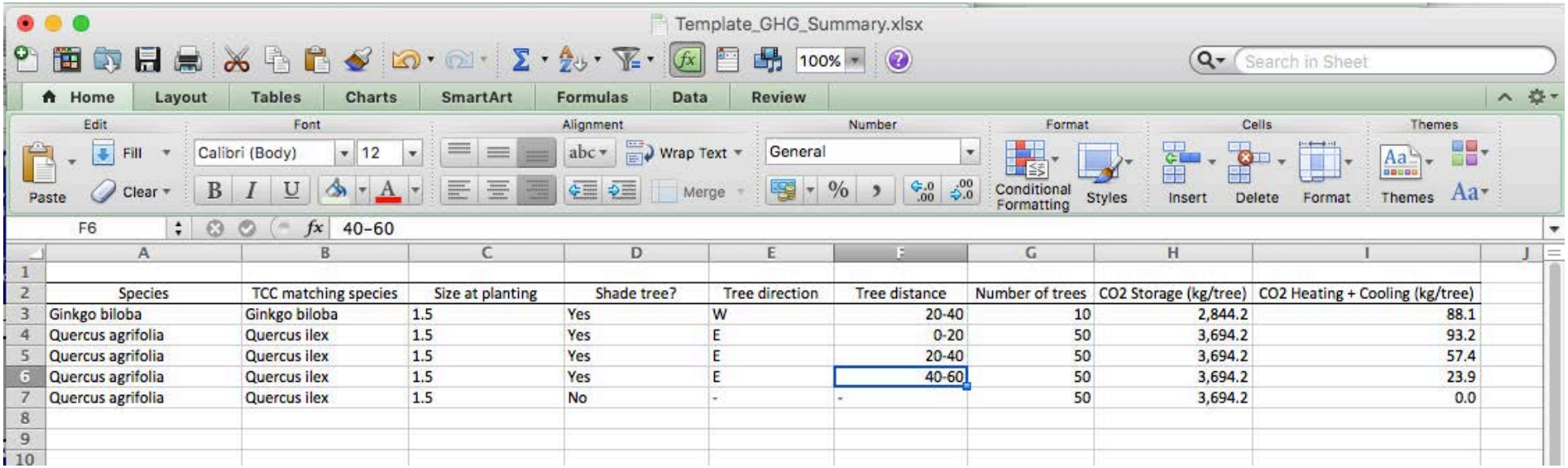
Output Help

Figures 7-10 — **Carbon Calculator Results** (annual)

Energy reductions		Emission reductions (CO_2 equivalents)			CO_2 Sequestration	Total CO_2 Stored	Above ground biomass
Cooling	Heating	Cooling	Heating	Cooling + Heating	(A value of 0.0 indicates no tree growth)		(dry weight)
kWh/tree	MBtu/tree	(kg/tree)	(kg/tree)	(kg/tree)	(kg/tree)	(kg/tree)	(kg/tree)
258.44	**-0.393**	**78.3**	**-20.9**	**57.4**	**146.8**	**3694.2**	**1570.3**
kWh/tree	GJ/tree	lb/tree	lb/tree	lb/tree	(lb/tree/year)	(lb/tree)	(lb/tree)
258.44	-0.414	172.6	-46.0	126.7	323.6	8,144.4	3,461.9

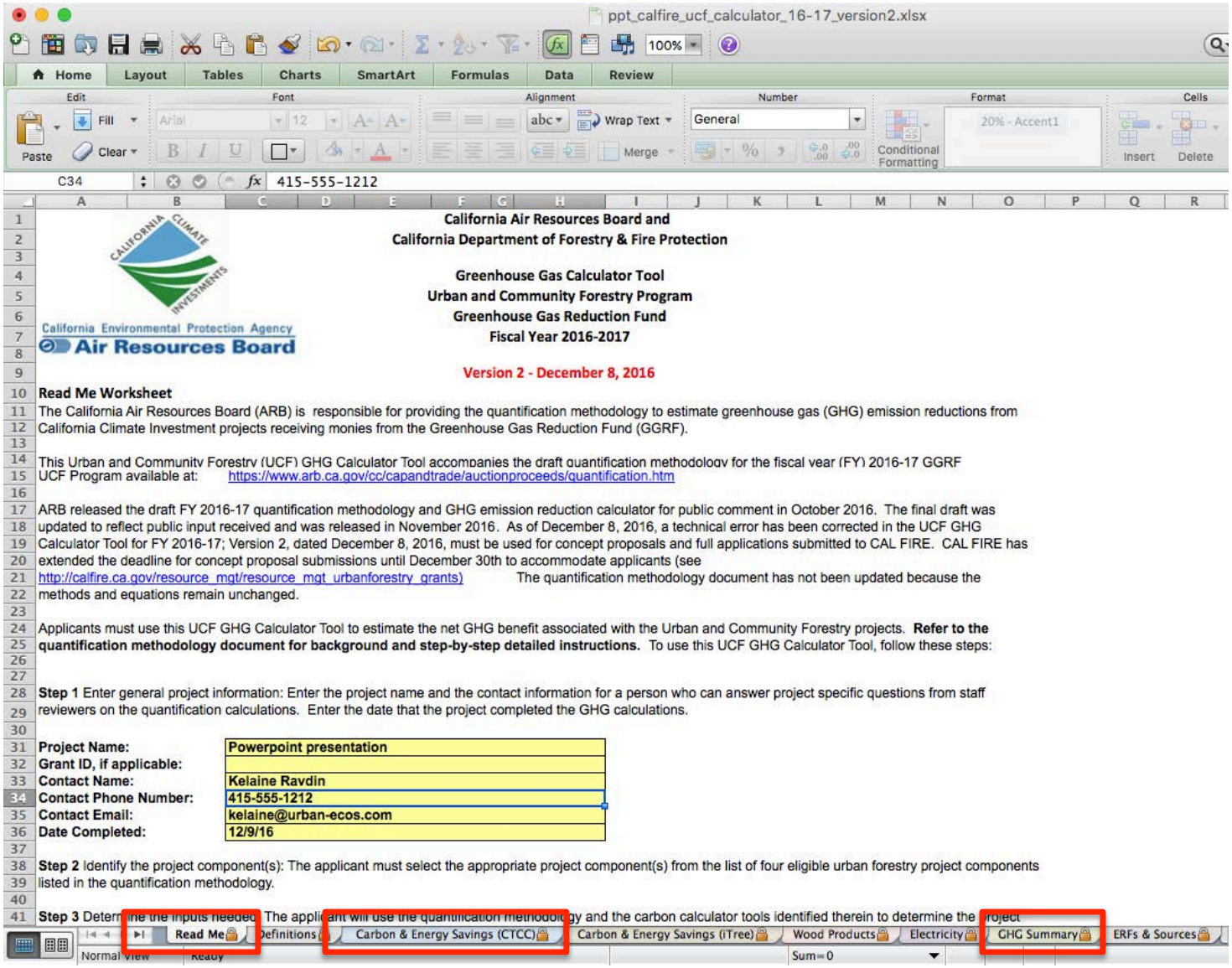
	A	B	C	D	E	F	G	H	I
2	Species	TCC matching species	Size at planting	Shade tree?	Tree direction	Tree distance	Number of trees	CO2 Storage (kg/tree)	CO2 Heating + Cooling (kg/tree)
3	Ginkgo biloba	Ginkgo biloba	1.5	Yes	W	20-40	10	2,844.2	88.1
4	Quercus agrifolia	Quercus ilex	1.5	Yes	E	0-20	50	3,694.2	93.2
5	Quercus agrifolia	Quercus ilex	1.5	Yes	E	20-40	50	3,694.2	57.4
6	Quercus agrifolia	Quercus ilex	1.5	Yes	E	40-60	50	3,694.2	
7	Quercus agrifolia	Quercus ilex	1.5	No	-	-	50	3,694.2	

Completed tree list

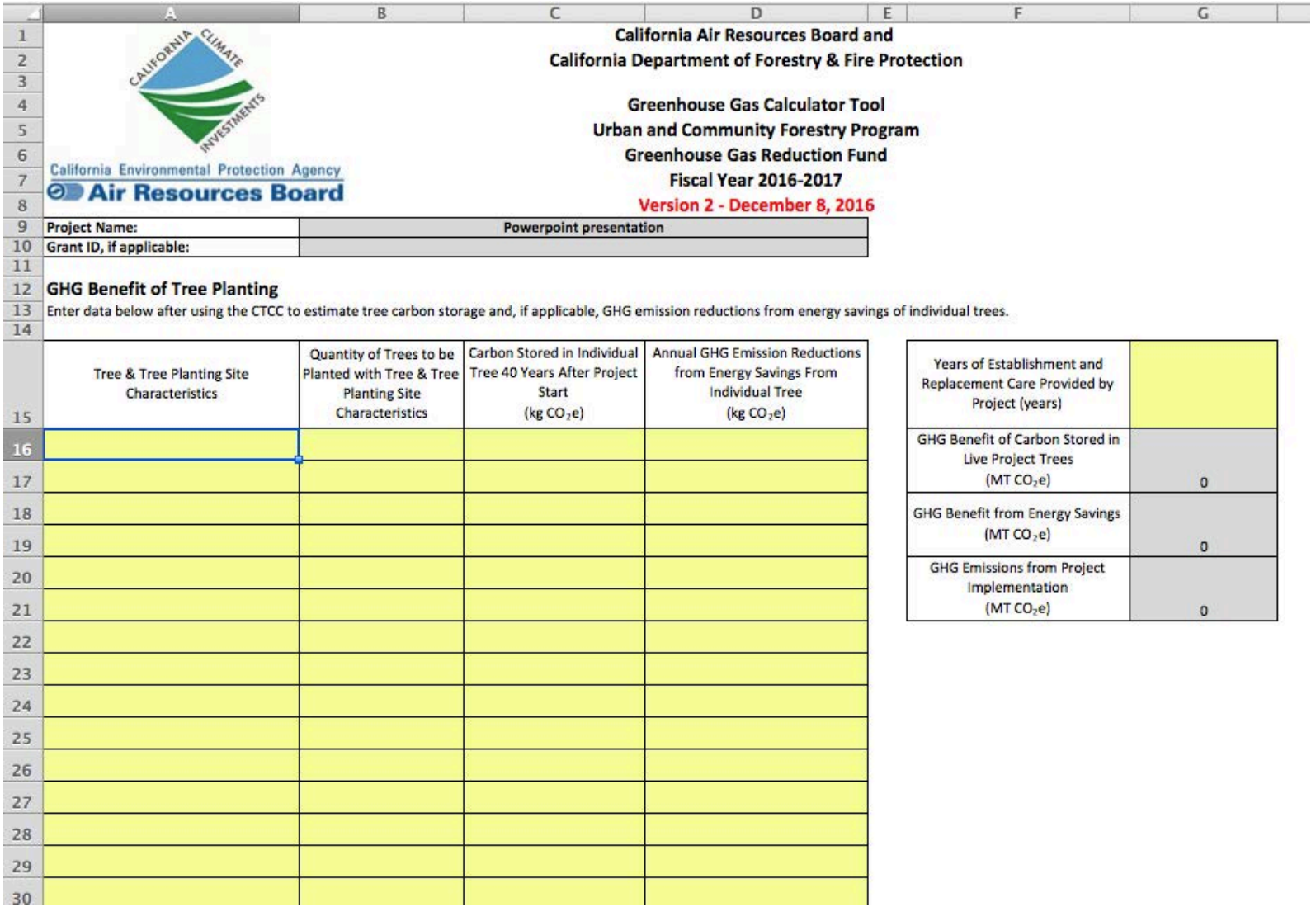


	A	B	C	D	E	F	G	H	I	J
1										
2	Species	TCC matching species	Size at planting	Shade tree?	Tree direction	Tree distance	Number of trees	CO2 Storage (kg/tree)	CO2 Heating + Cooling (kg/tree)	
3	Ginkgo biloba	Ginkgo biloba	1.5	Yes	W	20-40	10	2,844.2	88.1	
4	Quercus agrifolia	Quercus ilex	1.5	Yes	E	0-20	50	3,694.2	93.2	
5	Quercus agrifolia	Quercus ilex	1.5	Yes	E	20-40	50	3,694.2	57.4	
6	Quercus agrifolia	Quercus ilex	1.5	Yes	E	40-60	50	3,694.2	23.9	
7	Quercus agrifolia	Quercus ilex	1.5	No	-	-	50	3,694.2	0.0	
8										
9										
10										

ARB GHG Calculator



Carbon & Energy Savings (CTCC)



California Air Resources Board and
California Department of Forestry & Fire Protection

Greenhouse Gas Calculator Tool
Urban and Community Forestry Program
Greenhouse Gas Reduction Fund
Fiscal Year 2016-2017
Version 2 - December 8, 2016

California Environmental Protection Agency
Air Resources Board

Project Name:	Powerpoint presentation
Grant ID, if applicable:	

GHG Benefit of Tree Planting

Enter data below after using the CTCC to estimate tree carbon storage and, if applicable, GHG emission reductions from energy savings of individual trees.

Tree & Tree Planting Site Characteristics	Quantity of Trees to be Planted with Tree & Tree Planting Site Characteristics	Carbon Stored in Individual Tree 40 Years After Project Start ($kg\ CO_2e$)	Annual GHG Emission Reductions from Energy Savings From Individual Tree ($kg\ CO_2e$)

Years of Establishment and Replacement Care Provided by Project (years)	
GHG Benefit of Carbon Stored in Live Project Trees ($MT\ CO_2e$)	0
GHG Benefit from Energy Savings ($MT\ CO_2e$)	0
GHG Emissions from Project Implementation ($MT\ CO_2e$)	0

Enter data from template

California Air Resources Board and
California Department of Forestry & Fire Protection

California Environmental Protection Agency
Air Resources Board

Greenhouse Gas Calculator Tool
Urban and Community Forestry Program
Greenhouse Gas Reduction Fund
Fiscal Year 2016-2017
Version 2 - December 8, 2016

Project Name:	**Powerpoint presentation**
Grant ID, if applicable:	

GHG Benefit of Tree Planting

Enter data below after using the CTCC to estimate tree carbon storage and, if applicable, GHG emission reductions from energy savings of individual trees.

Tree & Tree Planting Site Characteristics	Quantity of Trees to be Planted with Tree & Tree Planting Site Characteristics	Carbon Stored in Individual Tree 40 Years After Project Start (kg CO_2e)	Annual GHG Emission Reductions from Energy Savings From Individual Tree (kg CO_2e)
Ginkgo, west 20-40'	10	2,844	88
Quercus agrifolia, no shade	50	3,694	0
Q. agrifolia, east 0-20	50	3,694	93
Q. agrifolia, east 20-40	50	3,694	57
Q. agrifolia, east 40-60	50	3,694	24

Years of Establishment and Replacement Care Provided by Project (years)	
GHG Benefit of Carbon Stored in Live Project Trees (MT CO_2e)	565.8122589
GHG Benefit from Energy Savings (MT CO_2e)	142
GHG Emissions from Project Implementation (MT CO_2e)	35

Adjust for care and replacements

Years of Establishment and Replacement Care Provided by Project (years)	
GHG Benefit of Carbon Stored in Live Project Trees ($MT\ CO_2e$)	565.8122589
GHG Benefit from Energy Savings ($MT\ CO_2e$)	142
GHG Emissions from Project Implementation ($MT\ CO_2e$)	35

Years of Establishment and Replacement Care Provided by Project (years)	3
GHG Benefit of Carbon Stored in Live Project Trees ($MT\ CO_2e$)	619.9506931
GHG Benefit from Energy Savings ($MT\ CO_2e$)	155
GHG Emissions from Project Implementation ($MT\ CO_2e$)	39

Years of Establishment and Replacement Care Provided by Project (years)	9
GHG Benefit of Carbon Stored in Live Project Trees ($MT\ CO_2e$)	744.26354
GHG Benefit from Energy Savings ($MT\ CO_2e$)	186
GHG Emissions from Project Implementation ($MT\ CO_2e$)	47

GHG Emissions

California Environmental Protection Agency
Air Resources Board

California Air Resources Board and
California Department of Forestry & Fire Protection

Greenhouse Gas Calculator Tool
Urban and Community Forestry Program
Greenhouse Gas Reduction Fund
Fiscal Year 2016-2017
Version 2 - December 8, 2016

Project Name:	**Powerpoint presentation**
Grant ID, if applicable:	

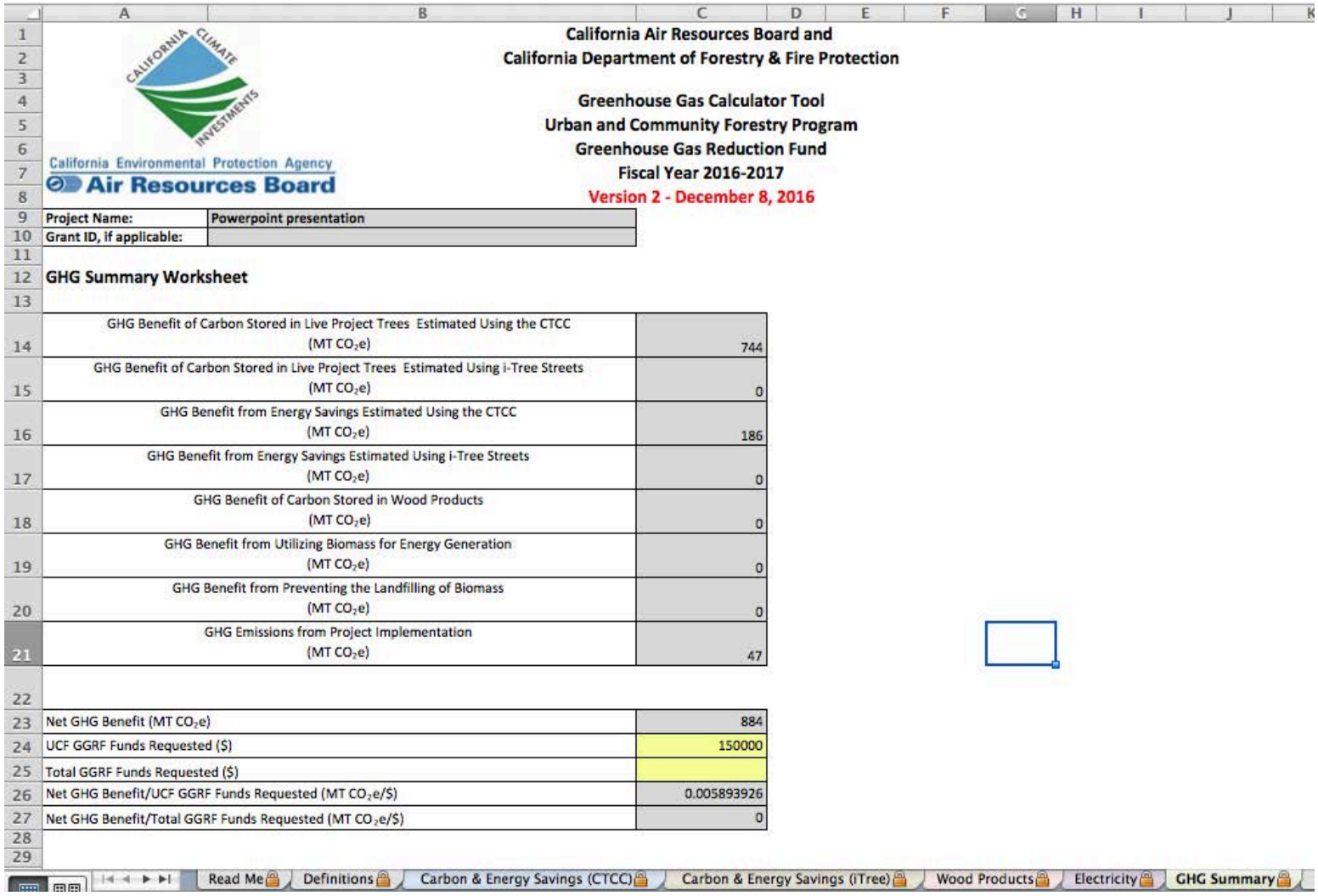
GHG Benefit of Tree Planting

Enter data below after using the CTCC to estimate tree carbon storage and, if applicable, GHG emission reductions from energy savings of individual trees.

Tree & Tree Planting Site Characteristics	Quantity of Trees to be Planted with Tree & Tree Planting Site Characteristics	Carbon Stored in Individual Tree 40 Years After Project Start (kg CO_2e)	Annual GHG Emission Reductions from Energy Savings From Individual Tree (kg CO_2e)
Ginkgo, west 20-40'	10	2,844	88
Quercus agrifolia, no shade	50	3,694	0
Q. agrifolia, east 0-20	50	3,694	93
Q. agrifolia, east 20-40	50	3,694	57
Q. agrifolia, east 40-60	50	3,694	24

Years of Establishment and Replacement Care Provided by Project (years)	
GHG Benefit of Carbon Stored in Live Project Trees (MT CO_2e)	565.8122589
GHG Benefit from Energy Savings (MT CO_2e)	142
GHG Emissions from Project Implementation (MT CO_2e)	35

Summary, enter project $



California Air Resources Board and
California Department of Forestry & Fire Protection

Greenhouse Gas Calculator Tool
Urban and Community Forestry Program
Greenhouse Gas Reduction Fund
Fiscal Year 2016-2017
Version 2 - December 8, 2016

California Environmental Protection Agency
Air Resources Board

Project Name:	Powerpoint presentation
Grant ID, if applicable:	

GHG Summary Worksheet

GHG Benefit of Carbon Stored in Live Project Trees Estimated Using the CTCC ($MT\ CO_2e$)	744
GHG Benefit of Carbon Stored in Live Project Trees Estimated Using i-Tree Streets ($MT\ CO_2e$)	0
GHG Benefit from Energy Savings Estimated Using the CTCC ($MT\ CO_2e$)	186
GHG Benefit from Energy Savings Estimated Using i-Tree Streets ($MT\ CO_2e$)	0
GHG Benefit of Carbon Stored in Wood Products ($MT\ CO_2e$)	0
GHG Benefit from Utilizing Biomass for Energy Generation ($MT\ CO_2e$)	0
GHG Benefit from Preventing the Landfilling of Biomass ($MT\ CO_2e$)	0
GHG Emissions from Project Implementation ($MT\ CO_2e$)	47

Net GHG Benefit ($MT\ CO_2e$)	884
UCF GGRF Funds Requested ($)	150000
Total GGRF Funds Requested ($)	
Net GHG Benefit/UCF GGRF Funds Requested ($MT\ CO_2e/\$$)	0.005893926
Net GHG Benefit/Total GGRF Funds Requested ($MT\ CO_2e/\$$)	0

Read Me | Definitions | Carbon & Energy Savings (CTCC) | Carbon & Energy Savings (iTree) | Wood Products | Electricity | GHG Summary

Questions

kelaine@urban-ecos.com

Growing Trees Make Great Neighborhoods

Urban Ecos