CARBON CAPTURE AND STORAGE: THE KEY TO MITIGATING CLIMATE CHANGE

GRACE DIETSCH
DIRECTOR OF CONSERVATION

FIVE RIVERS METROPARKS

Natural Areas Conservancy

Eco Logic

FIVE RIVERS METROPARKS

2024 - 2027 STRATEGIC PLAN FOCUS AREAS

FINANCIAL HEALTH

Deliver our public promise | Operate strategically | Ensure sufficient funding | Build and support great employees

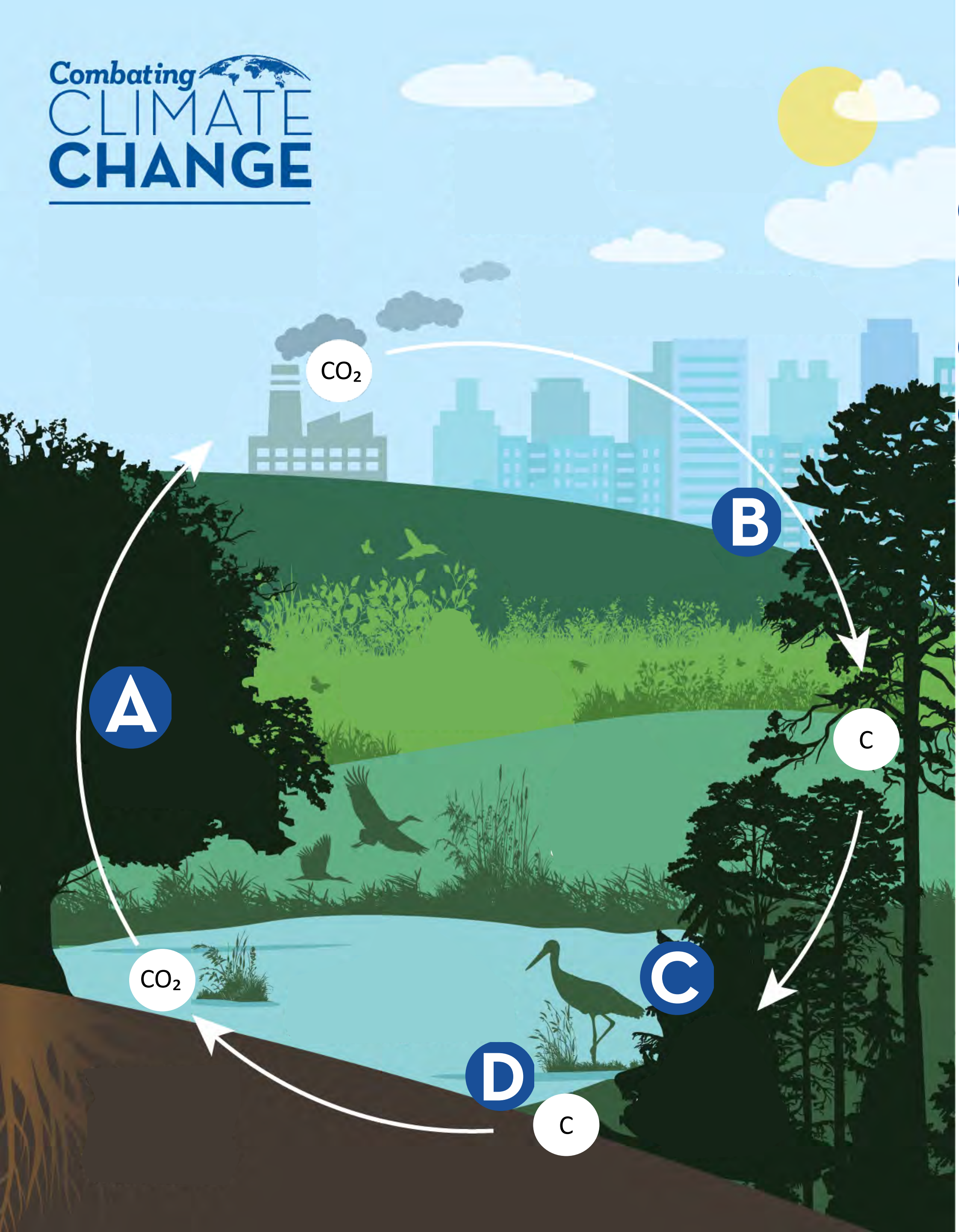
CLIMATE CHANGE LEADERSHIP

Become a carbon negative agency | Build physical resiliency to climate change impacts | Resource the agency to respond to climate change | Lead the community's response to climate change mitigation | Empower an all-staff response to climate change

DIVERSITY, EQUITY, INCLUSION

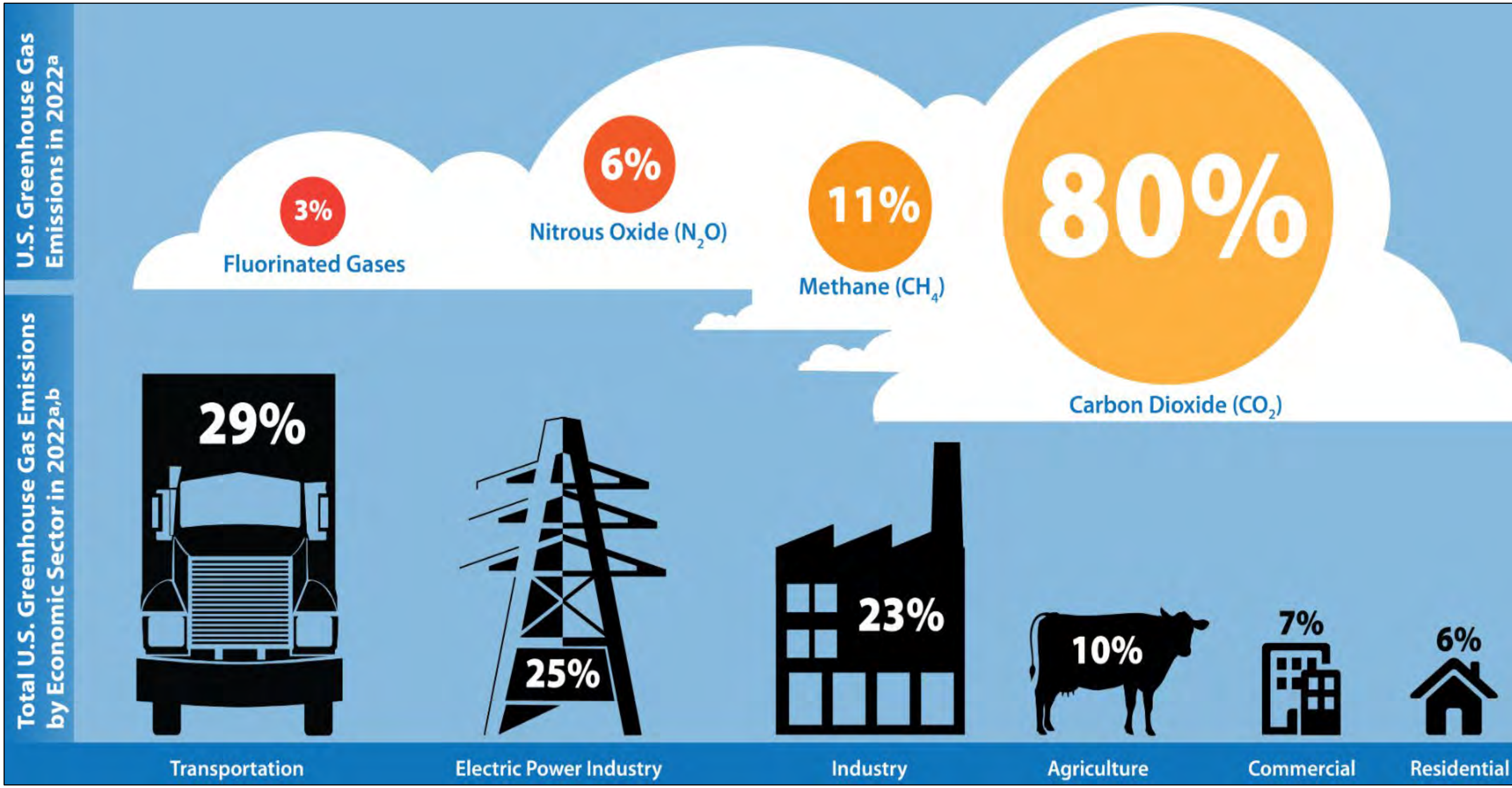
Meaningfully engage diverse communities | Create safe and welcoming parks, facilities, amenities and programs | Collaborate with regional partners to advance equity | Hire, train and promote a diverse workforce | FRMP's resource allocation advances equity

METROPARKS.ORG/STRATEGICPLAN

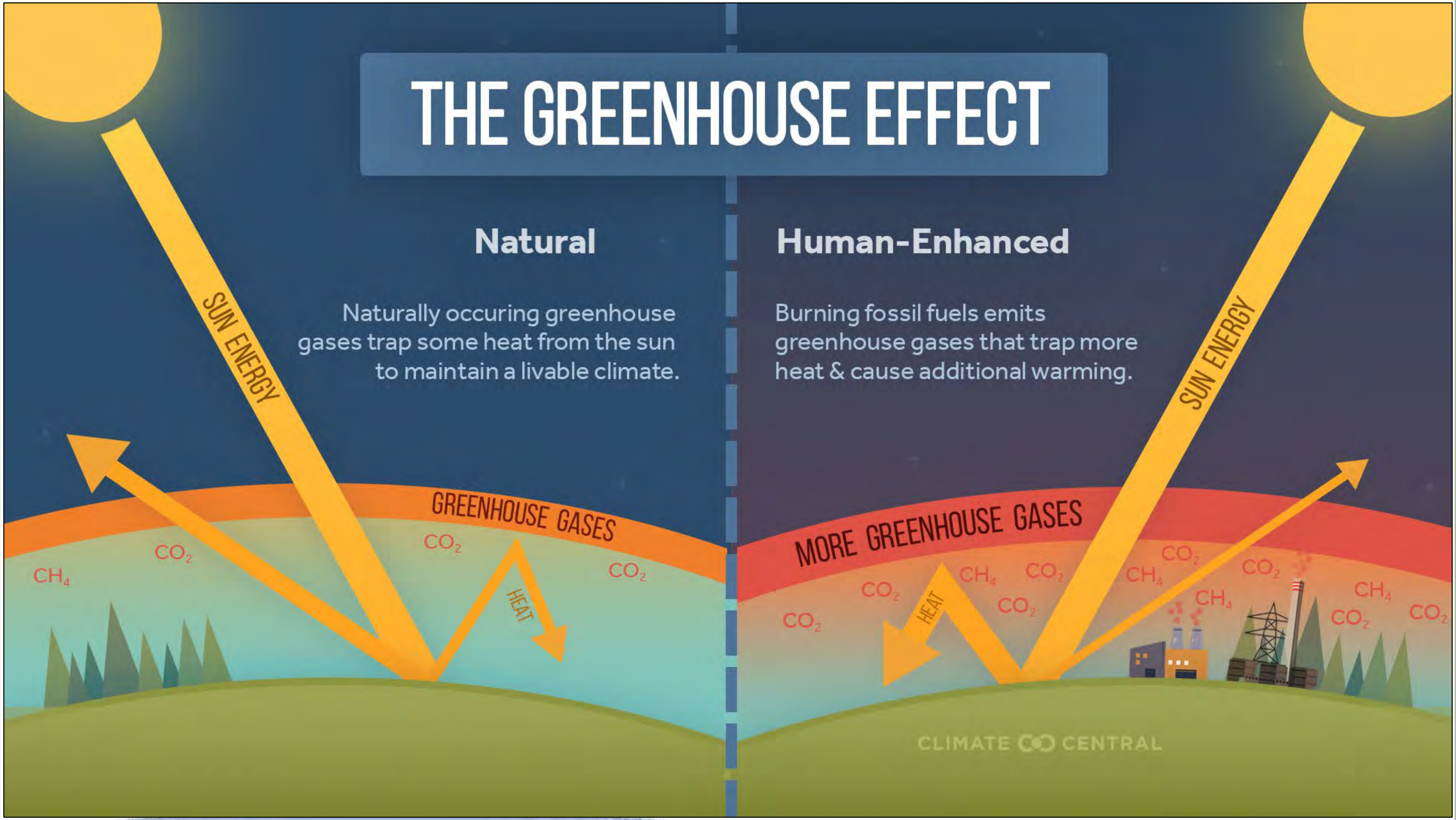


THE CARBON CYCLE

- **A** C enters the atmosphere as CO_2
- **B** CO_2 is absorbed by plants
- **C** C is consumed by animals
- **D** C enters the soil

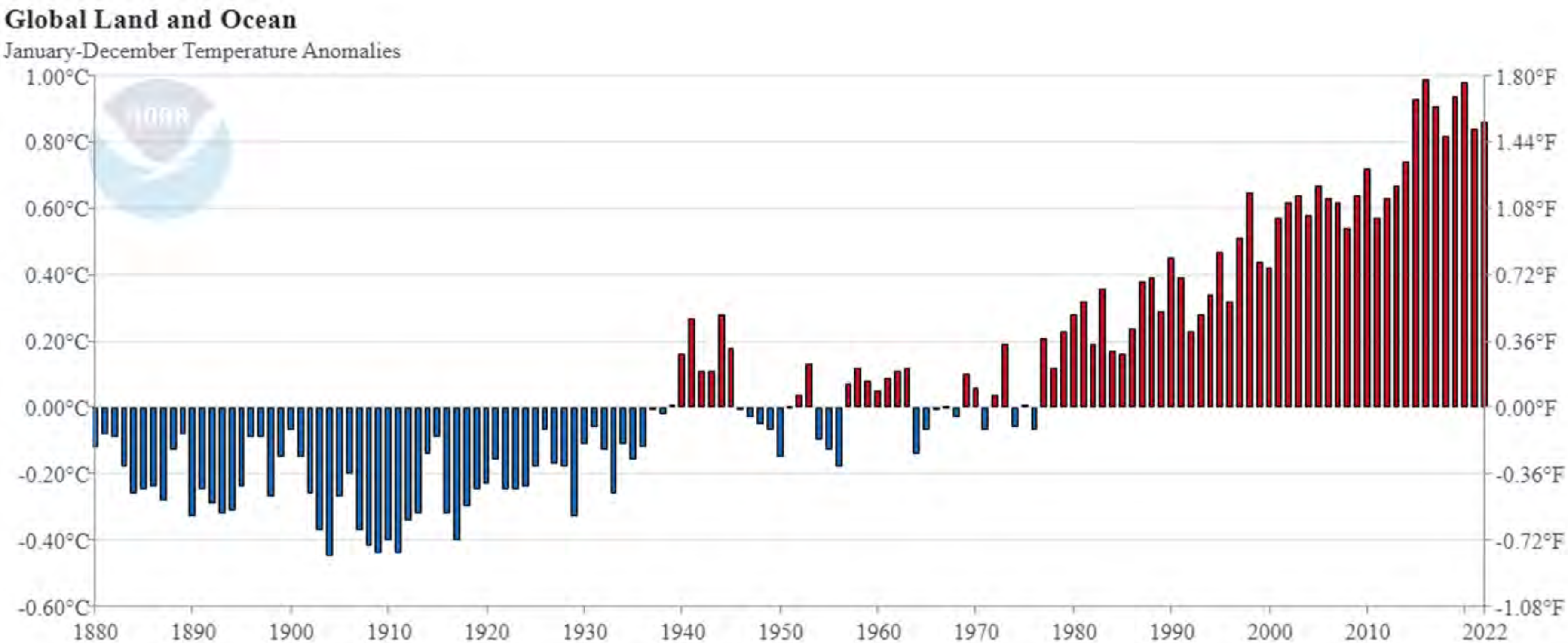


Source: USEPA, 2022



Source: ClimateCentral.org, 2024

Annual Change in Global Surface Temps



Local Impact – Dayton, OH

- 0.9˚F average annual temperature increase
  - **Highest in spring (up 2.2˚F)**
- Higher nighttime temperatures, fewer cold days
- 28.5% increase in annual precipitation
  - **Highest in fall (53.3% = 3.8”)**
- Severe storms increasing in frequency and intensity
  - **71% increase in total volume of rainfall**

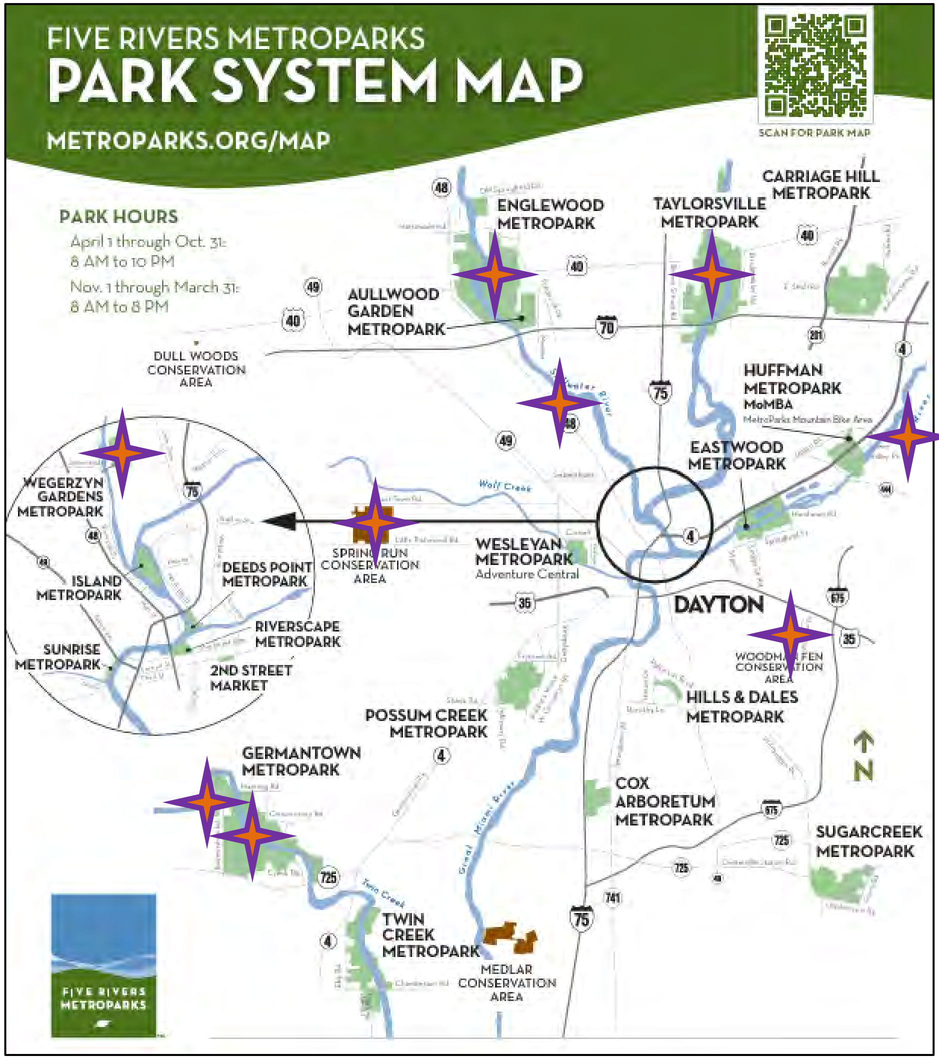
Source: Miami Valley Regional Planning Commission, Priority Climate Action Plan

Soil Carbon Study

- 54 field data points, 4 soil samples at each point (216 samples)
  - Forests
    - High quality forests
    - Medium quality forests
    - Low quality forests
    - Riparian/floodplain forests
  - Wetlands
    - Emergent
    - Forested
    - Fen
  - Prairies
    - High quality remnant
    - Medium quality
    - Low quality

Soil Carbon Study Locations

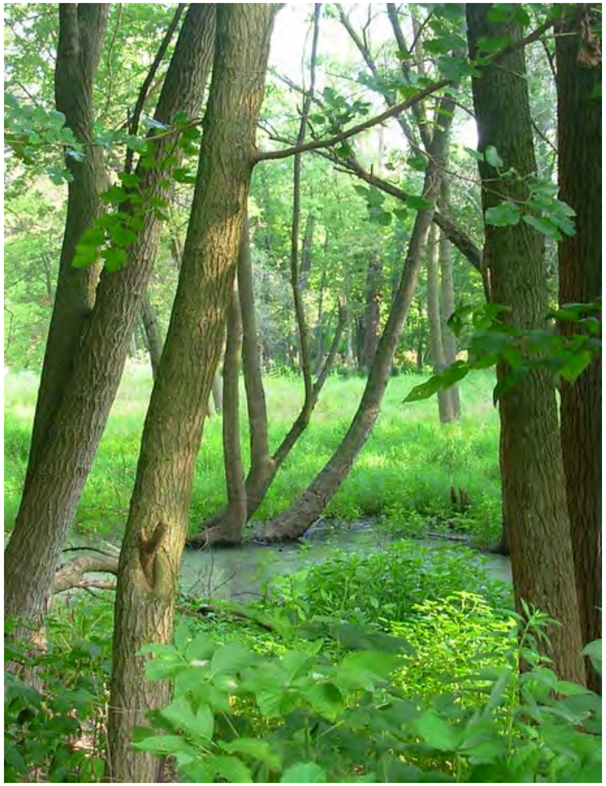
- Germantown MP
- Englewood MP
- Taylorsville MP
- Upper Twin CA
- Great Miami Mitigation Bank
- Woodman Fen CA
- Wegerzyn Gardens MP
- Huffman Prairie (WPAFB)
- Stillwater River CA



Plant Communities - Forests



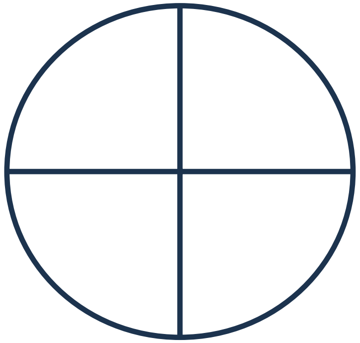

Plant Communities - Wetlands



Plant Communities - Prairies

Soil Carbon Study Methods

- 10m circle at each sampling point (54)
    - ID, measure all trees
    - Estimate understory and herbaceous cover
    - Estimate percent native/nonnative
    - Measured woody debris at N-S, E-W intercepts



- 4 soil cores at each point
    - 12” x 1.5” core

Soil Carbon Study – Soil Analysis

- Rutgers Soil Testing Laboratory
    - Soil core volume
    - Bulk density
    - Volume coarse fragments
    - Volume fine fragments
    - % organic Carbon

Carbon Study Analysis

- Soil Organic Carbon Stock

VOLUME OF BELOWGROUND ROOTS

$$V_{crt} = \Sigma(R_{crt} * ABM_t * 0.6) / SPG_{sp}$$

where

V_{crt} = volume (cm^3) of coarse roots in plot x

R_{crt}= coarse root component ratio of tree t in plot x– Eq. 2

ABM_t =aboveground biomass of tree *t in plot x* (kg))- Eq. 1

0.6= Proportion of coarse roots in top 30cm (Jackson et al 1996)

SPG_{sp}= Specific gravity of species of tree t in plot x (table x)

x = plot size in Ha

SOIL ORGANIC CARBON IN PLOT

$$C_{sx} = (V_{sx} * BD_x * PC_x)/1E6$$

where

C_{sx} = SOC in plot *x* to 30 cm (Mg)

V_{sx} = volume of soil in plot x to 30 cm (cm3/ha) – Eq. 14

PC_x = percent organic carbon for plot x (ratio)

BD_x = soil bulk density for plot x (g/cm3)

1E6 = conversion from g to Mg

VOLUME OF MINERAL SOIL PER PLOT

$$V_{sx} = (V_{p30} - V_{xr})*(1-CF_x)$$

where

V_{sx} = volume of soil in plot *x* to 30 cm depth (cm^3)

V_{p30} = total volume (cm^3) of a plot to 30cm depth

V_{xr} = volume of roots in plot *x* to 30 cm depth (cm^3)- Eq. 13

CF_x = coarse fragment volume of plot *x* (ratio)

SOIL ORGANIC CARBON STOCK

$$C_s = C_{sx}/x$$

where

C_s = Extrapolated SOC per hectare at plot x (Mg/ha)

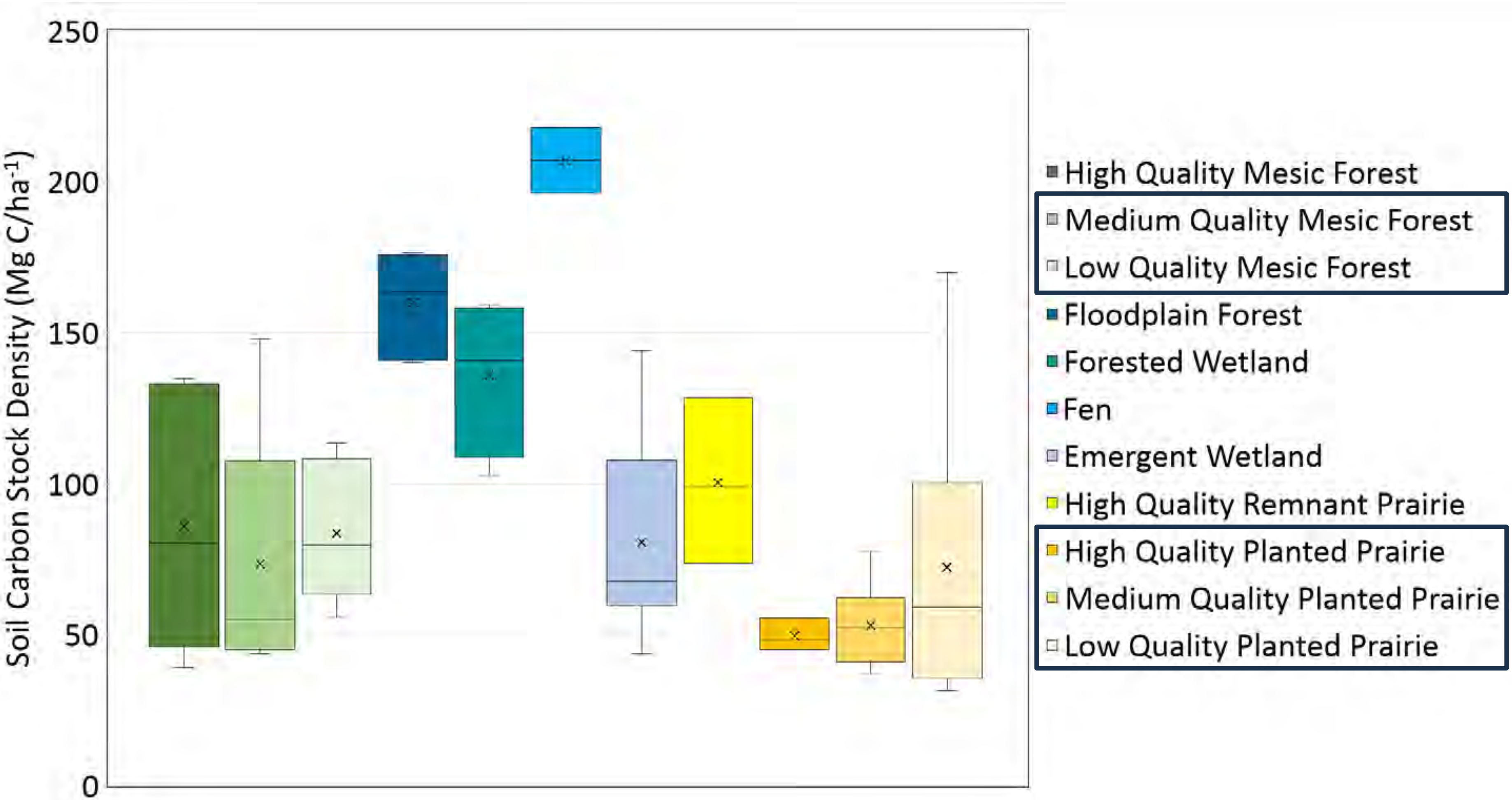
C_{sx} = SOC in plot *x* to 30 cm (Mg/ha) - Eq. 15

x = plot size in Ha

Source: Aggregated Methods for Calculating Tree Carbon Stock and Sequestration Rate, and Soil Carbon Stock from Field Collected Fixed Radius Plot Data. *Crystal Crown1, Clara Pregitzer1, Chloe Hanna2 (*1 Natural Areas Conservancy, 2 Yale School of the Environment)

Carbon Study Results

Soil Carbon Stock Density



Carbon Study Analysis

Natural Areas Conservancy

- Live Tree Carbon Stock Density

ABOVEGROUND BIOMASS

$$ABM_t = Exp(\beta_0 + \beta_1\ ln\ DBH_t)$$

where

ABM_t = aboveground biomass of tree *t* (kg dry weight)

Exp = exponential function

β_0 and β_1 = species group coefficients (*S1*)

ln = natural log

DBH_t* = diameter at breast height of tree t (cm)

*equation intended for trees ≥ 2.5 cm DBH

TOTAL STEM BIOMASS

$$TBM_t = ABM_t + R_{frt}*ABM_t + R_{crt}*ABM_t$$

where

TBM_t = total biomass of tree *t* (kg dry weight)

ABM_t = aboveground biomass of tree t (kg) – Eq. 1

R_{frt} = fine root component ratio of tree t - Eq. 2

R_{crt} = coarse root component ratio of tree t – Eq. 2

BELOWGROUND RATIOS

$$R_{ct} = Exp(\beta_0 + \beta_1*LN(DBH_t))$$

where

R_{ct} = ratio of component *c* to aboveground biomass of tree *t*

Exp = exponential function

β_0 and β_1 = Belowground component coefficients (table 1)

DBH_t = diameter at breast height of tree t (cm)

LIVE TREE CARBON STOCK DENSITY

$$C_t = (0.50*\Sigma(TBM_t/1000))/x$$

where

C_t = carbon stored in live trees for plot *x* (Mg/ha)

TBM_t = total biomass of tree t in plot (kg) – Eq. 3

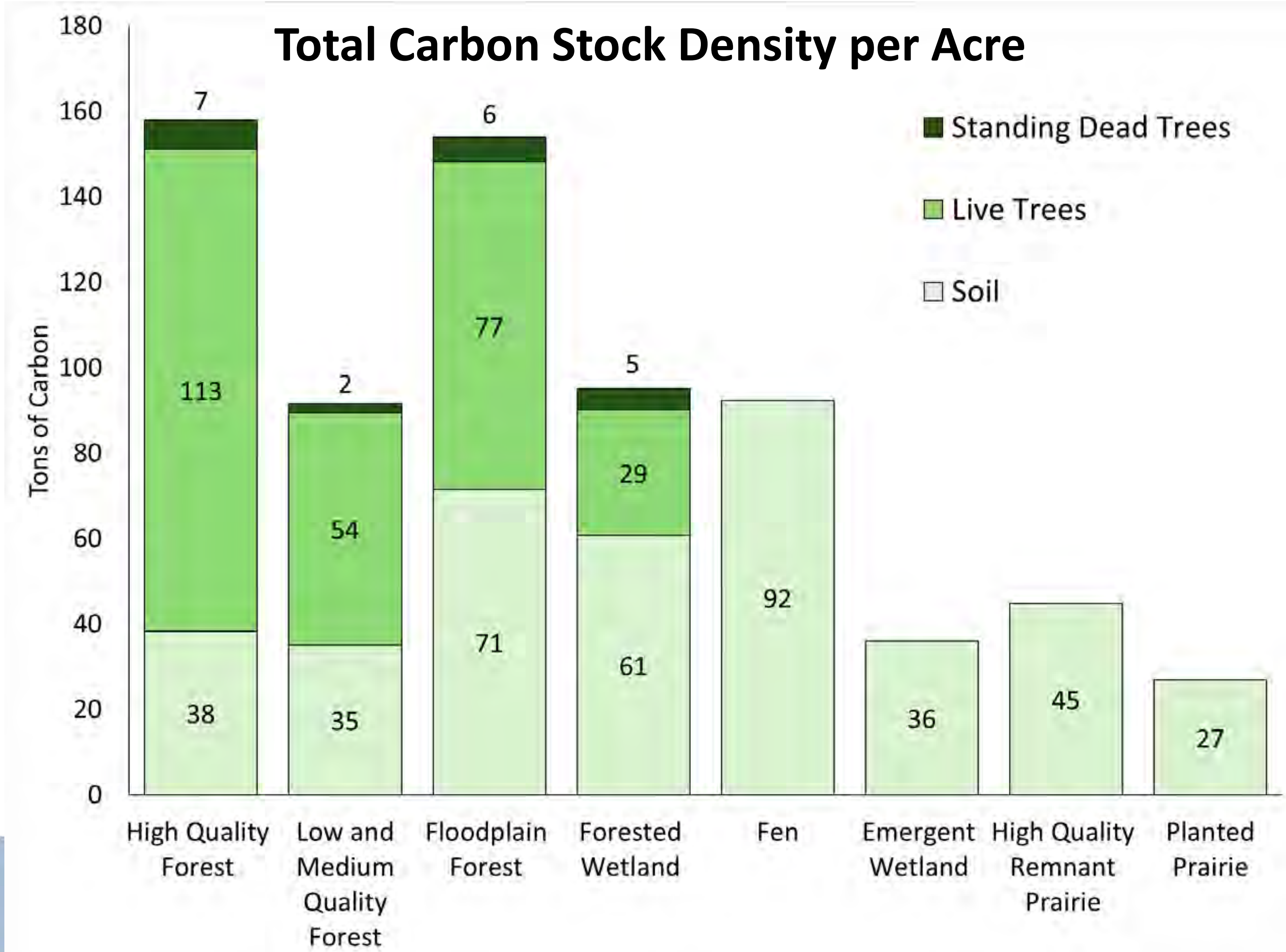
0.50 = conversion to carbon

1000 = conversion from kg to Mg

[illegible] =plot size in Ha

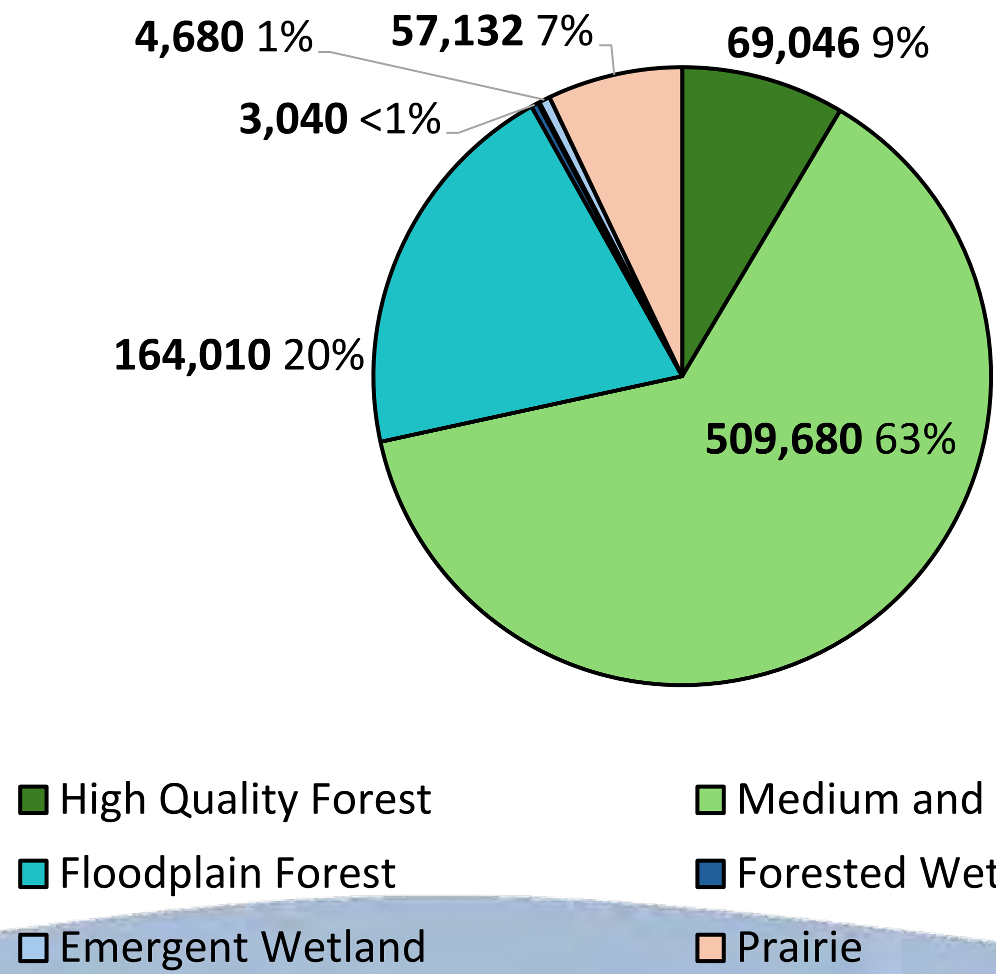
Source: Aggregated Methods for Calculating Tree Carbon Stock and Sequestration Rate, and Soil Carbon Stock from Field Collected Fixed Radius Plot Data. *Crystal Crown1, Clara Pregitzer1, Chloe Hanna2 (*1 Natural Areas Conservancy, 2 Yale School of the Environment)

Carbon Study Results



Total Carbon Stock Density Per Habitat

807,588 Tons of Carbon



Habitat Type	Acres
High Quality Forest	437
Medium and Low Quality Forest	5,540
Floodplain Forest	1,065
Forested Wetland	32
Emergent Wetland	130
Prairie	2,116

Carbon Study Analysis

Natural Areas Conservancy

- Carbon Sequestration Rate (Mg C/h)

POTENTIAL RELATIVE INCREMENT

$$PRI_t = b_1\, DBH_{t1}^{b2}\, b_3^{DBHt1}$$

where

PRI_t = potential relative increment of tree *t* (ratio)

DBH_{t1} = year 1 DBH of tree t (cm)

b_1, b_2, b_3 = species-specific coefficients

NET SEQUESTRATION PER TREE

$$NS_t = (TBM_{t2} - TBM_{t1})*0.50$$

where

NS_t = net sequestration of tree *t* (kg)

TBM_{t2} = year 2 DBH of tree t (cm)- Eq 6

TBM_{t1} = year 1 DBH of tree t (cm)

0.50 = conversion to carbon

PROJECTED DBH IN YEAR 2

$$DBH_{t2} = (PRI_t*DBH_{t1}) + DBH_{t1}$$

where

PRI_t = potential relative increment of tree t – Eq 5

DBH_{t1} = year 1 DBH of tree t (cm)

DBH_{t2} = year 2 DBH of tree *t* (cm)

ANNUAL SEQUESTRATION RATE

$$SeqC_x = (\Sigma(NS_t)/1000)/x$$

where

$SeqC_x$ = C sequestered annually by trees in plot *x* (Mg/ha)

NS_t = net sequestration of tree *t* (kg)

1000 = conversion from kg to Mg

x =plot size in hectares

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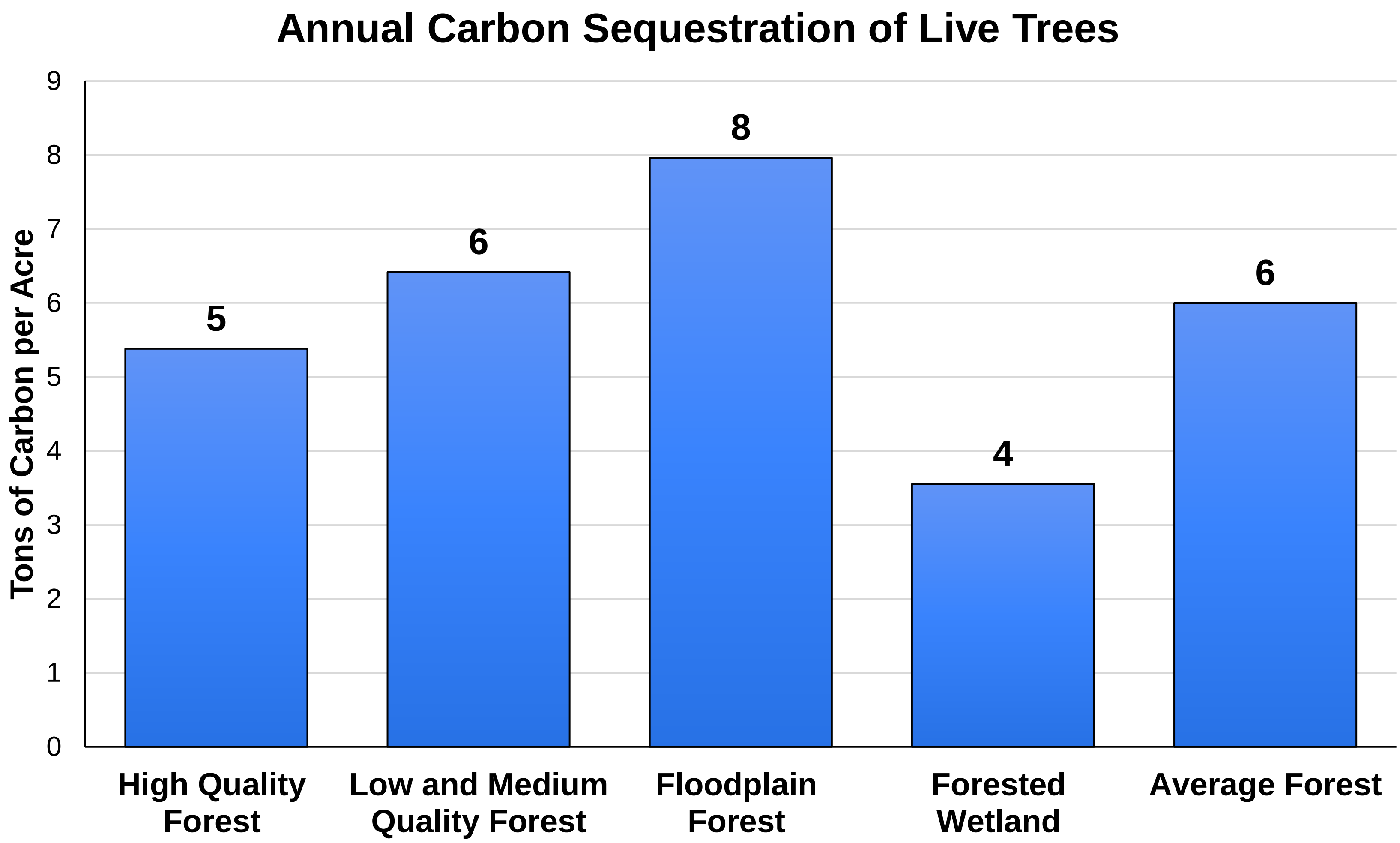
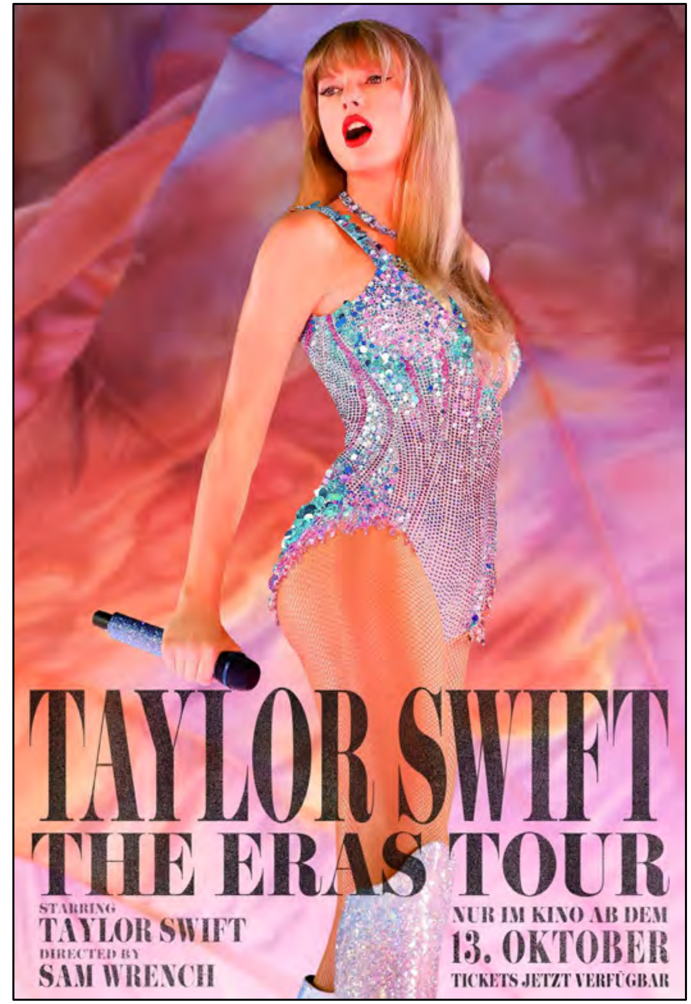
Carbon Study Results



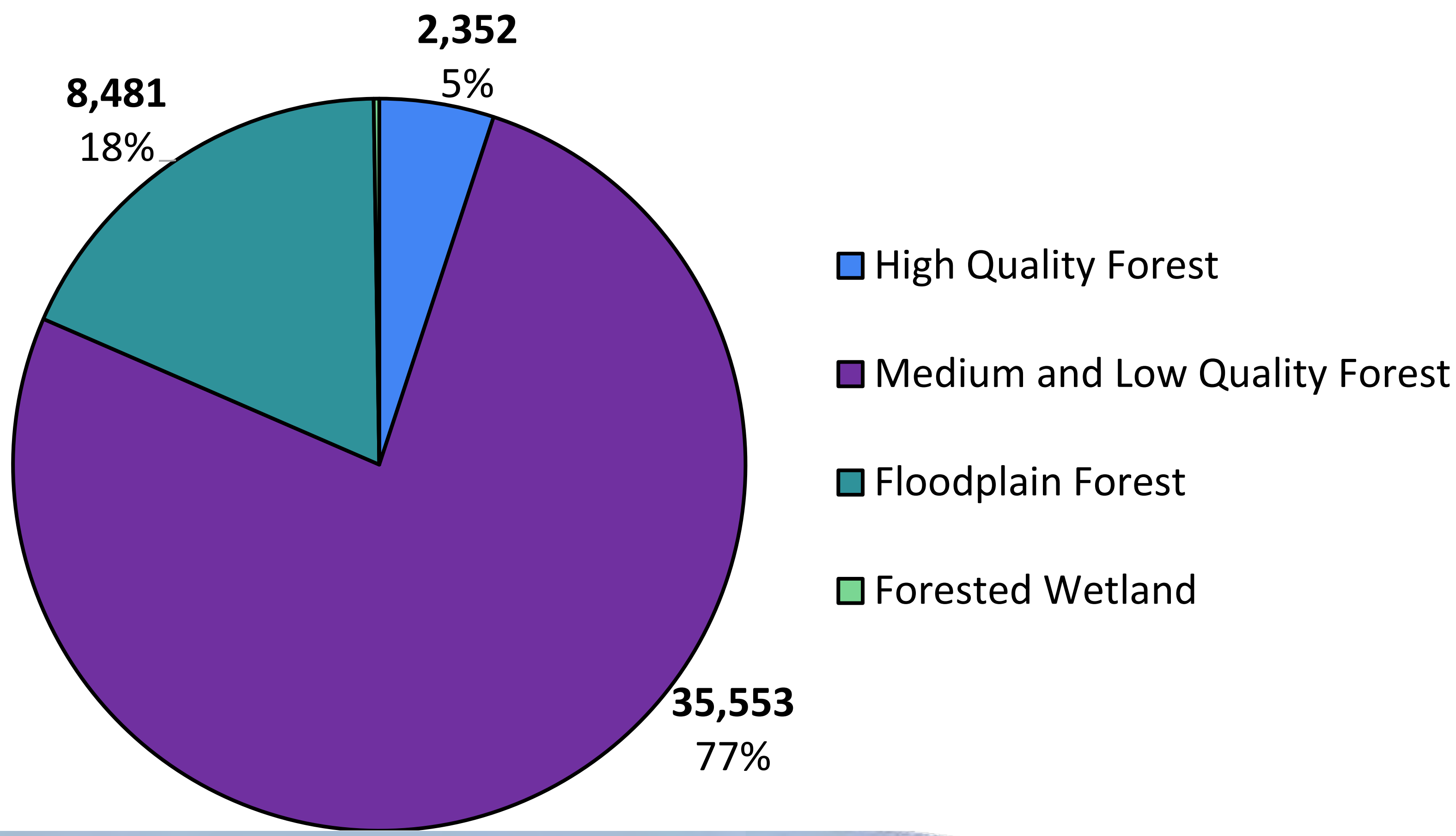
Carbon Study Results

26 ACRES



Total Annual Carbon Sequestration of Live Trees across FRMP

Tons of Carbon per Acre per Year



Carbon Study Results – In Summary

- FRMP lands sequester 46,500 tons of C per year
- Removes 172,223 tons of CO_2 per year

36,079 gasoline-powered passenger vehicles driven for one year

20,772 homes' energy use for one year

46.2 wind turbines running for a year

Source: https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator

Carbon Study Results – In Summary

- 1 acre of forest = 23 tons of C per year
- Removes 84 tons of CO_2 per year

17.8 gasoline-powered passenger vehicles driven for one year

10.3 homes' energy use for one year

3.9 garbage trucks of waste recycled instead of landfilled

High Quality Forest	Ave. Seq.	Trees
Acer_nigrum	4	2
Acer_saccharum	17	61
Aesculus_glabra	4	15
Carya_cordiformis	83	2
Celtis_occidentalis	24	2
Cercis_canadensis	11	1
Fagus_grandifolia	16	6
Fraxinus_americana	3	11
Fraxinus_quadrangulata	8	7
Liriodendron_tulipifera	51	1
Lonicera_maackii	3	5
Ostrya_virginiana	9	6
Quercus_alba	24	1
Quercus_macrocarpa	100	1
Quercus_muehlenbergii	41	4
Quercus_rubra	95	2
Tilia_americana	10	3
Ulmus_americana	12	2
Ulmus_rubra	27	3
Viburnum_prunifolium	3	1
Average	**17**	**136**

Average Sequestration Per Tree (kg)

- **831 trees**
- **48 tree species**

Forested Wetland	Ave. Seq.	Trees
Acer_negundo	26	3
Acer_saccharinum	72	1
Acer_saccharum	18	5
Asimina_triloba	3	7
Carya_cordiformis	34	1
Carya_laciniosa	18	8
Catalpa_speciosa	7	1
Celtis_occidentalis	10	1
Cephalanthus_occidentalis	3	3
Fraxinus_nigra	3	6
Fraxinus_pennsylvanica	3	24
Fraxinus_profunda	2	5
Fraxinus_quadrangulata	4	10
Gleditsia_triacanthos	44	2
Juglans_nigra	21	1
Lonicera_maackii	3	3
Quercus_shumardii	69	2
Ulmus_americana	18	8
Average	**11**	**91**

Floodplain Forest	Ave. Seq.	Trees
Acer_negundo	21	62
Acer_saccharinum	42	19
Celtis_occidentalis	24	11
Cephalanthus_occidentalis	3	3
Fraxinus_pennsylvanica	3	2
Platanus_occidentalis	15	6
Populus_deltoides	27	31
Ulmus_americana	6	6
Average	**24**	**140**

Medium/Low Quality Forest	Ave. Seq.	Trees
Acer_negundo	30	4
Acer_nigrum	34	7
Acer_rubrum	13	7
Acer_saccharum	16	98
Aesculus_glabra	5	5
Carya_cordiformis	90	1
Carya_ovata	39	6
Celtis_occidentalis	21	14
Cercis_canadensis	8	29
Elaeagnus_umbellata	6	3
Fagus_grandifolia	13	1
Fraxinus_americana	6	19
Fraxinus_quadrangulata	2	2
Gleditsia_triacanthos	8	3
Gymnocladus_dioicus	38	2
Juglans_nigra	33	3
Juniperus_virginiana	17	10
Liquidambar_styraciflua	3	10
Liriodendron_tulipifera	31	5
Lonicera_maackii	3	100
Maclura_pomifera	5	78
Ostrya_virginiana	4	2
Prunus_serotina	28	3
Pyrus_calleryana	15	1
Quercus_alba	46	4
Quercus_muehlenbergii	47	4
Quercus_rubra	51	5
Rhus_spp.	3	1
Robinia_pseudoacacia	13	13
Tilia_americana	10	4
Tree_broadleaf	13	1
Tree_unknown	7	1
Ulmus_americana	13	15
Ulmus_rubra	9	2
Average	**12**	**464**

But Trees Can't Do it All

- Sequestration varies by species, size, age, etc.
- Forests can reach equilibrium
- Trees die quickly and in large quantities
- Invasive species

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Importance of Urban Forests

- Journal of Applied Ecology: *Native trees are responsible for the high carbon density in urban natural area forests across eight United States cities*
- Evaluated 1,852 plots in 8 cities
    - 55% carbon stored is in above ground biomass
    - Storage increased with proportion of native species
    - Carbon density higher in urban forests than rural
- Increased invasive plant management
- Forest preservation

THANK YOU!

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Crystal Crown, Senior Manager of Data & Analytics, Natural Areas Conservancy

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Carbon Sequestration By Species

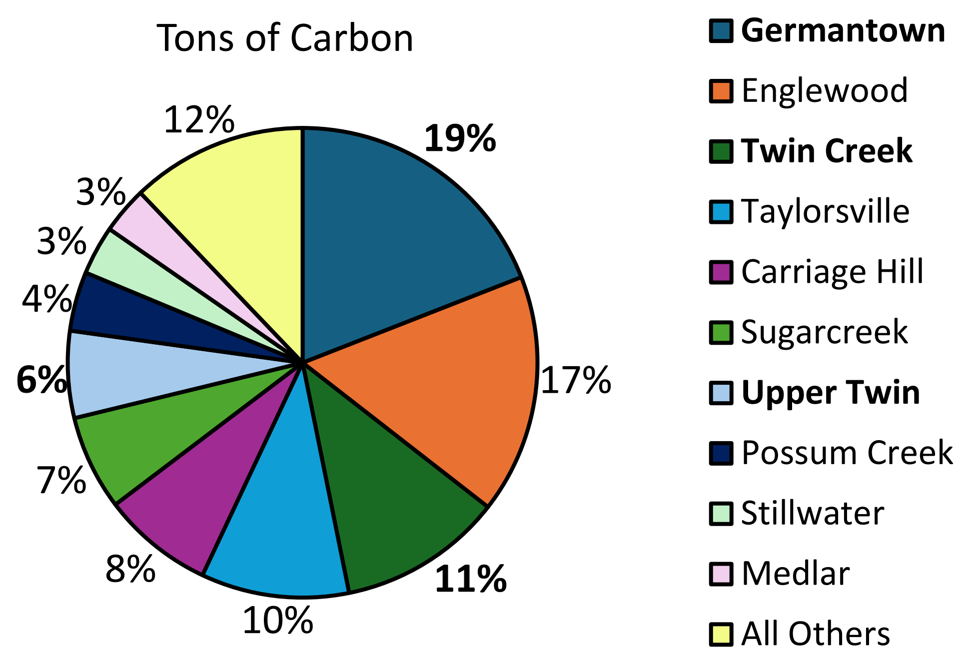
831 trees, 48 tree species, range 2 – 100 kg

Species	Average Net Sequestration Per Stem (kg)	Number of Trees	Coefficients
Acer_negundo	22	69	Average, Bragg 2003
Acer_nigrum	28	9	Average, Bragg 2003
Acer_rubrum	13	7	Provided, Bragg 2005
Acer_saccharinum	43	20	Provided, Bragg 2005
Acer_saccharum	17	164	Provided, Bragg 2005
Aesculus_glabra	4	20	Average, Bragg 2003
Asimina_triloba	3	7	Average, Bragg 2003
Carya_cordiformis	72	4	Average, Bragg 2003
Carya_laciniosa	18	8	Average, Bragg 2003
Carya_ovata	39	6	Average, Bragg 2003
Catalpa_speciosa	7	1	Average, Bragg 2003
Celtis_occidentalis	22	28	Average, Bragg 2003
Cephalanthus_occidentalis	3	6	Average, Bragg 2003
Cercis_canadensis	8	30	Average, Bragg 2003
Elaeagnus_umbellata	6	3	Average, Bragg 2003
Fagus_grandifolia	15	7	Provided, Bragg 2005
Fraxinus_americana	5	30	Provided, Bragg 2005
Fraxinus_nigra	3	6	Provided, Bragg 2005
Fraxinus_pennsylvanica	3	26	Provided, Bragg 2003
Fraxinus profunda	2	5	Provided, Bragg 2003
Fraxinus_quadrangulata	6	19	Provided, Bragg 2003
Gleditsia_triacanthos	22	5	Average, Bragg 2003
Gymnocladus_dioicus	38	2	Average, Bragg 2003
Juglans_nigra	30	4	Average, Bragg 2003

Species	Average Net Sequestration Per Stem (kg)	Number of Trees	Coefficients
Juniperus_virginiana	17	10	Average, Bragg 2003
Liquidambar_styraciflua	3	10	Average, Bragg 2003
Liriodendron_tulipifera	34	6	Average, Bragg 2003
Lonicera_maackii	3	108	Average, Bragg 2003
Maclura_pomifera	5	78	Average, Bragg 2003
Ostrya_virginiana	8	8	Average, Bragg 2003
Platanus_occidentalis	15	6	Average, Bragg 2003
Populus_deltoides	27	31	Average, Bragg 2003
Prunus_serotina	28	3	Provided, Bragg 2003
Prunus_serotina ssp. capuli	22	1	Provided, Bragg 2003
Pyrus_calleryana	15	1	Average, Bragg 2003
Quercus_alba	41	5	Provided, Bragg 2005
Quercus_macrocarpa	100	1	Average, Bragg 2003
Quercus_muehlenbergii	44	8	Average, Bragg 2003
Quercus_rubra	63	7	Provided, Bragg 2005
Quercus_shumardii	69	2	Average, Bragg 2003
Rhus_spp.	3	1	Average, Bragg 2003
Robinia_pseudoacacia	13	13	Average, Bragg 2003
Tilia_americana	10	7	Provided, Bragg 2005
Tree_broadleaf	13	1	Average, Bragg 2003
Tree_unknown	7	1	Average, Bragg 2003
Ulmus_americana	13	31	Provided, Bragg 2005
Ulmus_rubra	20	5	Average, Bragg 2003
Viburnum_prunifolium	3	1	Average, Bragg 2003

Total Carbon Stock Density Per Park

Park	Total Carbon Stock
Aullwood MP	354
Carriage Hill MP	61,977
Cox Arboretum MP	9,912
Dull Woods CA	772
Eastwood MP	4,570
Englewood MP	133,096
Germantown MP	**154,074**
Hills and Dales MP	5,310
Huffman MP	20,150
Island MP	169
Medlar CA	26,123
MoMBA MP	5,881
Needmore CA	11,811
Possum Creek MP	33,001
Sandridge CA	382
Spring Run CA	16,274
Stillwater CA	27,232
Sugarcreek MP	52,772
Taylorsville MP	82,341
Twin Creek MP	**91,328**
Upper Twin CA	**48,348**
Wegerzyn MP	11,202
Wesleyan MP	8,158
Woodman Fen CA	3,074
Grand Total	807,588



Carbon Study Results

Total Carbon Stock Density per Acre