Review of Agricultural Water Use in South Carolina

C. Alex Pellett

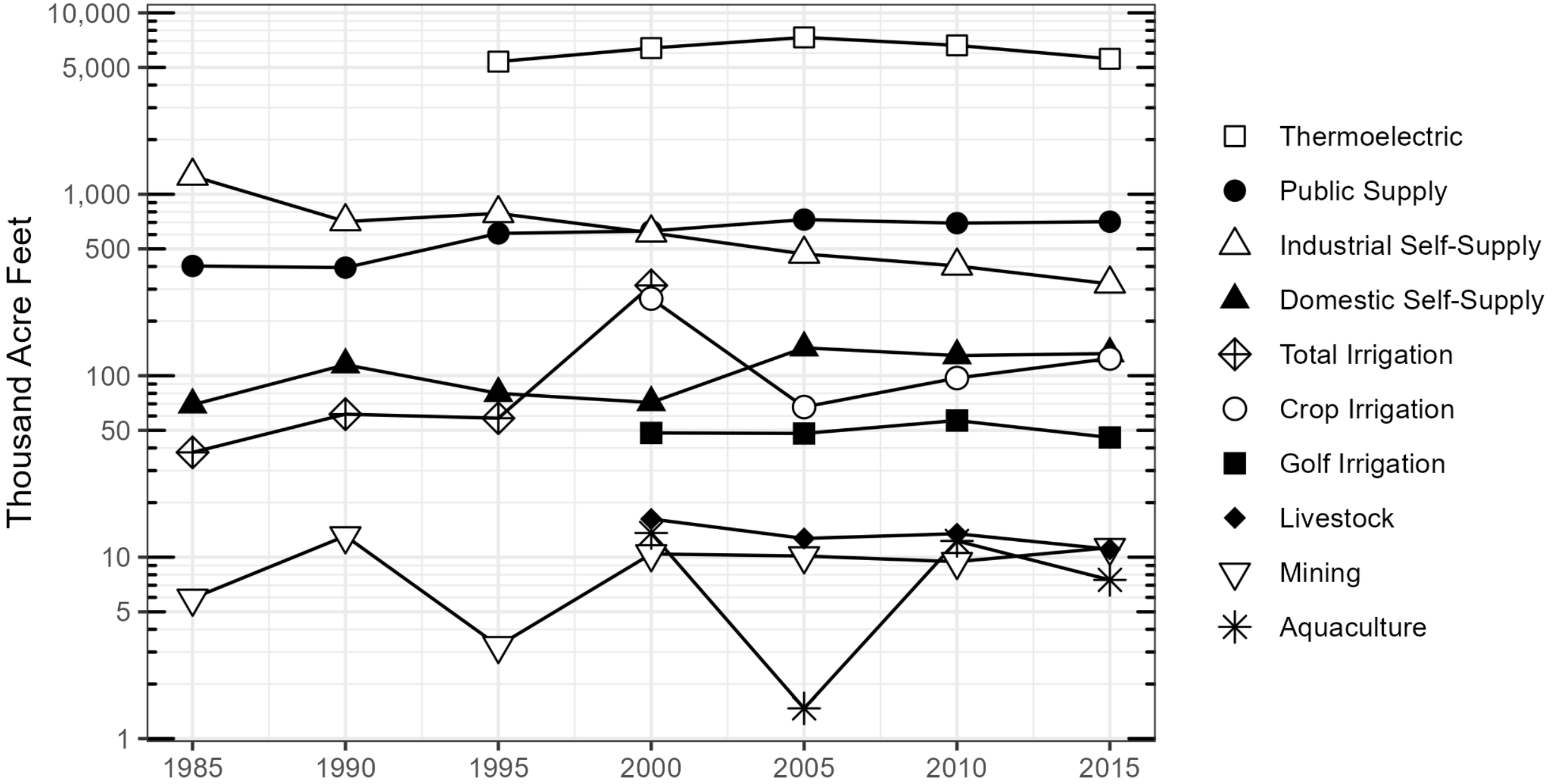
Hydrologist, South Carolina Department of Natural Resources

PhD Candidate, Plant and Environmental Sciences, Clemson University

Motivation

- Further research on agricultural water use was recommended by meeting participants during the development of water demand projection methods. (Walker 2018)
- Public comments on the draft projection methods brought up agriculture more than any other sector. (Pellett 2019, appendix C)
- Edisto River Basin Council members requested revisions to the water demand projections for agriculture and not other sectors. (Walker 2020).

Annual Water Use in South Carolina by Sector, 1985-2015



Source: USGS Water Use Data for the Nation

Other Agricultural Water Use

Livestock

~10,000 AFY, not including *irrigation* of forage or feed crops. Estimate derived from livestock counts in USDA Census of Agriculture 2017, tables 12, 19, 28, 29, and 30 and per capita water use estimates from Lovelace (2009).

Aquaculture

1,000 – 2,000 AFY in SCWU, or ~10,000 AFY according to USGS.

Irrigation under protection

60-150 AFY (FRIS 2013 Table 4; IWMS 2018 Table 4)

Dataset	Source	Reporting Unit	Time Period	Kinds of Information	Limitations/Gaps
Water Use Database (SCWU)	SC DHEC	Source water intake	Monthly, 1983-2021	Water withdrawal volume; intake locations.	3 MGM reporting threshold. Changing regulations and compliance. Self-reported values. Farm ponds.
Crop Acreage	USDA FSA	County	Annually, 2009-2022	Total and irrigated acreages for each crop in each county.	Only includes participants in FSA programs.
Census of Agriculture (COA)	USDA NASS	County	5-years, 2002-2017	Total and irrigated acreages for each crop in each county. Livestock counts.	Self-reported values.
Irrigation & Water Management Survey (IWMS)	USDA NASS	State	5-years, 2003-2018	Qualitative detail regarding agricultural water use.	Self-reported values. Small sample size. <50% response rate.
Clemson Irrigation Surveys	Smith, 2000; Sawyer 2018.	County	Annually, 1997-2000. Again in 2018	Irrigated acreage by distribution system for each county. 2018 survey includes qualitative detail.	The original survey is out-of-date. The updated survey had a low response rate in some counties.
SC Water Withdrawal Survey	Pellett and Walker, 2018	Withdrawer	One-time survey	Brief questionnaire with optional detailed form.	One time survey of permitted and registered water users. ~50% response rate.
Sprinkler Polygons	Pellett, 2020; Sekaran and Payero 2023	Field Scale	2-years, 2009-2021	Delineations of irrigated area polygons; center pivot geometry.	Lower resolution imagery in earlier years. Limited to visible irrigation.

Selected Survey Results (Sawyer et al 2018)

- the average respondent irrigated less than 500 acres, more in the Western and Low Country CUAs;
- over two-thirds of irrigated acres were row crops, with the remaining acreage in turf/hay, orchard, fruits/vegetables, other, or ornamentals, in decreasing order;
- nearly 60% of respondents used fixed-rate center pivots, and less than 10% used variable-rate center pivots;
- over 80% of respondents used fertigation, and over one-third of respondents used chemigation; and,
- over half of respondents intended to expand their irrigated acreage, and only 4% planned to decrease irrigated acreage.

Sawyer, Calvin, Jeffrey Allen, Mathew Smith, Thomas Walker, David Willis, Thomas Dobbins, Derrick Phinney, Kim Counts Morganello, Bryan Smith, Jose Payero, Adam Kantrovich and Nathan Smith (2018) "Agricultural Water Use in South Carolina: Preliminary Results of the South Carolina Agricultural Water Use and Irrigation Survey" Presentation to the South Carolina Water Resources Conference, 17 Oct. 2018

Selected Survey Results (Pellett & Walker 2018)

- over 75% of respondents considered their water supply critically important to their operation;
- over half of respondents were very concerned about water availability in the future;
- about a third of respondents planned to increase water usage in the next five years, and less than 3% planned to decrease; and,
- of those planning increased water use, the majority intended to use groundwater.

Pellett, C. Alex and Walker, Thomas III (2018) "Water Users' Perspectives: Summary of Withdrawal Survey Responses and Commentary," Journal of South Carolina Water Resources: Vol. 5 : Iss. 1 , Article 3. DOI: https://doi.org/10.34068/JSCWR.05.03 Available at: https://tigerprints.clemson.edu/jscwr/vol5/iss1/3

Consumptive Use

- Generally, agricultural water use has been assumed to be 100% consumptive in SC and GA water planning.
- This assumption is questionable, but precise estimates of consumptive use require site-specific information.
- Agricultural water use ranges from 3% - 27% of total annual water consumption in SC, generally from 5% - 15% in most years.
  - Nix, Heather Bergerud and Rad, Mani Rouhi (2023) "An Introduction to Consumptive Use of Water in South Carolina," Journal of South Carolina Water Resources: Vol. 9 : Iss. 1 , Article 10. Available at: https://tigerprints.clemson.edu/jscwr/vol9/iss1/10

Consumptive Use – stakeholder comments

- In some cases, center pivots have been found to be 80-90% consumptive.
- Irrigation through subsurface draintile often results in return flows to surface water and/or infiltration to groundwater. On a state-wide basis, subsurface irrigation is relatively minor and has not been expanding. Subsurface irrigation could be (is?) predominant in some areas of the state (in the Pee Dee basin?).
- Maximum water consumption (evapotranspiration) can be estimated using established methods without the need for field investigation. This could be relevant for water availability models and calculation of safe yield.

Irrigation Depth

Year	Water source			Acre Feet applied						Total
	Ground	Surface	Off-farm	<100	100-199	200-499	500-999	1,000-1,999	2,000+	
2003	6.9	6.7	2.4	4.1	(D)	6.4	(D)	(D)	(D)	**7.0**
2008	9.4	10.9	(D)	4.7	7.0	8.1	9.1	11.5	23.2	**9.9**
2013	6.7	6.7	9.4	3.8	4.9	6.4	8.2	8.1	10.9	**6.9**
2018	9.7	7.3	10.5	5.5	7.2	7.5	10.7	13.7	11.3	**9.7**

Water source data from: FRIS 2003 Table 11; FRIS 2008 Table 11; FRIS 2013 Table 4; IWMS 2018 Table 4

Quantity applied data from: FRIS 2003 Table 12; FRIS 2008 Table 12; FRIS 2013 Table 6; IWMS 2018 Table 7.

- Irrigators who apply greater volumes have tended to irrigate deeper.
- In 2008, the largest volume-class reportedly averaged nearly two feet.
- The largest volume-classes of irrigators might have the best economies of scale to irrigate liberally.
- Consistently, the smallest volume-class has applied lower depths than the overall average.

Discontinuation

	Farms				Acres			
	2003	2008	2013	2018	2003	2008	2013	2018
Permanent discontinuation	26	179	76	131	1,180	1,815	323	249
Sufficient soil moisture	535	7	281	362	23,976	668	31,431	1,389
Irrigation is uneconomical	10	52	53	204	532	124	636	996
Shortage of surface water	-	89	51	25	-	(D)	114	25
Shortage of ground water	-	88	-	-	-	88	-	-
Available surface water too salty	-	-	44	77	-	-	222	351
Converted to non-irrigating agriculture	10	8	15	-	375	80	1,684	-
Converted to non-agricultural uses	-	-	9	-	-	-	9	-
Restrictions on water use	-	-	8	-	-	-	16	-
Loss of water rights	-	-	-	-	-	-	-	-
Sold or leased water rights	-	-	43	-	-	-	172	-
Sold or leased irrigated land	-	-	-	-	-	-	-	-
Other or unspecified (see text)	273	249	333	25	7,575	3,984	6,756	-
Total	**545**	**353**	**668**	**463**	**24,351**	**6,092**	**40,000**	**2,204**

Sources: 2003 FRIS Table 42; 2008 FRIS Table 43; 2013 FRIS Table 27; 2018 IWMS Table 27

Under-reporting in SCWU

The USDA NASS Surveys (IWMS and FRIS) have consistently estimated more irrigators than the number reported in the SCWU database.

Most years, total irrigation volumes have matched closely, with the exception of 2018, when the NASS Survey indicated ~25% more irrigation volume than the SCWU database.

The Coefficient of Variation for irrigation volume in the 2018 IWMS is estimated at 36.7%.

TABLE: Comparison of the number of farms and irrigation volume by water source in IWMS and SCWU data.

	Year	Irrigators			Volume (AF)	
		IWMS	Permittees	Permits	IWMS	SCWU
Ground	2003	702	132	154	18,041	21,323
	2008	472	149	179	58,233	59,513
	2013	697	226	269	57,034	52,652
	2018	1,109	413	500	175,732	130,700
Surface	2003	306	98	100	12,243	16,057
	2008	308	100	105	27,847	35,215
	2013	217	97	102	18,543	22,122
	2018	272	97	104	26,313	32,525
Total	2003	951	191	215	30,332	37,380
	2008	712	203	238	86,236	94,727
	2013	1,046	277	325	77,382	74,774
	2018	1,489	458	554	203,411	163,225

IWMS data is "Acres in the open" from: FRIS 2003 Table 11; FRIS 2008 Table 11; FRIS 2013 Table 4; IWMS 2018 Table 4

Irrigation below 3 MGM

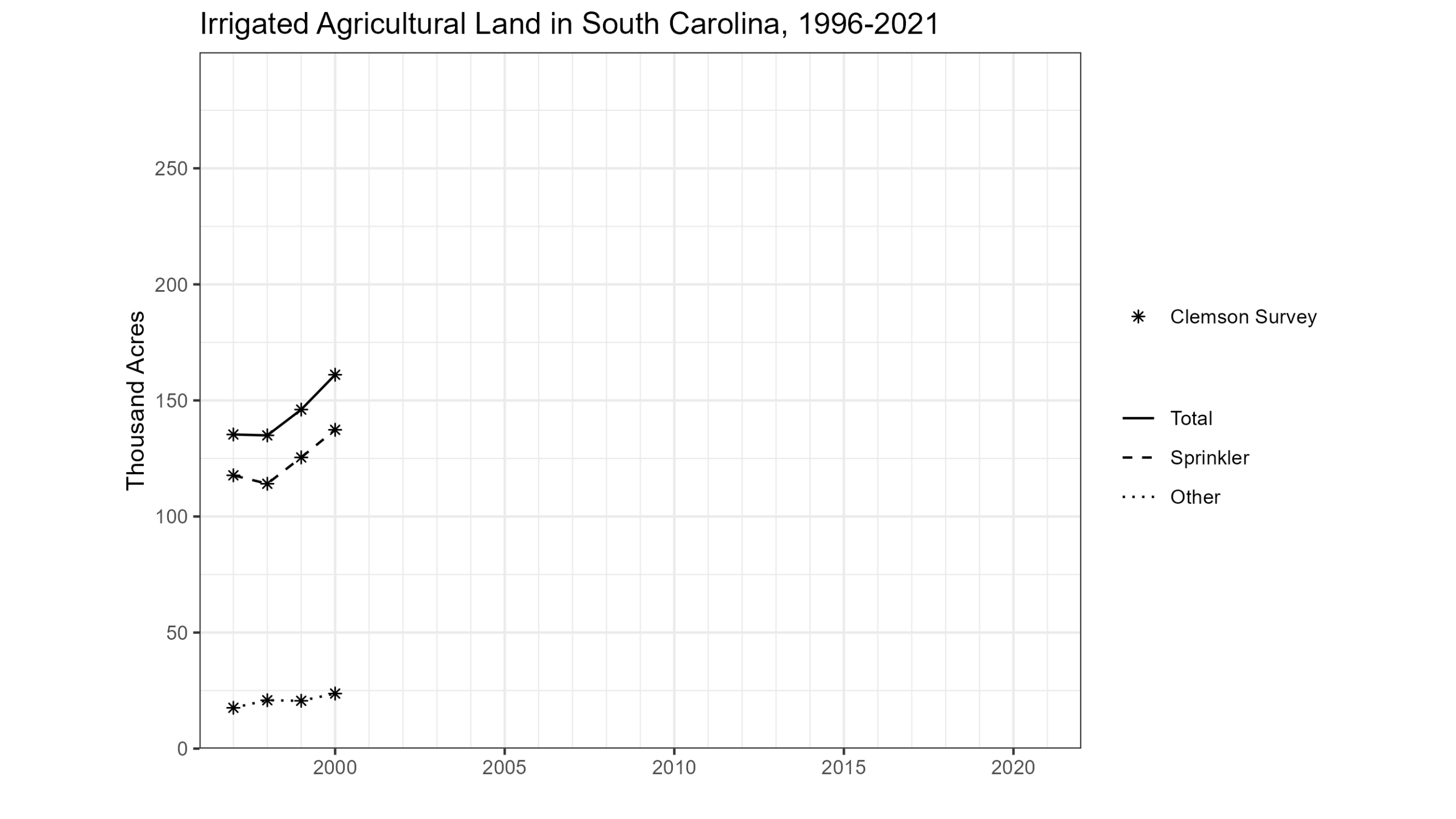
Small-volume irrigators (<100 AFY) are the only class of irrigators which are consistently under-reported in the SCWU database.

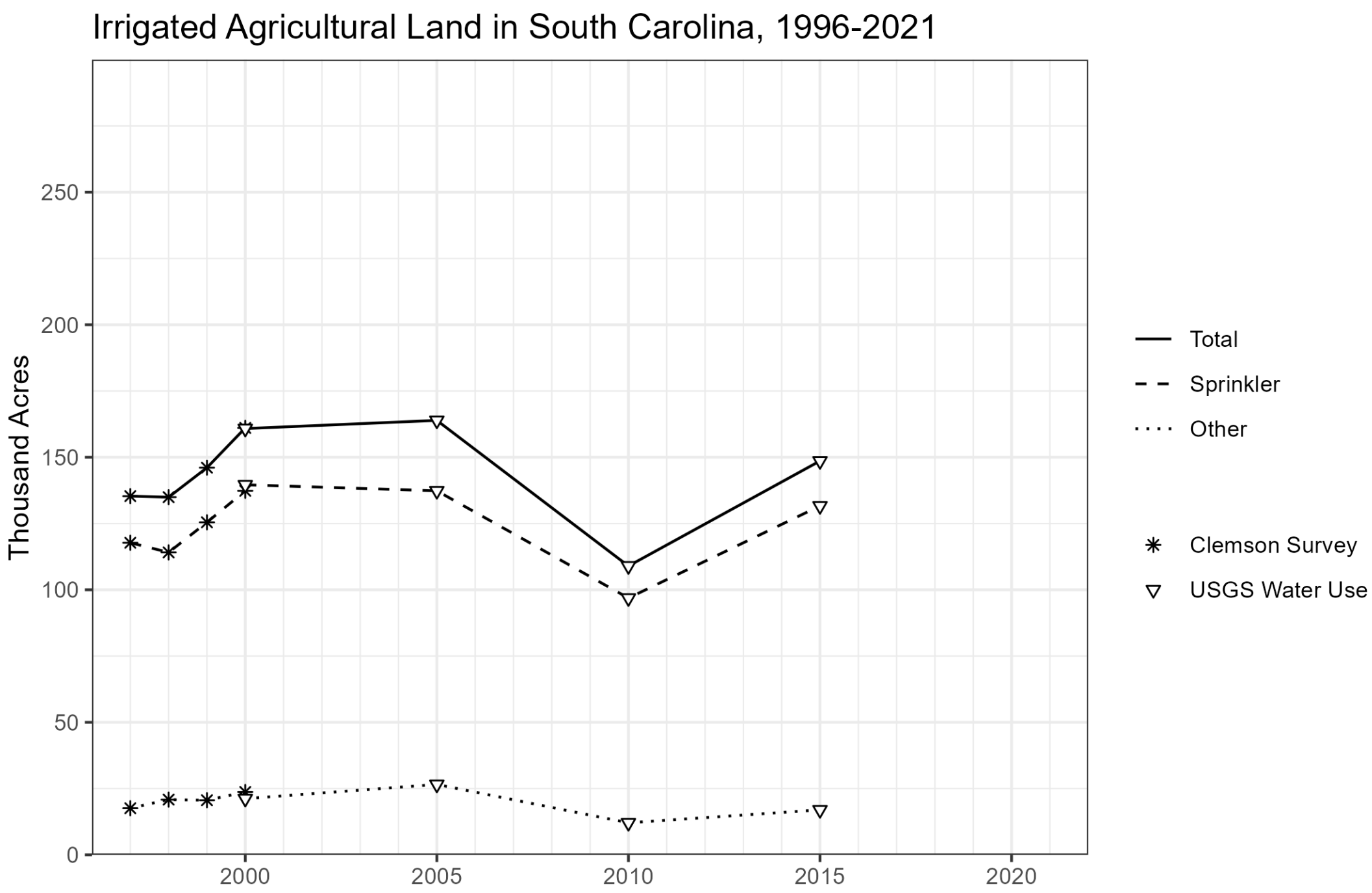
The 3 MGM reporting threshold equals 9.2 AFM.

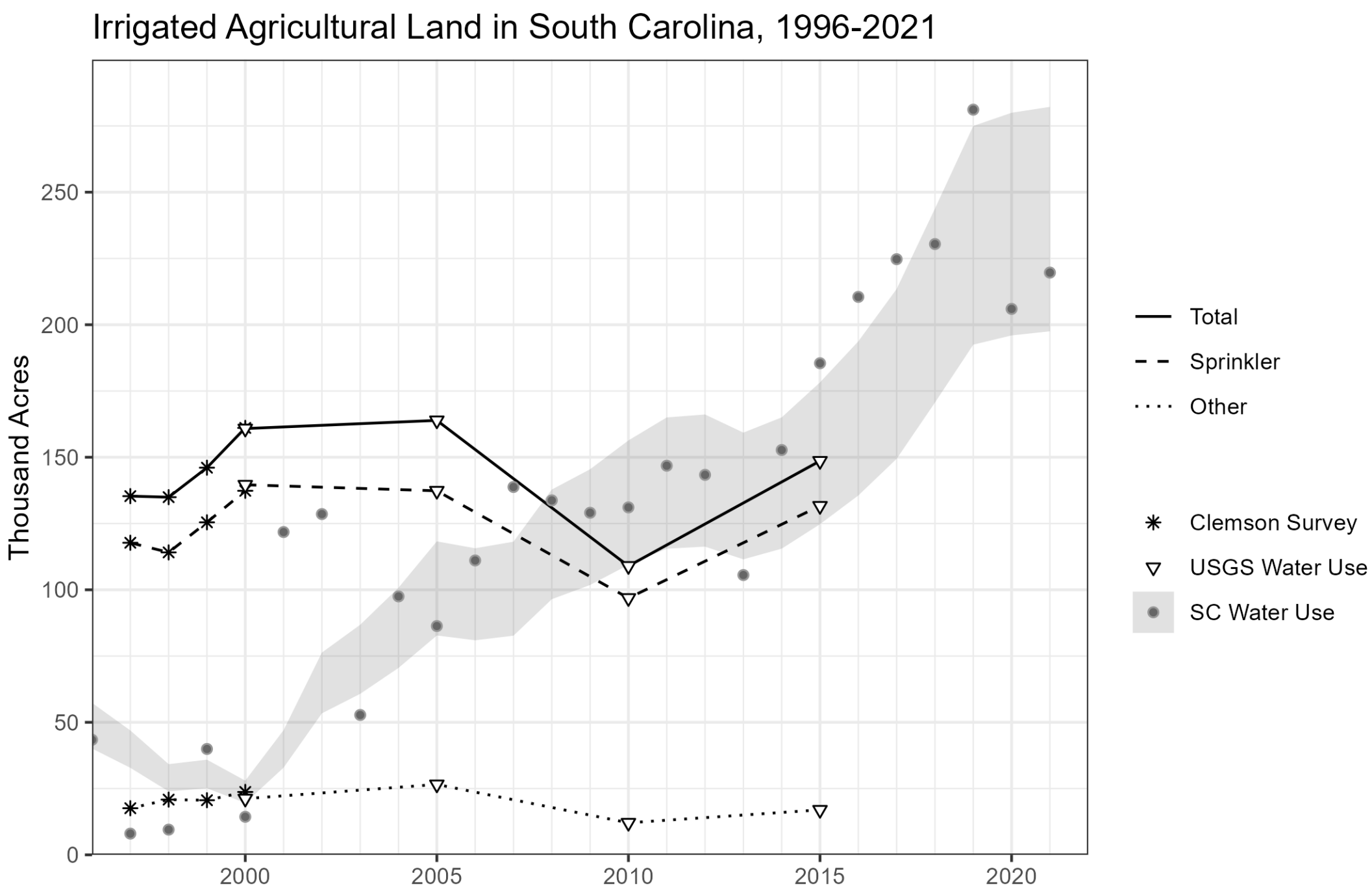
Perhaps 1,000 irrigators below the 3 MGM threshold, irrigating a total of 2,000 – 5,000 AFY

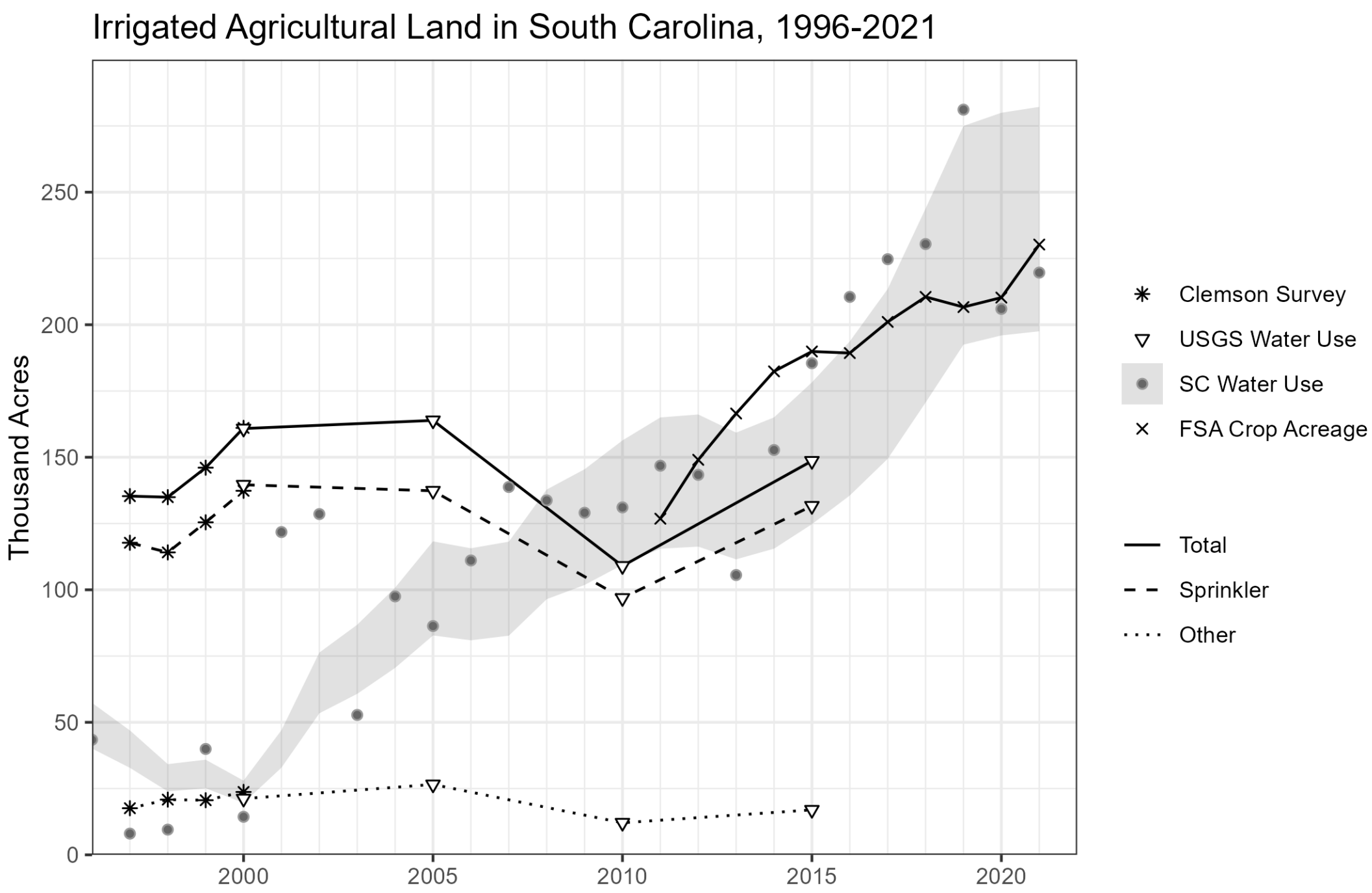
Acre Feet applied	Year	Irrigators			Volume (AF)		
		IWMS	Permittees	Permits	IWMS	Permittees	Permits
<100	2003	900	136	156	6,283	2,656	3,417
	2008	589	111	126	8,471	3,334	4,144
	2013	856	181	216	10,567	4,521	5,541
	2018	1,156	219	273	13,065	8,000	10,675
100-199	2003	19	16	22	(D)	2,290	3,011
	2008	42	30	40	6,028	4,436	5,958
	2013	31	31	39	4,275	4,235	5,428
	2018	50	73	101	6,581	10,459	14,263
200-499	2003	19	19	19	6,633	5,580	5,444
	2008	34	21	32	10,320	6,623	9,927
	2013	40	31	36	11,990	9,830	11,520
	2018	114	87	106	44,263	28,246	33,913
500-999	2003	6	10	8	(D)	6,320	4,986
	2008	28	23	22	18,550	16,098	14,755
	2013	26	20	21	18,347	13,730	14,511
	2018	68	46	42	45,656	31,001	27,696
1,000-1,999	2003	6	7	7	8,160	9,431	9,418
	2008	14	5	5	19,346	6,045	5,881
	2013	9	9	7	13,677	12,285	9,297
	2018	41	20	19	46,350	26,835	25,628
2,000+	2003	1	3	3	(D)	11,103	11,103
	2008	5	13	13	23,521	58,191	54,063
	2013	5	5	6	18,378	30,173	28,477
	2018	11	13	13	47,436	58,683	51,051

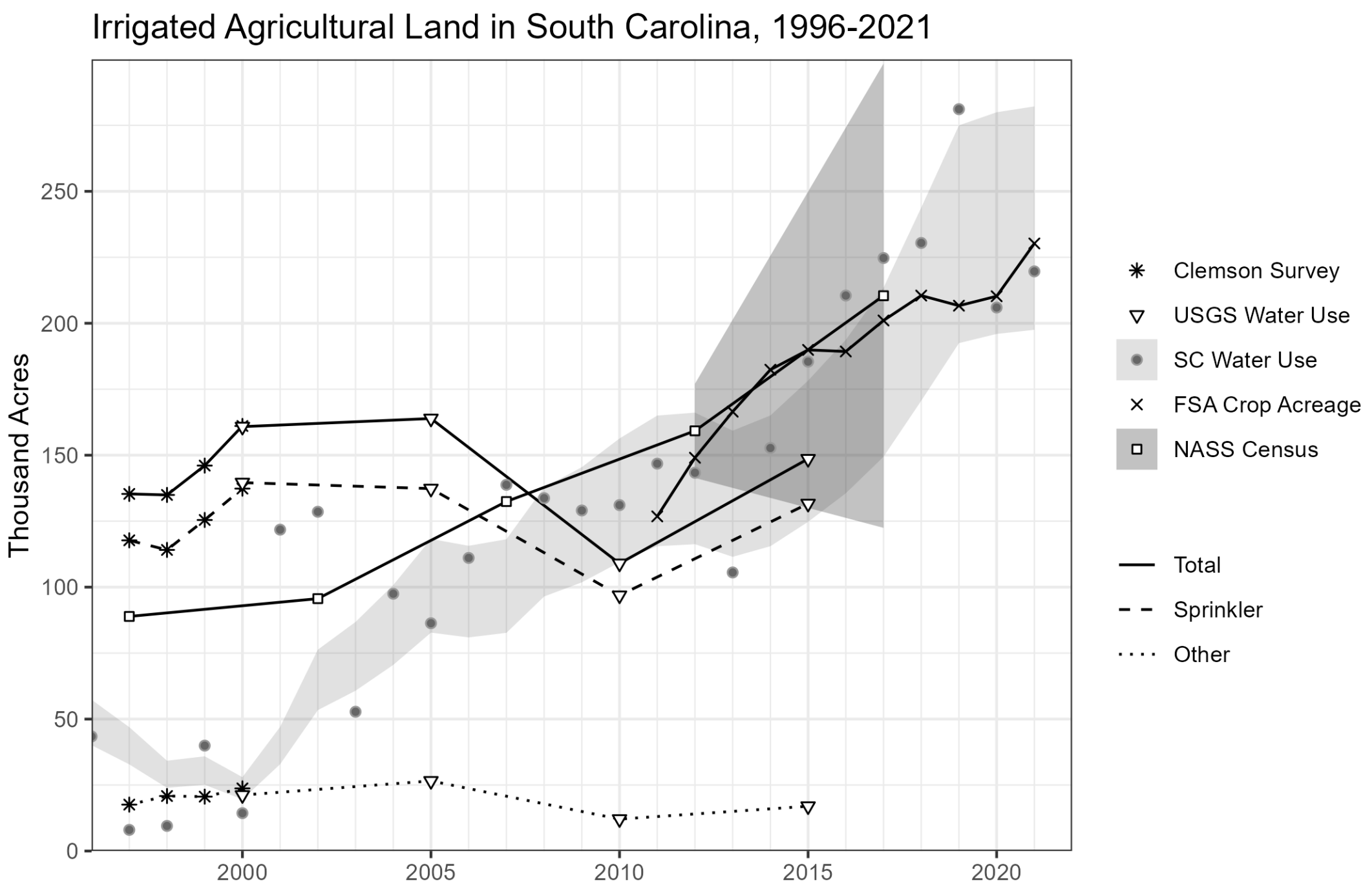
IWMS data is "Acres in the open" from : FRIS 2003 Table 12; FRIS 2008 Table 12; FRIS 2013 Table 6; IWMS Table 7.

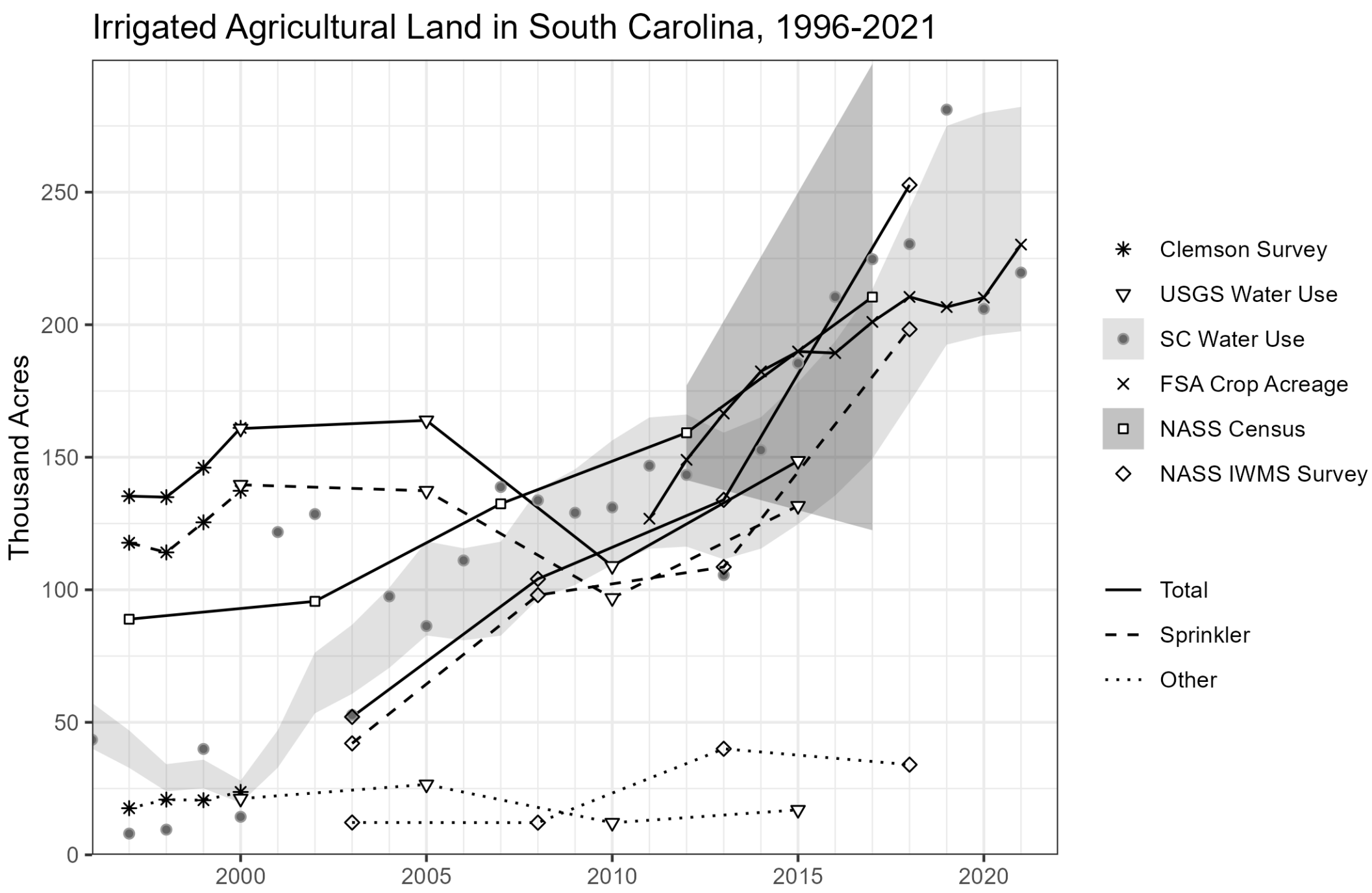

Irrigated Agricultural Land in South Carolina, 1996-2021
Thousand Acres
250
200
150
100
50
0
2000
2005
2010
2015
2020
Clemson Survey
Total
Sprinkler
Other

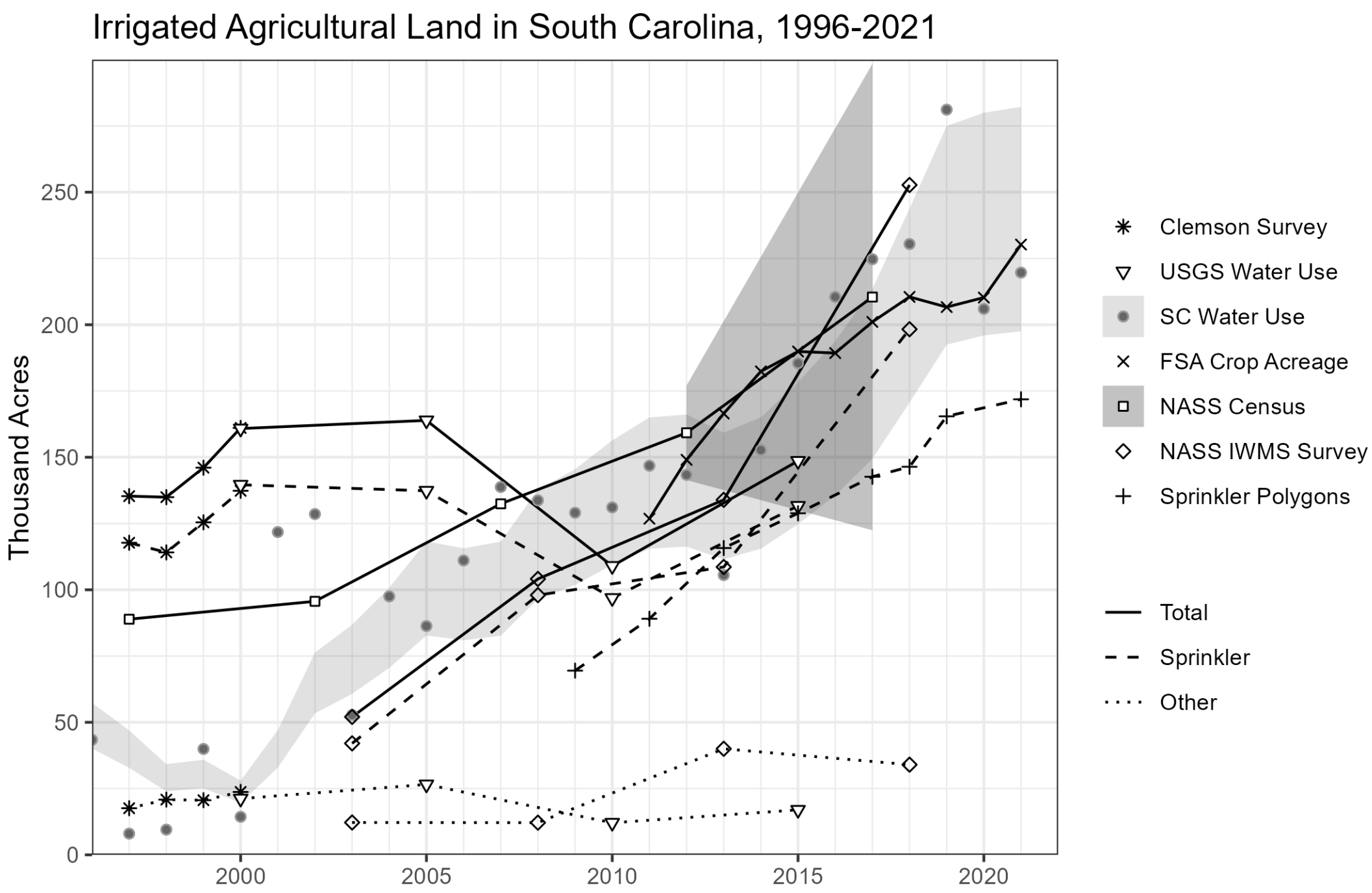

Irrigated Agricultural Land in South Carolina, 1996-2021
Thousand Acres
250
200
150
100
50
0
2000
2005
2010
2015
2020
Total
Sprinkler
Other
Clemson Survey
USGS Water Use

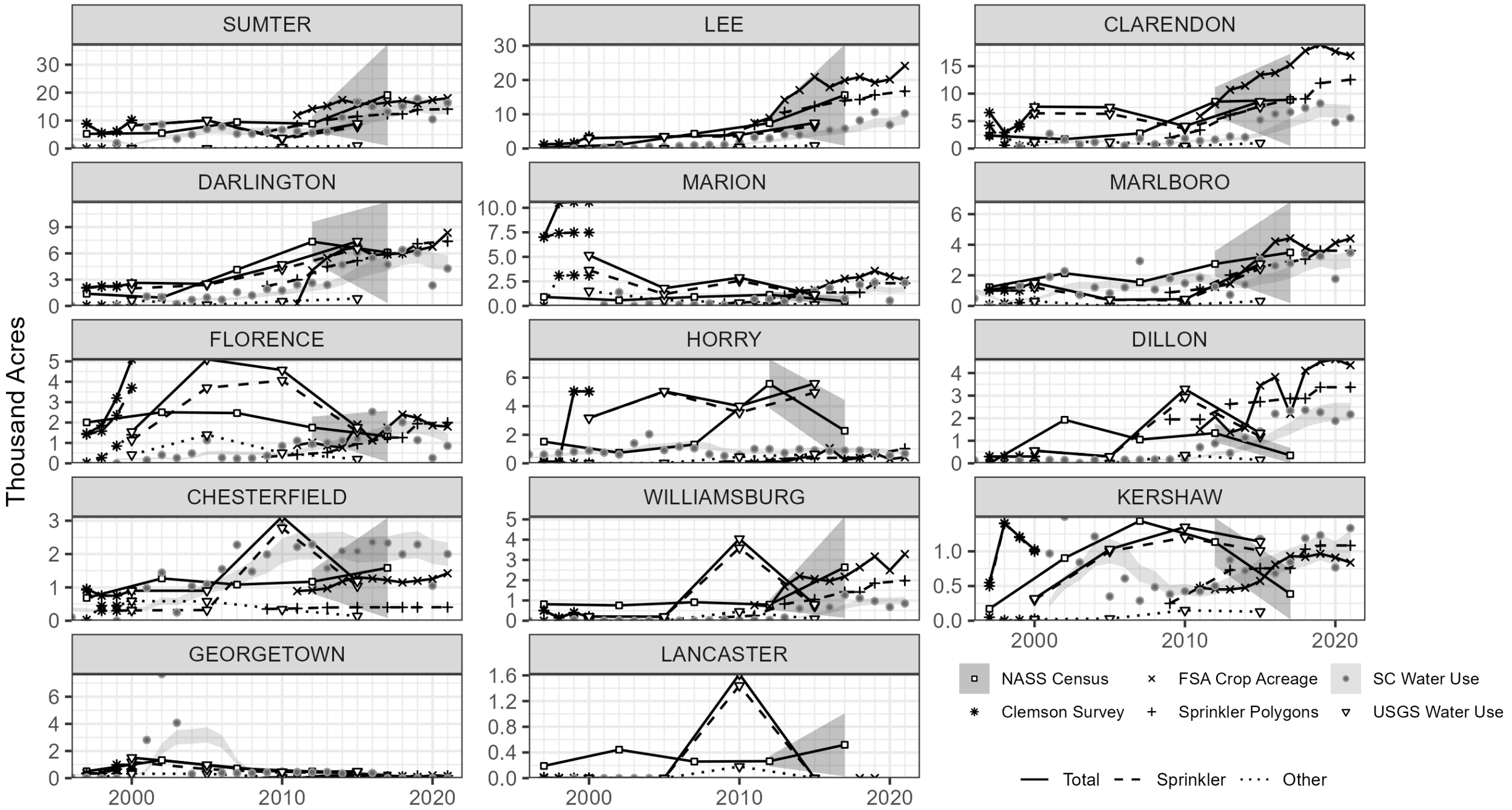

Irrigated Agricultural Land in South Carolina, 1996-2021
Thousand Acres
250
200
150
100
50
0
2000
2005
2010
2015
2020
Total
Sprinkler
Other
Clemson Survey
USGS Water Use
SC Water Use


Irrigated Agricultural Land in South Carolina, 1996-2021
Thousand Acres
0
50
100
150
200
250
2000
2005
2010
2015
2020
Clemson Survey
USGS Water Use
SC Water Use
FSA Crop Acreage
Total
Sprinkler
Other


Irrigated Agricultural Land in South Carolina, 1996-2021
Thousand Acres
0
50
100
150
200
250
2000
2005
2010
2015
2020
Clemson Survey
USGS Water Use
SC Water Use
FSA Crop Acreage
NASS Census
Total
Sprinkler
Other


Irrigated Agricultural Land in South Carolina, 1996-2021
Thousand Acres
0
50
100
150
200
250
2000
2005
2010
2015
2020
Clemson Survey
USGS Water Use
SC Water Use
FSA Crop Acreage
NASS Census
NASS IWMS Survey
Total
Sprinkler
Other


Irrigated Agricultural Land in South Carolina, 1996-2021
Thousand Acres
250
200
150
100
50
0
2000
2005
2010
2015
2020
Clemson Survey
USGS Water Use
SC Water Use
FSA Crop Acreage
NASS Census
NASS IWMS Survey
Sprinkler Polygons
Total
Sprinkler
Other


Irrigated Agricultural Land in Counties Overlying the Pee Dee Basin of South Carolina, 1996-2
Thousand Acres
SUMTER
LEE
CLARENDON
DARLINGTON
MARION
MARLBORO
FLORENCE
HORRY
DILLON
CHESTERFIELD
WILLIAMSBURG
KERSHAW
GEORGETOWN
LANCASTER
2000
2010
2020
NASS Census
FSA Crop Acreage
SC Water Use
Clemson Survey
Sprinkler Polygons
USGS Water Use
Total
Sprinkler
Other

Can irrigation continue to expand?

- Irrigators have commented on limited availability of suitable land for center pivot sprinklers.
- Geographic constraints on center pivots do not appear to limit projected growth (44% over 50 years).
- Economic and logistical constraints may reduce growth in the short-term.
- Medium and long-term agro-economic trends could promote growth.
- Hotter and more variable weather could promote growth.

Geographic Constraints on Center Pivots

Dataset	Source	Constraints
Irrigated Area Polygons	Pellett 2020, Sekaran and Payero 2021	Existing irrigation is a constraint on future growth. This dataset is also used to evaluate the relevance of the other constraints.
Landcover	USGS National Land Cover Dataset, Sanchez et al. 2018	Open water, wetlands, developed areas. Sanchez' projection of future development in year 2065 provides an estimate of increasing constraints.
Soil	USDA SSURGO	Hydric Soils that are unsuitable for agriculture.
Elevation	USGS National Elevation Dataset	Areas with high slope.
Protected Areas	USGS PAD-US	Protected areas may be unavailable for agriculture.
Parcels	SCDNR internal dataset	Small parcels may be unsuitable for agriculture.

Web Map ranking irrigable areas for projected growth of irrigation