Impact of Changing Climate on Ex-situ Carbon Storage

Pine Plantation Research and Decision Support Tool Rollout

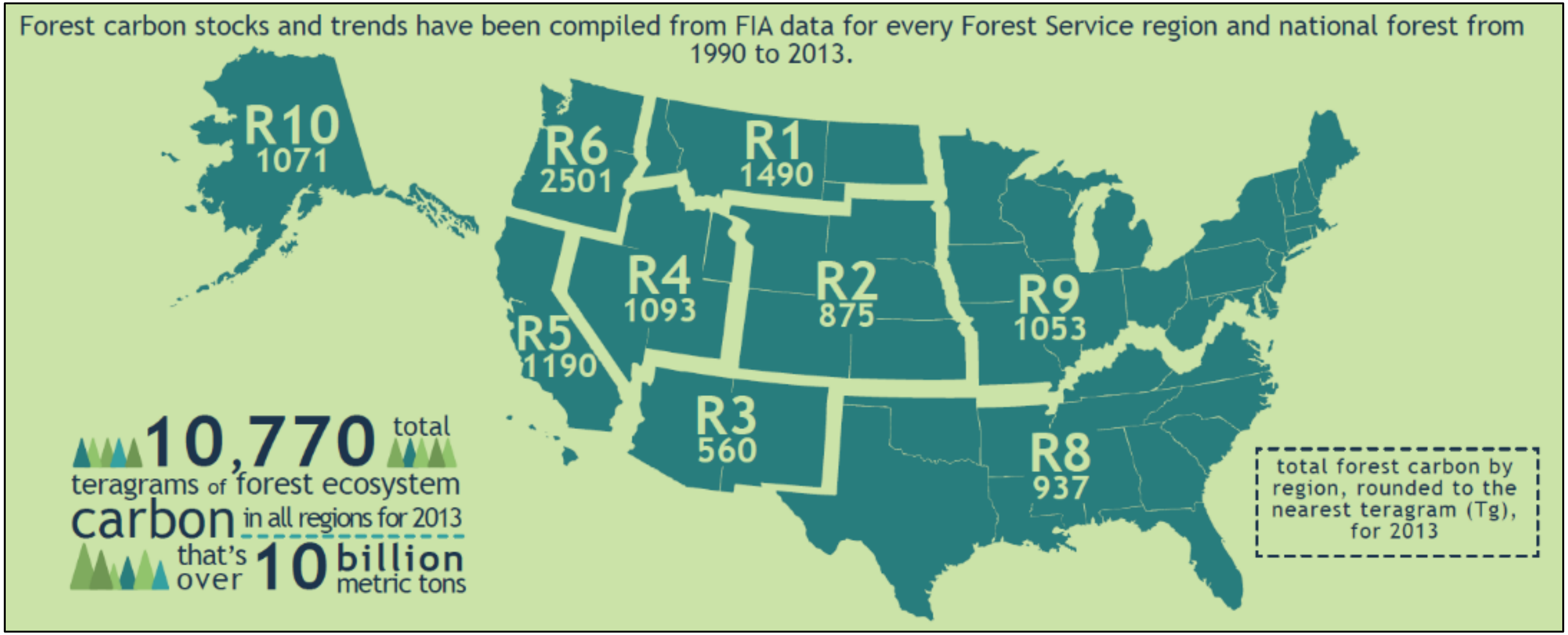
May 16-17, 2017 Athens, GA

Puneet Dwivedi[1], Carlos Gonzalez-Benecke[2], Robert Teskey[1], Tim Martin[3]

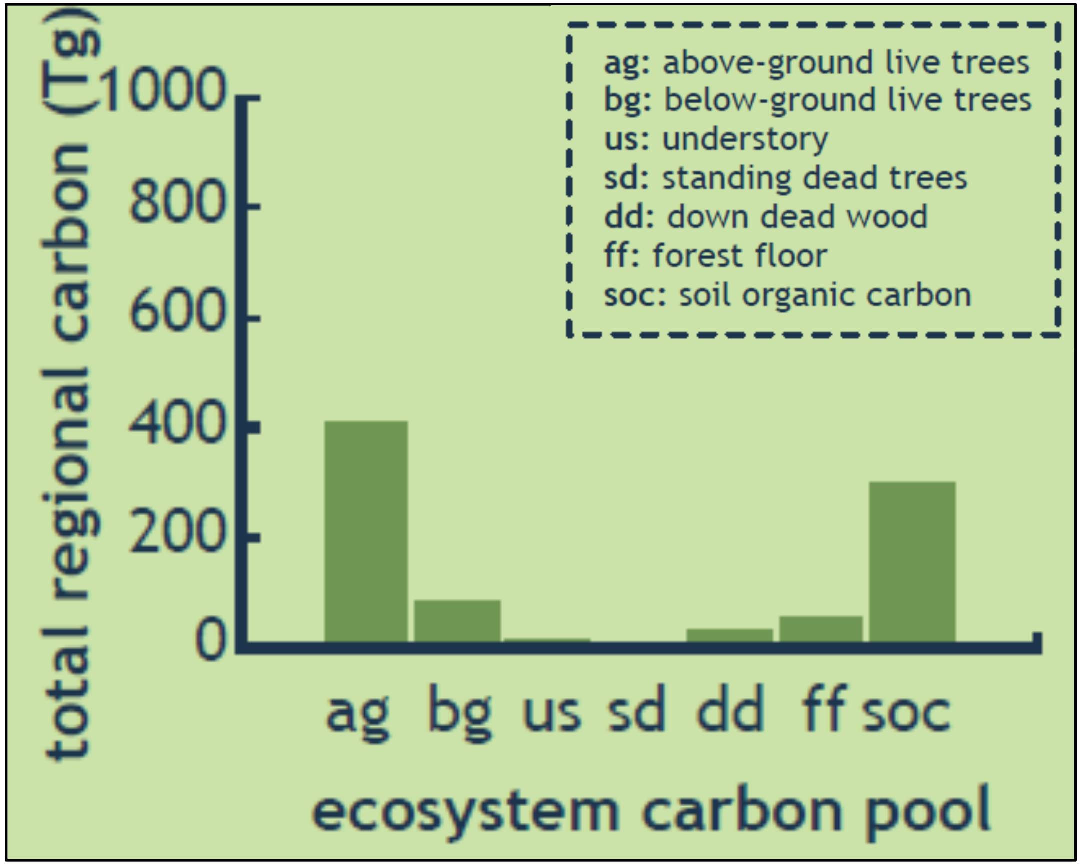
[1] Warnell School of Forestry and Natural Resources, University of Georgia | [2] College of Forestry, Oregon State University | [3] School of Forest Resources & Conservation, University of Florida

United States Department of Agriculture

National Institute of Food and Agriculture



Forest carbon stocks and trends have been compiled from FIA data for every Forest Service region and national forest from 1990 to 2013.
R10
1071
R6
2501
R1
1490
R4
1093
R2
875
R9
1053
R5
1190
R3
560
R8
937
10,770 total
teragrams of forest ecosystem
carbon in all regions for 2013
that's over 10 billion metric tons
total forest carbon by region, rounded to the nearest teragram (Tg), for 2013



ag: above-ground live trees
bg: below-ground live trees
us: understory
sd: standing dead trees
dd: down dead wood
ff: forest floor
soc: soil organic carbon
total regional carbon (Tg)
1000
800
600
400
200
0
ag
bg
us
sd
dd
ff
soc
ecosystem carbon pool

PINEMAP

CARBON CYCLING THROUGH WOOD PRODUCTS: THE ROLE OF WOOD AND PAPER PRODUCTS IN CARBON SEQUESTRATION

KENNETH E. SKOG †
GERALDINE A. NICHOLSON

ABSTRACT

This study provides historical estimates and projections of U.S. carbon sequestered in wood and paper products and compares them to amounts sequestered in U.S. forests. There are large pools of carbon in forests, in wood and paper products in use, and in dumps and landfills. The size of these carbon pools is increasing. Since 1910, an estimated 2.7 Pg (petagrams; $\times 10^9$ metric tons) of carbon have accumulated and currently reside in wood and paper products in use and in dumps and landfills, including net imports. This is notable compared with the current inventory of carbon in forest trees (13.8 Pg) and forest soils (24.7 Pg). On a yearly basis, net sequestration of carbon in U.S. wood and paper products (additions including net imports, minus emissions from decay and burning each year) is projected to increase from 61 Tg/year in 1990 to 74 Tg/year by 2040, while net additions (sequestration) in forests is projected to decrease from 274 to 161 Tg/year. Net sequestration is increasing in products and landfills because of an increase in wood consumption and a decrease in decay in landfills compared with phased-out dumps. If the total projected amount of products required is regarded as fixed, the net carbon sequestration in products and landfills can be increased by 1) shifting product mix to a greater proportion of lignin-containing products, which decay less in landfills; 2) increasing product recycling; 3) increasing product use-life; and 4) increasing landfill CH_4 burning in place of fossil fuels.

Research into reducing global carbon emissions and increasing carbon sequestration has been spurred by recognition that increasing levels of CO_2 in the atmosphere will affect the global climate. The main nonhuman sources of atmospheric CO_2 are animal respiration and decay of biomass (16). However, increases in atmospheric levels are attributed mainly to fossil fuel burning and deforestation. While efforts to hold down emissions of CO_2 continue, increases in CO_2 emissions can also be offset, to a degree, by accumulation in carbon sinks such as plant biomass and oceans. It is therefore prudent to focus research efforts both on increasing carbon in sinks and reducing carbon emissions. To this end, at the United Nations Conference on Environment and Development in 1992, the United States joined other nations in signing the Framework Convention on Climate Change, an international agreement to address the problems of global climate change. To implement the agreement, the President developed the Climate Change Action Plan (3), which set the objective of returning U.S. greenhouse gas emissions to 1990 levels by the year 2000. The plan set a goal to hold down growth of U.S. carbon emissions by 100 Tg[1] between 1990 and 2000 (3). The 1997 Kyoto Conference of the Parties to the United Nations Framework Convention would, if ratified by the U.S. Senate, commit the U.S. to reducing carbon emissions to 7 percent less than the 1990 level (14). In 1992, U.S. wood consumption was 19×10^9 ft.^{3} or 147 Tg carbon (5).

In 1990, U.S. CO_2 emissions were 1,367 Tg carbon equivalent (3). Wood and paper products play an important role in mitigating these emissions by sequestering carbon, which helps to mitigate carbon buildup in the atmosphere. There are currently large pools of carbon

[1] Carbon is commonly measured in teragrams (Tg), which is $\times 10^6$ metric tons, or petagrams (Pg), which is $\times 10^9$ metric tons. There is 1 Tg of carbon in ~130×10^6 ft.^{3} of wood or 2.2×10^9 board feet of soft-wood lumber.

The authors are, respectively, Project Leader, Timber Demand and Technology Assessment Research, USDA Forest Serv., Forest Prod. Lab., One Gifford Pinchot Dr., Madison, WI 53705; and Administrator of Economic Studies, Power Plant Research Program, Maryland Dept. of Natural Resources, 580 Taylor Ave., Annapolis, MD 21401. The use of trade or firm names in this publication is for reader information and does not imply endorsement by the U.S. Dept. of Agriculture of any product or service. The research for this paper was supported, in part, by a grant from the Environmental Protection Agency, Office of Policy, Planning, and Analysis. We thank Rich Birdsey, Linda Heath, and two *FPJ* reviewers for helpful comments on earlier drafts of this paper. This paper was received for publication in June 1997. Reprint No. 8675.
† Forest Products Society Member.

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Sequestration of carbon in harvested wood products for the United States

Kenneth E. Skog*

Abstract

The Intergovernmental Panel on Climate Change (IPCC) provides guidelines for countries to report greenhouse gas removals by sinks and emissions from sources. These guidelines allow use of several accounting approaches when reporting the contribution of harvested wood products (HWP) under the United Nations Framework Convention on Climate Change. Using extensions of methods suggested by the IPCC and a software model called WOODCARB II in Microsoft Excel®, this paper presents estimates of the U.S. HWP contribution to annual greenhouse gas removals in the agriculture, forestry, land use, and land use change sector. In 2005, the contribution to removals was 30 Tg (million metric tons) C (carbon) and 31 Tg C for the Production and Atmospheric Flow Approaches, respectively, and 44 Tg C for the Stock Change Approach. This range is 17 to 25 percent of C removals by forests, or would offset 42 percent to 61 percent of residential natural gas C emissions in 2005. The contribution has declined under the Production and Atmospheric Flow Approaches since 1990 and has increased under the Stock Change Approach. The Stock Change estimate has increased because it explicitly includes C in increasing net imports of wood and paper products. The contribution estimates were validated by adjusting the half-life of products in use in order to match independent estimates of carbon in housing in 2001 and annual wood and paper discards to solid-waste disposal sites (SWDS) during 1990 to 2001. Estimates of methane emissions from wood and paper in landfills were also checked against independent estimates of total landfill methane emissions. A Monte-Carlo simulation used to assess the effect of uncertainty in inputs suggests the 90 percent confidence interval for removal contribution estimates under the three approaches is within –23% to +19%.

Harvested wood products (HWP) are any product from wood including lumber, panels, paper, and paperboard, as well as wood used for fuel.[1] There are at least two settings where estimates of additions to carbon stored in HWP or emissions associated with HWP may aid in making decisions about the role of HWP in greenhouse gas emissions from sources and removals by sinks and in managing HWP to influence greenhouse gas emissions and sinks. The first is national level reporting by countries under the UN Framework Convention on Climate Change (UNFCCC). Under the UNFCCC, countries report annually on greenhouse gas emissions and changes in sinks. This information is intended to aid in international discussions and any agreements about managing greenhouse gas emissions and sinks. The second setting is within-country reporting by entities that manage forestland and provide wood for products or reporting by entities that produce wood products. This information is intended to aid national discussions and agreements about managing greenhouse gas emissions and sinks within a country. This paper focuses on providing national level methods and estimates of carbon sinks and emissions associated with HWP.

Annual additions of carbon to stocks of HWP are estimated to be substantial worldwide in comparison to annual net additions to forests (Winjum et al. 1998, UNFCCC 2003), but estimates are uncertain (Skog et al. 2004). This paper presents revised methods and estimates of annual U.S. carbon additions to HWP sinks for annual reports of greenhouse gas emis-

[1] The fate of wood carbon that is harvested but left on harvest sites is accounted for with the forest and with HWP.

The author is Supervisory Research Forester, USDA Forest Serv., Forest Products Lab., Madison, Wisconsin (kskog@fs.fed.us). Mike Nichols' (USDA Forest Serv., Northern Research Sta.) work to prepare virtually all the wood and paper products production and trade data sets in a spreadsheet for the WOODCARB II model is greatly appreciated. The Woodcarb II spreadsheet model is built on a spreadsheet model framework build by Kim Pingoud (VTT, Finland). Thank you to the scientists who provided review comments for the internal Forest Serv. review that resulted in corrections and improvements to the Woodcarb II model. The use of trade or firm names in this publication is for reader information and does not imply endorsement by the USDA of any product or service. The Forest Products Lab. is maintained in cooperation with the Univ. of Wisconsin. This paper was received for publication in April 2008. Article No. 10475.
*Forest Products Society Member.

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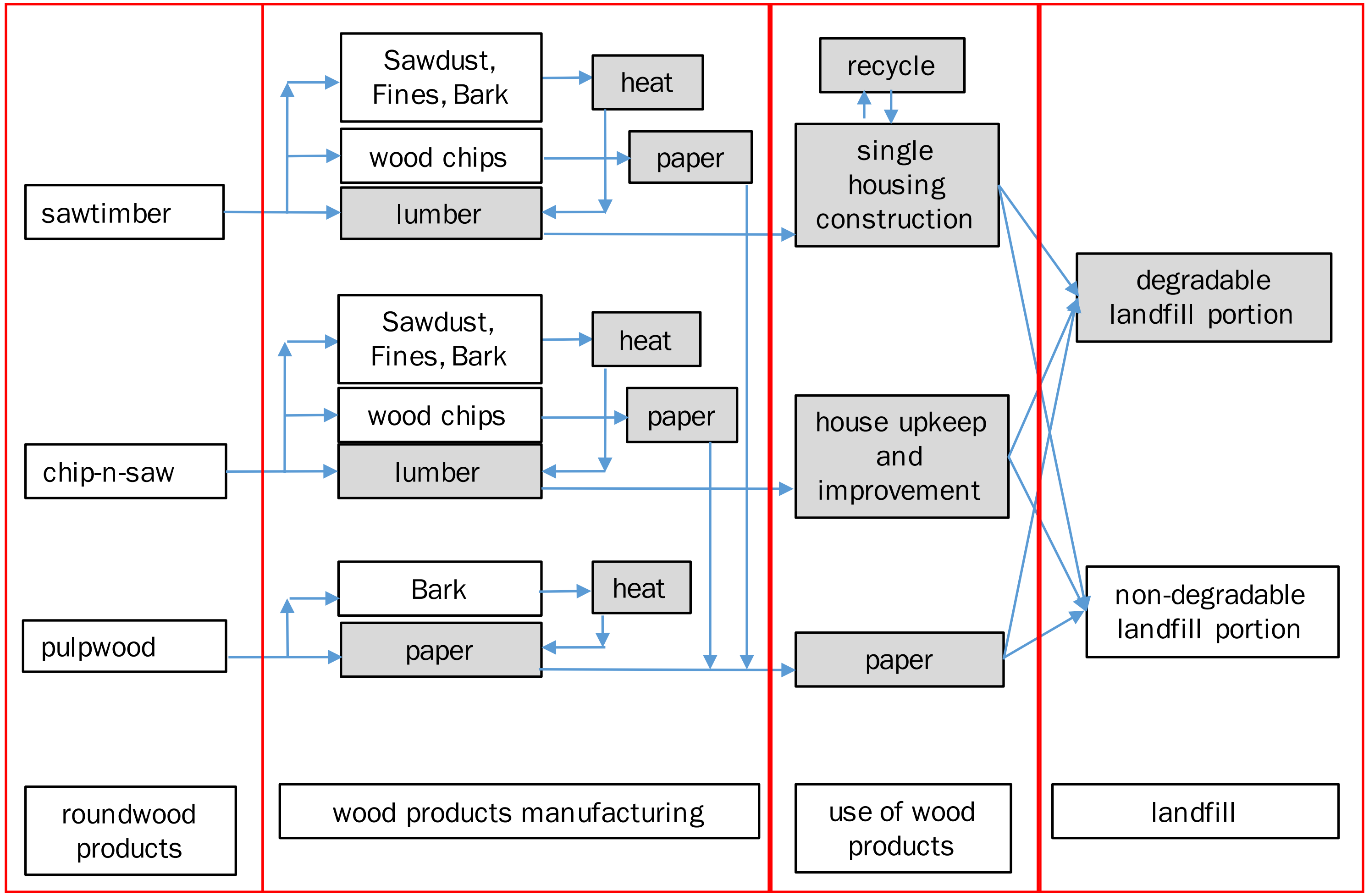
Objectives of the Study

1. How ex-situ carbon storage is affected by changing climate across southern United States?
2. How ex-situ carbon storage is influenced by site indices in the presence of changing climate?
3. What the inherent opportunities and risks related with ex-situ carbon storage?

System Boundary



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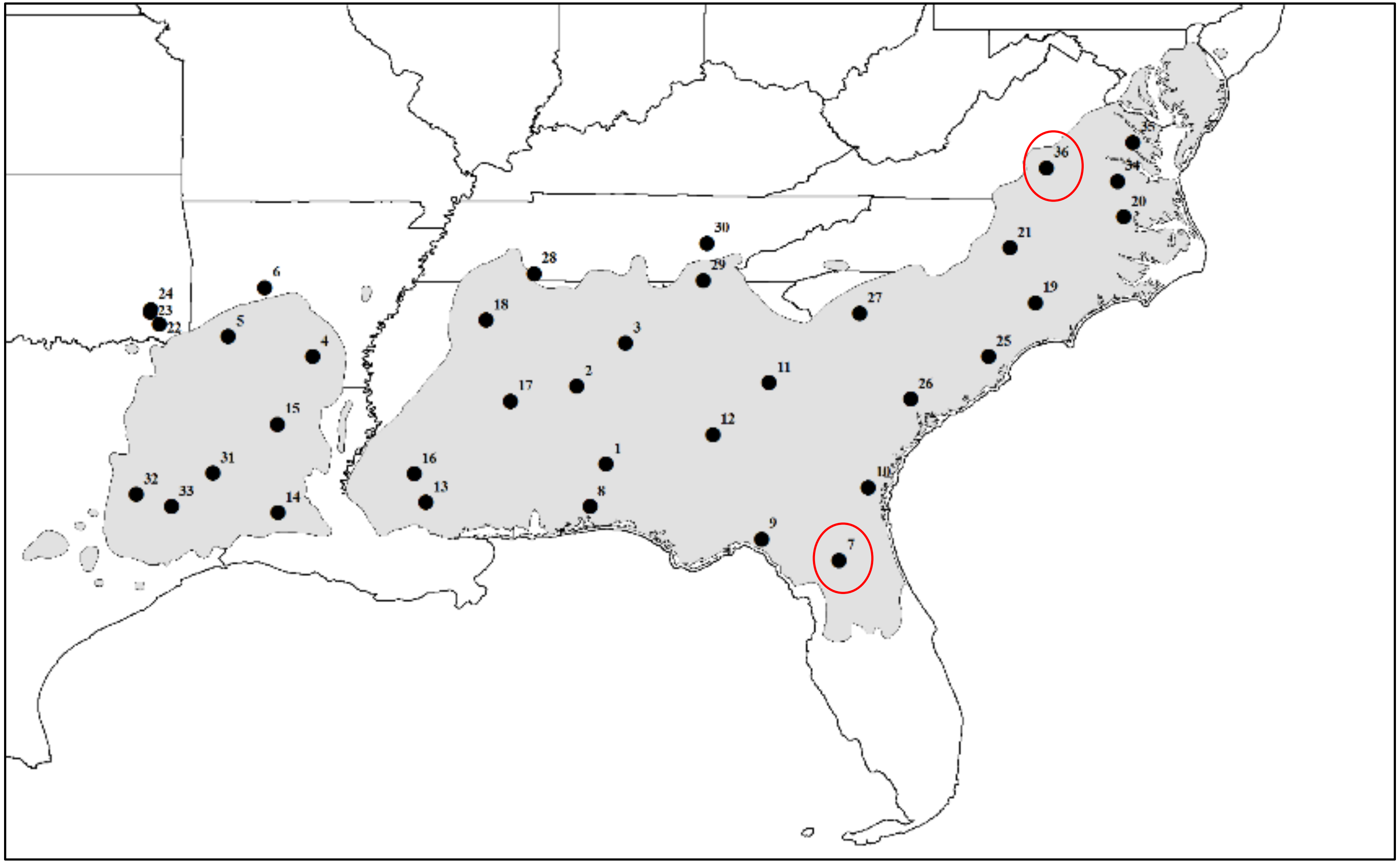

3-PG

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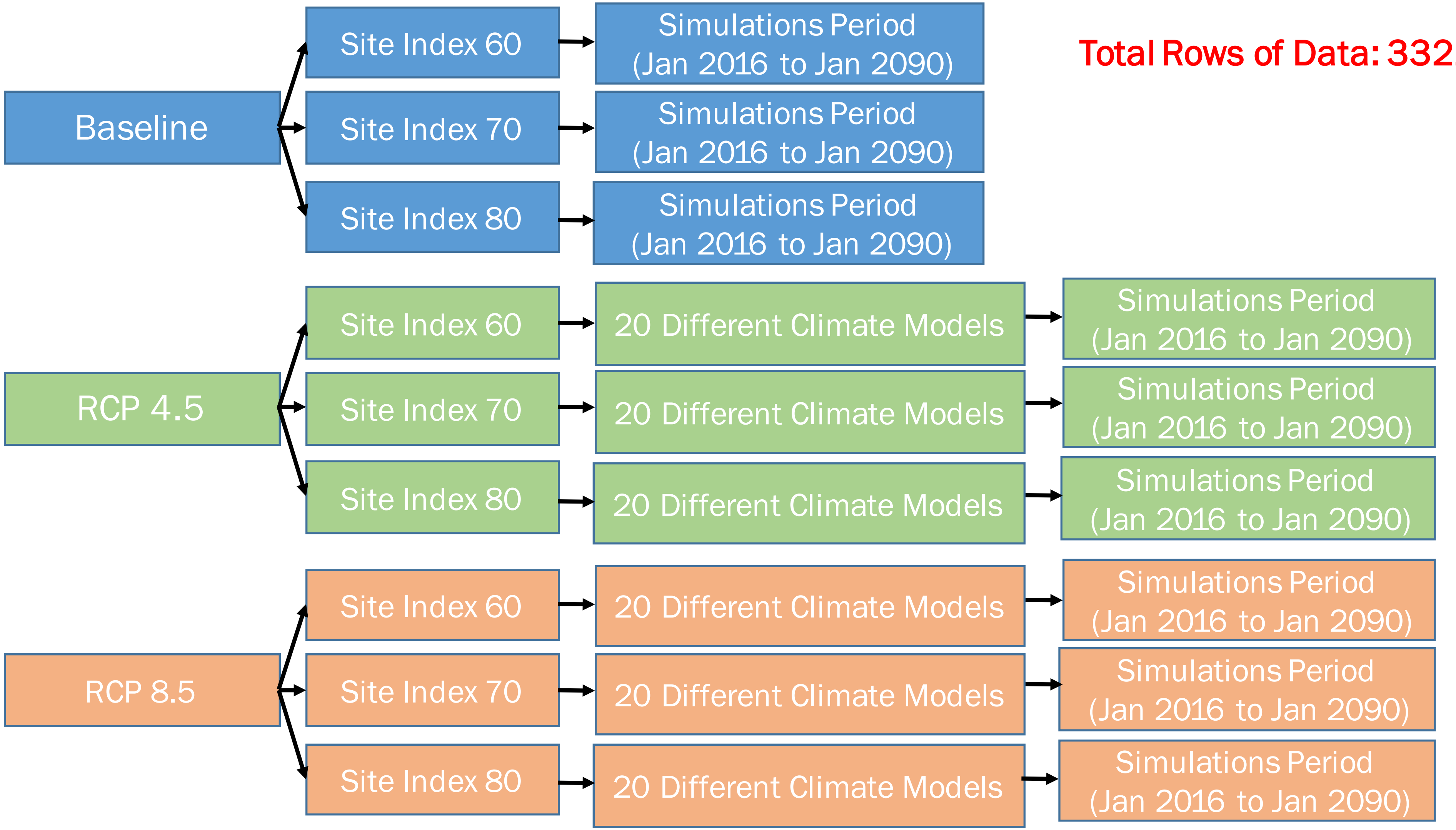

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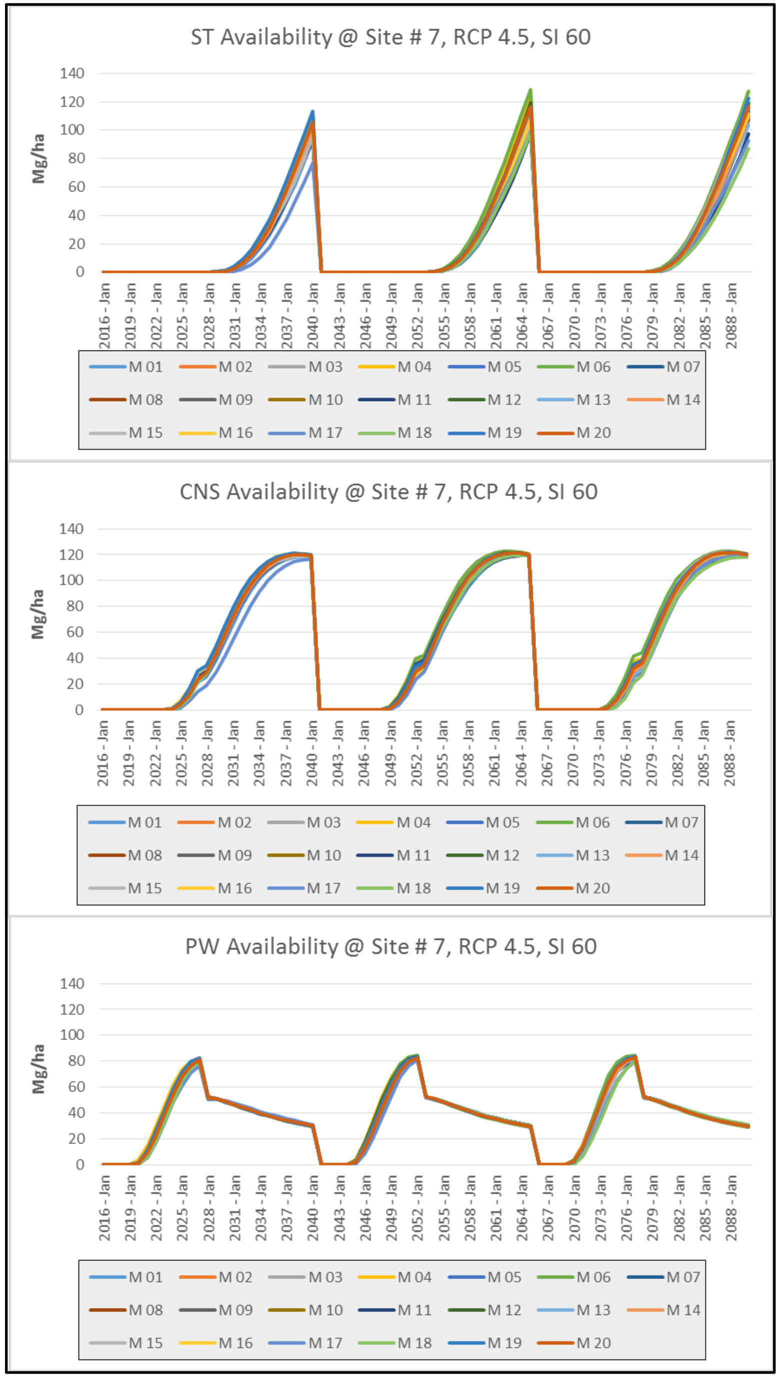
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CNS Availability @ Site # 7, RCP 4.5, SI 60
PW Availability @ Site # 7, RCP 4.5, SI 60
Mg/ha
0 20 40 60 80 100 120 140
2016 - Jan 2019 - Jan 2022 - Jan 2025 - Jan 2028 - Jan 2031 - Jan 2034 - Jan 2037 - Jan 2040 - Jan 2043 - Jan 2046 - Jan 2049 - Jan 2052 - Jan 2055 - Jan 2058 - Jan 2061 - Jan 2064 - Jan 2067 - Jan 2070 - Jan 2073 - Jan 2076 - Jan 2079 - Jan 2082 - Jan 2085 - Jan 2088 - Jan
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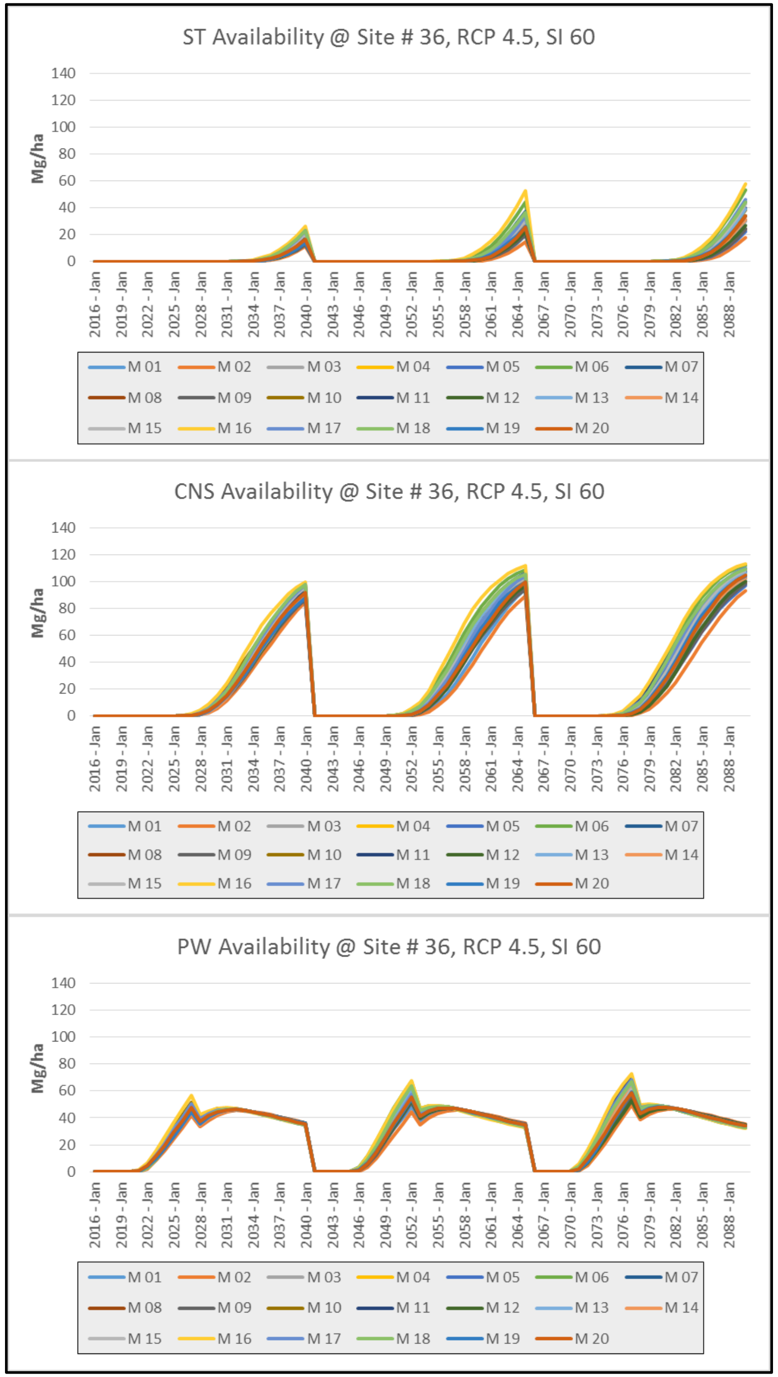
M 08 M 09 M 10 M 11 M 12 M 13 M 14
M 15 M 16 M 17 M 18 M 19 M 20


ST Availability @ Site # 36, RCP 4.5, SI 60
CNS Availability @ Site # 36, RCP 4.5, SI 60
PW Availability @ Site # 36, RCP 4.5, SI 60
Mg/ha
0 20 40 60 80 100 120 140
2016 - Jan 2019 - Jan 2022 - Jan 2025 - Jan 2028 - Jan 2031 - Jan 2034 - Jan 2037 - Jan 2040 - Jan 2043 - Jan 2046 - Jan 2049 - Jan 2052 - Jan 2055 - Jan 2058 - Jan 2061 - Jan 2064 - Jan 2067 - Jan 2070 - Jan 2073 - Jan 2076 - Jan 2079 - Jan 2082 - Jan 2085 - Jan 2088 - Jan
M 01 M 02 M 03 M 04 M 05 M 06 M 07
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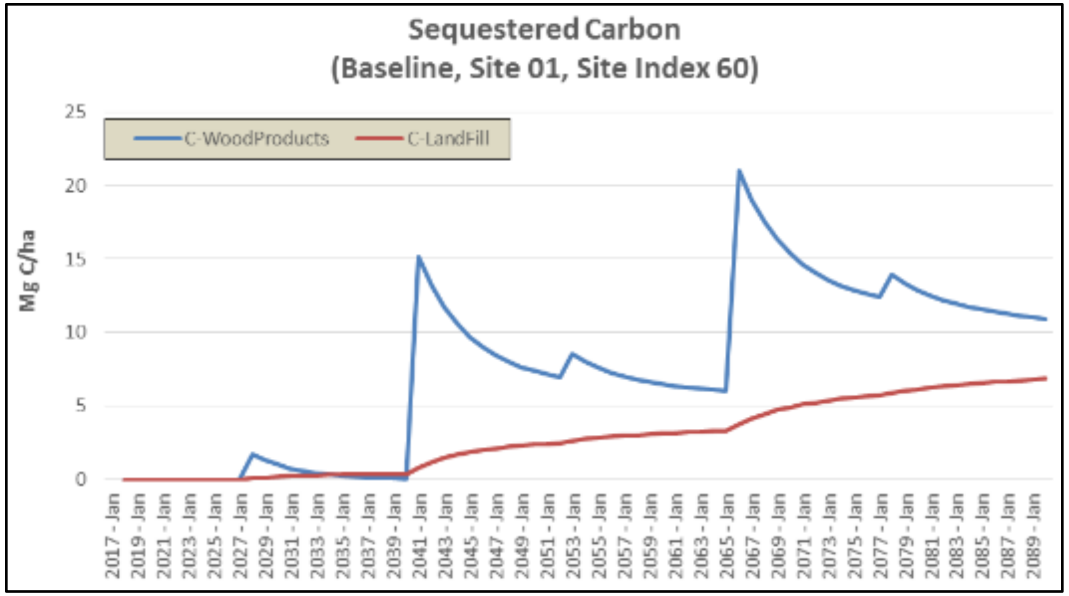
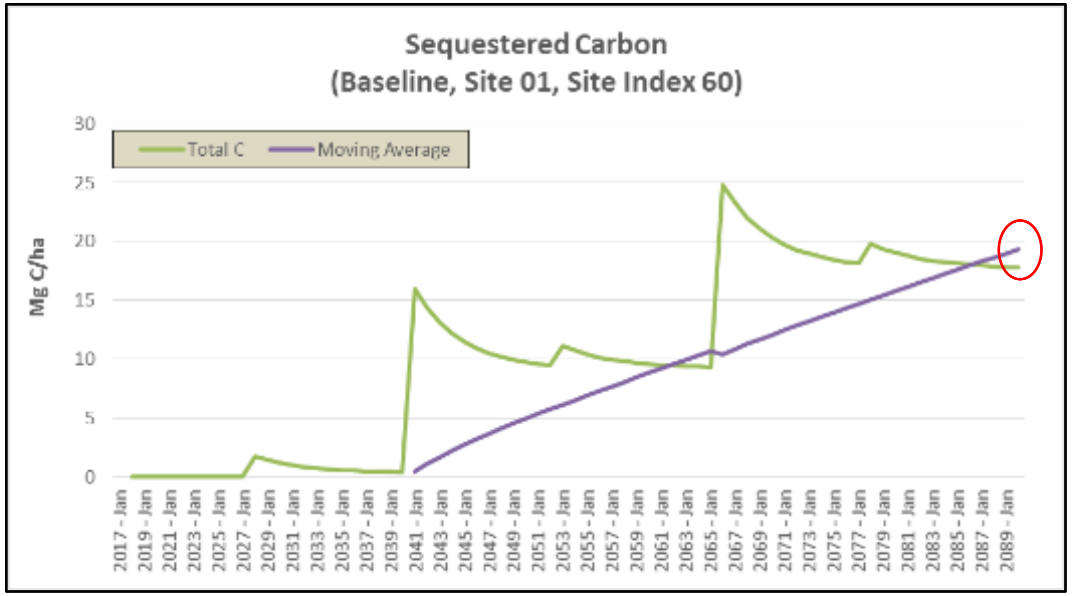
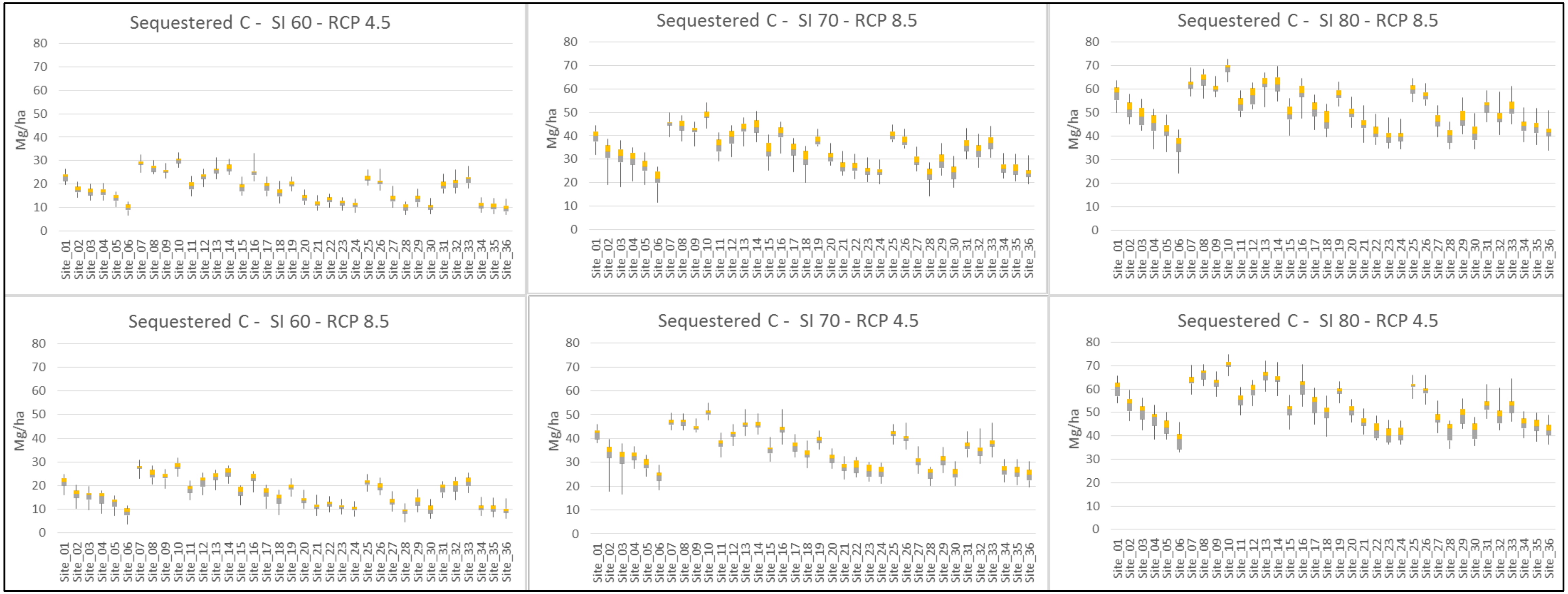
M 15 M 16 M 17 M 18 M 19 M 20

Trajectory of Sequestered Carbon

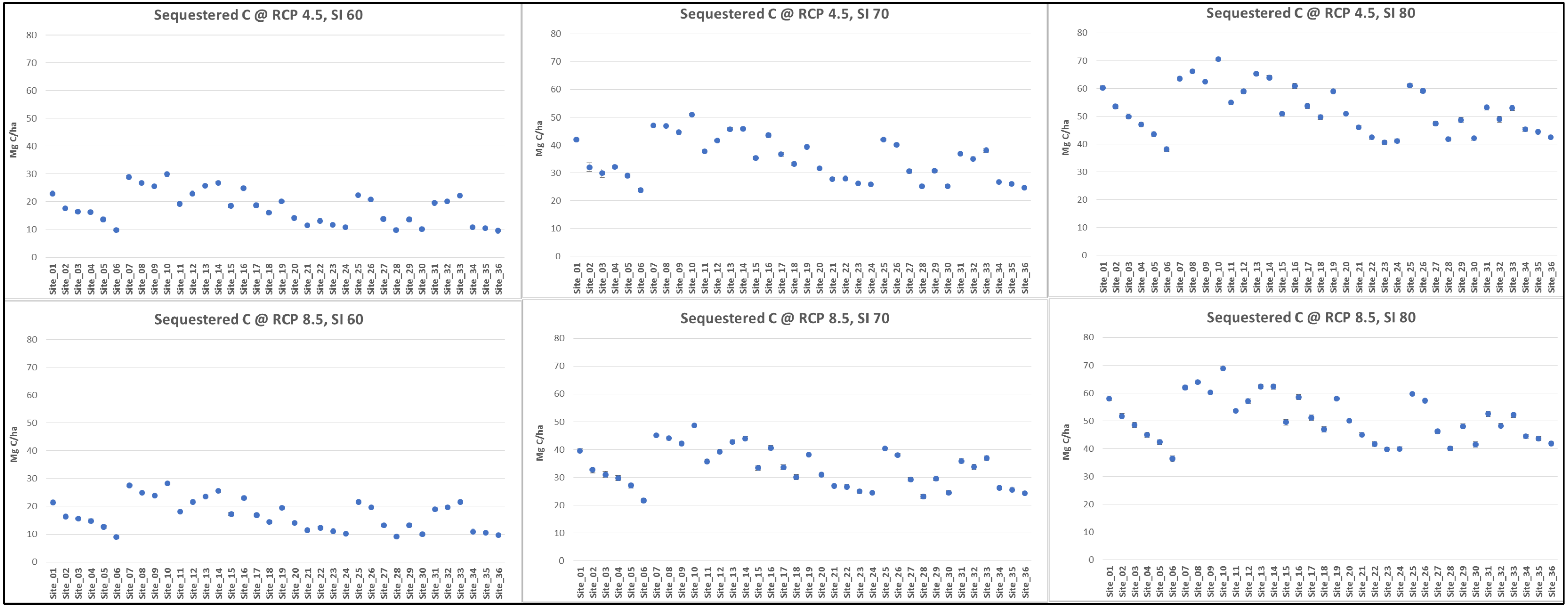




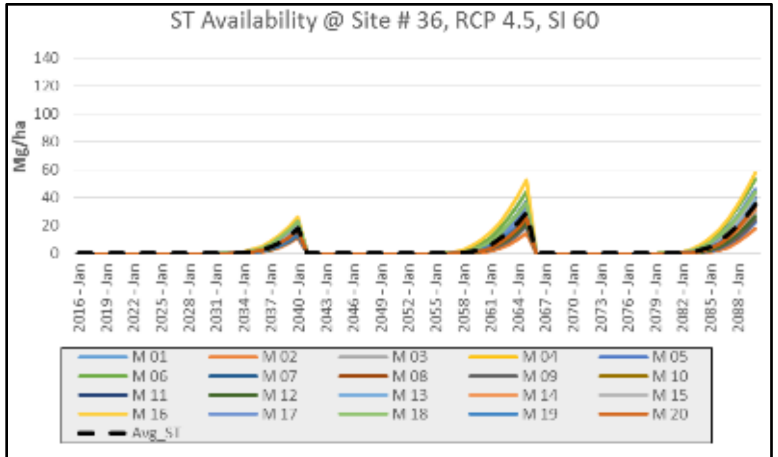
Box Plot of Sequestered Carbon for 20 Different Climate Models



Mean (with standard error) of Sequestered Carbon for 20 Climate Models



Input Data



ST Availability @ Site # 36, RCP 4.5, SI 60
Mg/ha
140
120
100
80
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40
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0
2016 - Jan
2019 - Jan
2022 - Jan
2025 - Jan
2028 - Jan
2031 - Jan
2034 - Jan
2037 - Jan
2040 - Jan
2043 - Jan
2046 - Jan
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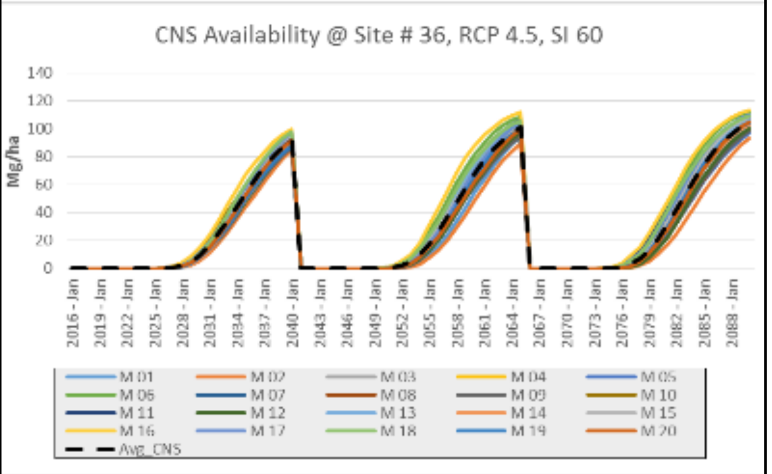
Avg_ST



CNS Availability @ Site # 36, RCP 4.5, SI 60
Mg/ha
140
120
100
80
60
40
20
0
2016 - Jan
2019 - Jan
2022 - Jan
2025 - Jan
2028 - Jan
2031 - Jan
2034 - Jan
2037 - Jan
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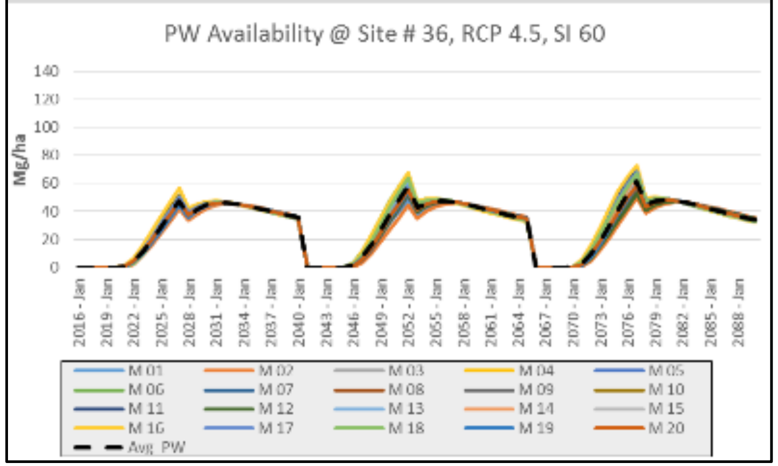
Avg_CNS



PW Availability @ Site # 36, RCP 4.5, SI 60
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2028 - Jan
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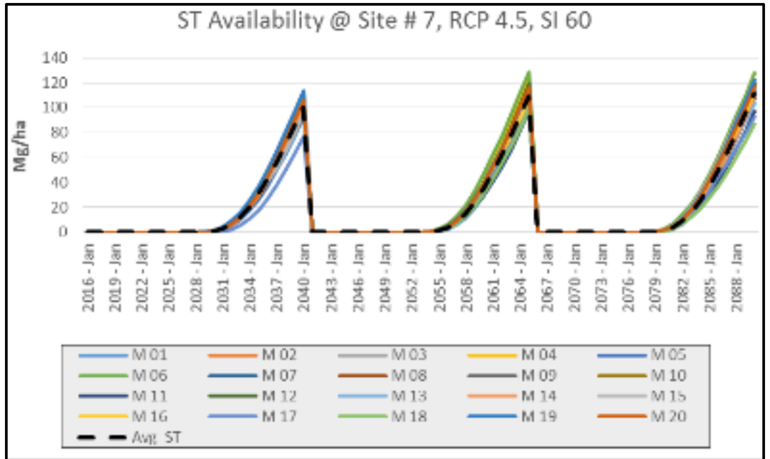
Avg_PW



ST Availability @ Site # 7, RCP 4.5, SI 60
Mg/ha
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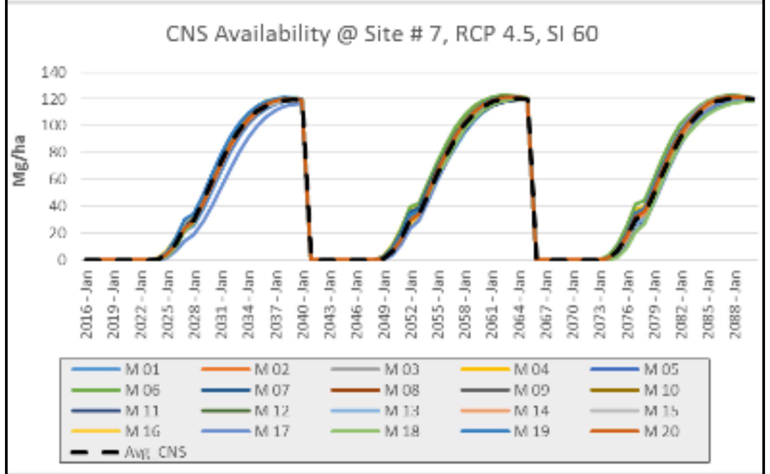
Avg_ST



CNS Availability @ Site # 7, RCP 4.5, SI 60
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2031 - Jan
2034 - Jan
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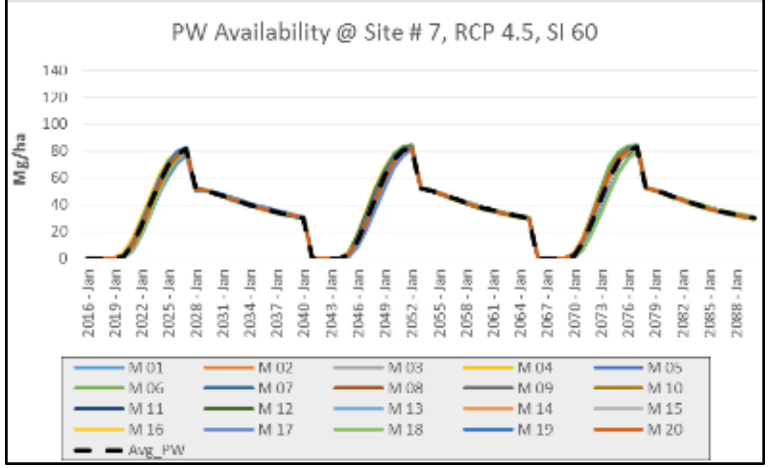
Avg_CNS



PW Availability @ Site # 7, RCP 4.5, SI 60
Mg/ha
140
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80
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2016 - Jan
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2025 - Jan
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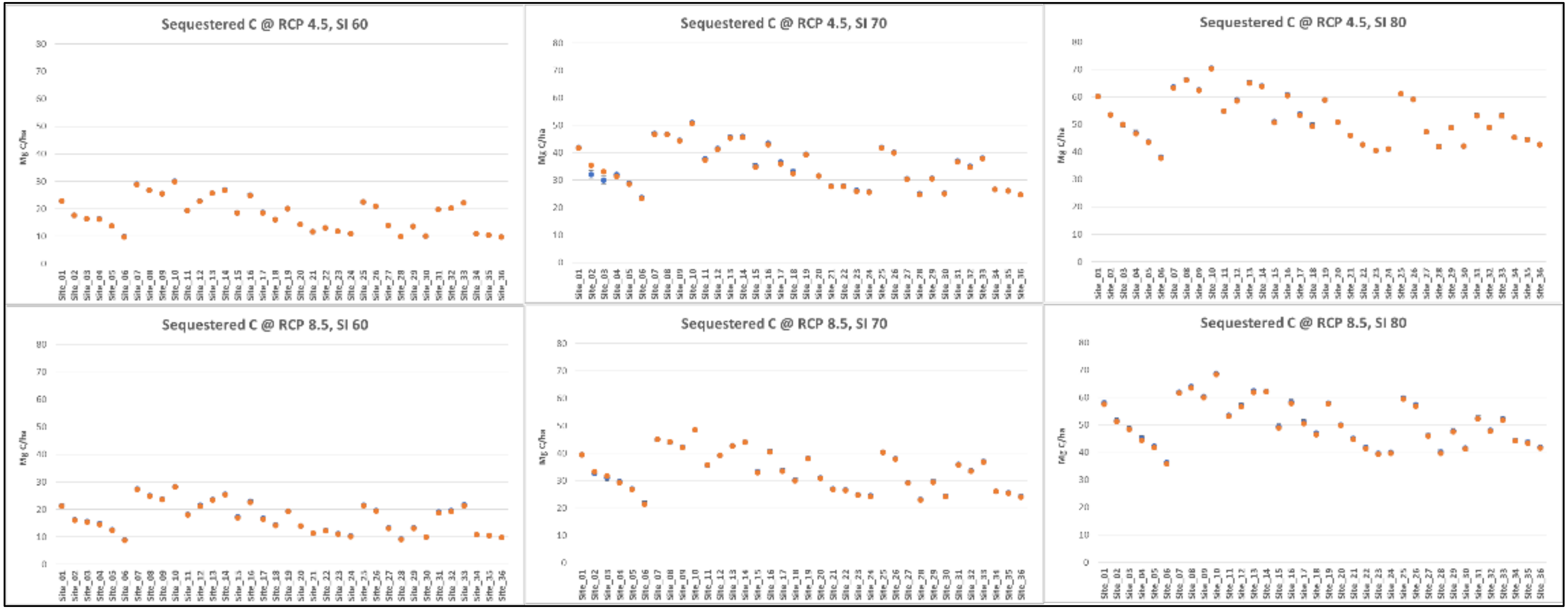
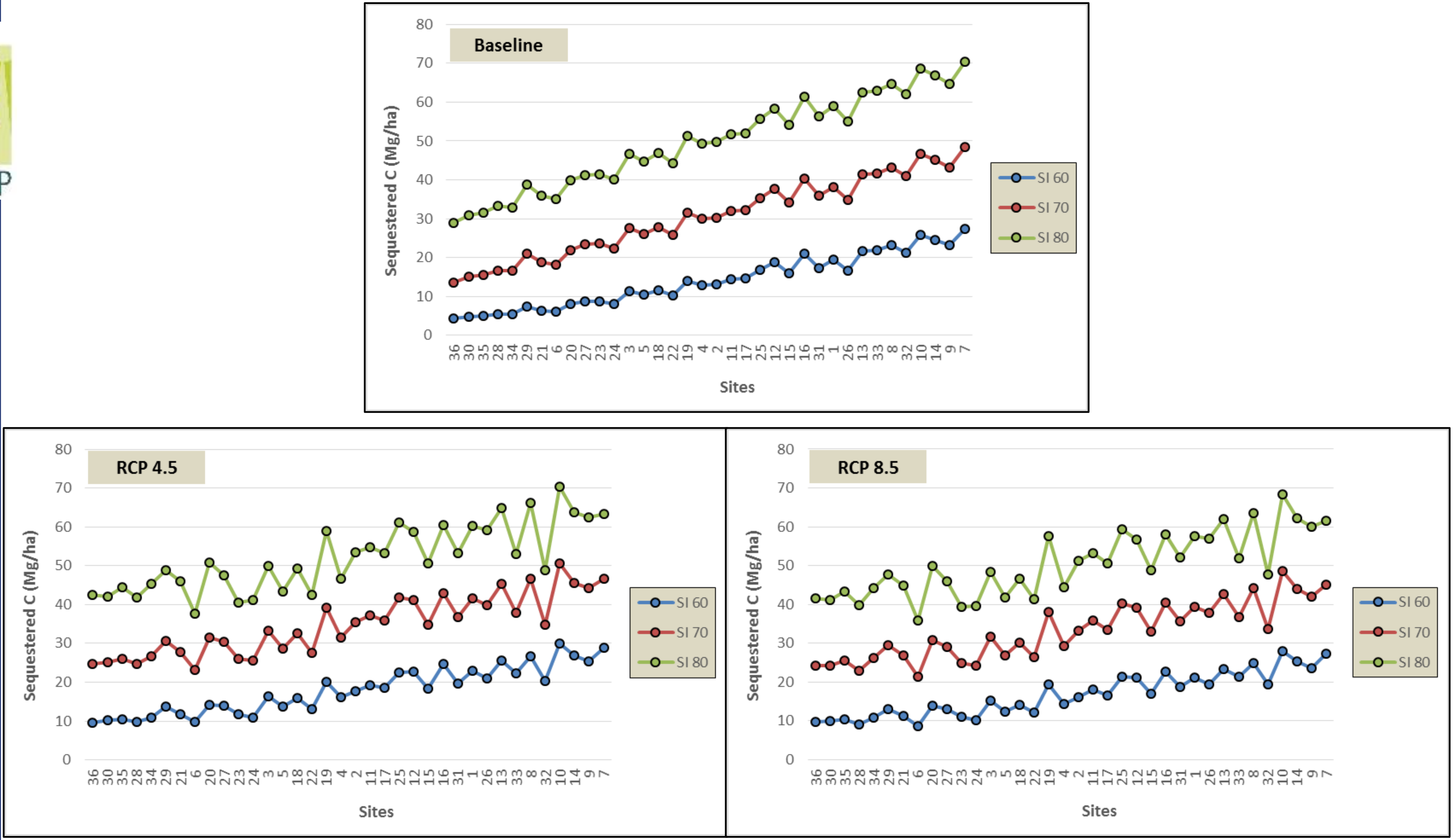
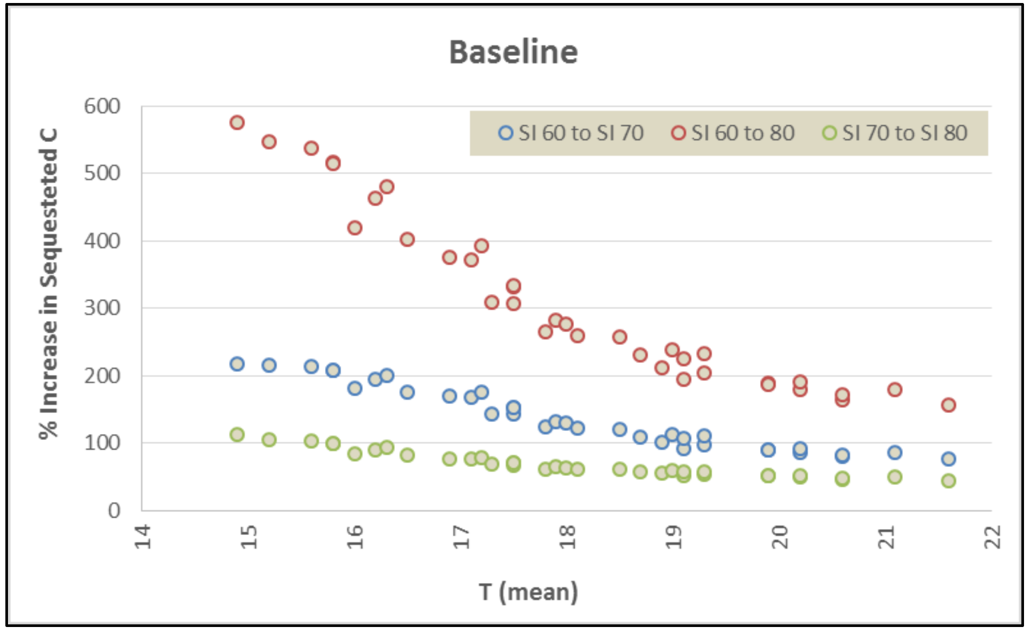
Avg_PW

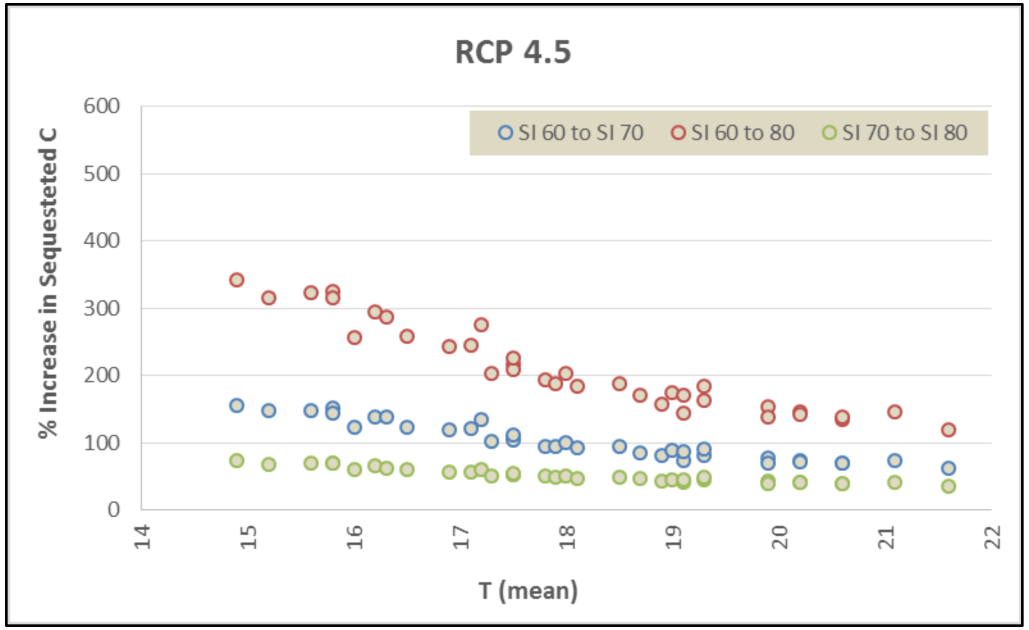
Mean (with standard error) of Sequestered Carbon for 20 Climate Models Superimposed on Sequestered Carbon Obtained from Average Yields

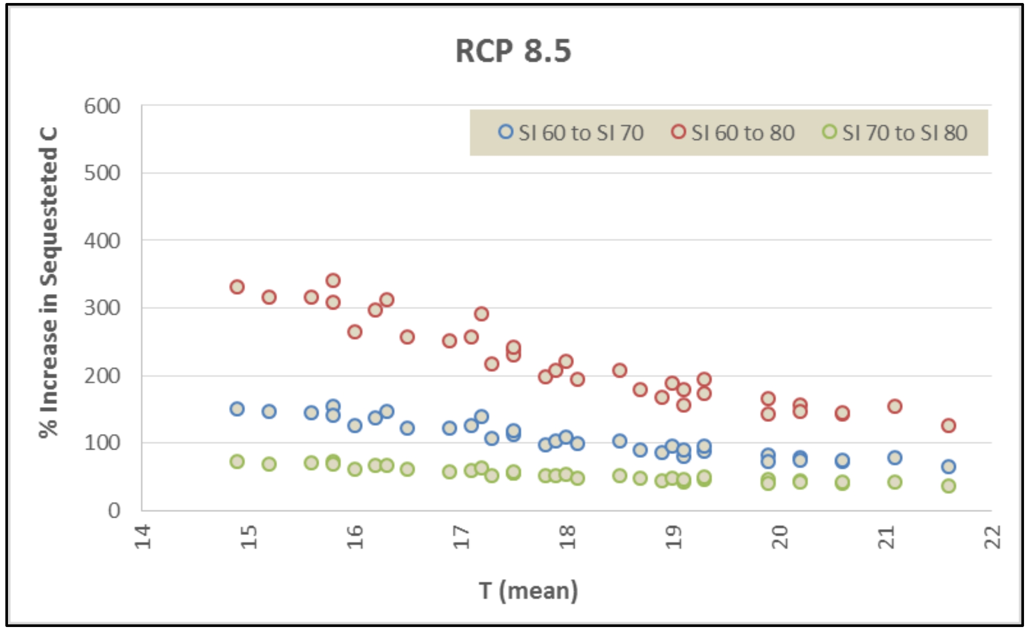




Sites are arranged in the increasing order of average temperature from left to right.







	SI 60 to SI 70	SI 60 to SI 80	SI 70 to SI 80
Baseline	137.9	310.4	68.9
RCP 4.5	102.9	210.5	51.6
RCP 8.5	106.7	219.9	53.5

(average across 36 sites for % increase in sequestered C)

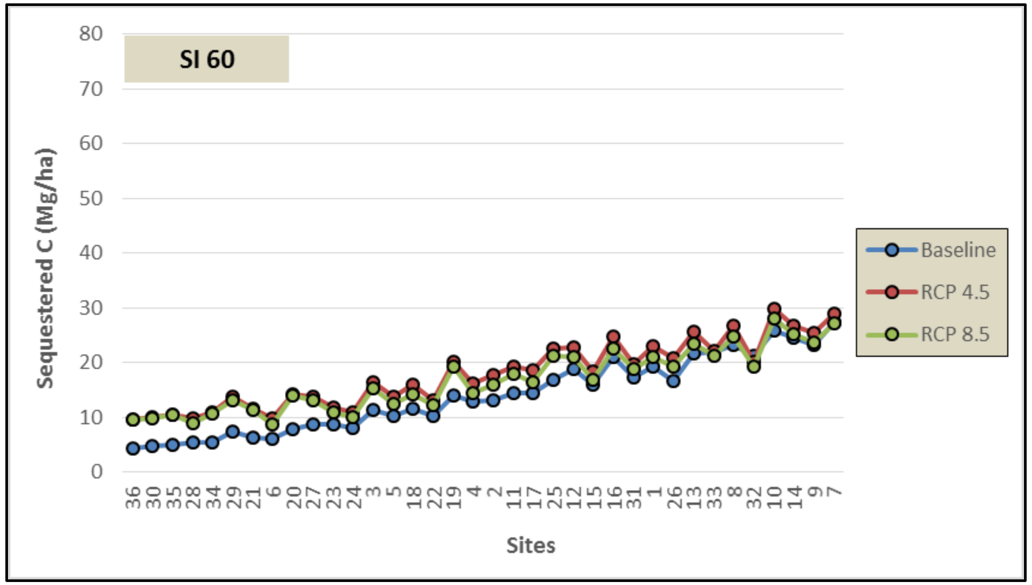
Note: All numbers are %.

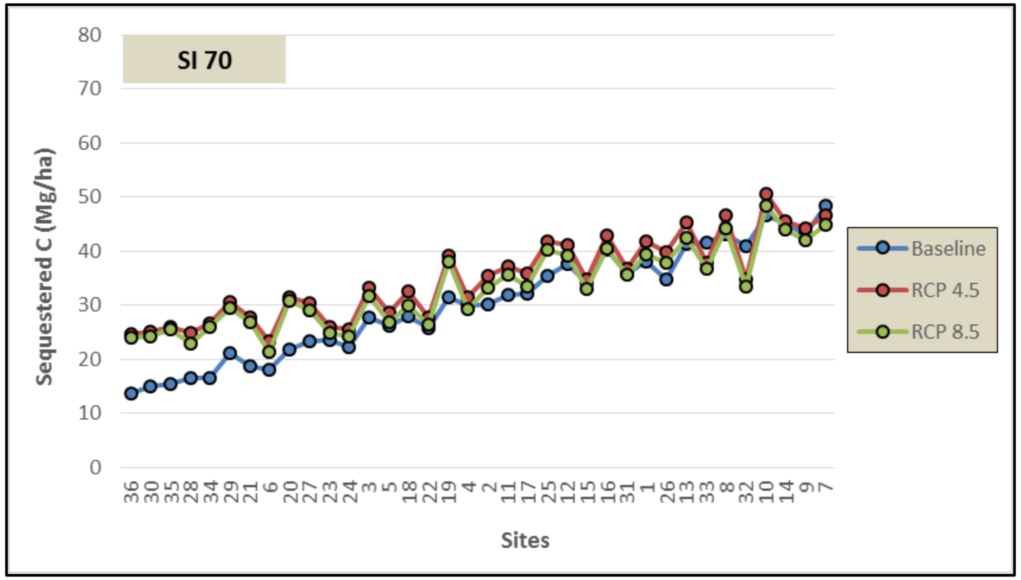
Sites are arranged in the increasing order of average temperature from left to right.

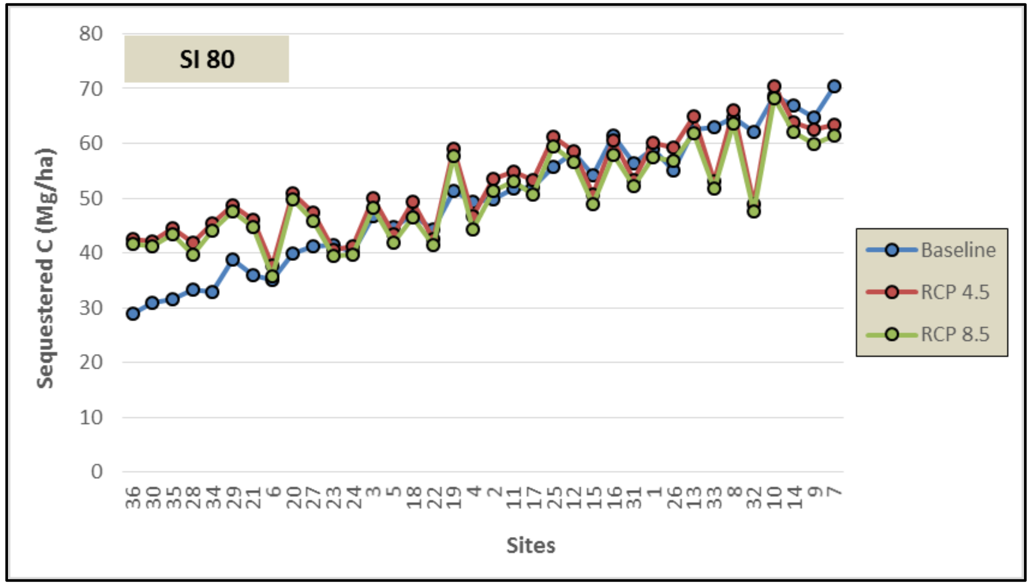
		SI 60 to SI 80		
		ST	CNS	PW
Rotation I	Site # 7 (warmest)	151.9	-2.2	-14.6
(25^{th} year)	Site # 36 (coldest)	747.6	30.3	-19.5
Rotation II	Site # 7 (warmest)	139.4	-4.6	-15.6
(50^{th} year)	Site # 36 (coldest)	500.6	19.4	-18.6
Rotation III	Site # 7 (warmest)	140.1	-6.8	-17.6
(75^{th} year)	Site # 36 (coldest)	423.5	15.3	-18.1

@ RCP 4.5.

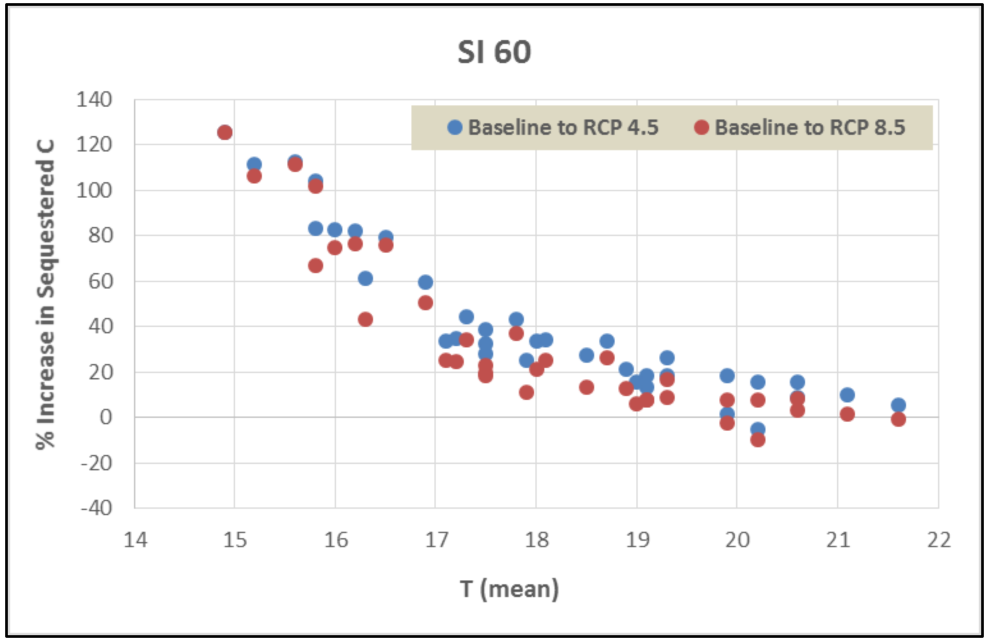
Note: All numbers are in %.

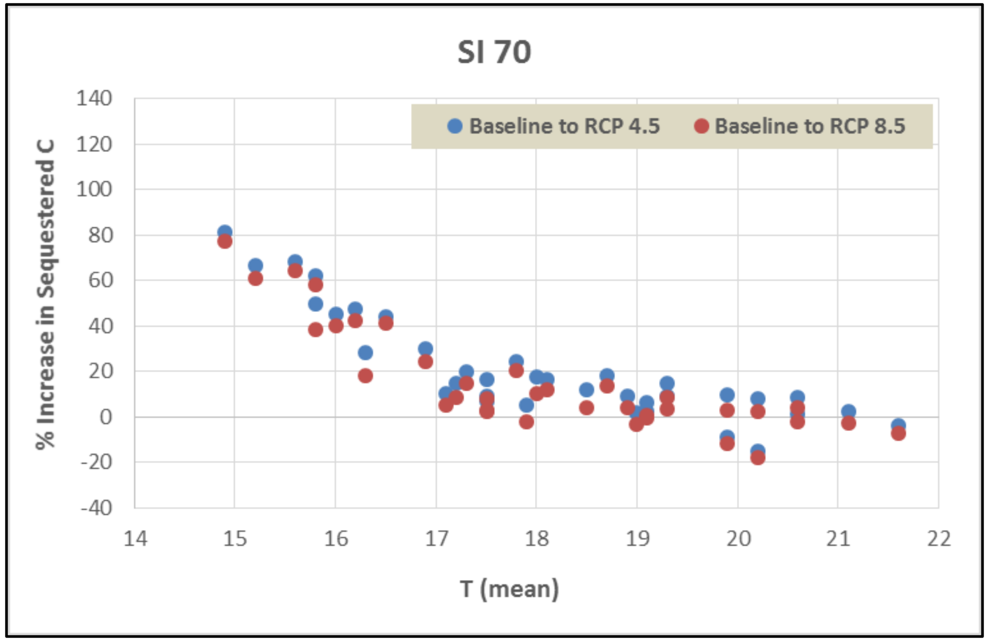


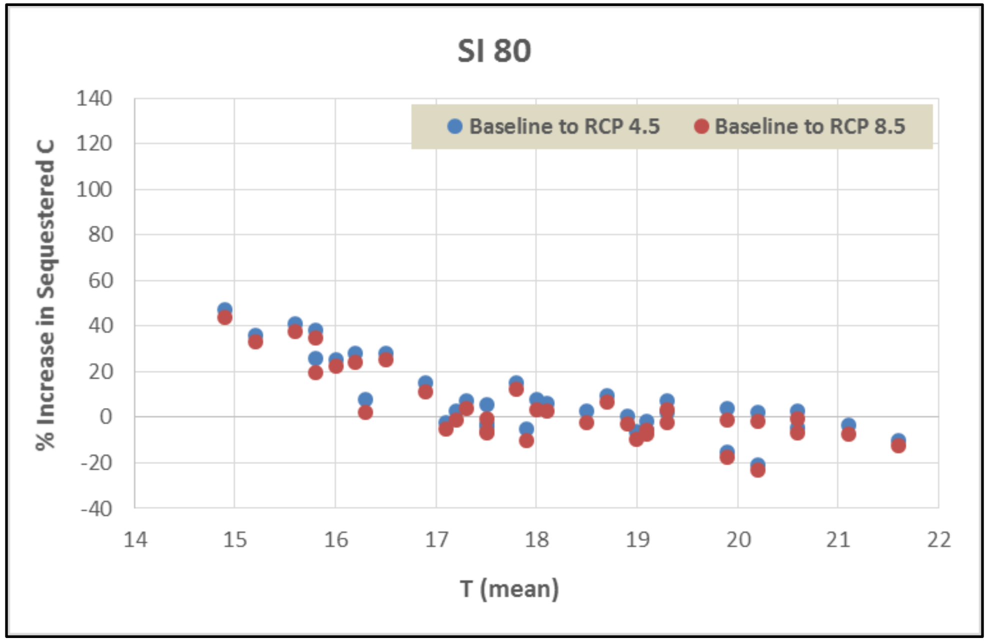




Sites are arranged in the increasing order of average temperature from left to right.





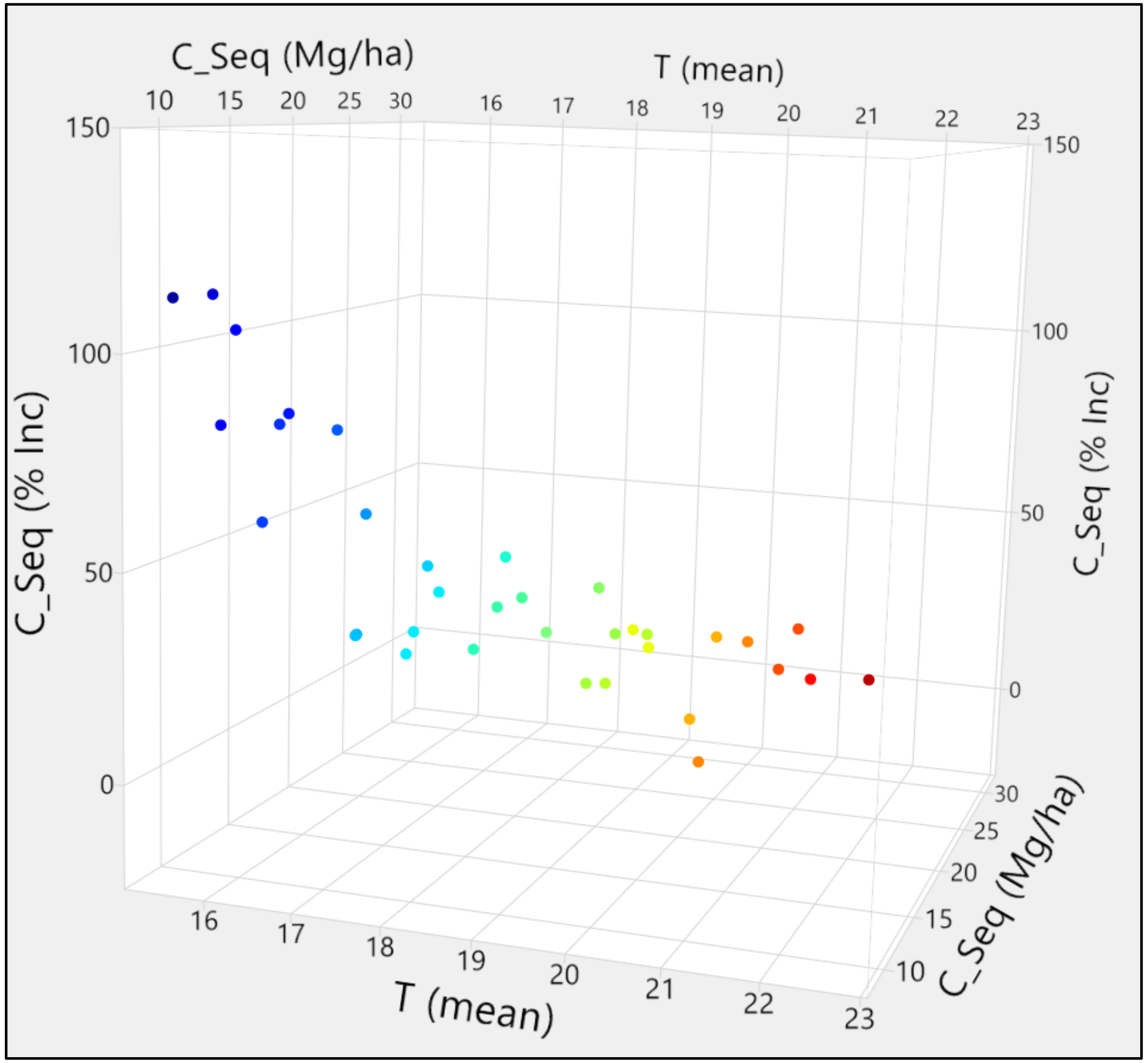


	Baseline to RCP 4.5	Baseline to RCP 8.5
SI 60	41.5	33.0
SI 70	20.5	15.1
SI 80	7.9	4.3

(across 36 sites)

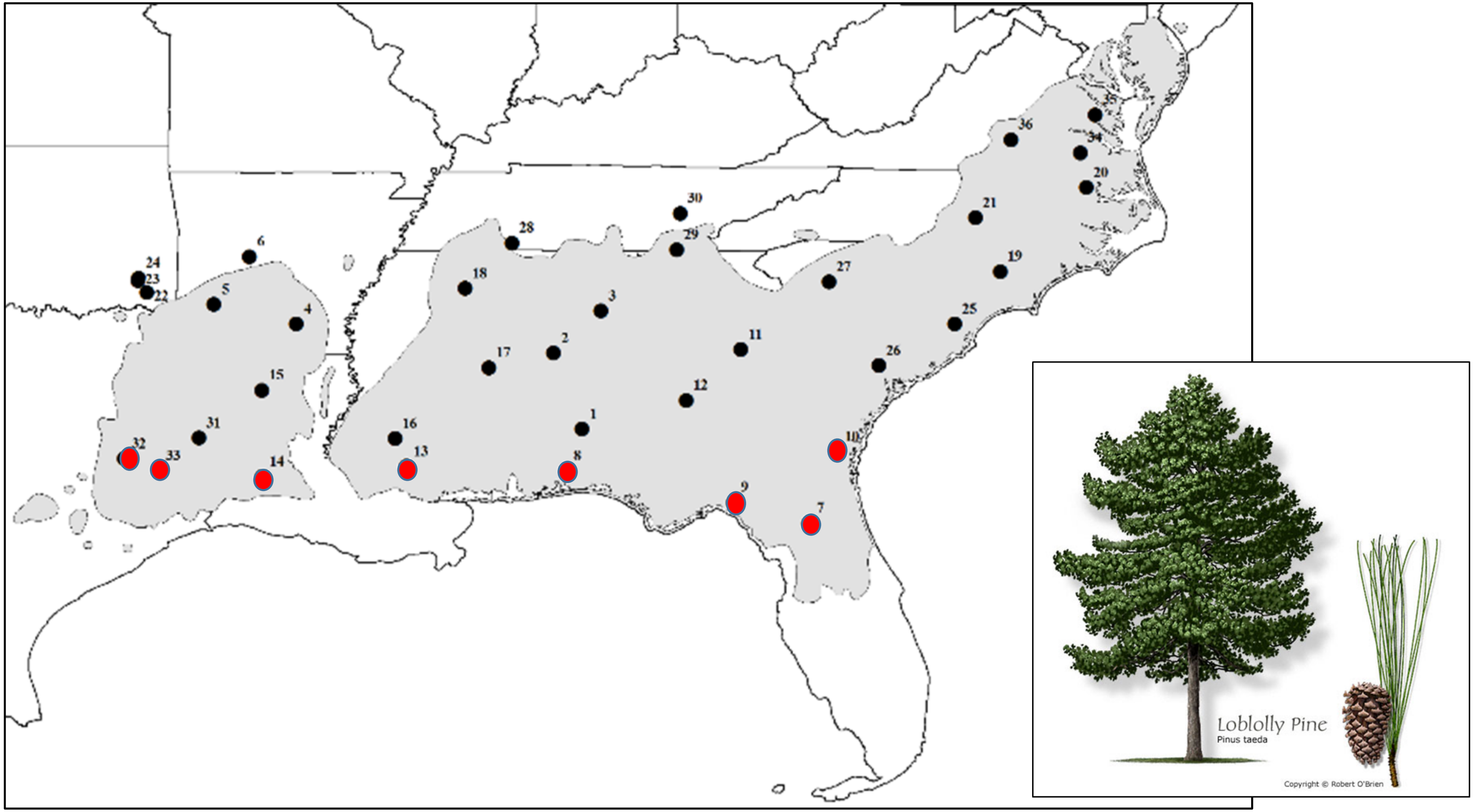
Note: All numbers are in %.

Conclusion



% increase in sequestered carbon is from Baseline to RCP 4.5 | Carbon sequestered is for RCP 4.5 | SI is 60.

Conclusion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Loblolly Pine
Pinus taeda
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Thanks!

puneetd@uga.edu

Warnell School of Forestry & Natural Resources
UNIVERSITY OF GEORGIA
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