Growing Trees Make Great Neighborhoods

Calculating Greenhouse Gas (CO_2) Benefits of Trees

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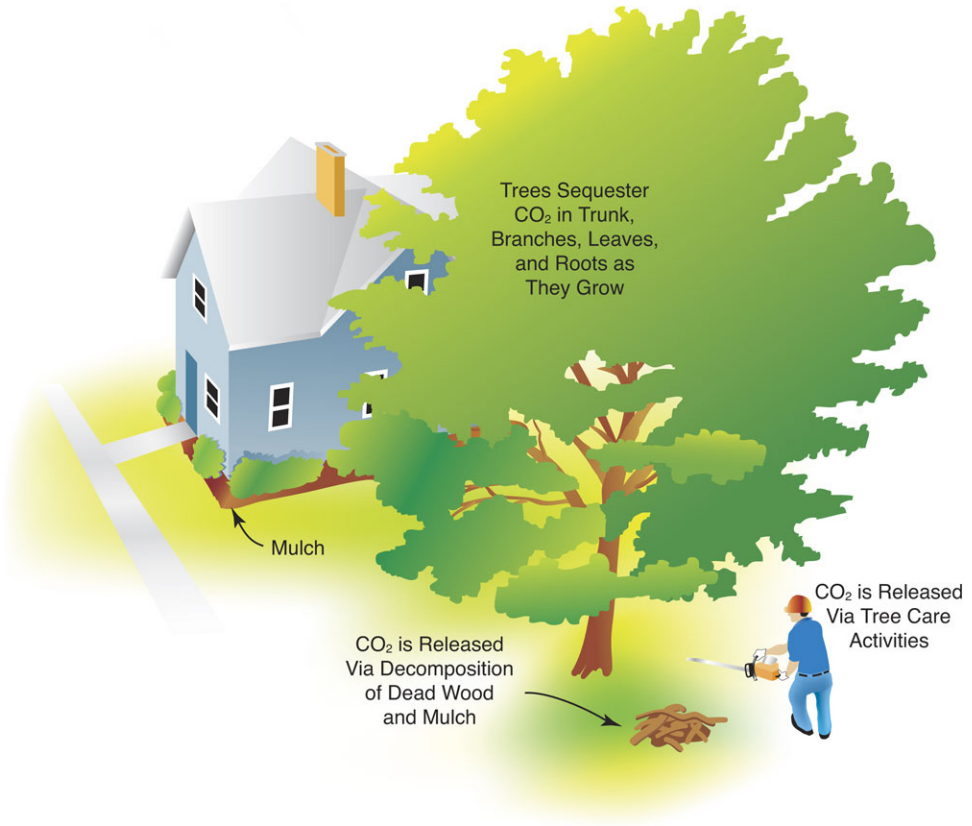
Urban Ecos

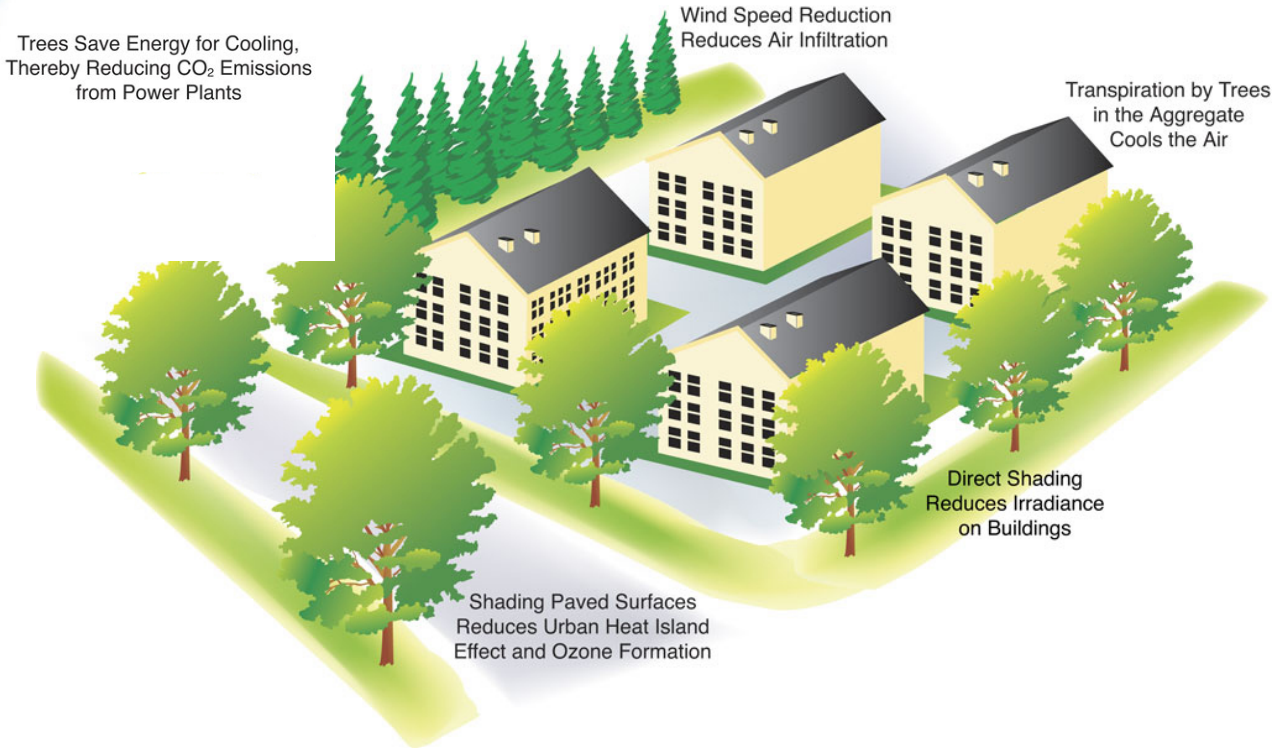
Trees and greenhouse gas benefits: storage (sequestration)

****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

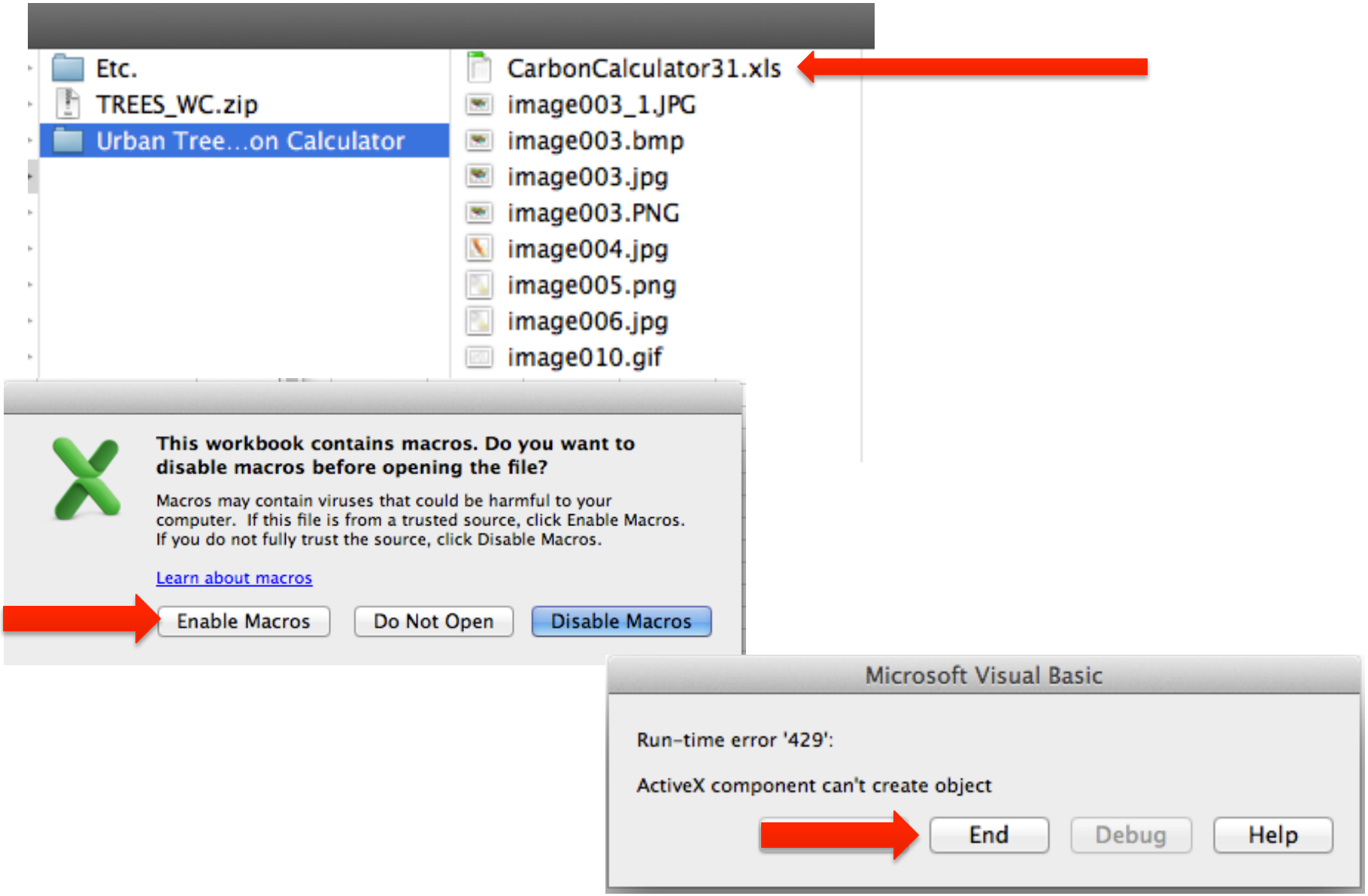


Avoided emissions are presented *on an annual basis*.

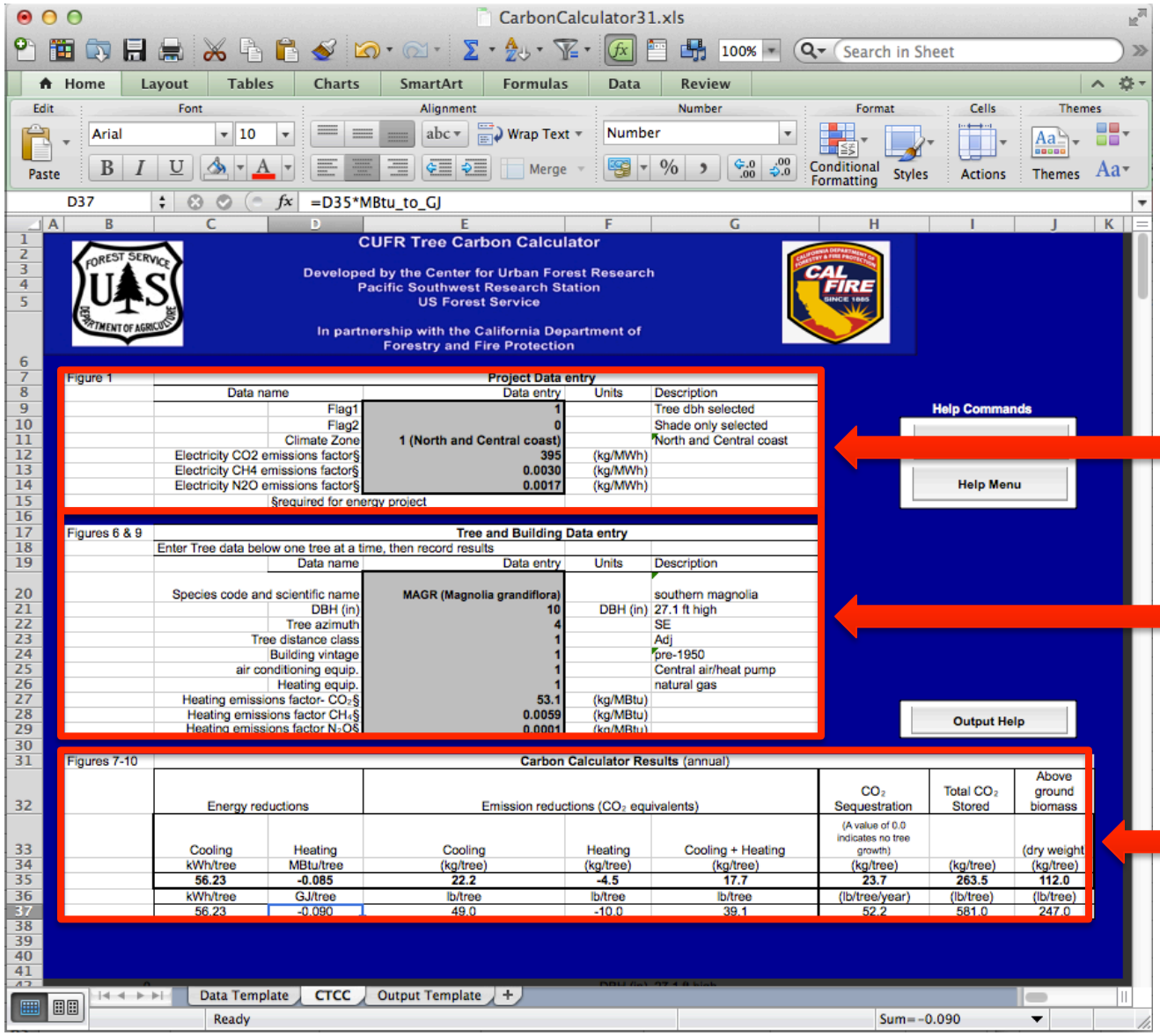
Tools for estimating GHG benefits

- Tree Carbon Calculator:
  www.fire.ca.gov/resource_mgt/downloads/TREES_WC.zip
- EcoSmart Landscapes:
  www.ecosmartlandscapes.org/
- Tree Asset Manager (EcoSmart Landscapes Enterprise version):
  www.treeassetmanager.com/carbon-calculator.html
- iTree Design:
  www.itreetools.org/design.php

Tree Carbon Calculator



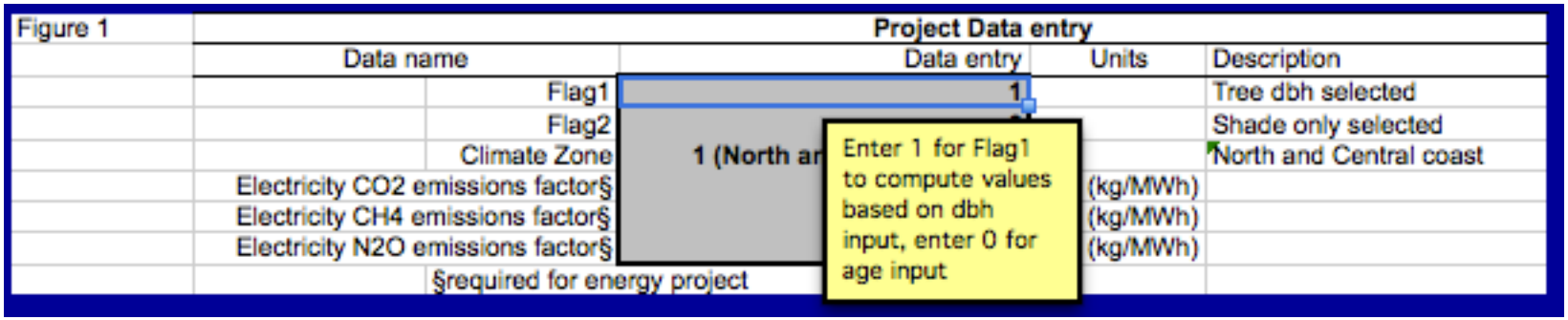
Three major components



Project inputs: DBH vs age

Figure 1

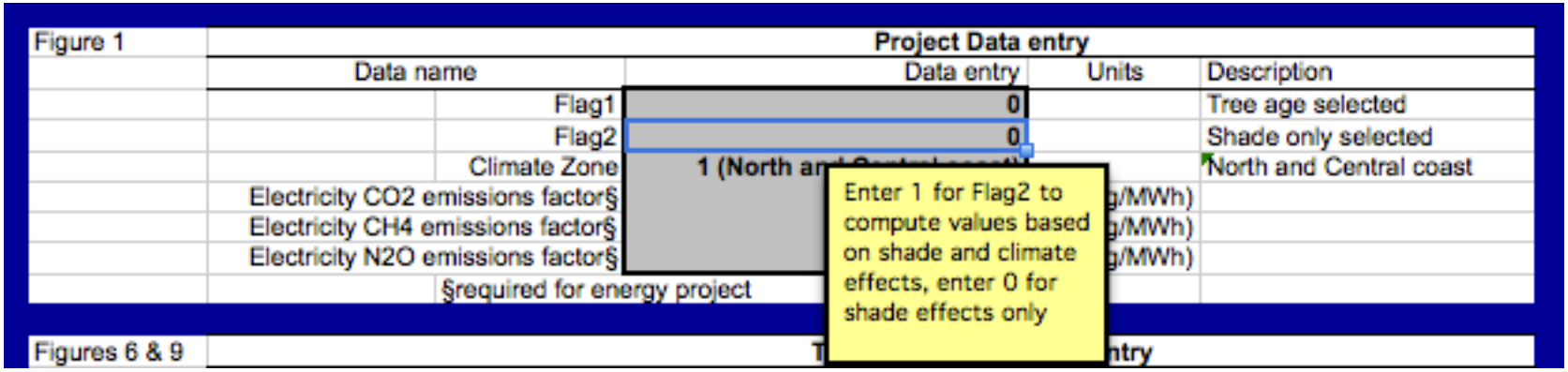
Project Data entry			
Data name	Data entry	Units	Description
Flag1	1		Tree dbh selected
Flag2	0		Shade only selected
Climate Zone	1 (North and Central coast)		North and Central coast
Electricity CO2 emissions factor§	395	(kg/MWh)	
Electricity CH4 emissions factor§	0.0030	(kg/MWh)	
Electricity N2O emissions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



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			

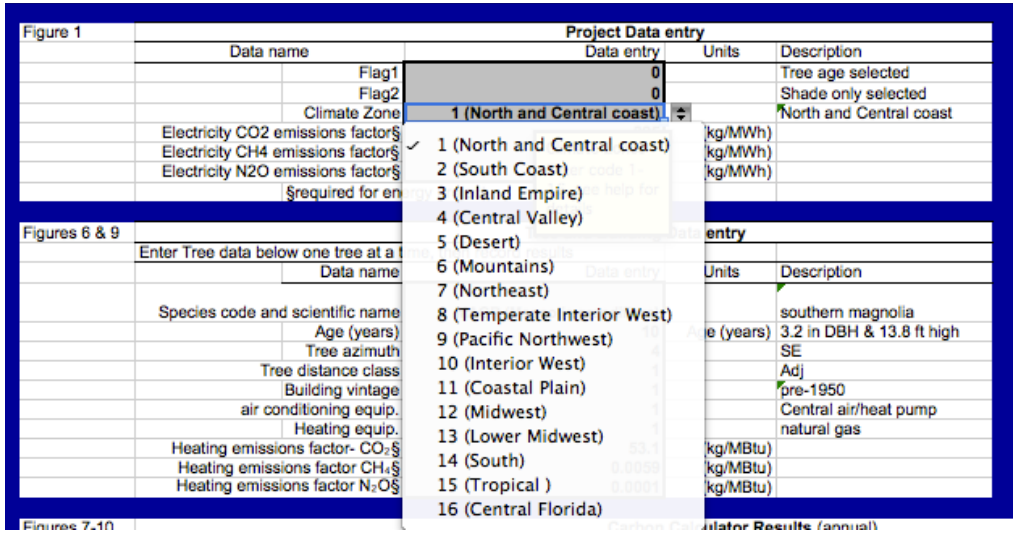


**Trees have direct effects on energy use when a tree shades a building (shade effects). When *very large* numbers of trees are planted, they can also have an effect on a city's climate (climate effects). Very few projects will have climate effects. **

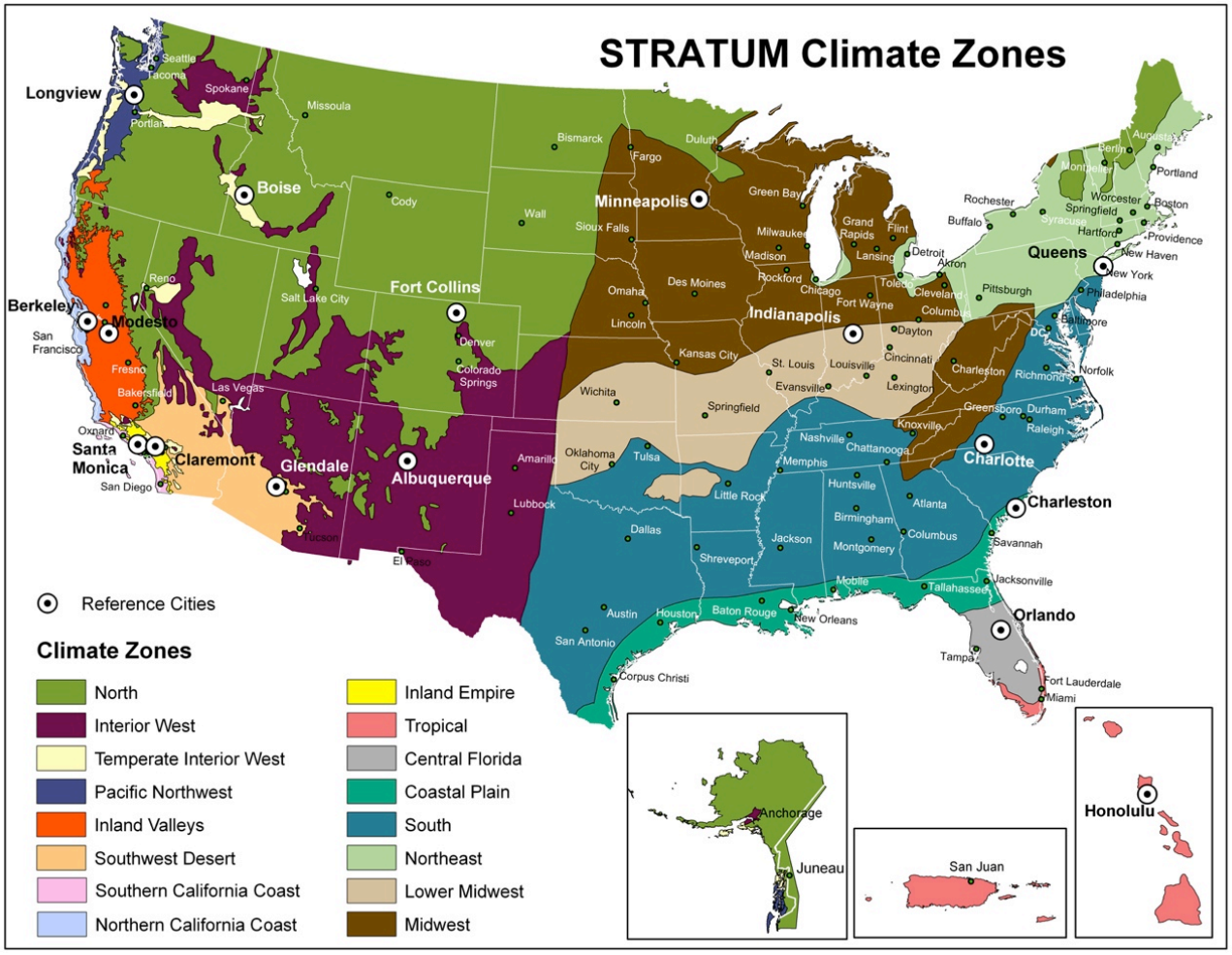
HINT: Enter 0 to use shade only

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			

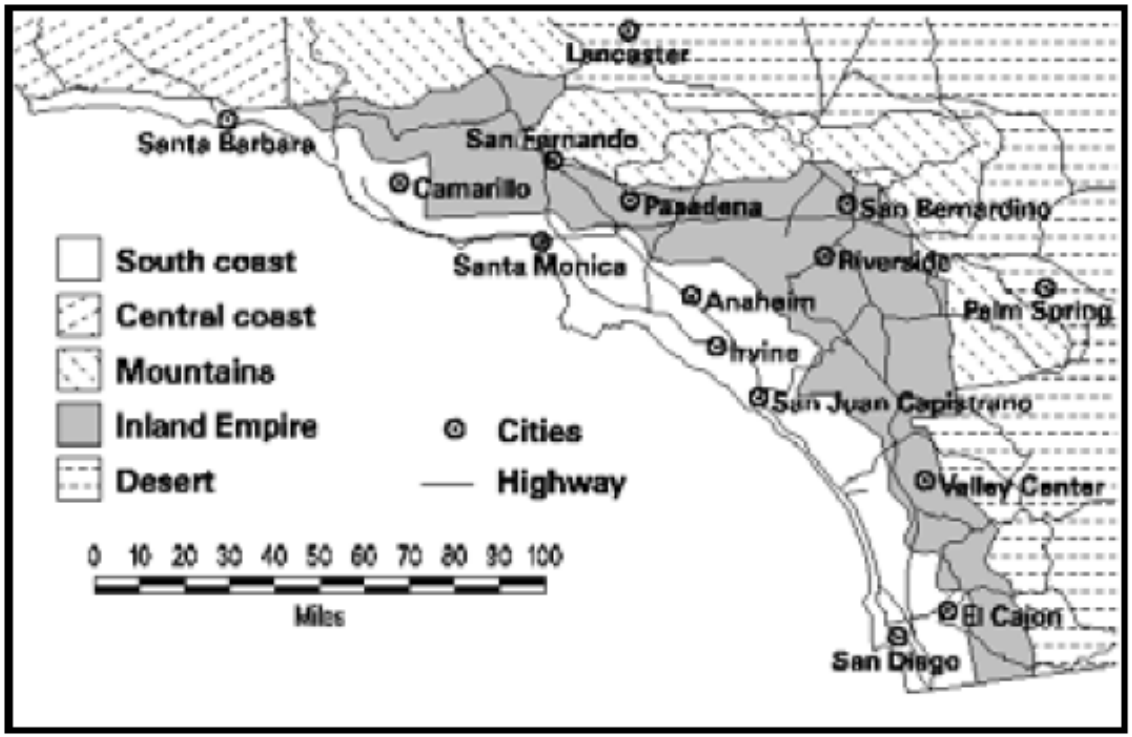


Climate zones



www.itreetools.org/streets/images/climate_zones.jpg

So Cal climate zones

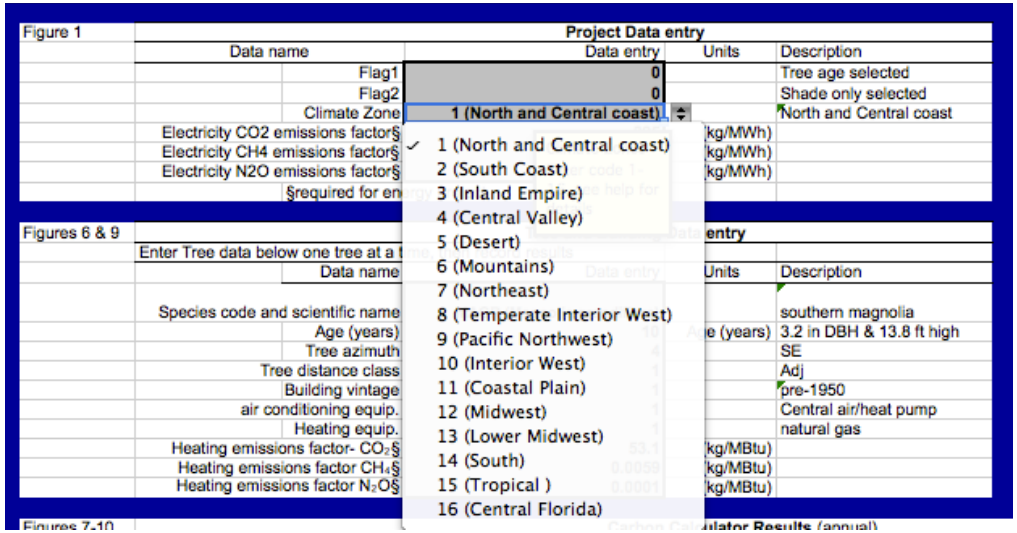


- South coast = Southern CA Coast
- Central coast = Northern CA Coast
- Mountains = Temperate Interior West
- Inland Empire = Inland Empire
- Desert = Southwest Desert

Tree Guidelines for Inland Empire Communities
www.treesearch.fs.fed.us/pubs/45967

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

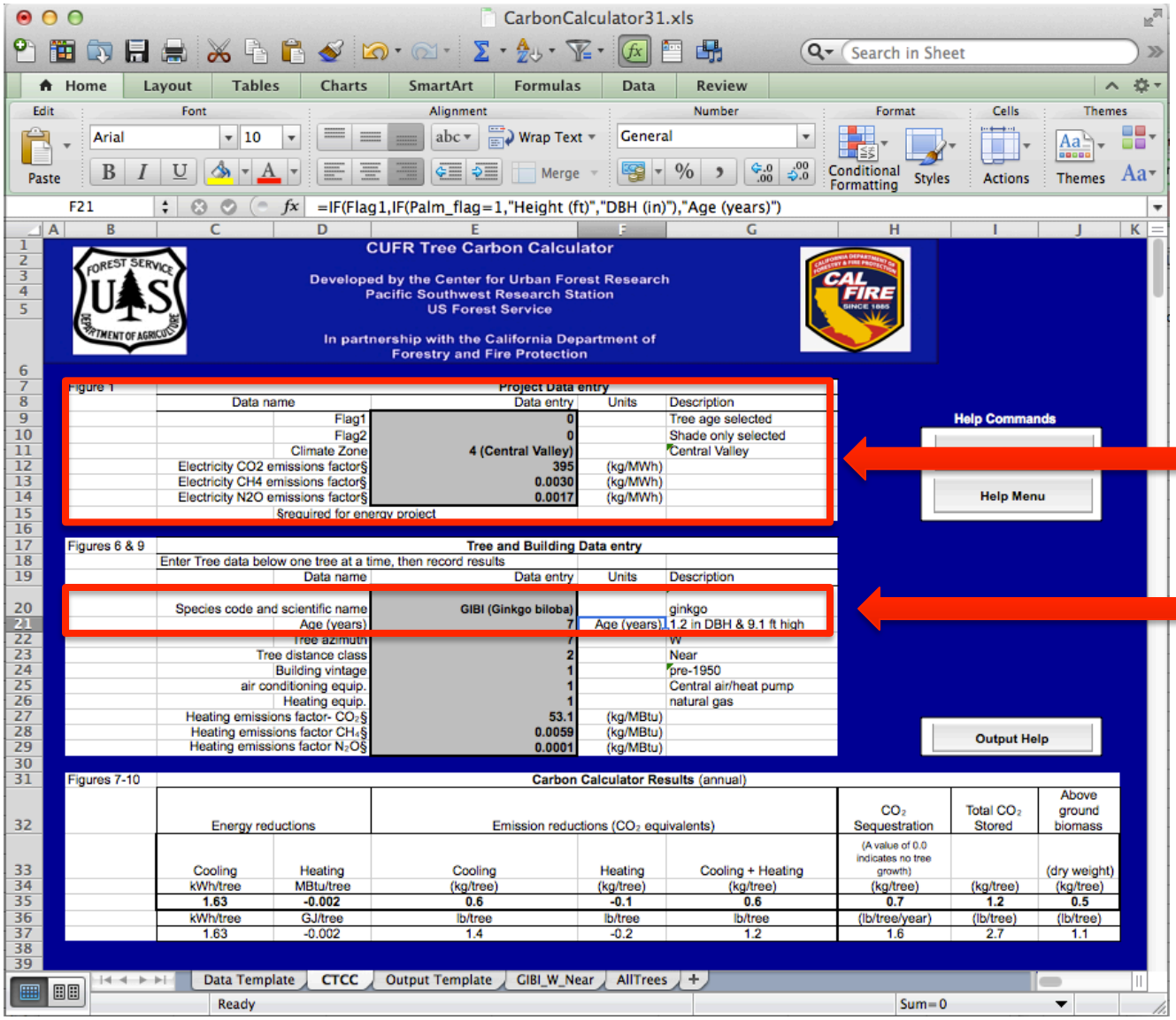
Project inputs: emissions factors

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: leave as defaults

Calculating CO_2 storage

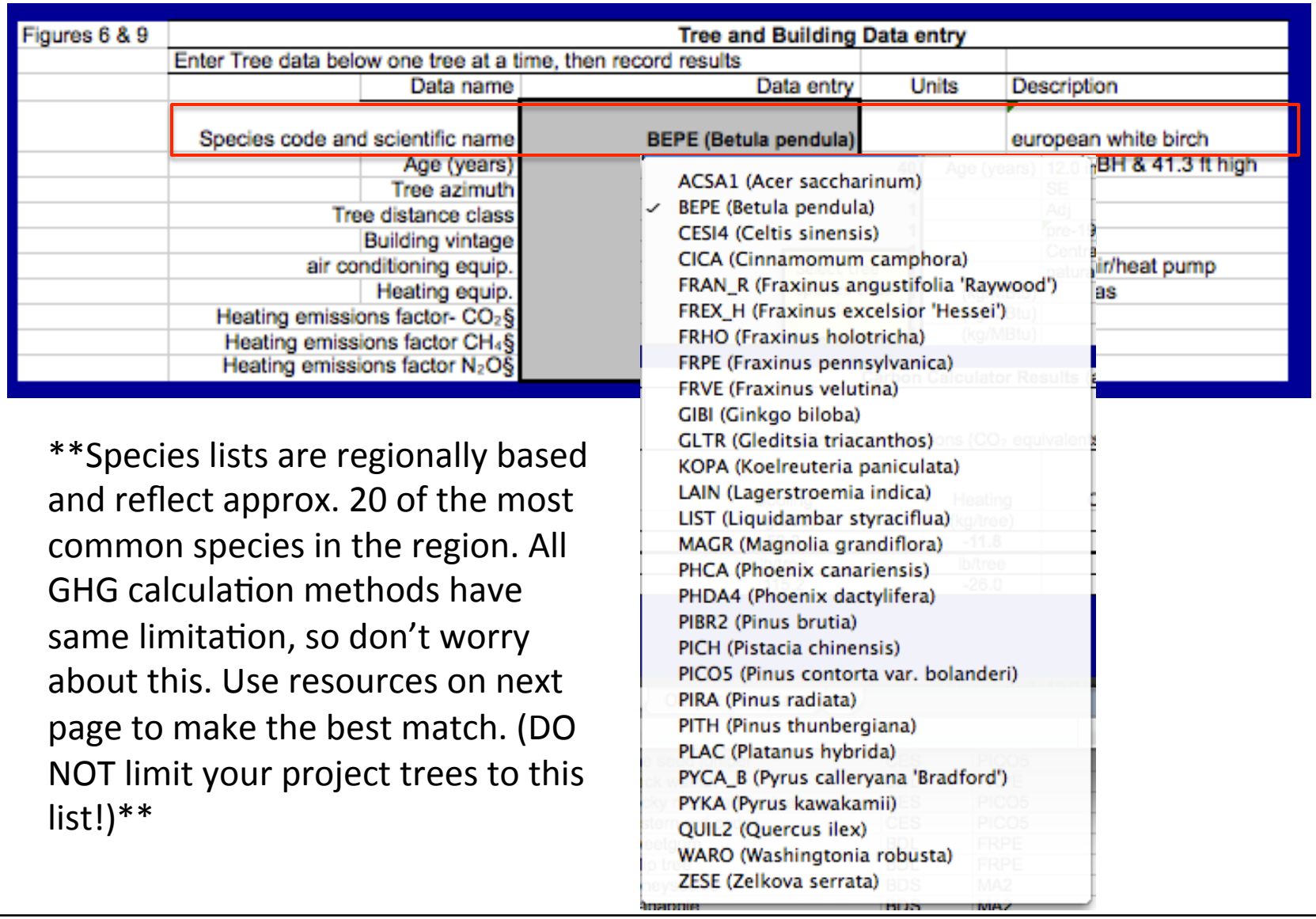


Project inputs

CO_2 storage inputs

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

CO_2 storage tree inputs: species



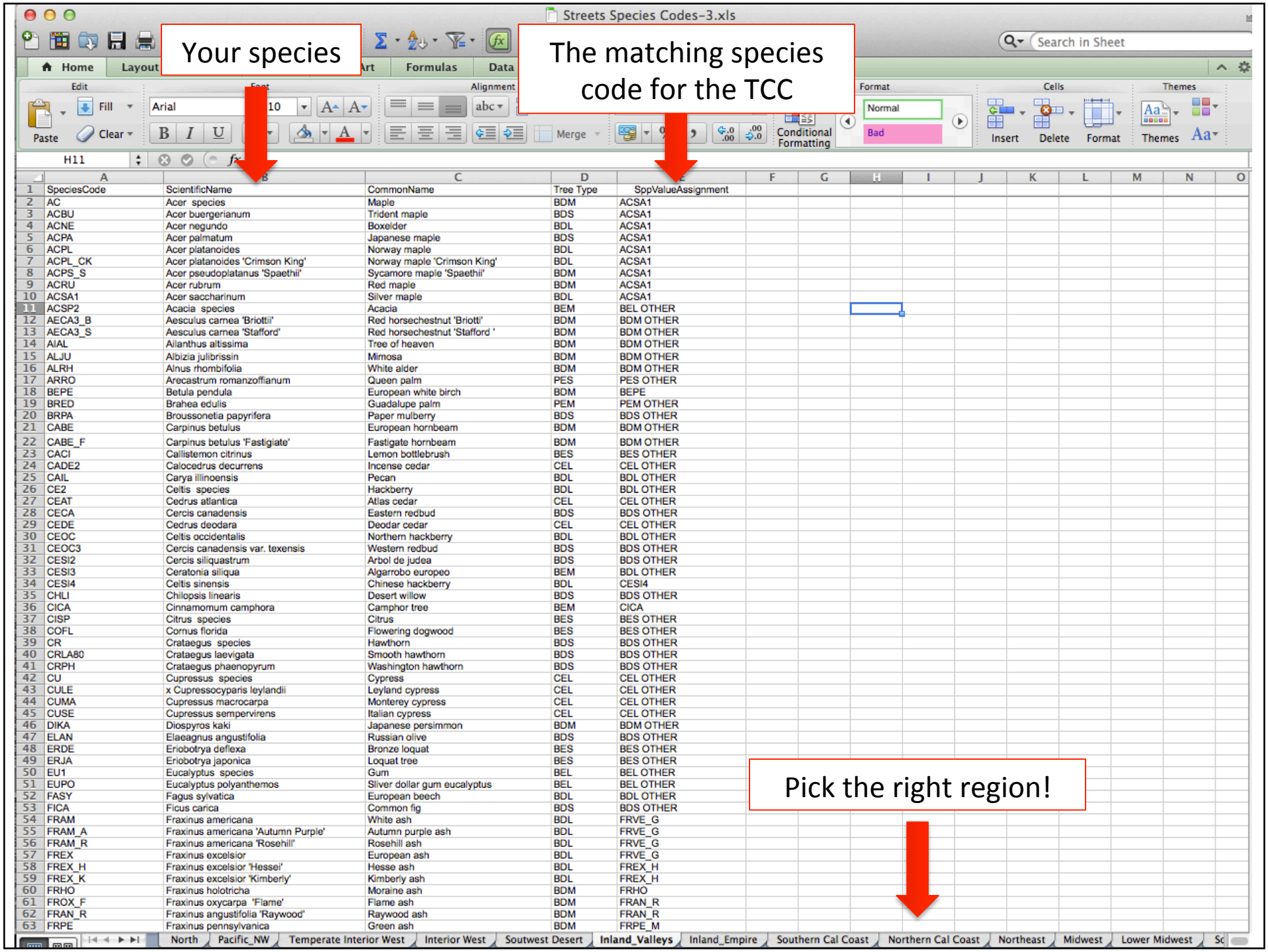
Figures 6 & 9	Tree and Building Data entry			
	Enter Tree data below one tree at a time, then record results			
	Data name	Data entry	Units	Description
	Species code and scientific name	BEPE (Betula pendula)		european white birch
	Age (years)			BH & 41.3 ft high
	Tree azimuth			
	Tree distance class			
	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



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	SpeciesCode	ScientificName	CommonName	Tree Type	SppValueAssignment										
2	AC	Acer species	Maple	BDM	ACSA1										
3	ACBU	Acer buergerianum	Trident maple	BDS	ACSA1										
4	ACNE	Acer negundo	Boxelder	BDL	ACSA1										
5	ACPA	Acer palmatum	Japanese maple	BDS	ACSA1										
6	ACPL	Acer platanoides	Norway maple	BDL	ACSA1										
7	ACPL_CK	Acer platanoides 'Crimson King'	Norway maple 'Crimson King'	BDL	ACSA1										
8	ACPS_S	Acer pseudoplatanus 'Spaethii'	Sycamore maple 'Spaethii'	BDM	ACSA1										
9	ACRU	Acer rubrum	Red maple	BDM	ACSA1										
10	ACSA1	Acer saccharinum	Silver maple	BDL	ACSA1										
11	ACSP2	Acacia species	Acacia	BEM	BEL OTHER										
12	AECA3_B	Aesculus carnea 'Briottii'	Red horsechestnut 'Briotti'	BDM	BDM OTHER										
13	AECA3_S	Aesculus carnea 'Stafford'	Red horsechestnut 'Stafford '	BDM	BDM OTHER										
14	AIAL	Ailanthus altissima	Tree of heaven	BDM	BDM OTHER										
15	ALJU	Albizia julibrissin	Mimosa	BDM	BDM OTHER										
16	ALRH	Alnus rhombifolia	White alder	BDM	BDM OTHER										
17	ARRO	Arecastrum romanzoffianum	Queen palm	PES	PES OTHER										
18	BEPE	Betula pendula	European white birch	BDM	BEPE										
19	BRED	Brahea edulis	Guadalupe palm	PEM	PEM OTHER										
20	BRPA	Broussonetia papyrifera	Paper mulberry	BDS	BDS OTHER										
21	CABE	Carpinus betulus	European hornbeam	BDM	BDM OTHER										
22	CABE_F	Carpinus betulus 'Fastigiate'	Fastigate hornbeam	BDM	BDM OTHER										
23	CACI	Callistemon citrinus	Lemon bottlebrush	BES	BES OTHER										
24	CADE2	Calocedrus decurrens	Incense cedar	CEL	CEL OTHER										
25	CAIL	Carya illinoensis	Pecan	BDL	BDL OTHER										
26	CE2	Celtis species	Hackberry	BDL	BDL OTHER										
27	CEAT	Cedrus atlantica	Atlas cedar	CEL	CEL OTHER										
28	CECA	Cercis canadensis	Eastern redbud	BDS	BDS OTHER										
29	CEDE	Cedrus deodara	Deodar cedar	CEL	CEL OTHER										
30	CEOC	Celtis occidentalis	Northern hackberry	BDL	BDL OTHER										
31	CEOC3	Cercis canadensis var. texensis	Western redbud	BDS	BDS OTHER										
32	CESI2	Cercis siliquastrum	Arbol de judea	BDS	BDS OTHER										
33	CESI3	Ceratonia siliqua	Algarrobo europeo	BEM	BDL OTHER										
34	CESI4	Celtis sinensis	Chinese hackberry	BDL	CESI4										
35	CHLI	Chilopsis linearis	Desert willow	BDS	BDS OTHER										
36	CICA	Cinnamomum camphora	Camphor tree	BEM	CICA										
37	CISP	Citrus species	Citrus	BES	BES OTHER										
38	COFL	Cornus florida	Flowering dogwood	BES	BES OTHER										
39	CR	Crataegus species	Hawthorn	BDS	BDS OTHER										
40	CRLA80	Crataegus laevigata	Smooth hawthorn	BDS	BDS OTHER										
41	CRPH	Crataegus phaenopyrum	Washington hawthorn	BDS	BDS OTHER										
42	CU	Cupressus species	Cypress	CEL	CEL OTHER										
43	CULE	x Cupressocyparis leylandii	Leyland cypress	CEL	CEL OTHER										
44	CUMA	Cupressus macrocarpa	Monterey cypress	CEL	CEL OTHER										
45	CUSE	Cupressus sempervirens	Italian cypress	CEL	CEL OTHER										
46	DIKA	Diospyros kaki	Japanese persimmon	BDM	BDM OTHER										
47	ELAN	Elaeagnus angustifolia	Russian olive	BDS	BDS OTHER										
48	ERDE	Eriobotrya deflexa	Bronze loquat	BES	BES OTHER										
49	ERJA	Eriobotrya japonica	Loquat tree	BES	BES OTHER										
50	EU1	Eucalyptus species	Gum	BEL	BEL OTHER										
51	EUPO	Eucalyptus polyanthemos	Sliver dollar gum eucalyptus	BEL	BEL OTHER										
52	FASY	Fagus sylvatica	European beech	BDL	BDL OTHER										
53	FICA	Ficus carica	Common fig	BDS	BDS OTHER										
54	FRAM	Fraxinus americana	White ash	BDL	FRVE_G										
55	FRAM_A	Fraxinus americana 'Autumn Purple'	Autumn purple ash	BDL	FRVE_G										
56	FRAM_R	Fraxinus americana 'Rosehill'	Rosehill ash	BDL	FRVE_G										
57	FREX	Fraxinus excelsior	European ash	BDL	FRVE_G										
58	FREX_H	Fraxinus excelsior 'Hessei'	Hesse ash	BDL	FREX_H										
59	FREX_K	Fraxinus excelsior 'Kimberly'	Kimberly ash	BDL	FREX_H										
60	FRHO	Fraxinus holotricha	Moraine ash	BDM	FRHO										
61	FROX_F	Fraxinus oxycarpa 'Flame'	Flame ash	BDM	FRAN_R										
62	FRAN_R	Fraxinus angustifolia 'Raywood'	Raywood ash	BDM	FRAN_R										
63	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*.

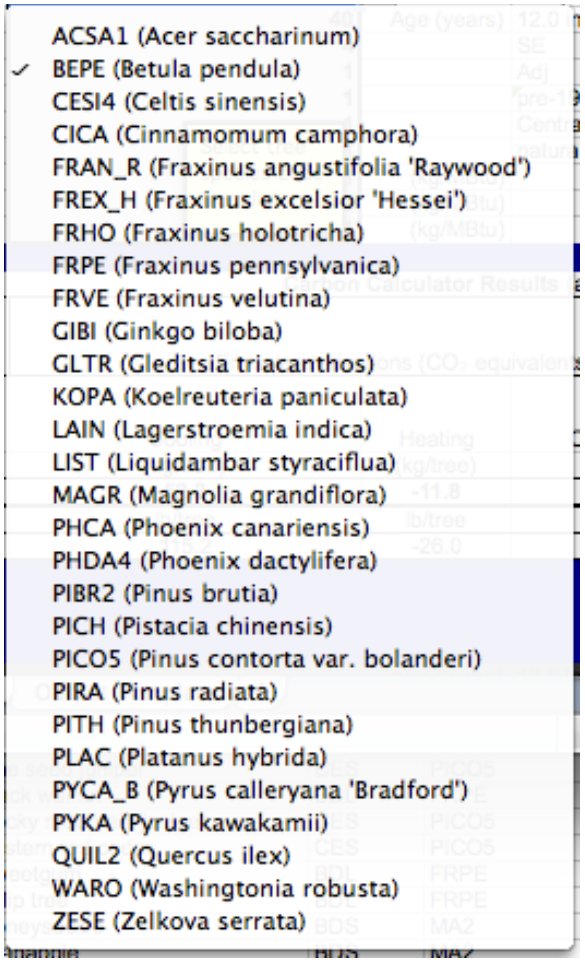
Species matching with iTree lists

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]CH
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.

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

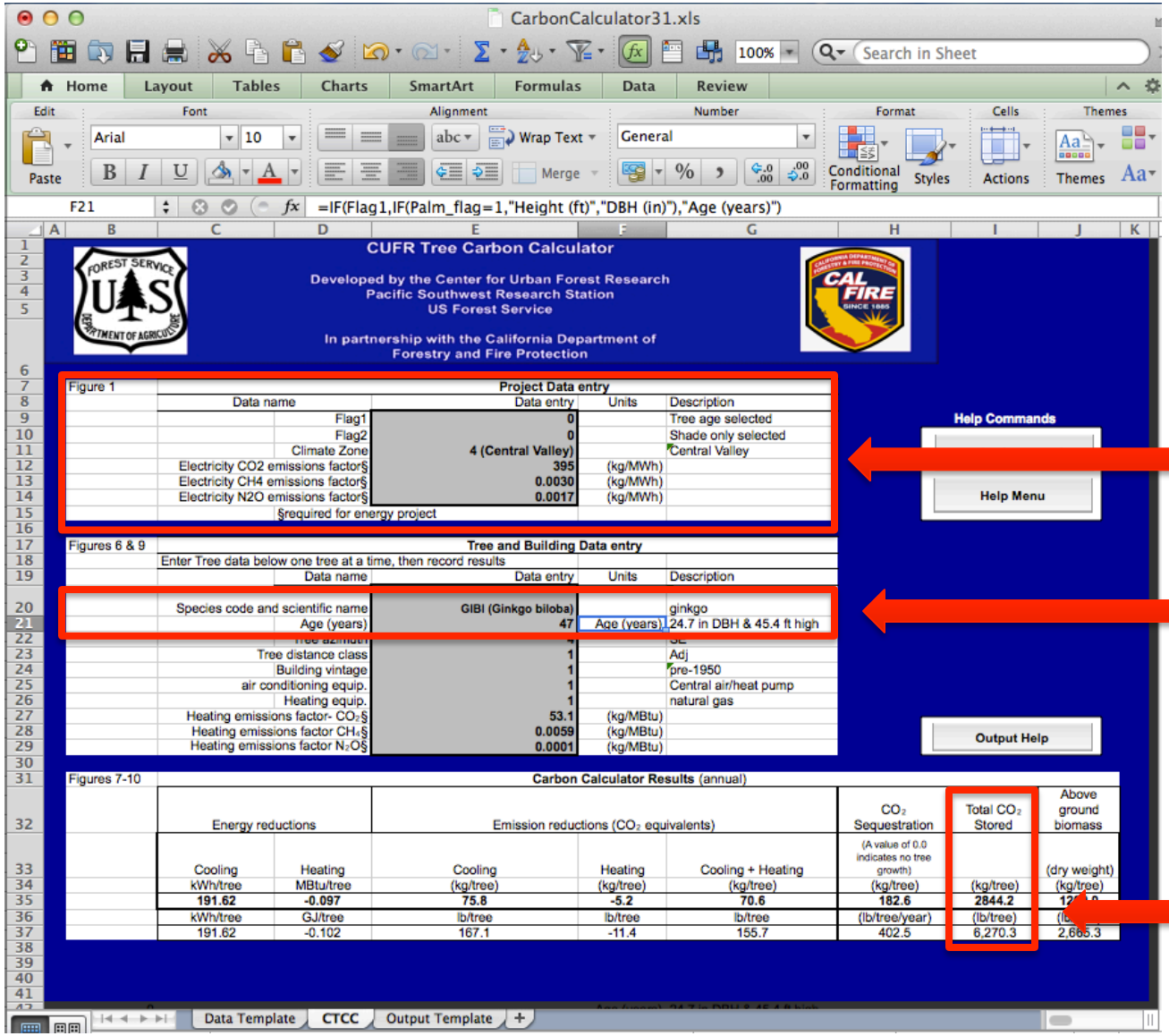
CO_2 storage tree inputs: age

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 40 years to that number to reflect 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 47 in age box to reflect age of tree 40 years after planting.**

HINT: enter age of tree 40 years after planting

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 40 years of the project.

CO_2 storage output

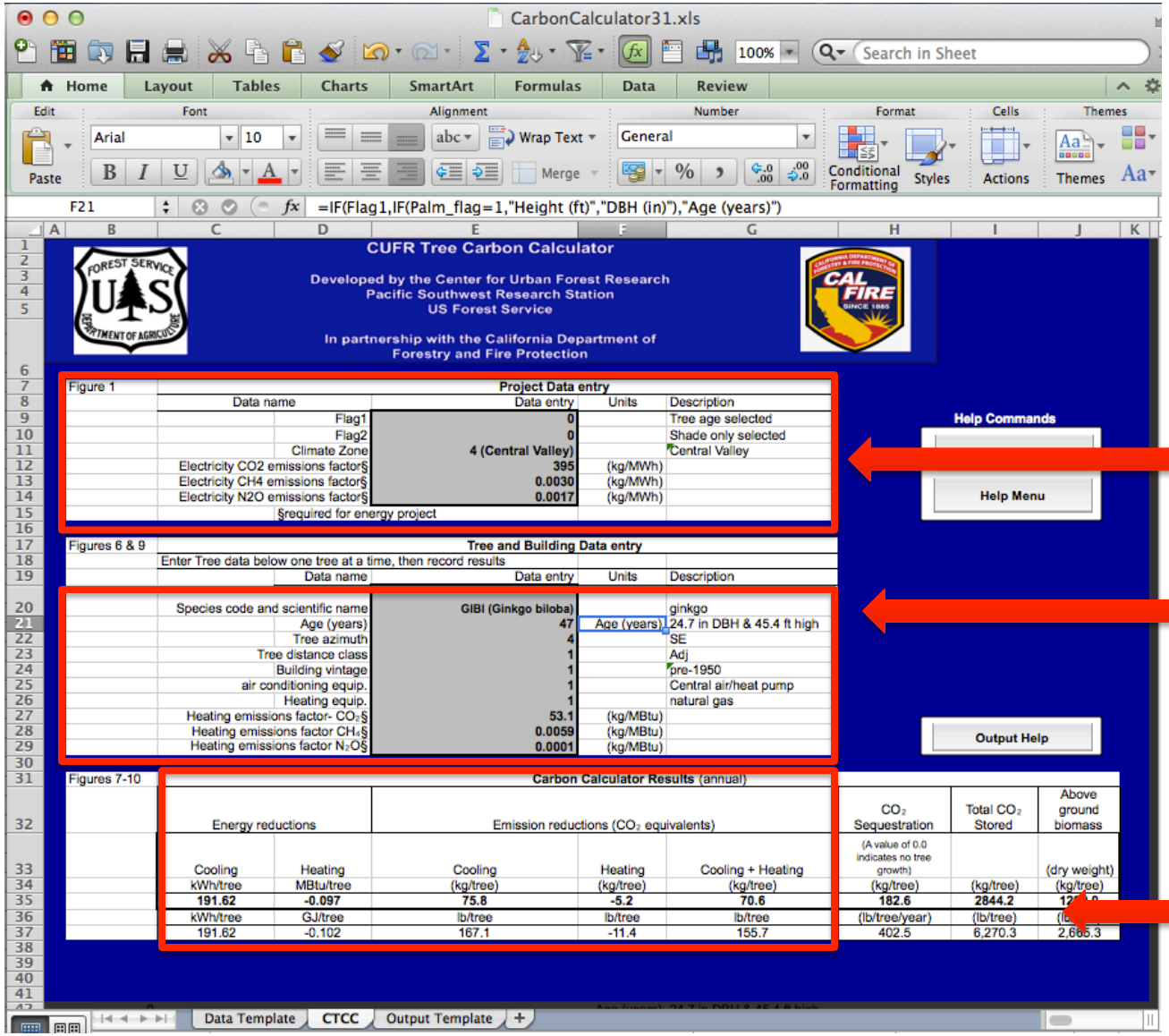
CO_2 Sequestration	Total CO_2 Stored	Above ground biomass
(A value of 0.0 indicates no tree growth)		(dry weight)
(kg/tree)	(kg/tree)	(kg/tree)
182.6	**2844.2**	**1209.0**
(lb/tree/year)	(lb/tree)	(lb/tree)
402.5	6,270.3	2,665.3

Annual sequestration

Total storage for project lifetime

HINT: record Total CO_2 Stored in kg

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

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: Same as above

Avoided CO_2 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	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)	

Find starting age of tree as above (by starting at age 1 and watching dbh until dbh = ~1 inch). This is project year 1. You'll be recording outputs for avoided CO2 and energy conserved ONE YEAR AT A TIME for 40-year project lifespan.

HINT: Each year must be input, one at a time!

Avoided CO_2 tree inputs: azimuth

Figures 6 & 9

Tree and Building Data entry

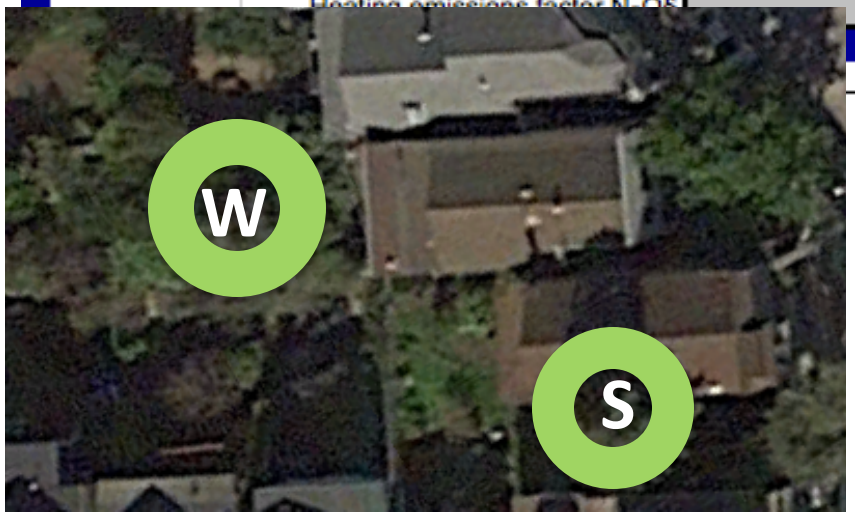
Enter Tree data below one tree at a time, then record results

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)

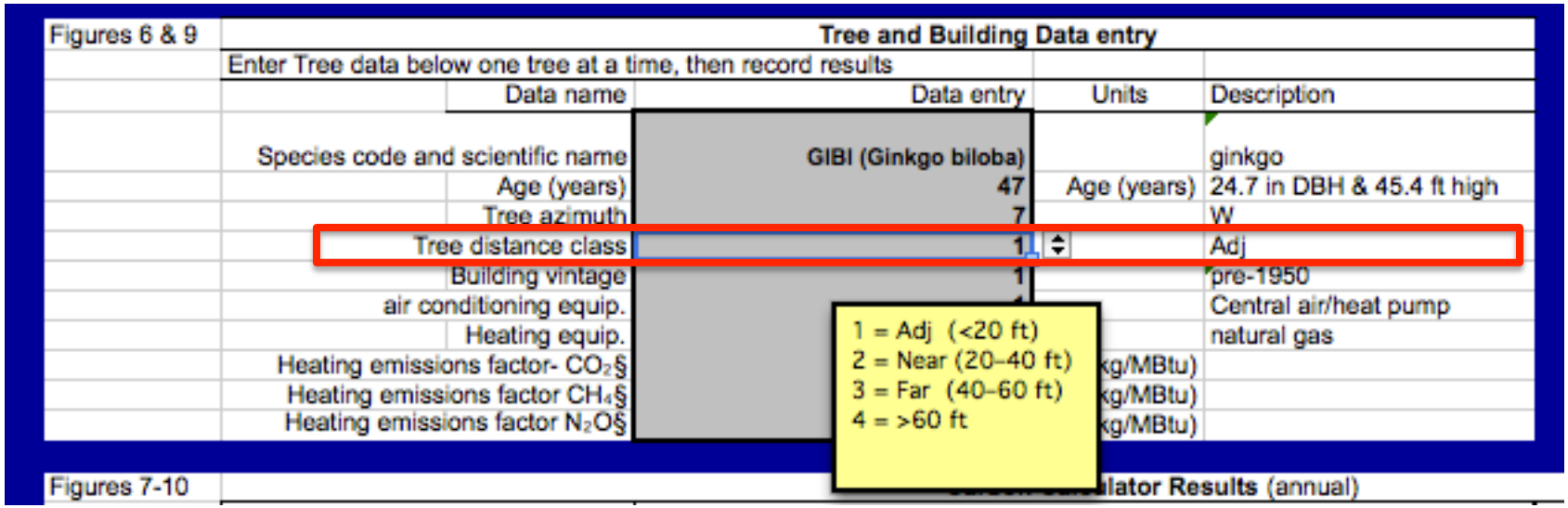
Emission reductions (CO_2 equivalents)



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

HINT: Which side of the building is the tree on?

Avoided CO_2 tree inputs: distance



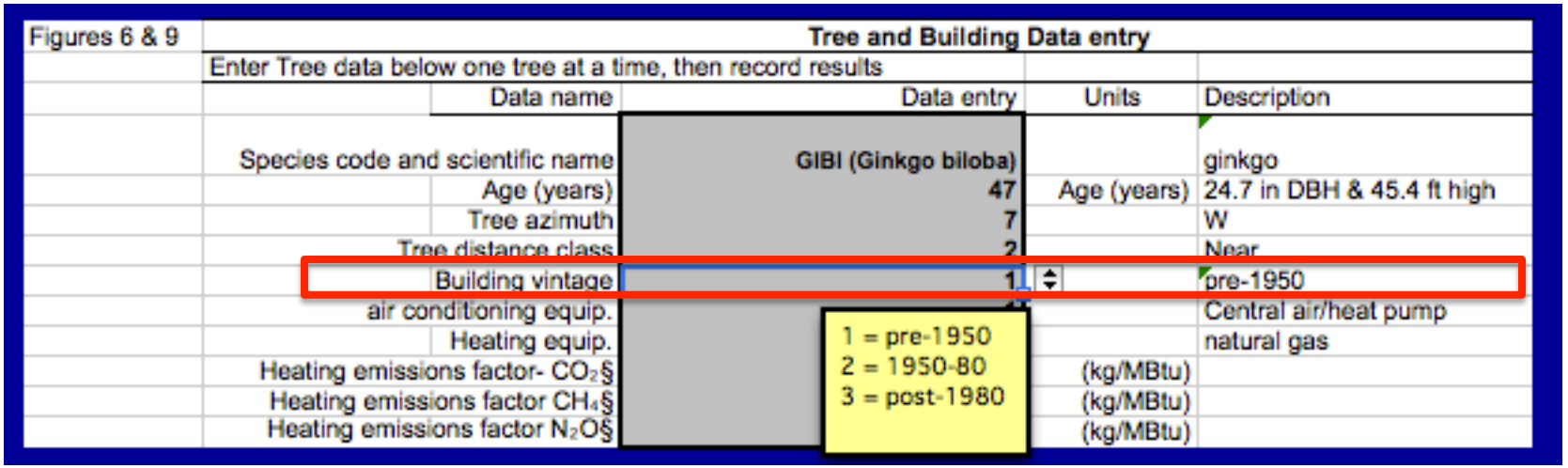
Figures 6 & 9	Tree and Building Data entry			
	Enter Tree data below one tree at a time, then record results			
	Data name	Data entry	Units	Description
	Species code and scientific name	GIBI (Ginkgo biloba)		ginkgo
	Age (years)	47	Age (years)	24.7 in DBH & 45.4 ft high
	Tree azimuth	7		W
	Tree distance 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 building?

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: How is the building heated and cooled?

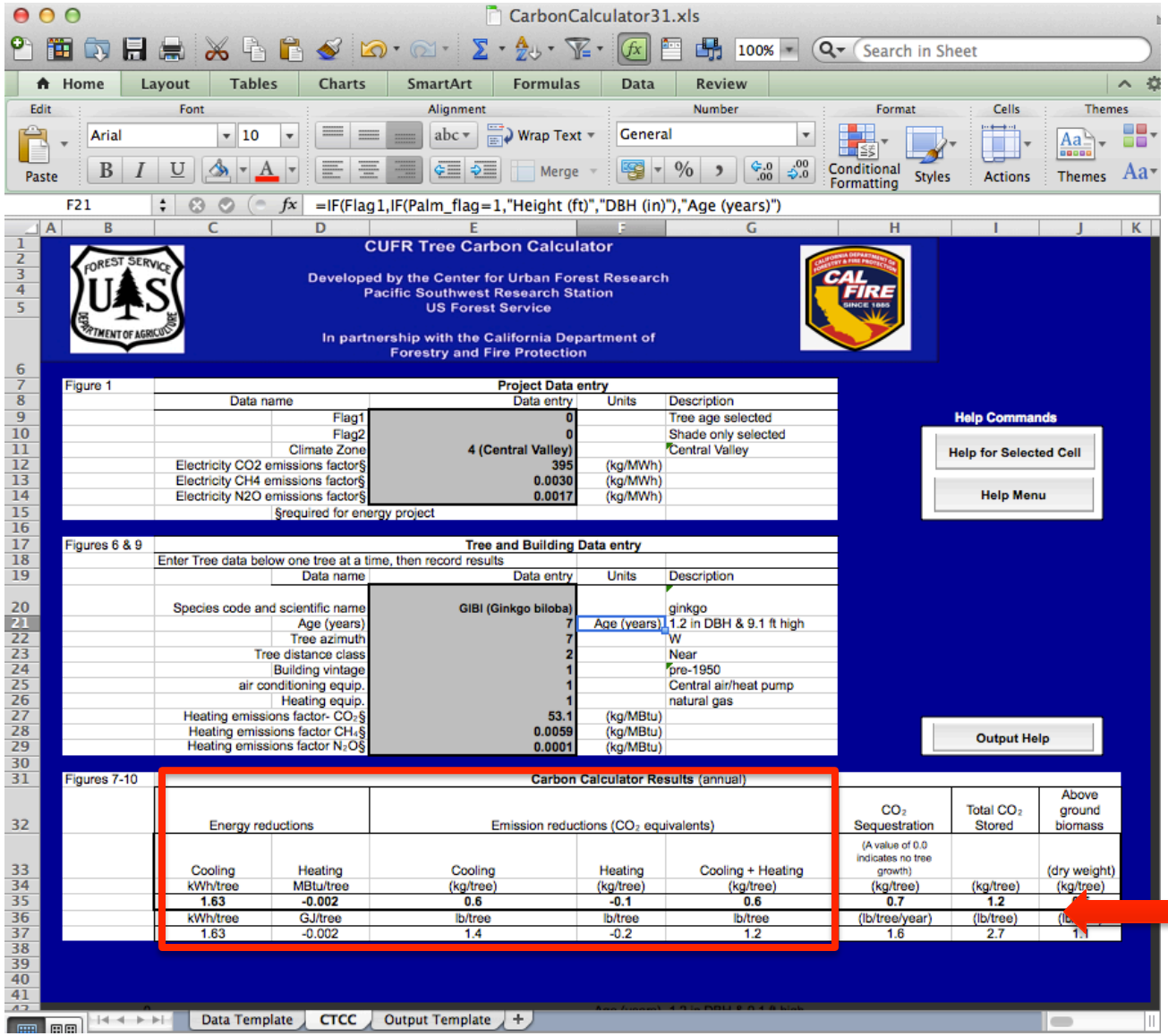
Avoided CO_2 tree inputs: heating emissions

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)	

Default values are for natural gas heating, since this is the most common. For electric heat pumps, copy the emissions factors from the project inputs fields above. Other fuels will have different emissions factors.

HINT: Leave as is for natural gas heating

Calculating avoided CO_2 and energy conserved



Avoided CO_2 and energy conservation outputs

Avoided CO_2 and energy conservation outputs, project year 1

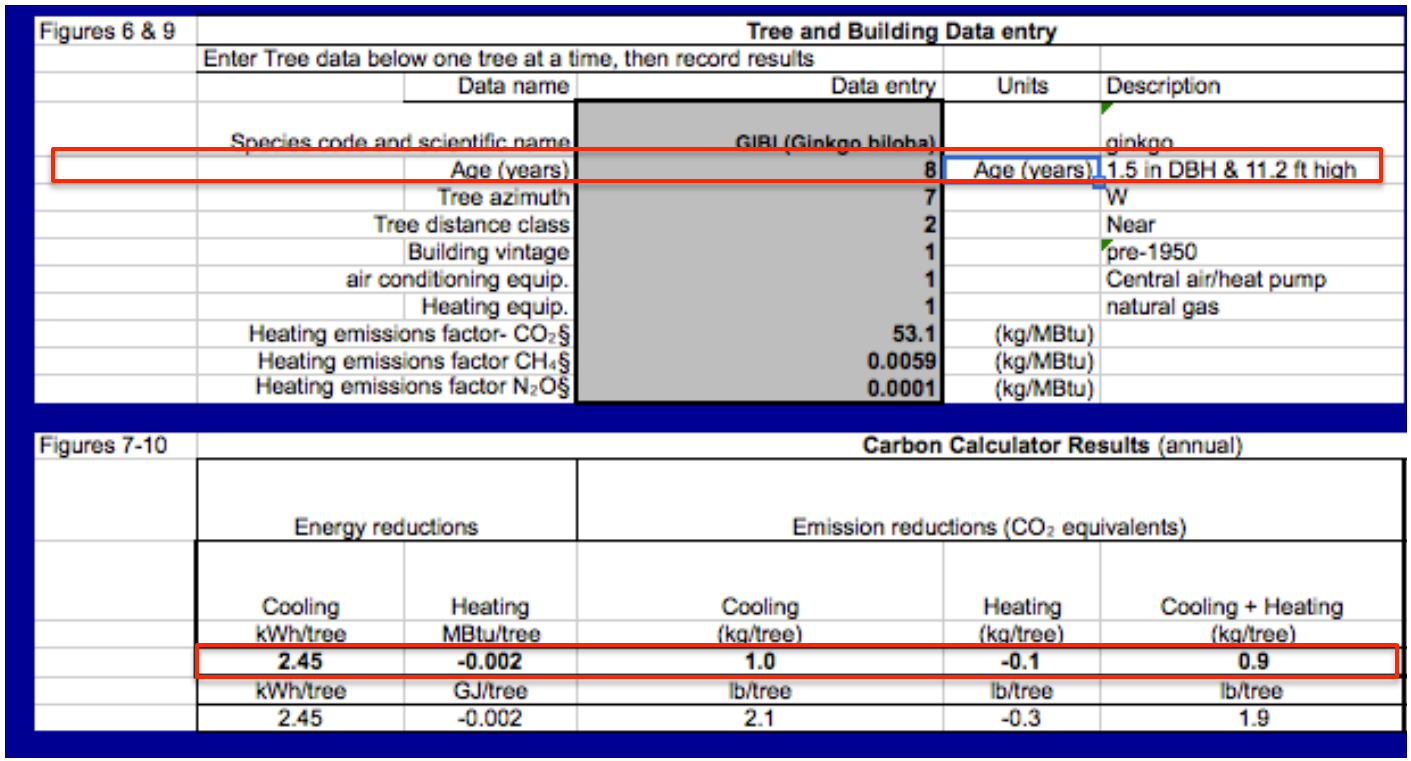
Energy reductions		Emission reductions (CO_2 equivalents)		
Cooling	Heating	Cooling	Heating	Cooling + Heating
kWh/tree	MBtu/tree	(kg/tree)	(kg/tree)	(kg/tree)
1.63	**-0.002**	**0.6**	**-0.1**	**0.6**
kWh/tree	GJ/tree	lb/tree	lb/tree	lb/tree
1.63	-0.002	1.4	-0.2	1.2

**Outputs from left to right:

- Energy reductions, cooling (kWh/tree) = number of kilowatt-hours of electricity for cooling conserved because tree is shading building
- Energy reductions, heating (MBtu/tree) = number of mega-British thermal units of energy for heating conserved (or added) because tree is shading building (if number is negative it means tree is increasing heating usage)
- Emission reductions = pounds of CO2eq not emitted because of reduced energy use**

HINT: Copy and paste the whole (metric) row

Avoided CO_2 and energy conservation outputs, project year 2



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

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

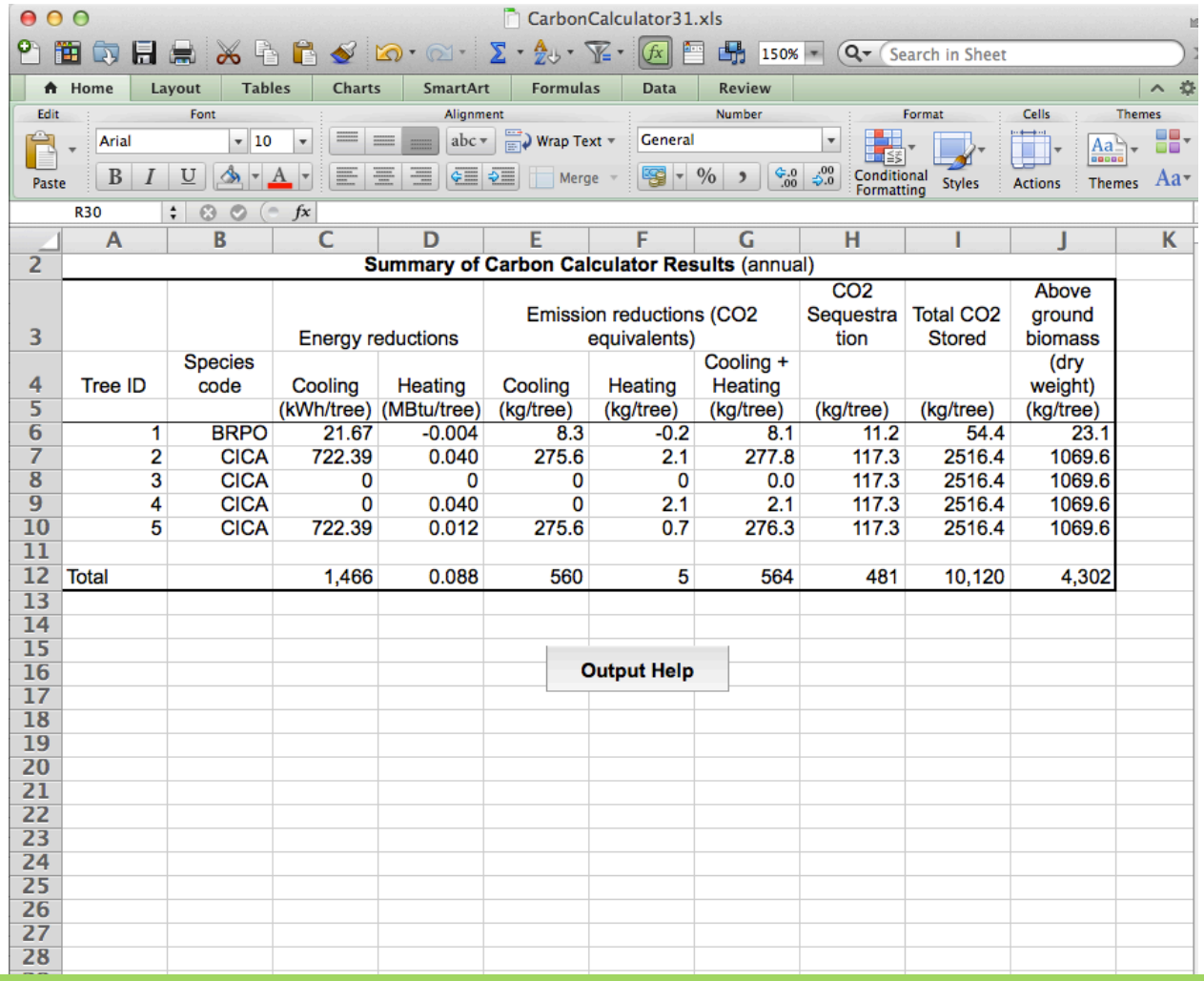
Data name	Data entry	Units	Description
Species code and scientific name	GIBI (Ginkgo biloba)		ginkgo
Age (years)	8	Age (years)	1.5 in DBH & 11.2 ft high
Tree azimuth	7		W
Tree distance class	2		Near
Building vintage	1		pre-1950
air conditioning equip.	1		Central air/heat pump
Heating equip.	1		natural 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)	

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

Energy reductions		Emission reductions (CO_2 equivalents)		
Cooling	Heating	Cooling	Heating	Cooling + Heating
kWh/tree	MBtu/tree	(kg/tree)	(kg/tree)	(kg/tree)
2.45	**-0.002**	**1.0**	**-0.1**	**0.9**
kWh/tree	GJ/tree	lb/tree	lb/tree	lb/tree
2.45	-0.002	2.1	-0.3	1.9

HINT: Repeat for all 40 years, copying and pasting rows

Output *template*



Summary of Carbon Calculator Results (annual)

Tree ID	Species code	Energy reductions: Cooling (kWh/tree)	Energy reductions: Heating (MBtu/tree)	Emission reductions (CO2 equivalents): Cooling (kg/tree)	Emission reductions (CO2 equivalents): Heating (kg/tree)	Emission reductions (CO2 equivalents): Cooling + Heating (kg/tree)	CO2 Sequestration (kg/tree)	Total CO2 Stored (kg/tree)	Above ground biomass (dry weight) (kg/tree)
1	BRPO	21.67	-0.004	8.3	-0.2	8.1	11.2	54.4	23.1
2	CICA	722.39	0.040	275.6	2.1	277.8	117.3	2516.4	1069.6
3	CICA	0	0	0	0	0.0	117.3	2516.4	1069.6
4	CICA	0	0.040	0	2.1	2.1	117.3	2516.4	1069.6
5	CICA	722.39	0.012	275.6	0.7	276.3	117.3	2516.4	1069.6
Total		1,466	0.088	560	5	564	481	10,120	4,302

Output Help

HINT: This is just a template. You should build your own.

A template for these grants

	A	B	C	D	E	F	G
1	**Species name**	Ginkgo biloba					
2	**Tree azimuth**	West					
3	**Tree distance**	Near (20-40 ft)					
4			**Energy reductions**		**Emission reductions (CO2 equivalents)**		
5	**Tree age**	**Project year**	**Cooling (kWh/tree)**	**Heating (MBtu/tree)**	**Cooling (kg/tree)**	**Heating (kg/tree)**	**Cooling + Heating (kg/tree)**
6							
7	7	1	1.63	-0.002	1.4	-0.2	1.2
8	8	2	2.45	-0.002	2.1	-0.3	1.9
9	9	3	8.49	-0.004	7.4	-0.5	6.9
10	10	4	14.98	-0.006	13.1	-0.7	12.4
11	11	5	21.86	-0.009	19.1	-0.9	18.1
12	12	6	29.08	-0.011	25.4	-1.2	24.2
13	13	7	36.60	-0.013	31.9	-1.5	30.4
14	14	8	44.39	-0.016	38.7	-1.8	37.0
15	15	9	52.97	-0.018	46.2	-2.0	44.2
16	…						
17	46	40	270.03	-0.055	235.5	-6.1	229.4
18	40-year total per tree		482.48	-0.14	420.77	-15.10	405.67
19							

Data Template | CTCC | Output Template | GIBI_W_Near | All

1. You'll need one of these worksheets for each unique combination of species, azimuth, and distance.
2. Tree age you entered.
3. Row you copied and pasted for each year of project.
4. 40-year project totals for one tree
5. The only number you really need: 40-year total cooling + heating emission reductions (but cooling and heating energy reduction numbers are good co-benefits!)

All trees totals

	A	B	C	D	E	F	G	H
1	**Species**	**Azimuth**	**Distance**	**40-year emission reductions (kg/tree)**	**Total CO2 stored (kg/tree)**	**No. of trees of this kind**	**Total emissions reductions (metric tons)**	**Total CO2 stored (metric tons)**
2	Ginkgo biloba	West	Near (20-40 ft)	405.67	2662	100	40.6	266.2
3	Ginkgo biloba	West	Adj (0-20 ft)	457.32	2662	100	45.7	266.2
4	Ginkgo biloba	Not shading			2662	500		1331
5	Acer rubrum	West	Near (20-40 ft)	525.7	4505	250	131.4	1126.25
6	Acer rubrum	East	Near (20-40 ft)	502.8	4505	200	100.6	901
7							318.3	3890.7
8								
9								

Data Template | CTCC | Output Template | GIBI_W_Near | AllTrees | +

1. Total emissions reductions (column G) = per-tree 40-year emission reductions (column D) * No. of trees of this kind (column F)
2. Total CO2 stored (column H) = per-tree total CO2 stored (column E) * No. of trees of this kind (column F)
3. Project totals (row 7) = sum of column G or sum of column H

Estimating co-benefits

- Get energy conservation benefits from TCC
- Use Community Tree Guides for stormwater, air quality, property value benefits

Table 12—Annual benefits (dollars per tree) at 5-year intervals and 40-year average for a representative large tree (velvet ash)

	Year 5		Year 10		Year 15		Year 20		Year 25		Year 30		Year 35		Year 40		40-year average	
Benefits/tree	**RU**	**Value**	**RU**	**Value**	**RU**	**Value**	**RU**	**Value**	**RU**	**Value**	**RU**	**Value**	**RU**	**Value**	**RU**	**Value**	**RU**	**Value**
		Dollars		*Dollars*		*Dollars*		*Dollars*		*Dollars*		*Dollars*		*Dollars*		*Dollars*		*Dollars*
Cooling (kWh):																		
Yard: west	27	5.80	84	17.87	151	32.12	215	45.85	266	56.76	306	65.28	347	73.90	372	79.21	221	47.10
Yard: south	19	4.02	59	12.67	111	23.71	162	34.52	212	45.12	257	54.73	302	64.40	328	69.82	181	38.62
Yard: east	18	3.77	54	11.54	98	20.99	141	30.15	186	39.66	228	48.56	270	57.49	291	62.04	161	34.28
Public	16	3.41	48	10.31	88	18.80	127	27.04	167	35.70	206	43.84	244	52.05	267	56.96	146	31.01
Heating (kBtu):																		
Yard: west	33	0.57	91	1.57	163	2.82	234	4.04	295	5.10	347	5.99	398	6.88	421	7.28	248	4.28
Yard: south	34	0.58	90	1.55	159	2.75	227	3.92	286	4.94	336	5.80	386	6.66	410	7.09	241	4.16
Yard: east	-44	-0.76	-143	-2.47	-189	-3.27	-220	-3.79	-207	-3.58	-173	-2.99	-138	-2.39	-101	-1.75	-152	-2.62
Public	38	0.66	103	1.78	183	3.16	261	4.50	327	5.64	381	6.58	435	7.52	462	7.98	274	4.73
Net energy (kBtu):																		
Yard: west	306	6.38	929	19.44	1,670	34.94	2,385	49.89	2,958	61.86	3,409	71.27	3,865	80.77	4,138	86.48	2,458	51.38
Yard: south	222	4.60	684	14.22	1,272	26.47	1,846	38.43	2,403	50.06	2,904	60.53	3,407	71.07	3,686	76.90	2,053	42.78
Yard: east	133	3.01	398	9.07	796	17.73	1,195	26.36	1,654	36.09	2,105	45.57	2,559	55.11	2,810	60.29	1,456	31.65
Public	198	4.07	587	12.09	1,065	21.96	1,529	31.54	2,001	41.34	2,438	50.41	2,877	59.56	3,134	64.94	1,729	35.74
Net carbon dioxide (lb):																		
Yard: west	24	0.08	73	0.24	132	0.44	189	0.63	240	0.80	282	0.94	327	1.09	363	1.21	204	0.68
Yard: south	19	0.06	57	0.19	106	0.35	154	0.51	203	0.68	249	0.83	296	0.99	333	1.11	177	0.59
Yard: east	9	0.03	26	0.09	56	0.19	88	0.29	128	0.43	170	0.57	214	0.71	249	0.83	118	0.39
Public	18	0.06	51	0.17	93	0.31	135	0.45	179	0.60	221	0.74	264	0.88	299	1.00	158	0.53
Air pollution (lb):[a]																		
Ozone uptake	0.02160	0.03	0.06662	0.08	0.13163	0.16	0.20107	0.25	0.28160	0.35	0.36529	0.46	0.45770	0.57	0.55175	0.69	0.26	0.32
Nitrous oxide uptake + avoided:	0.01906	0.02	0.05757	0.07	0.11063	0.14	0.16501	0.21	0.22301	0.28	0.27967	0.35	0.34001	0.43	0.39103	0.49	0.20	0.25
Sulfur dioxide uptake + avoided:	0.00441	0.01	0.01358	0.02	0.02560	0.05	0.03778	0.07	0.05049	0.09	0.06275	0.11	0.07575	0.13	0.08647	0.15	0.04	0.08
Small particulate matter uptake + avoided	0.00781	0.02	0.05185	0.15	0.14323	0.42	0.27524	0.80	0.40912	1.20	0.54043	1.58	0.66898	1.96	0.79121	2.31	0.36	1.06
Volatile organic compounds avoided	0.00097	0.00	0.00291	0.00	0.00540	0.00	0.00782	0.00	0.01015	0.01	0.01224	0.01	0.01434	0.01	0.01553	0.01	0.01	0.00
Biogenic volatile organic compounds released	0.00000	0.00	0.00000	0.00	0.00000	0.00	0.00000	0.00	0.00000	0.00	0.00000	0.00	0.00000	0.00	0.00000	0.00	0.00	0.00

Community Tree Guides

- Desert Southwest
  www.itreetools.org/streets/resources/Streets_CTG/CUFR_72_Desert_Southwest_CTG.pdf
- Northern California
  www.fs.fed.us/psw/publications/documents/psw_gtr228/psw_gtr228.pdf
- Southern California
  www.itreetools.org/streets/resources/Streets_CTG/CUFR_48_Southern_California_Coast_CTG.pdf
- Inland Empire
  www.itreetools.org/streets/resources/Streets_CTG/CUFR_52_Inland_Empire_CTG.pdf
- Central Valley
  www.itreetools.org/streets/resources/Streets_CTG/CUFR_38_Inland_Valleys_CTG.pdf
- Northern Mountains and Prairies
  www.itreetools.org/streets/resources/Streets_CTG/CUFR_258_North_CTG.pdf
- Temperate Interior West
  www.fs.fed.us/psw/publications/documents/psw_gtr206/psw_gtr206.pdf

Estimating CO_2 *emissions*

"Typically, CO_2 released due to tree planting, maintenance, and other program-related activities is about 2-8% of annual CO_2 reductions obtained through sequestration and avoided power plant emission (McPherson and Simpson 1999)."

--Community Tree Guides

Growing Trees Make Great Neighborhoods

Questions

kelaine@urban-ecos.com

Urban Ecos

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