FORECASTING FLORIDA CITRUS PRODUCTION WITH A STRUCTURAL MODEL OF CITRUS SUPPLY

Derek Farnsworth | Assistant Professor

Who am I?

- Assistant Professor
  - Food and Resource Economics @ UF
  - Teaching and Extension appointment
  - Graduate of UC Davis ag-econ

- Avid computer nerd

- Frisbee and badminton enthusiast

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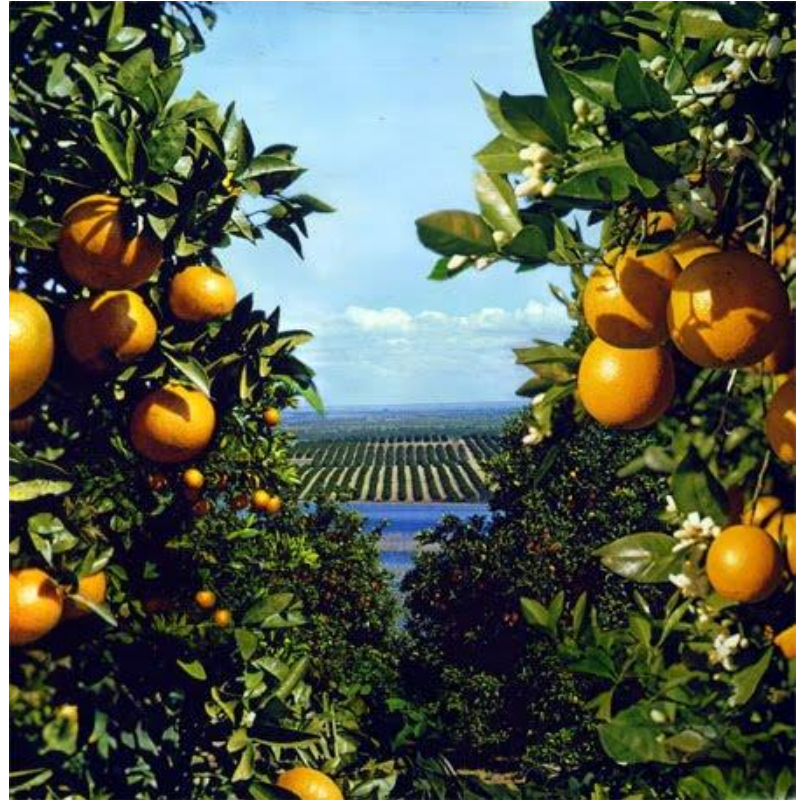
Introduction

- *Why model citrus supply <u>now</u>?*
  - **Citrus greening** has dramatically <u>reduced citrus production</u> in Florida (50%+ decrease since 2004)
  - Greening has also <u>changed the tree-age distribution</u>

- *We want to predict what future production may look like given these structural changes*

Production and yield for the top ten citrus producing countries in 2016

Rank	Country	Production (10^6 lbs)	Average yield (10^3 lbs/ac)
1	China	83,607	225
2	Brazil	43,192	203
3	India	26,550	135
4	Mexico	17,880	133
5	United States of America	16,566	251
6	Spain	15,481	170
7	Egypt	10,601	178
8	Turkey	9,464	258
9	Nigeria	8,957	43
10	Iran (Islamic Republic of)	8,256	169

Countries reporting citrus greening infections
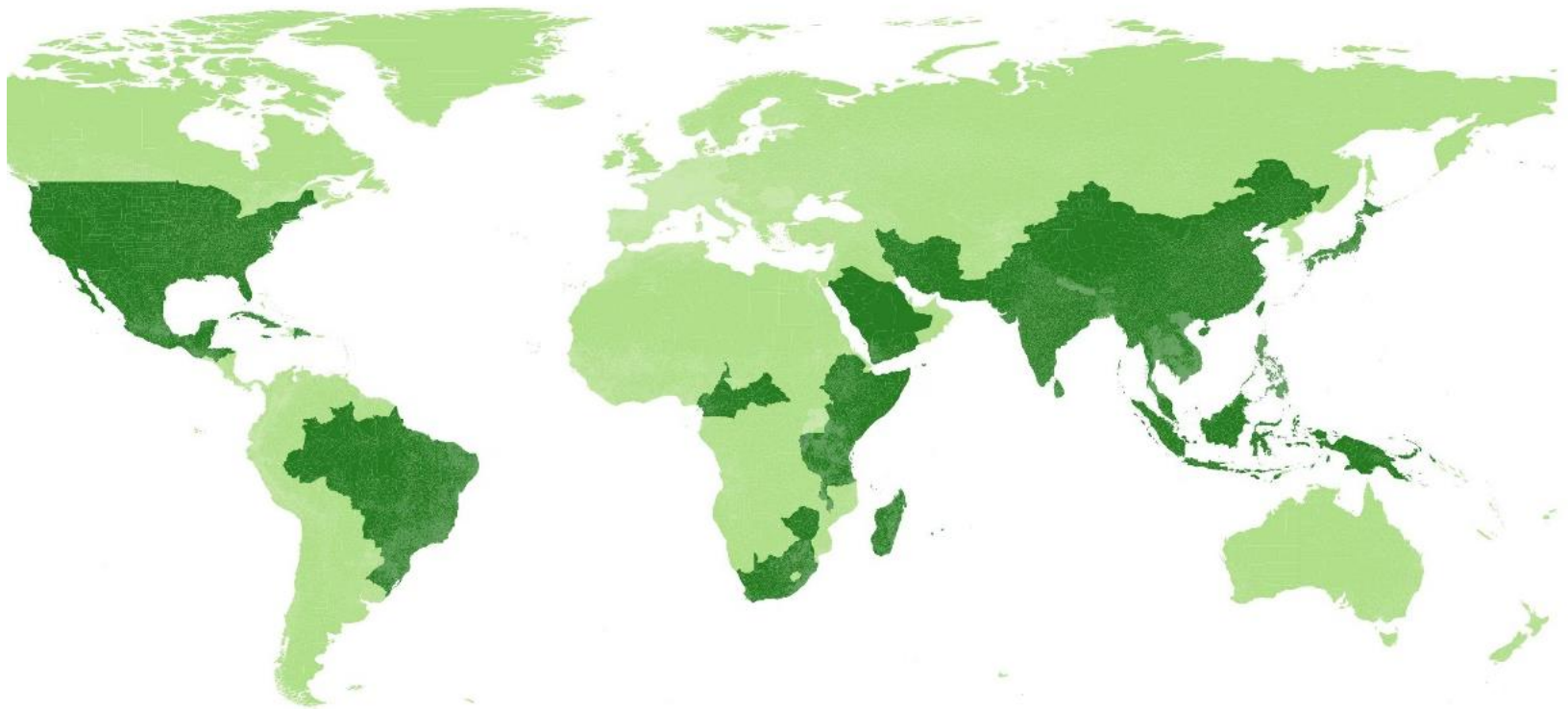
Model

- Assume bearing volume follows a modified inverse hyperbolic tangent function

$$y_{a_t} = \frac{\delta_0}{2} \left[1 + \tanh\left(\delta_1 + \delta_2 a_t\right) \right]$$

Bearing Volume — — Growth in Volume
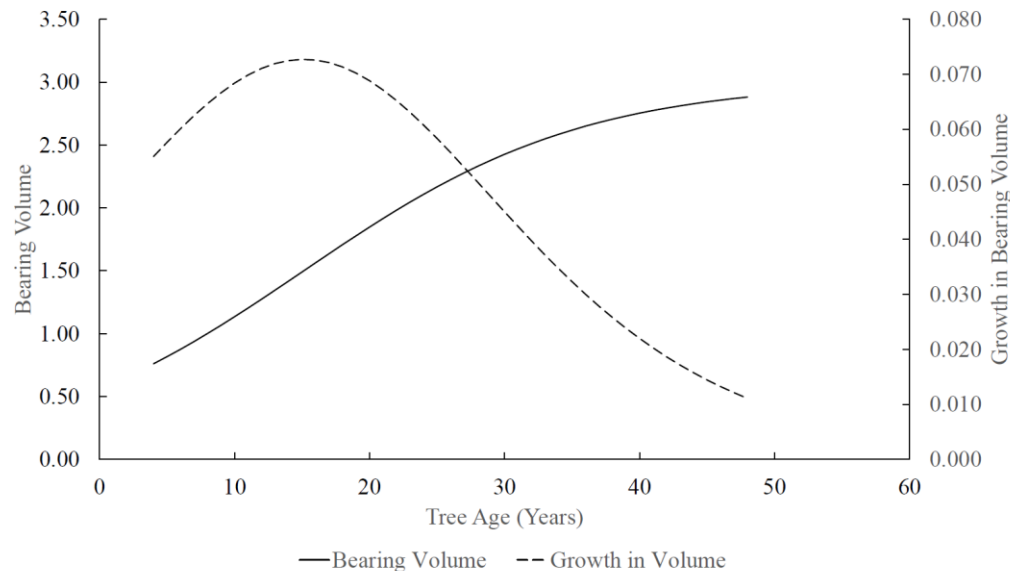
Model

$$y_t = \sum_{s=1}^{S} \omega_{st} \frac{\delta_0 + \delta_3 D_t}{2} \left[1 + \tanh\left(\left[\delta_1 + \delta_4 D_t\right] + \left[\delta_2 + \delta_5 D_t\right] a_s\right)\right]$$

- *y* – bearing volume
- *D* – average grove density
- *w* – share of trees in age group *s*
- *a* – age of trees in group *s*

- Estimated using nonlinear least squares

Data

- Florida Agricultural Statistics Service
  - Number of citrus trees and acreage
  - Biannually 1968 – 2008
  - Annually 2009 – 2015

  - Yield and price annually for all years

Results

Figure 2: Estimated Residual Squared for Tree Yield Model

Results

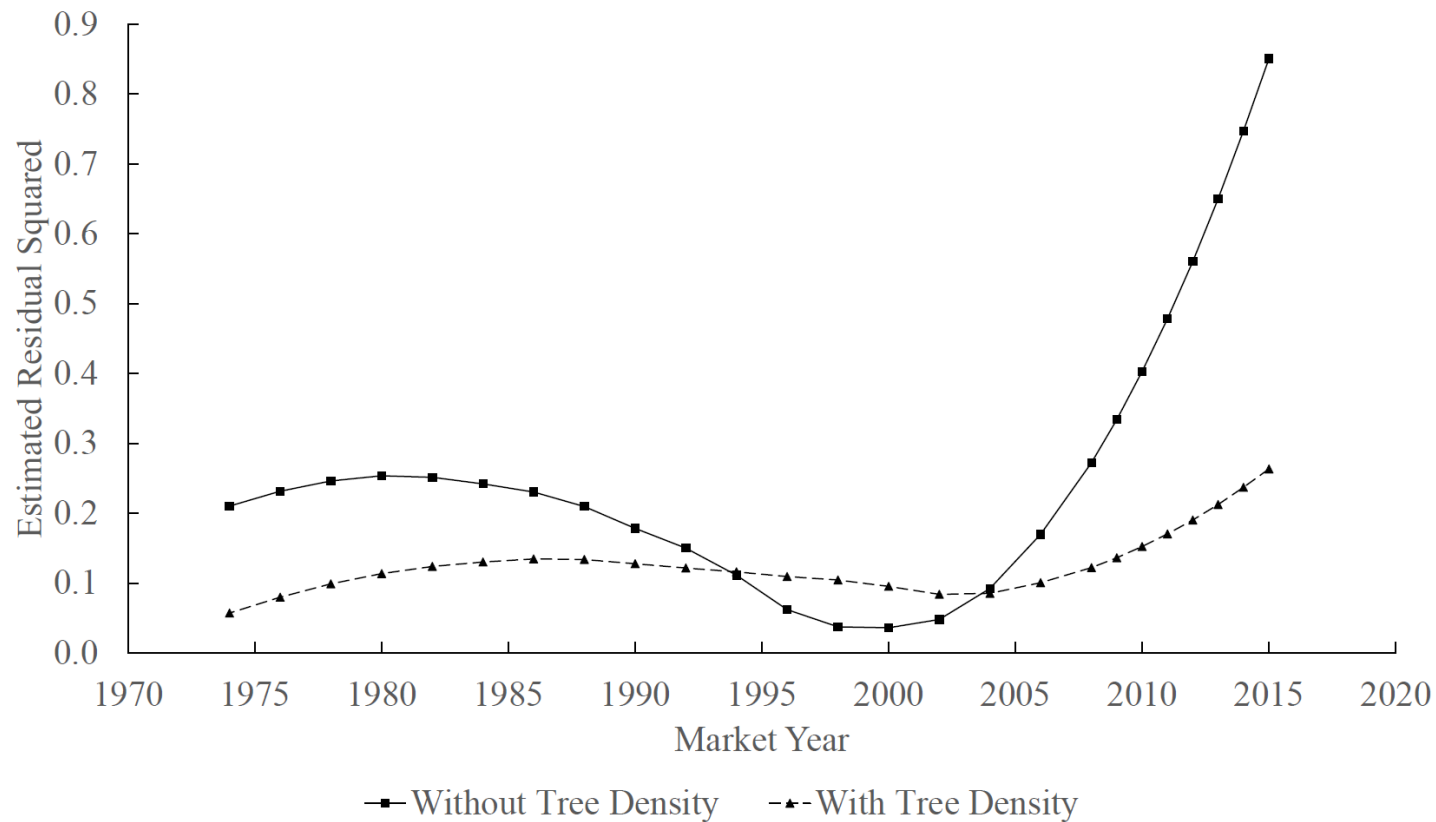

Figure 3: Tree Yield by Age With and Without Density Effect
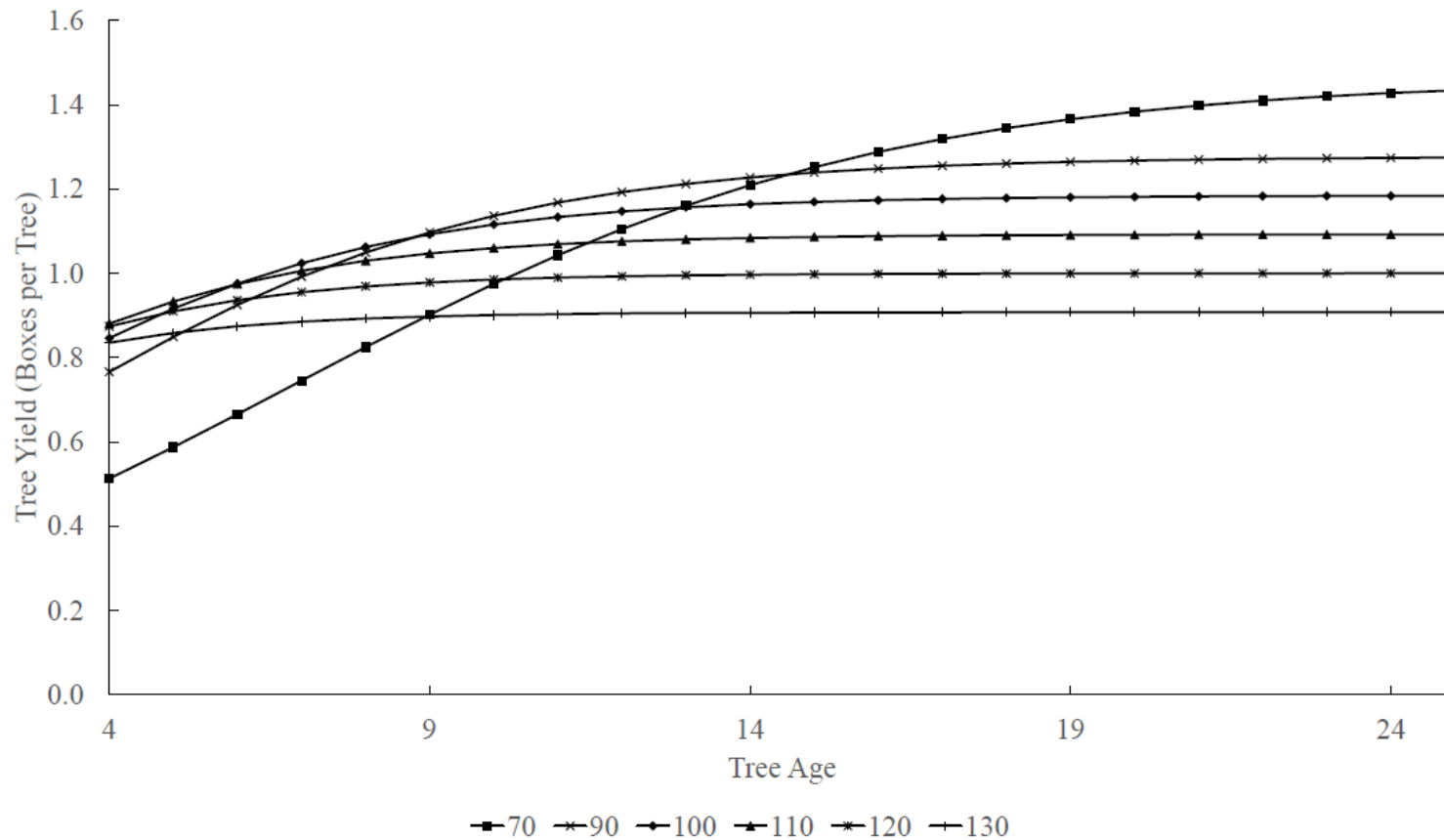
Results

Figure 4: Tree Yield as a Function of Tree Density
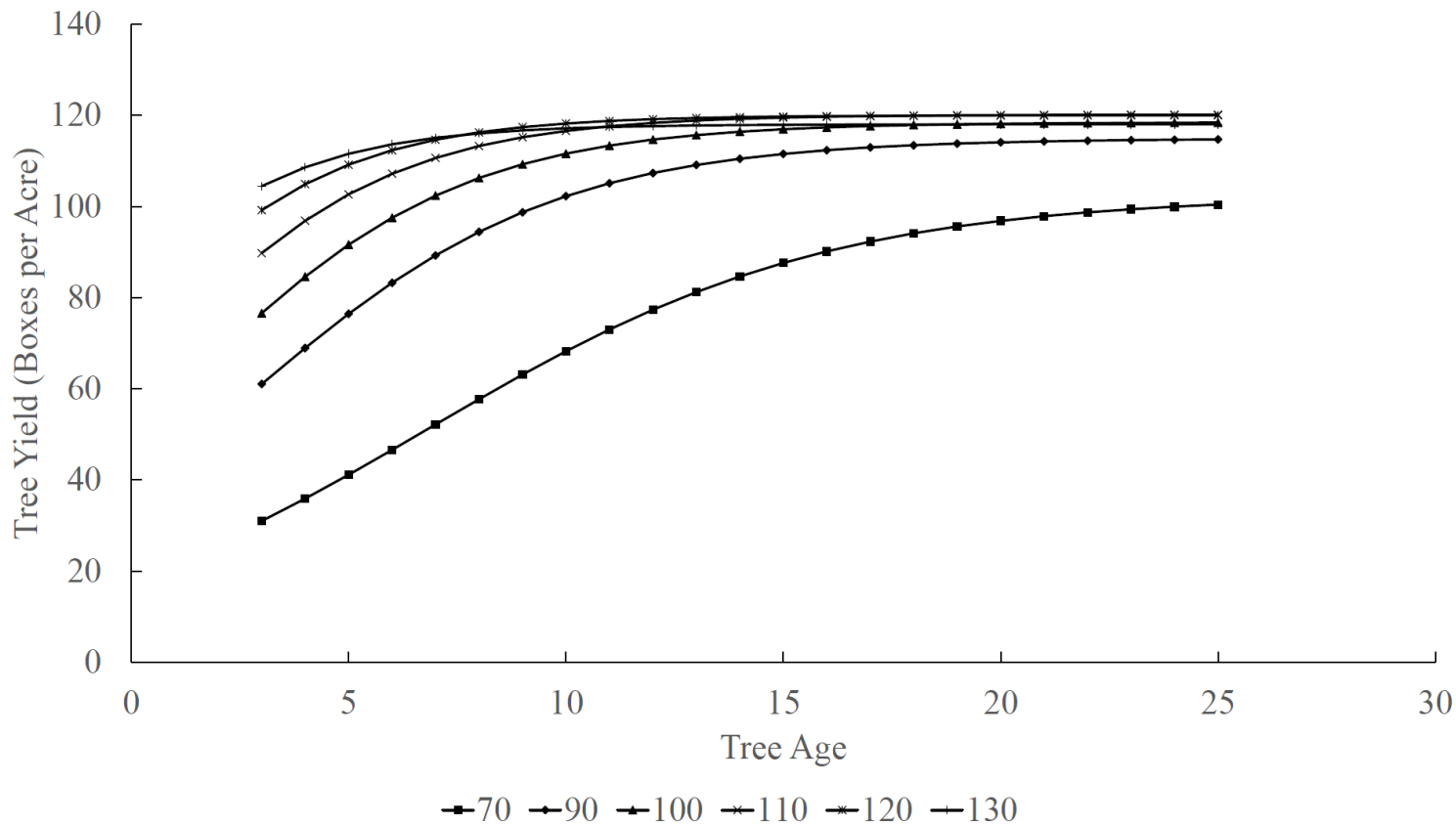
Results

Figure 5: Yield per Acre as a Function of Tree Density

Table 2: Citrus Production Data

	Observed					Computed					
Year	Bearing Trees	Bearing Acres	Tons	Boxes	Price	Bearing Trees	Bearing Acres	Yield per Tree	Bearing Tree Age	Bearing Tree Density	Unweighted Density
2015	54,382	405.5	4,356	96,800	9.34	54,401.3	405,600	1.7794	20.9326	134.6822	134.1255
2014	55,889	418.7	4,712	104,700	9.63	55,891.7	418,900	1.8733	20.6443	134.0965	133.4249
2013	57,144	429.2	6,012	133,600	7.43	57,146.1	429,944	2.3379	20.1634	133.7809	132.9152
2012	57,459	433.4	6,602	146,700	9.92	57,460.4	433,508	2.5531	19.7696	133.4666	132.5475
2011	58,158	440.0	6,322	140,500	8.41	58,160.4	440,130	2.4157	19.3226	133.1489	132.1437
2010	59,561	451.0	6,017	133,700	6.96	59,560.8	451,196	2.2448	18.7477	133.0762	132.0065
2009	60,754	459.1	7,313	162,500	5.77	60,752.9	459,228	2.6748	18.2529	133.4196	132.2935
2008	61,742	463.9	7,659	170,200	6.61	61,740.6	463,994	2.7567	17.7194	134.1878	133.0634
2007	63,950	475.9	5,805	129,000	10.28	63,950.0	463,900	2.0172	16.9786[a]	139.3646[a]	137.8530
2006	65,954	491.0	6,647	147,700	5.51	65,954.4	490,971	2.2394	16.9580	135.6253	134.3346
2005	72,592	541.8	6,741	149,800	3.49	72,592.0	491,000	2.0636	16.5343[a]	150.1167[a]	147.8452
2004	75,392	564.8	10,890	242,000	2.89	75,391.7	564,844	3.2099	16.5765	135.0974	133.4735
2003	78,037	587.6	9,135	203,000	3.17	78,037.0	564,800	2.6013	16.2906[a]	140.2113[a]	138.1675
2002	77,596	586.9	10,350	230,000	3.47	77,595.9	586,859	2.9641	16.0962	134.1431	132.2224
2001	79,565	605.0	10,049	223,300	3.21	79,565.0	586,900	2.8065	15.9393[a]	137.8456[a]	135.5682
2000	78,721	602.1	10,485	233,000	3.67	78,721.0	602,136	2.9598	15.5564	132.9716	130.7362
1999	79,608	612.6	8,370	186,000	4.84	79,608.0	602,100	2.3364	14.9639[a]	134.6130[a]	132.2172
1998	78,587	609.2	10,980	244,000	3.69	78,586.5	609,194	3.1049	14.3905	131.4153	129.0008
1997	78,525	624.9	10,179	226,200	3.54	78,525.0	609,200	2.8806	13.9277[a]	131.2520[a]	128.8986
1996	75,287	594.8	9,149	203,000	4.40	75,286.6	594,775	2.6964	13.4969	129.1740	126.5800
1995	69,295	562.8	9,248	205,500	3.74	69,295.0	594,800	2.9656	14.6240[a]	118.1561[a]	116.5013
1994	61,708	510.8	7,849	174,400	4.09	61,707.7	510,819	2.8262	14.2730	123.6855	120.8015
1993	56,601	489.2	8,397	186,600	3.48	56,601.0	510,800	3.2968	16.0108[a]	112.2809[a]	110.8085
1992	49,577	444.4	6,291	139,800	5.93	49,577.1	444,421	2.8199	16.0167	113.8578	111.5544
1991	44,077	420.9	6,822	151,600	5.89	44,077.0	444,400	3.4394	17.9825[a]	100.2918[a]	99.1832
1990	40,666	399.5	4,959	110,200	6.21	40,666.0	399,505	2.7099	19.1042	103.9398	101.7910
1989	36,750	388.7	6,597	146,600	7.41	36,750.0	399,500	3.9891	20.6344[a]	93.1669[a]	91.9900
1988	35,537	380.2	6,210	138,000	7.58	35,537.3	400,259	3.8832	22.2242	102.3148	88.7858
1987	33,752	375.4	5,387	119,700	5.22	30,338.5	380,200	3.9455	23.3242[a]	100.3724[a]	79.7963
1986	32,708	367.6	5,364	119,200	3.94	32,708.0	387,399	3.6444	23.4435	97.4640	84.4297
1985	35,537	420.1	4,676	103,900	7.10	33,265.8	367,600	3.1234	24.7753[a]	107.7230[a]	90.4925
1984	39,778	474.2	5,252	166,700	5.75	39,097.7	488,054	4.2637	25.8040	88.7729	80.1094
1983	44,228	536.8	6,282	139,600	5.15	42,583.8	474,200	3.2782	25.4353[a]	100.4089[a]	89.8013
1982	46,079	560.2	5,661	125,800	4.28	46,078.6	571,091	2.7301	25.3193	85.7452	80.6852
1981	47,079	573.4	7,758	172,400	4.04	46,138.0	560,200	3.7366	24.6092[a]	87.5878[a]	82.3598
1980	47,366	576.6	9,302	206,700	3.72	47,366.3	586,582	4.3639	24.2225	85.4851	80.7497
1979	46,955	571.5	7,380	164,000	4.66	46,109.4	576,600	3.5568	24.3339[a]	83.9803[a]	79.9678
1978	42,455	579.0	7,551	167,800	4.14	47,454.5	586,353	3.5360	23.4901	85.2890	80.9316
1977	42,278	594.3	8,406	186,800	2.17	41,861.2	579,000	4.4624	22.1771[a]	76.4727[a]	72.2992
1976	48,374	596.4	8,154	181,200	1.77	48,373.8	606,416	3.7458	22.8334	85.4988	79.7700
1975		610.4	7,799	173,300	1.62	47,967.1	596,400	3.6129	21.9166[a]	83.6977[a]	80.4278
1974		614.6	7,461	165,800	1.47	49,466.9	622,813	3.3517	21.8012	84.3503	79.4250
1973		619.6	7,636	169,700	1.56	48,581.2	614,600	3.4931	21.3313[a]	85.1613[a]	79.0453
1972		624.2	6,165	137,000	2.04	49,786.5	632,253	2.7517	21.0196	83.5069	78.7446
1971		660.5	6,402	142,300	1.46	49,334.7	624,200	2.8844	19.8219[a]	88.0587[a]	79.0367

[a] These data for the 'odd years' is approximated by allocating the observed rate of change over two adjacent surveys

Conclusion

- Structural model and analysis shows that **tree age and density have significantly changed**

- This structural change may cause us to <u>underestimate greening losses</u>

- Still need to forecast…

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