Forest Clearing Rates in the Sourcing Region for Enviva Pellet Mills in Virginia and North Carolina, U.S.A.

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1. Introduction

Since the early 2010s the southeastern U.S. has become a central hub for the sourcing and manufacturing of wood pellets exported to Europe and the U.K. for heating and power generation (*1, 2*). Production continues to rise, with the U.S. exporting approximately 7.26 million metric tons ("tonnes") of wood pellets in 2020, mostly produced in the southeastern U.S., and with the U.K. utility company Drax Power burning more than 4.6 million tonnes of those wood pellets in 2020 (*3, 4*). The Danish energy company Ørsted is another large consumer of wood pellets from the southeastern U.S., providing about one-third of Denmark's district heating and one-fourth of the country's total power generation with wood pellets and chips (see reporting and briefs).

Some of the earliest large-scale pellet manufacturing plants were established in northeastern North Carolina and southeastern Virginia. Enviva owns and operates three plants in that area, including one in Ahoskie, North Carolina, another in Northampton, North Carolina, and a third in Southampton, Virginia (Figure 1). These mills came online in 2011, early 2013, and late 2013, and had a production capacity of approximately 1.4 million tonnes of pellets per year until 2019 when the maximum capacity of the three mills increased to over 1.9 million tonnes per year (*5-8*). Enviva added a fourth mill in Sampson County, North Carolina becoming operational in 2016.

The wood used to produce these pellets is sourced from forests in the vicinity of pellet mills. This demand increases harvest extraction and may be expanding the area of forest that is harvested each year. The industry claims that their material is sourced only from the wood waste or wood 'residue' generated by clearcut harvesting, including tree tops, branches, and discarded trunks that are not of commercial value for sawtimber or other wood products, along with secondary feedstocks from sawmill and wood industry residues. However investigative reporting by watchdog journalists and environmental groups has documented whole trees of large diameter being extracted from mature hardwood forest, including swamplands, and trucked for direct delivery to wood pellet mill sites such as Enviva's Northampton, Southampton, and Ahoskie mills from 2013 through to 2019 (*9, 10*). This has raised an alarm about unsustainable and damaging logging practices used to source this industry, as well as the clearcutting of iconic, hardwood forests within the region. Also of concern is the climate warming impact of the bioenergy sector, which contributes to the clearing of growing forests that were sequestering atmospheric carbon, redirects harvested wood from storage within wood products toward the faster-release carbon emissions pathway associated with prompt combustion to produce energy, and does so with a fuel that is of low energy density and has high greenhouse gas emission per unit of energy produced (*11, 12*).

Pellet mill and biomass energy companies alike have come under pressure to source their material sustainably, leading to the establishment of institutions such as the Sustainable Biomass Program (see https://sbp-cert.org/) which seeks to evaluate the sustainability of biomass extraction operations and to certify them as sustainable where appropriate. The SBP reports for Enviva's mills approach sustainability with an emphasis on (a) biomass growth exceeding harvesting removals, (b) avoiding the use of threatened or endangered species for wood pellet production, (c) avoiding high conservation value areas, (d) use of best practices for forest management and regrowth, and (e) sourcing of pellet feedstocks principally from so-called residues and low value roundwood as described above (*5-7*). However, the large volume of material consumed by Enviva's mills within the region calls into question whether these constraints are truly being met. Moreover, meeting forest harvesting sustainability criteria, as outlined in the SBP program, provides no assurance that atmospheric carbon is not increased by forest bioenergy use (including its harvesting, processing, transport and combustion). Furthermore, the SBP program has been criticized for a lack of independence and other deficiencies in the program's ability to provide credible assurances that its sustainability standards are being met (*13*). Furthermore, Enviva argues that their practices are maintaining a sustainable extent and biomass stock of forestland within the region given the market pull of a new demand for biomass. However, this claim has not been demonstrated with large-scale quantitative measurement, nor has it been analyzed with respect to forest types. It remains unclear how the pattern and rate of forest clearings have responded to pellet mill operations – something that can be reliably quantified with satellite remote sensing of forest extent and annual forest loss conducted at a medium resolution (30 m x 30 m).

This study utilizes the best-available satellite data records to map the harvesting of forests in the source regions of mills over time, and to analyze time series to detect whether harvesting has increased as a result of mill operations. We examine the rates of clearing by forest type. Also, we diagnose whether there has been a conversion of forestlands from hardwoods to softwoods, and if there has been an expansion (or decline) of forest cover in the area surrounding mills.

2. Study Region

The study area encompasses areas within 100 km radii of the Enviva pellet mills at Northampton, Southampton, and Ahoskie (Figure 1) (the "3-mill area"). We define these areas as approximate "source regions" for each of the mills, and confirmed that this extent is consistent with Enviva's Track and Trace tool (https://www.envivabiomass.com/sustainability/responsible-sourcing/track-trace/). The latitude, longitude coordinates for each pellet mill are: Enviva Northampton: 36.504969, -77.611456; Enviva Southampton: 36.666902, -76.971844; Enviva Ahoskie: 36.269097, -76.965500. Also, we defined a reference region, or control, outside of the influence of the three mills to serve as a baseline against which we can measure the influence of pellet mill operations. Use of a control group or reference region is a common approach for measuring the effect of a factor such as a change in land ownership or land conservation status on forest clearing when in the presence of a potentially time-varying baseline state (*14, 15*). We use Enviva's Sampson pellet mill (35.120949 latitude, -78.183700 longitude) as the reference region in this study because it is located within the same general physiographic region as the other three mills, and has a similar forest type composition (Table 1) but experienced pellet mill operations only from 2016. This reference area is representative of the forest clearing trends in a region free of pellet mill activity prior to 2016 when the pellet mill operations began in Sampson.

The source region for these mills rests predominantly within the Atlantic coastal plain (Figure 1). Forest types are dominated by Loblolly/Shortleaf Pine softwood, Oak/Hickory hardwood, and Oak/Gum/Cypress hardwood forest types, with some mixed Oak/Pine stands (Tables 1, 2, Figure 2).

The region's forests are intensively harvested for a range of wood products manufactured at pulp mills and saw timber mills, but this utilization and extraction has been shifting over time. For example, a hardwood paper pulp mill in Franklin, Virginia was closed in 2010, coincident with the economic downturn. This closure reduced the demand for hardwood harvesting in the 3-mill area just before the pellet mill operations came online. Though International Paper Company re-purposed the mill as a fluff pulp mill opening in 2012, the fluff pulp supply relies on softwoods. Thus, a return of forest clearing at the rate prior to pellet mill operations would indicate the effect of pellet mills, particularly for deciduous hardwoods.

Figure 1. Map of the study region displaying the location of the Enviva wood pellet mills used in this study, the perimeter of Enviva's current map outlining its primary wood supply for these mills, and including this study's 3-mill source regions (blue circles) and its reference region (orange circle minus overlap with the blue circles). The base map displays the UDSA-NRCS Major Land Resource Areas our study region is located at, including Atlantic Coast Flatwoods, Tidewater, Coastal Plain, Sand Hills, and Piedmont.

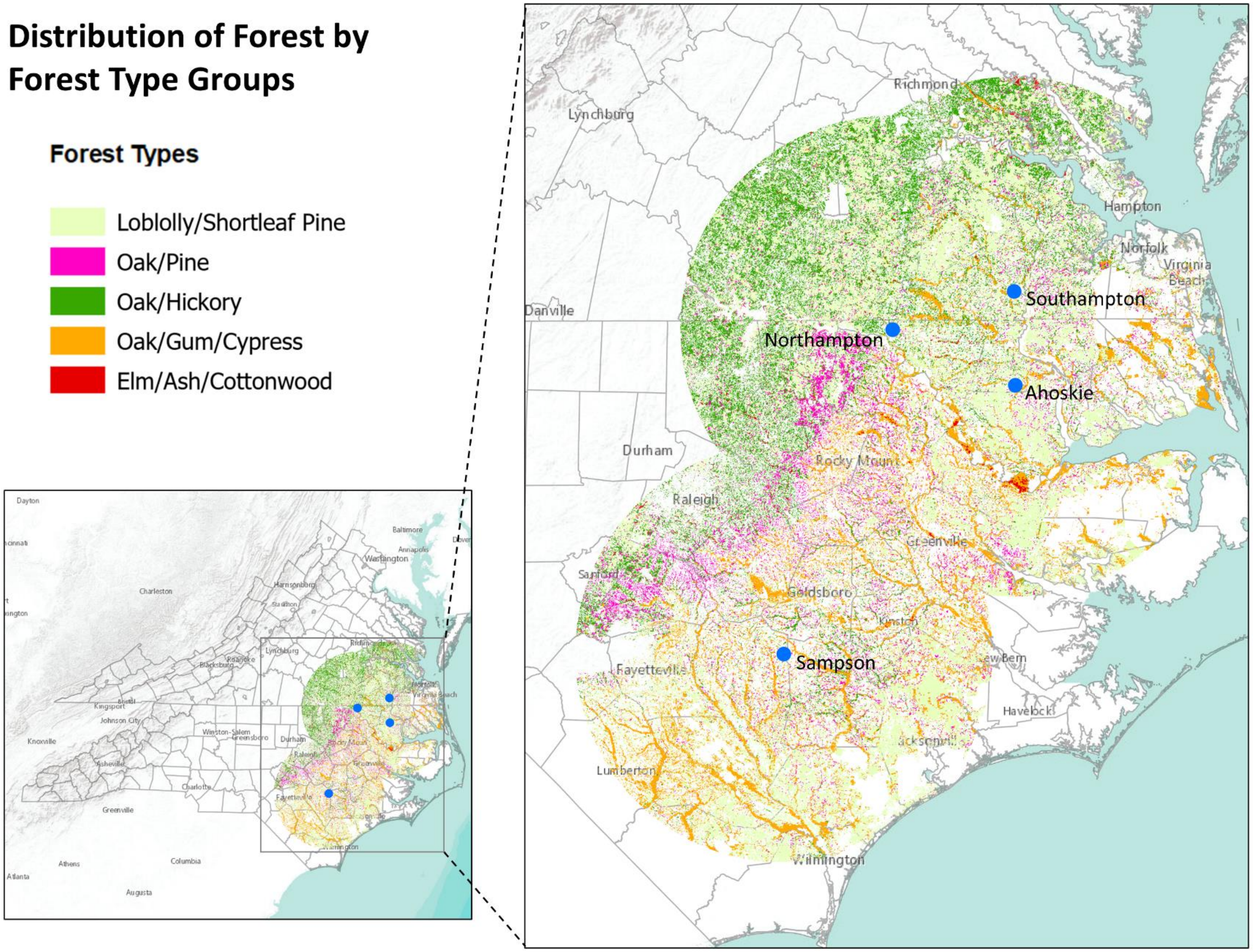

Figure 2. Distribution of forest within the study region according to forest type groups of the U.S. Forest Service.

Table 1. Forest Area in 2000 by Forest Type Group in the 3-Mill and Reference Areas.

Forest Area in 2000	3-Mill [ha]	3-Mill [% of total]	Reference [ha]	Reference [% of total]
Loblolly/Shortleaf Pine	1,106,527	51%	604,379	53%
Oak/Pine	187,947	9%	118,990	10%
Oak/Hickory	594,475	27%	118,297	10%
Oak/Gum/Cypress	261,445	12%	295,933	26%
Elm/Ash/Cottonwood	18,427	1%	2,946	0%
Deciduous	1,062,294	49%	536,166	47%
Coniferous	1,106,527	51%	604,379	53%
Total	2,168,822	100%	1,140,545	100%

Table 2. Area of forestland by forest type in each 100 km radius surrounding the pellet mill and the reference region, as well as for the 3-mill areas combined.

Forest Area in 2000 [ha]	Northampton	Southampton	Ahoskie	3-Mill	Reference
Loblolly/Shortleaf Pine	844,455	738,936	736,137	1,106,527	604,379
Oak/Pine	152,495	107,925	130,672	187,947	118,990
Oak/Hickory	497,240	327,793	188,556	594,475	118,297
Oak/Gum/Cypress	159,111	173,161	246,187	261,445	295,933
Elm/Ash/Cottonwood	14,960	13,138	9,765	18,427	2,946
Deciduous*	823,805	622,018	575,180	1,062,294	536,166
Coniferous*	844,455	738,936	736,137	1,106,527	604,379
Total	1,668,261	1,360,954	1,311,317	2,168,822	1,140,545

*For the purposes of this study we assign forest type groups as follows: Coniferous includes White/Red/Jack Pine, Longleaf/Slash Pine, and Loblolly/Shortleaf Pine, and Deciduous includes Oak/Pine, Oak/Hickory, Oak/Gum/Cypress, and Elm/Ash/Cottonwood.

3. Methods

We mapped locations of annual forest clearing from 2001 to 2019 with the ~30 meter Global Forest Watch (GFW) year 2000 tree cover and 2001 to 2019 tree cover loss datasets (*16*). To compute areas of forest and of forest loss, we transformed the GFW dataset from its original 0.00025 degree resolution, World Geodetic System 1984 (WGS84) geographical coordinate system to the North American Datum of 1983 (NAD83) coordinate system, and then projected the data to the Albers Conical Equal Area projection with a 30 m resolution. We identified the forest type of cleared areas by clipping the GFW tree cover map to the U.S. Forest Service forest type group map representative of 2000 (*17*) and defined at the 30 m resolution according to the National Forest Carbon Monitoring System (*18*). Forest type groups were also aggregated into softwood coniferous and hardwood deciduous groups to allow us to detect whether forest clearings of hardwood stands increased after the initiation of pellet mill activity. We sampled the maps of forested area and forest clearings for four different pellet mill regions, and for the 3-mill area combined. We then mapped the distribution of forest area, and forest clearings from 2001 to 2019, by forest type on the 30 m x 30 m grid. We confirmed that the tree cover percent of the pixels included as forest in our analysis contains a tree cover percentage representative of true forestland by analysing the GFW tree cover percent. Forest areas included in our study had a median tree cover percentage of 97%, a 20th percentile tree cover percentage of 85%, and a tree cover of less than 40% for fewer than 5% of the pixels classed as forest.

We excluded forest disturbance and forest clearing events that are not likely to be related to market-driven biomass supply for wood products (see Appendix 1 for figures displaying areas filtered out of the analysis). We excluded areas marked as developed in 2016, areas that experienced wildfires, and areas that have a protected or public game land or non-harvestable status. Developed areas were identified with the 2016 National Land Cover Dataset (NLCD, 2016) (*19-22*), including those 30 m pixels classified as developed open space or low, medium, or high intensity developed land. Protected lands were identified with the USGS, Gap Analysis Program (GAP), Protected Areas Database of the United States (PAD-US 2.0) (*23*), with GAP classes 1, 2, or 3, and public, non-harvestable lands such as those owned and managed by the U.S. Fish and Wildlife Service or the U.S. Department of Defense. Wildfires were identified as those areas of moderate to high burn severity from 1999 to 2017 according to the 30 m Monitoring Trends in Burn Severity (MTBS) (*24*) with its data release of August 29, 2018.

We measured the area of forest cleared each year by forest type and by deciduous or coniferous groupings by counting the number of pixels within a region that had loss and multiplying by pixel area (900 m^2 or 0.09 ha). We computed the percentage of forested pixels that were cleared each year by dividing the area cleared in a given year by the area of forest in 2000. We analyzed annual time series of the area of forest loss and the percentage of forest loss relative to forest cover in 2000 for individual forest types and for all forest types combined. We compared pre-mill forest clearing rates to those after the initiation of mill activity (referred to as "post-mill"). We expressed average annual forest clearing for three time periods: 2004-2008, 2013-2015, and 2016-2018, and quantified their ratios to assess the change in clearing after the initiation of mill operations. These time periods were selected to represent pre- and post-mill clearing rates during years of relatively favourable economic conditions as defined by Gross

Domestic Product. This removes variability associated with economic downturns, such as the recent recession in the late 2000s that is well-known to have significantly diminished the forest products industries of the southern U.S. (*25-27*). The years 2001 to 2003 and 2008 to 2010 were excluded because of anomalously low Gross Domestic Product in 2001, 2002, 2008, and 2009 (The World Bank, 2021) (*28*), along with 2003 and 2010 to account for the lag in the return of markets that influence harvesting practices. We identified pre-mill forest clearings as those during 2004 to 2007. With the three mills coming online from 2011 to 2013, we defined post-mill forest clearings in two time periods, 2013 to 2015, and 2016 to 2018.

The forest clearing time series mapped by GFW in its version 1.7 involves two distinct data processing and analysis periods, one for 2000 to 2010 and a second from 2011 to 2019, with the latter involving a more sensitive sensor from Landsat 8 OLI as well as improved validation data and an improved forest loss model (http://earthenginepartners.appspot.com/science-2013-global-forest/download_v1.7.html). To guard against the potential non-stationarity that may result from these methodological changes over time, we compared forest clearing rates within the 3-mill source region to the time series of forest clearings seen within the Sampson pellet mill reference region prior to 2016 when mill operations were initiated there as well. Trends in the GFW dataset from 2011 to 2019 are not subject to this risk of non-stationarity, given temporal consistency in the satellite data and algorithm used to identify forest clearings.

To assess whether mill operations have led to a general increase in forest cover in the 3-mill source region, we measured changes in forest cover over time with the 30 m NLCD land cover datasets for 2001, 2011, and 2016. We did not rely on the GFW forest gain data for this purpose for several reasons. Firstly, at present the GFW forest gain estimates are only available for the period of 2001 to 2012 and thus are only representative of the time period prior to the initiation of pellet mill operations. Secondly, studies evaluating the GFW and similar datasets indicate that estimates of forest gains have lower accuracy than estimates of forest losses (*16*, *29-31*), partly because forest growth is a more gradual and complex ecological process (*32*) that is more difficult to detect (*30, 33*). We note the following general correspondences between the NLCD classes and those derived from the U.S. Forest Service forest type group map within this study's regions of interest: NLCD Coniferous corresponds to the Longleaf/Slash Pine and Loblolly/Shortleaf Pine forest type groups; NLCD Mixed corresponds to the Oak/Pine forest type group; NLCD Woody Wetlands corresponds partly to the Oak/Gum/Cypress forest type group but may also overlap with Elm/Ash Cottonwood and other forest types including the pine groups; NLCD Deciduous corresponds to a restricted subset of the Oak/Hickory forest type group. We computed changes in the area forested from the 2001 to 2011 and from 2011 to 2016 NLCD datasets, and quantified the annual average rate of change in forested area for all NLCD forest classes, with emphasis on the Deciduous, Mixed, and Woody Wetlands classes.

Finally, we estimate the total biomass yield associated with clearings in the combined 3-mill source region area, and compare it to the feedstock supply that is consumed by the three mills in recent years. We adopt a typical harvest yield of 93 green tons of biomass per acre (equal to 84 green tonnes of biomass per acre, or 208 green tonnes of biomass per hectare), and a pellet yield of 0.4464 dry tonnes of pellets per green tons of biomass furnished (equal to 0.4921 dry tonnes of pellets per green tonnes of biomass furnished) as reported by Spencer Phillips of Key-Log Economics (*34*). This harvest yield is consistent with the biomass density reported in our own work on southeastern U.S. forests, reporting an average biomass density of about 120 metric tonnes of dry biomass per hectare for harvestable forests (*35*), which equates to approximately 97 green tonnes of biomass per acre assuming a water content of 50%. We compute the potential pellet supply from:

Potential pellet supply [dry tonnes per year] = A x B x P

where A is the area cleared [hectares per year], B is green biomass yield per area cleared [green tonnes biomass furnished per hectare harvested], and P is dry pellet mass produced per unit green biomass furnished [dry tonnes pellets per green tonnes biomass]. Additionally, we compute the true total Enviva pellet supply estimated to be derived from deciduous harvesting from:

Enviva pellet supply from deciduous harvesting [dry tonnes pellets per year] = F x H x PS x P

where F is the pellet feedstock reported by Enviva [green tonnes of biomass feedstock per year], H is the percentage (=78%) from hardwoods as reported in Enviva's supply base reports (*5-7*), PS is the percentage (=87%) of pellets arriving from primary supply via direct harvesting in forests, and P is dry pellet mass produced per unit green biomass furnished [dry tonnes pellets per green tonnes biomass].

4. Results

4.1 Trends in Forest Clearing Rates

Deciduous forest clearing in the 3-mill region rose sharply after 2012 to a peak in 2017 (Figure 3). During the recession-free, pre-pellet-mill period of 2004 to 2008, the 3-mill area saw a gross forest clearing rate of 1.5% per year (16,425 hectares per year) (Table 3). Deciduous forest clearing dropped to 1.1% per year for 2009 to 2012 with the recession and coincident closure of the Franklin, VA hardwood paper and pulp mill. With the initiation of pellet mill operations in the region, deciduous forest clearing returned to the pre-recession level (1.5% per year) by 2013 to 2015, and then rose to 1.7% per year (18,480 ha per year) from 2016 to 2018. Oak/Hickory and Oak/Pine forests saw the largest increase in forest clearing from the mid-2000s to the mid- and late 2010s (Table 4).

Coniferous forest clearing had a similar pattern in the 3-mill region (Table 3, Figure 3). Gross coniferous forest clearing in this area was 2.6% per year from 2004 to 2008, decreased to 2.0% per year from 2009 to 2012, rose to 2.4% per year for 2013 to 2015 and 2.5% per year from 2016 to 2018. Time series of annual clearing rates for the dominant forest types are shown in Figures 4, 5, 6, and 7. A map of forest losses is displayed in Figure 8 for the entire region, and with a focus on specific cutout regions within the vicinity of the 3-mill cluster (Figures 9, 10).

Forests of the reference region experienced similar trends in clearing rates over time but with a smaller decline during the 2009 to 2012 period. Gross deciduous forest clearing in the reference region was fairly steady from 2004 to 2015, at around 1.3% per year. Thereafter, when the Sampson pellet mill began its operations in 2016, deciduous forest clearing rose to 1.9% per year from 2016 to 2018. Similarly, gross forest clearing of coniferous forests in the reference region was about 2.2% per year from 2004 to 2015 and rose to 2.9% per year by 2016 to 2018.

To summarize, we find that the rate of forest clearing increased markedly after the initiation of pellet mill operations at Northampton, Southampton, and Ahoskie. By 2013 to 2015, the 3-mill region saw deciduous forest clearing increase by 1.34 times that of 2009 to 2012, and by 2016 to 2018 it increased by 1.51 times, based on the rates reported in Table 4. By comparison, the reference region saw an increase of only 1.18 times for 2013 to 2015 relative 2009 to 2012. However, once pellet mill operations began at the Sampson mill, deciduous forest clearing rose to 1.54 times the rate during the recession period. Thus, it is very likely that the initiation of pellet mill operations contributed to elevated rates of deciduous forest clearing in the 3-mill region beginning in the early 2010s, and in the reference region beginning in 2016.

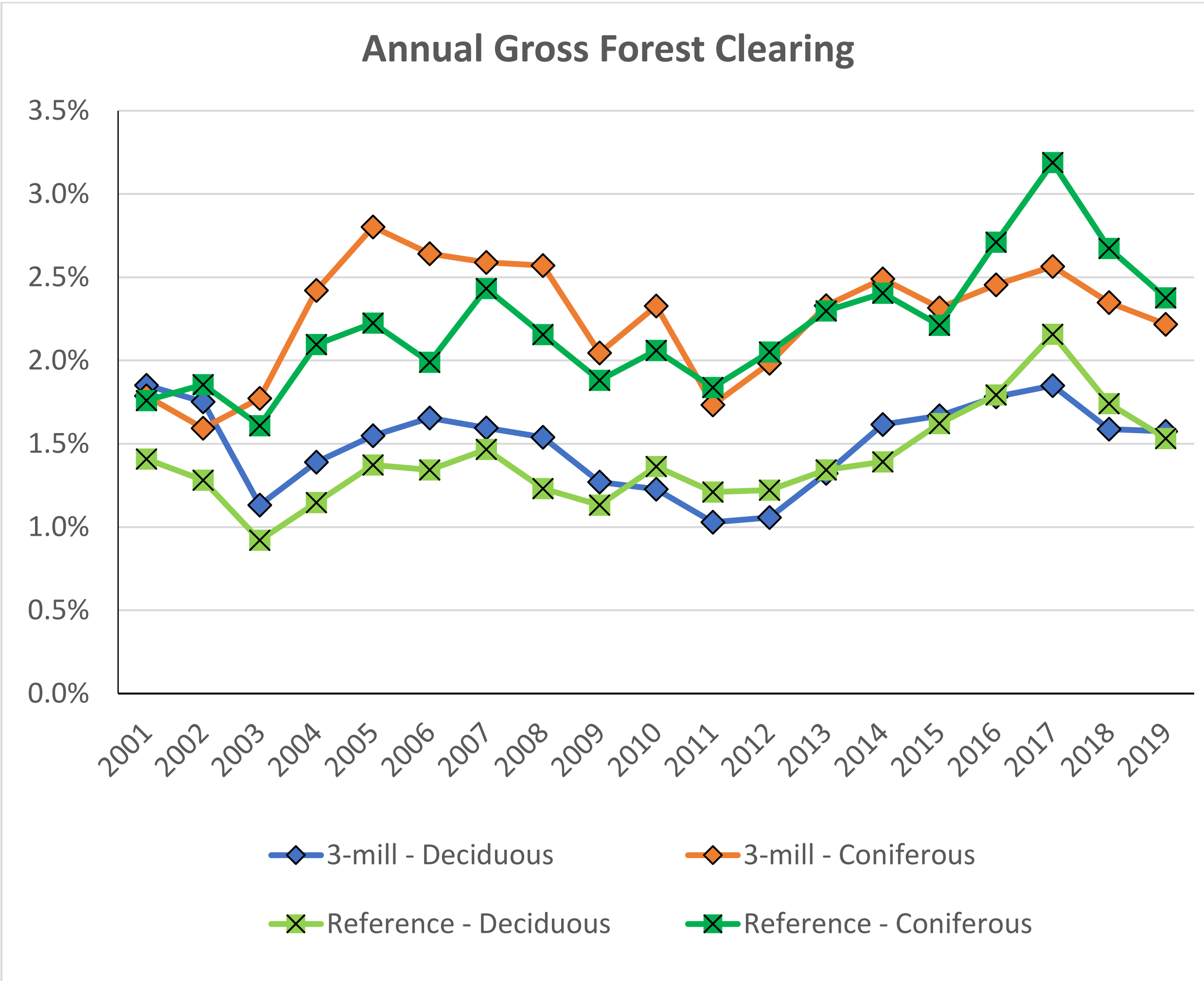

Figure 3. Time series of annual gross forest clearings as percent of year-2000 forestland for the 3-mill and reference regions and for both deciduous-dominated and coniferous-dominated forest types from 2001 to 2019.

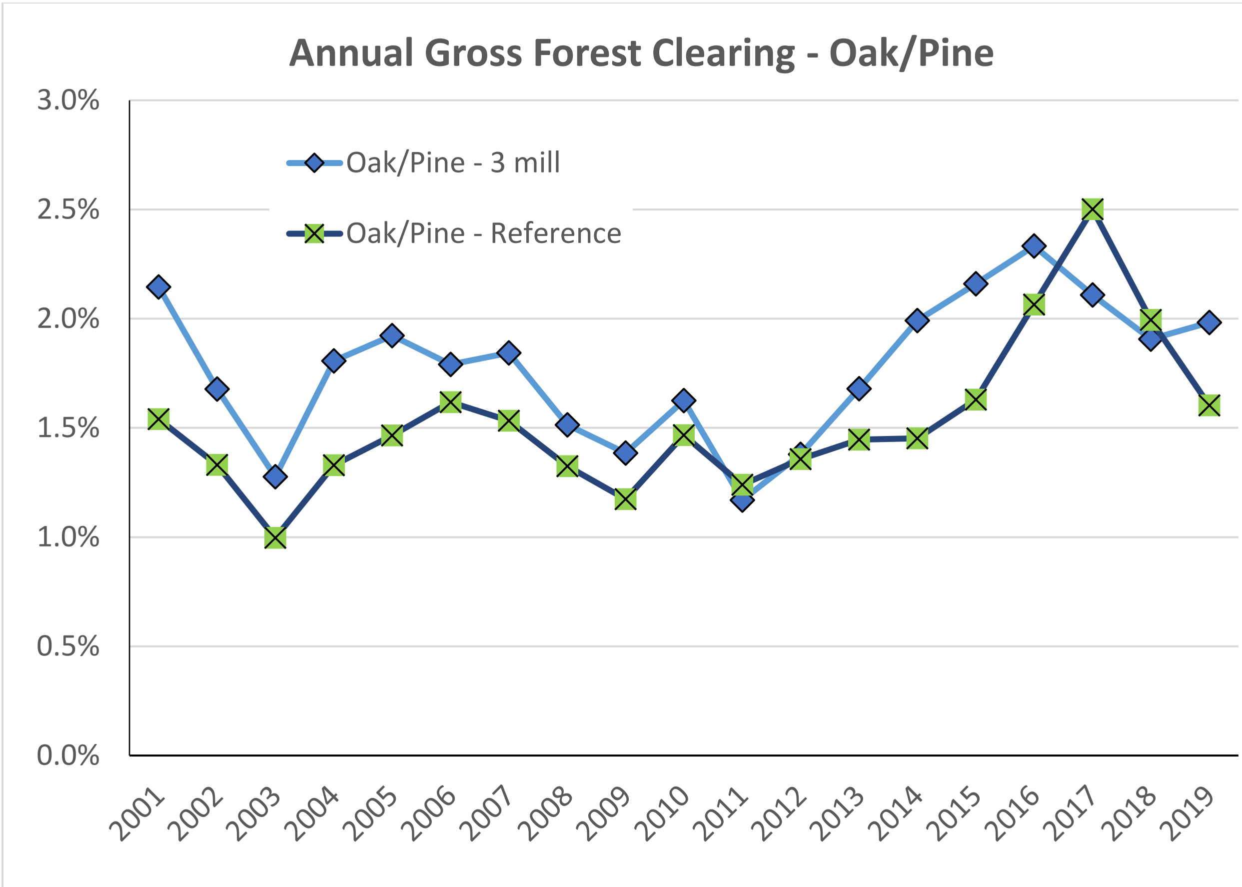

Figure 4. Time series of annual gross forest clearings for Oak/Pine forests within the 3-mill region and reference regions.

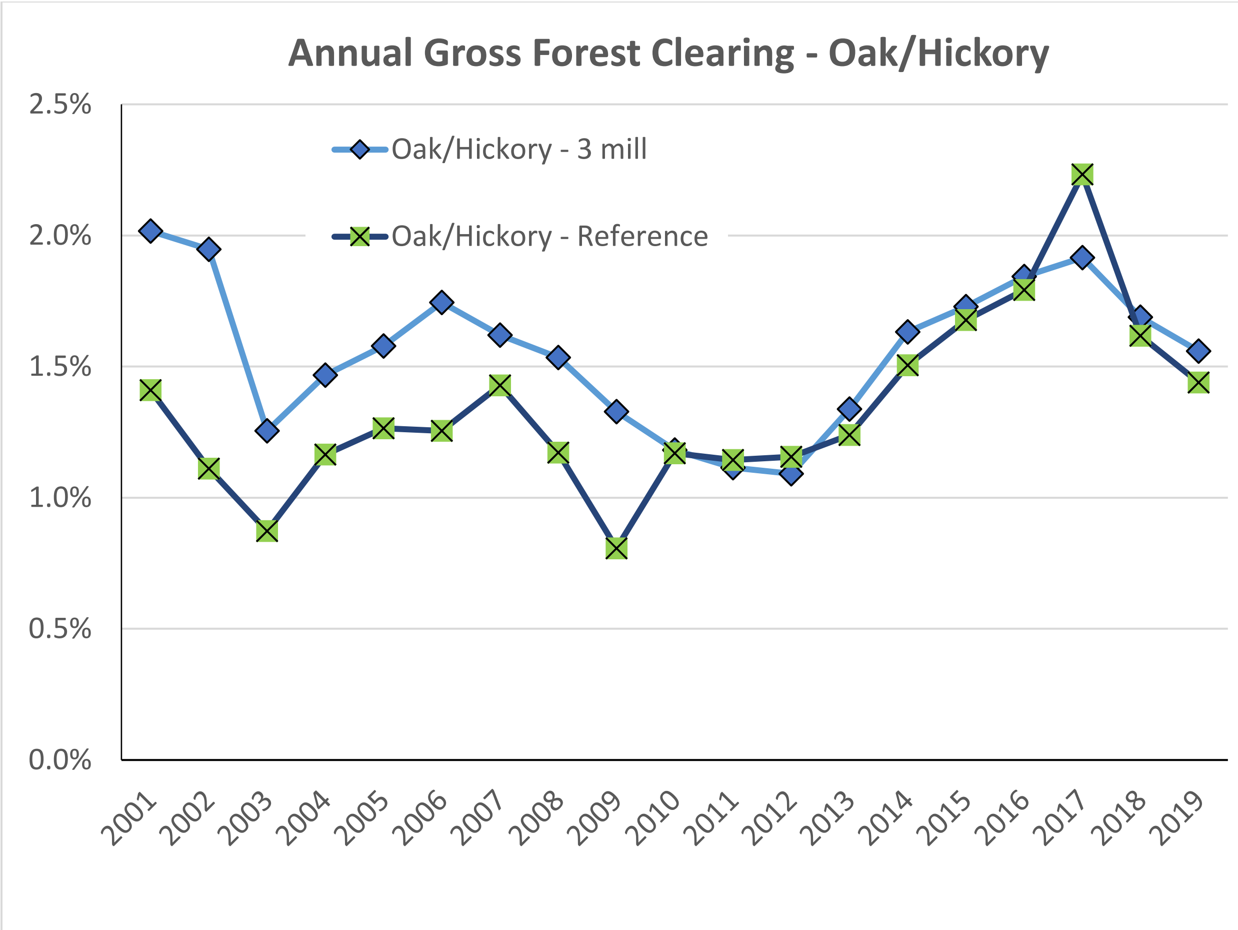

Figure 5. Time series of annual gross forest clearings for Oak/Hickory forests within the 3-mill region and reference regions.

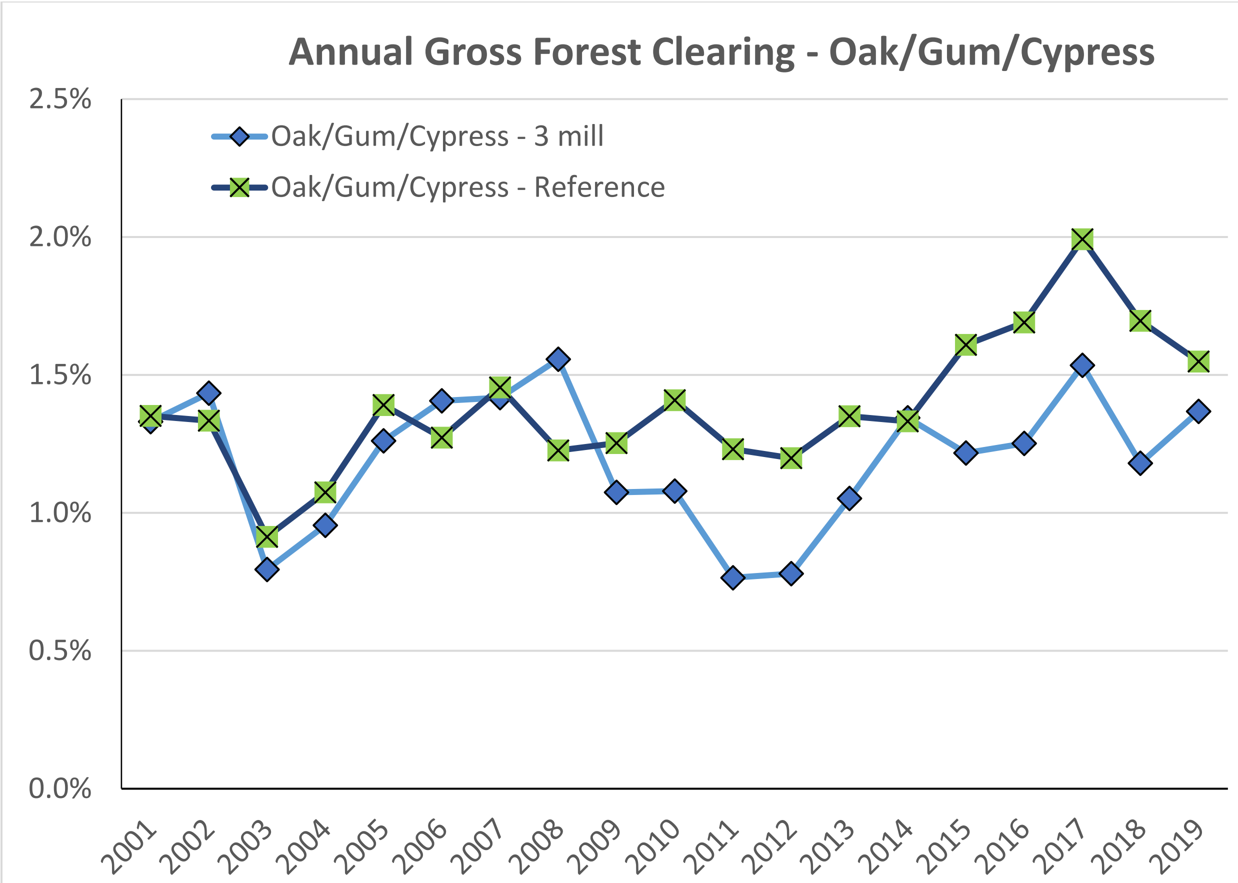

Figure 6. Time series of annual gross forest clearings for Oak/Gum/Cypress forests within the 3-mill and reference regions.

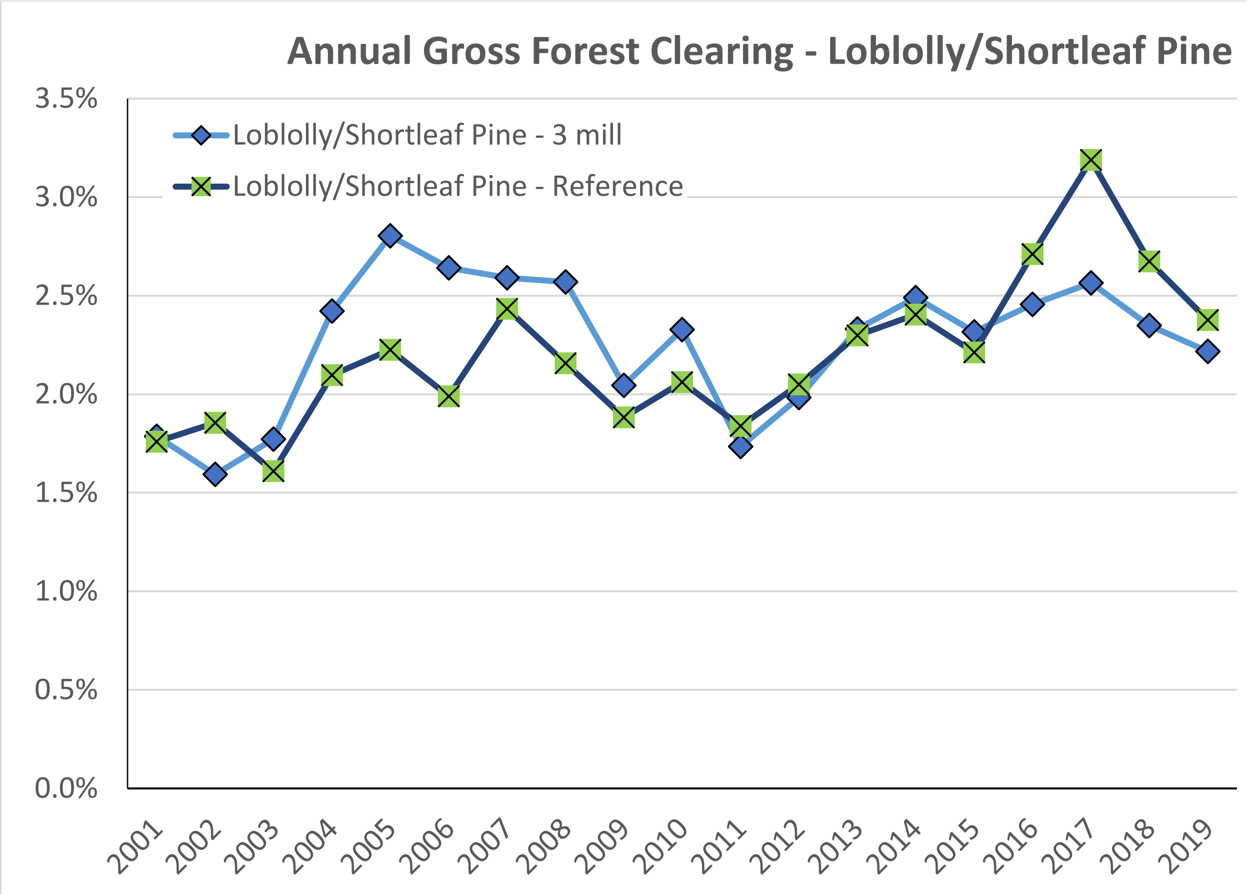

Figure 7. Time series of annual gross forest clearings for Loblolly/Shortleaf Pine forests within the 3-mill and reference regions.

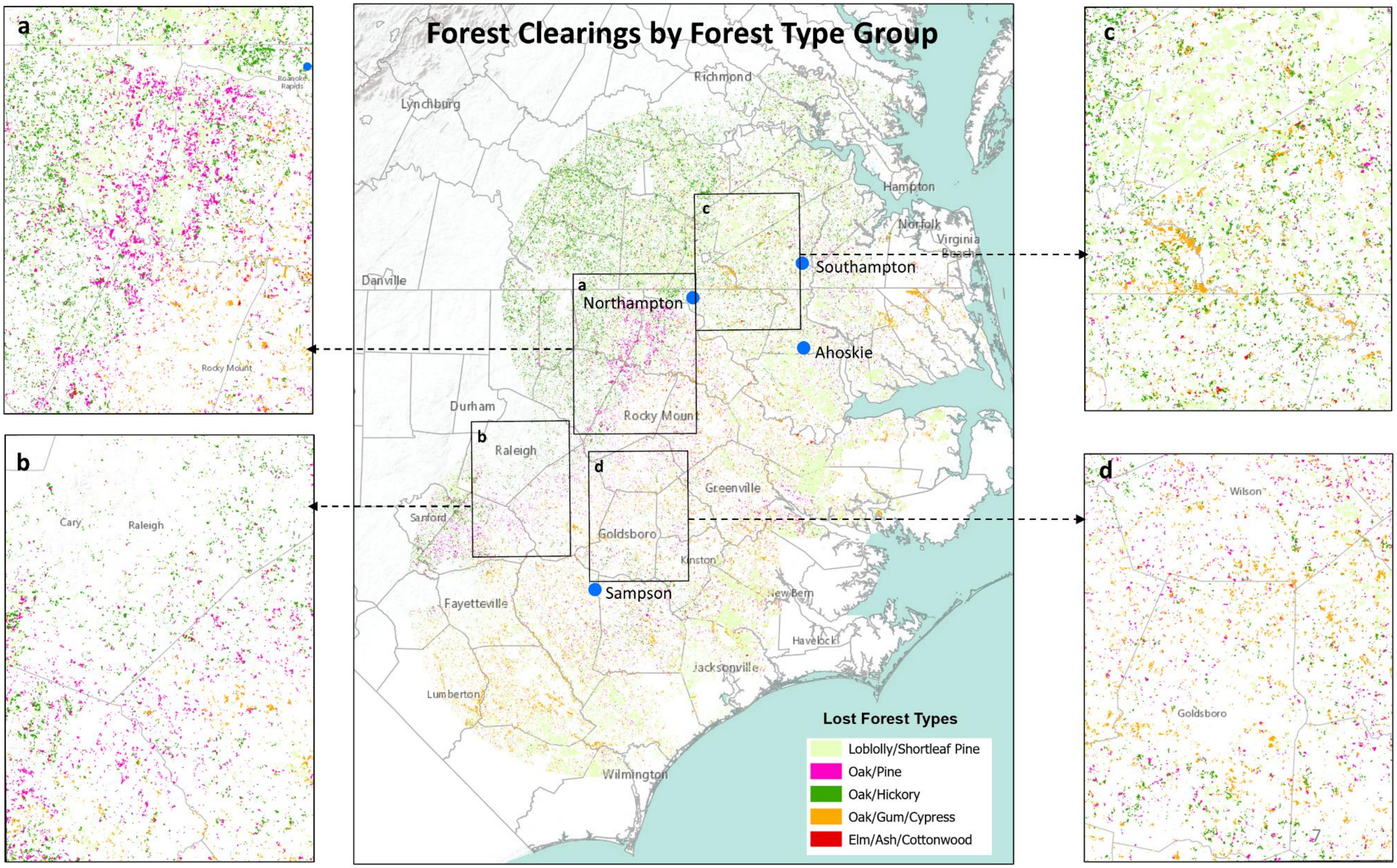

Figure 8. Forest clearings from 2001-2019 within the study region mapped by forest type group.

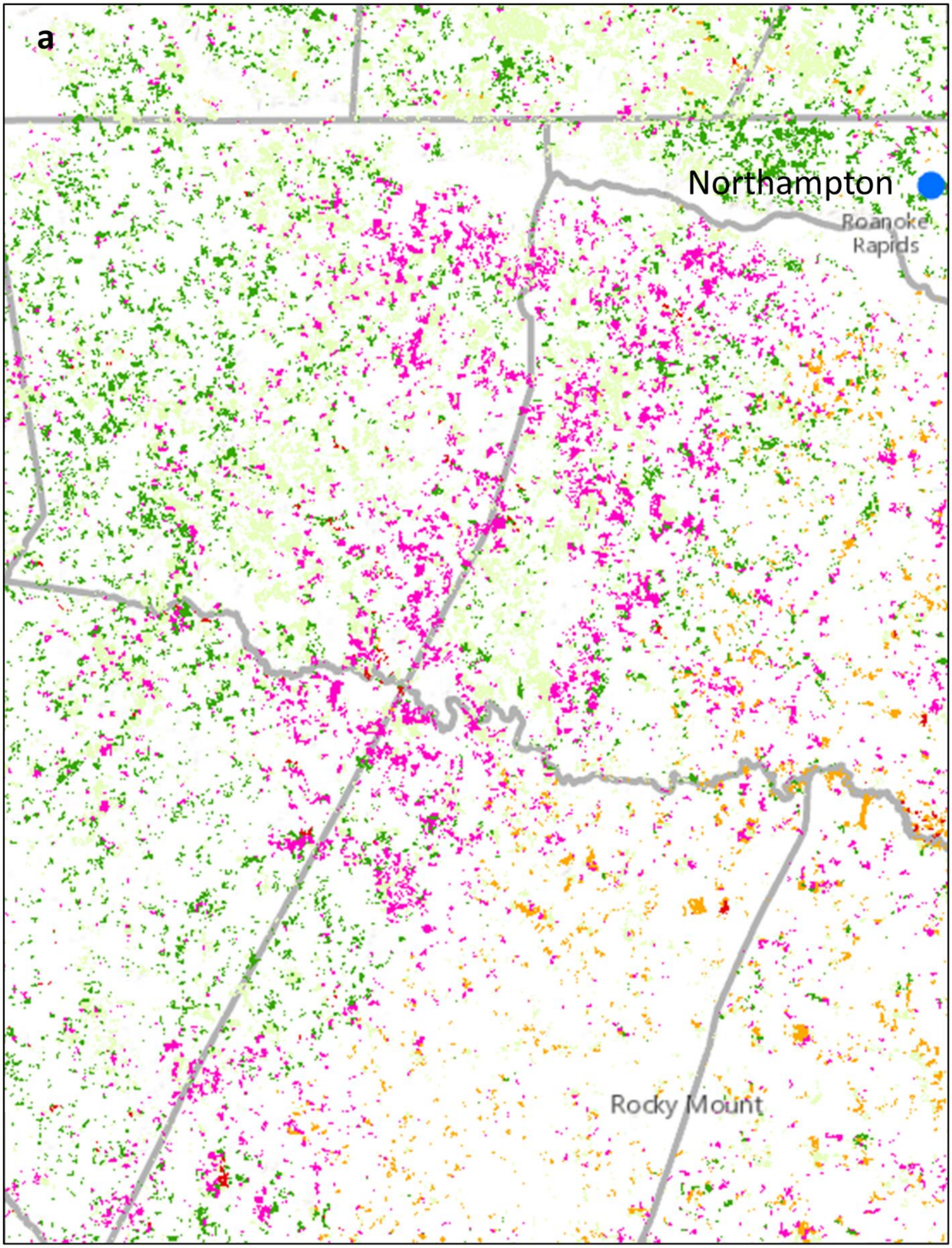

Figure 9. Forest clearings within the cutout region a.

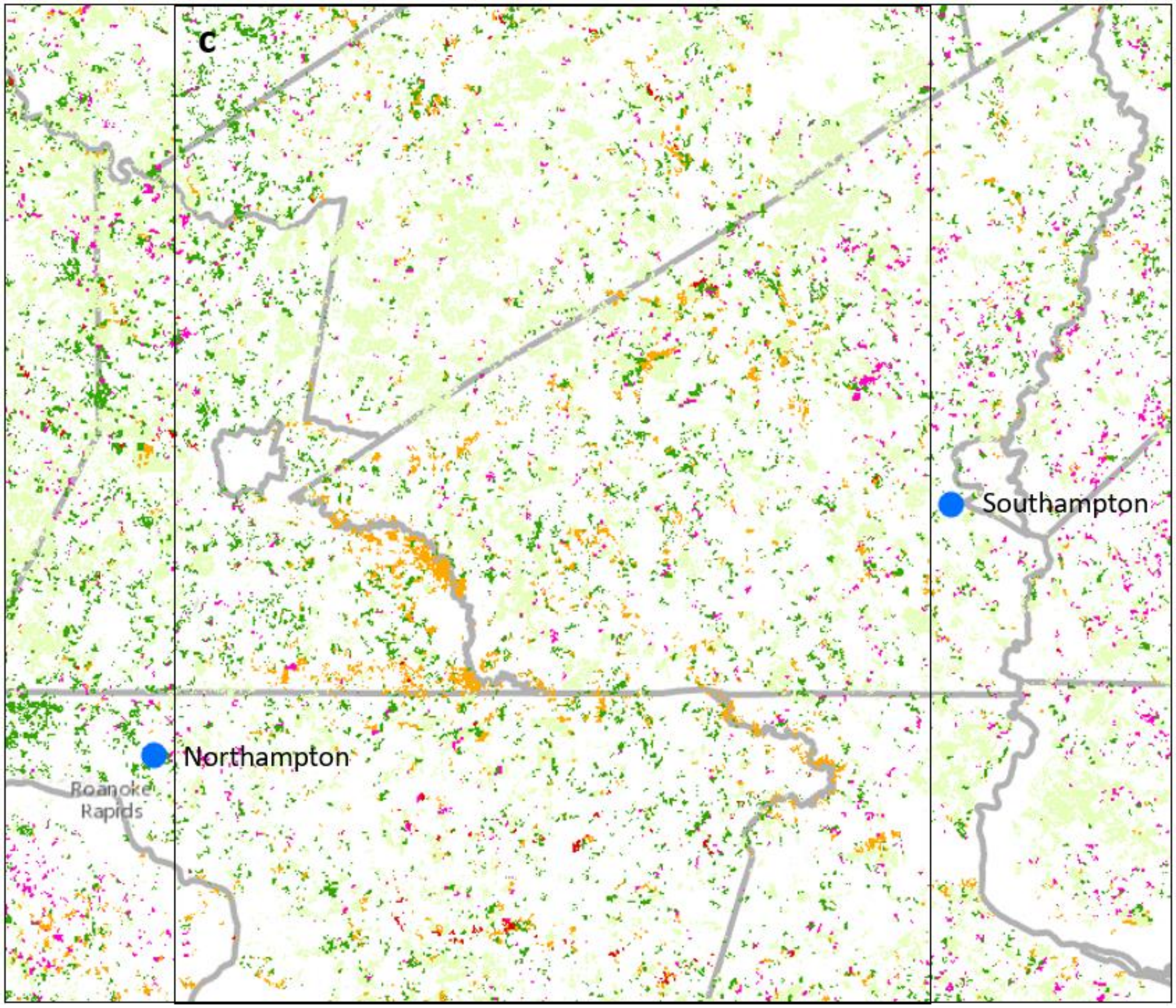

Figure 10. Forest clearings within the cutout region c (internal black box) shown within an extended landscape to show both Southampton and Northampton mills.

Table 3. Forest area in 2000 and the average annual rate of gross forest clearing in select time periods for the 3-mill and reference regions, reported for deciduous and coniferous forests separately.

	Forest Area in 2000	2004 - 2008		2009 - 2012		2013 - 2015		2016 - 2018	
	[ha]	[ha per yr]	[% per yr]	[ha per yr]	[% per yr]	[ha per yr]	[% per yr]	[ha per yr]	[% per yr]
3-mill									
Deciduous	1,062,294	16,425	1.5%	12,171	1.1%	16,317	1.5%	18,480	1.7%
Coniferous	1,106,527	28,830	2.6%	22,379	2.0%	26,323	2.4%	27,179	2.5%
Reference									
Deciduous	536,166	7,034	1.3%	6,603	1.2%	7,785	1.5%	10,171	1.9%
Coniferous	604,379	13,176	2.2%	11,833	2.0%	13,930	2.3%	17,268	2.9%

Table 4. Forest area in 2000 and the average annual rate of gross forest clearing in select time periods for the 3-mill and reference regions shown for individual forest types.

	Forest Area in 2000	2004 - 2008		2009 - 2012		2013 - 2015		2016 - 2018	
	[ha]	[ha / y]	[% / y]	[ha / y]	[% / y]	[ha / y]	[% / y]	[ha / y]	[% / y]
3-mill									
Oak/Pine	187,947	3,337	1.8%	2,612	1.4%	3,653	1.9%	3,976	2.1%
Oak/Hickory	594,475	9,448	1.6%	7,010	1.2%	9,311	1.6%	10,793	1.8%
Oak/Gum/Cypress	261,445	3,449	1.3%	2,418	0.9%	3,149	1.2%	3,457	1.3%
Elm/Ash/Cottonwood	18,427	191	1.0%	132	0.7%	203	1.1%	254	1.4%
Loblolly/Shortleaf Pine	1,106,527	28,830	2.6%	22,379	2.0%	26,323	2.4%	27,179	2.5%
Deciduous	1,062,294	16,425	1.5%	12,171	1.1%	16,317	1.5%	18,480	1.7%
Coniferous	1,106,527	28,830	2.6%	22,379	2.0%	26,323	2.4%	27,179	2.5%
Reference									
Oak/Pine	118,990	1,730	1.5%	1,559	1.3%	1,796	1.5%	2,602	2.2%
Oak/Hickory	118,297	1,487	1.3%	1,265	1.1%	1,744	1.5%	2,225	1.9%
Oak/Gum/Cypress	295,933	3,799	1.3%	3,766	1.3%	4,233	1.4%	5,304	1.8%
Elm/Ash/Cottonwood	2,946	18	0.6%	14	0.5%	13	0.4%	39	1.3%
Loblolly/Shortleaf Pine	604,379	13,176	2.2%	11,833	2.0%	13,930	2.3%	17,268	2.9%
Deciduous	536,166	7,034	1.3%	6,603	1.2%	7,785	1.5%	10,171	1.9%
Coniferous	604,379	13,176	2.2%	11,833	2.0%	13,930	2.3%	17,268	2.9%

4.2 Forest Area Changes, 2001 to 2016

First, we report the area of deciduous forest lost within the 3-mill area according to the NLCD, and focusing only on those areas that are labeled as deciduous forest according to the relatively restrictive classification of the NLCD. We find that the areal extent of NLCD-classified deciduous forest declined within the 3-mill region from 2001 to 2016 with an average annual rate of loss of about 3,861 hectares per year from an initial 320,523 ha in 2001 (Table 5). This is a net loss of NLCD-classified deciduous forest, whereas the prior section analyzed gross forest clearings with the GFW data. Over the 15-year period this translates to a total net loss of about 18.1% of the year-2001 deciduous forest in the 3-mill region, with the annual rate of loss being roughly the same for 2001 to 2011 as for 2011 to 2016. These deciduous forest losses are coincident with smaller gains of mixed forest and coniferous forest, which expanded by 1,387 hectares per year and 505 hectares per year, respectively.

Second, we use the NLCD as a point of comparison for the total forested area estimated with the GFW dataset. To make this comparison it is necessary to combine the NLCD Deciduous, Mixed, and Woody Wetland forest classes together because many of those areas are labeled as deciduous-dominant forest types in this study's forest type assignment to the GFW dataset. When doing so, we find good agreement regarding the area classified as deciduous forest between NLCD and this study's combination of the GFW data with the U.S. Forest Service forest type group map. For the three classes combined, the NLCD reports an average annual net loss of forest area of about 2,313 hectares per year, out of an initial 1.46 million hectares in 2001 across the 3-mill region (Table 5). Over the 15-year period this corresponds to a net loss of 2.4% of the year-2001 Deciduous, Mixed, and Woody Wetland forest areas combined, , with the annual rate of loss being comparable for 2001 to 2011 as for 2011 to 2016. By comparison, the reference region saw a 15-year loss of only 1.1% of its year-2001 Deciduous, Mixed, and Woody Wetland forest areas combined by 2016.

Table 5. Forest area and the change in forest area from the 2001, 2011, and 2016 NLCD datasets for the 3-mill and reference regions.

	3-Mill			Reference		
Forest Area [ha]	2001	2011	2016	2001	2011	2016
Deciduous (NLCD)	320,523	280,473	262,615	60,490	57,792	56,252
Mixed	456,690	472,577	477,497	125,173	125,699	126,071
Woody Wetlands	684,961	683,812	687,365	590,894	582,630	585,588
Deciduous + Mixed + W.W.	1,462,174	1,436,863	1,427,477	776,558	766,120	767,911
Coniferous	828,994	823,927	836,569	510,481	513,332	517,407
All Forest Types	2,291,168	2,260,790	2,264,046	1,287,039	1,279,452	1,285,318
Forest Area Change [ha per year]	2011 - 2001	2016 - 2011	2016 - 2001	2011 - 2001	2016 - 2011	2016 - 2001
Deciduous (NLCD)	-4,005	-3,572	-3,861	-270	-308	-283
Mixed	1,589	984	1,387	53	75	60
Woody Wetlands	-115	711	160	-826	592	-354
Deciduous + Mixed + W.W.	-2,531	-1,877	-2,313	-1,044	358	-576
Coniferous	-507	2,528	505	285	815	462
All Forest Types	-3,038	651	-1,808	-759	1,173	-115
Forest Area Change [% over total time interval]	2011 - 2001	2016 - 2011	2016 - 2001	2011 - 2001	2016 - 2011	2016 - 2001
Deciduous (NLCD)	-12.50%	-5.57%	-18.07%	-4.46%	-2.55%	-7.01%
Mixed	3.48%	1.08%	4.56%	0.42%	0.30%	0.72%
Woody Wetlands	-0.17%	0.52%	0.35%	-1.40%	0.50%	-0.90%
Deciduous + Mixed + W.W.	-1.73%	-0.64%	-2.37%	-1.34%	0.23%	-1.11%
Coniferous	-0.61%	1.52%	0.91%	0.56%	0.80%	1.36%
All Forest Types	-1.33%	0.14%	-1.18%	-0.59%	0.46%	-0.13%

4.3 Feedstock Supplied by the Harvested Area

We estimate that 1.9 million dry tonnes of pellets would be produced each year if all of the deciduous forest clearing within the 3-mill area (18,480 hectares per year) was used to produce wood pellets (Table 6). This is based on an assumed harvest yield of 84 green tonnes of biomass per acre (208 green tonnes of biomass per hectare), and an assumed pellet yield of 0.492 dry tonnes of pellets per green tonnes of biomass furnished (*34*).

By comparison, Enviva's supply base reports (*5-7*) indicate that each of the three pellet mills consume 700,000 to 980,000 tonnes of green biomass feedstock per year (Table 6). From 2016 to 2018, the three mills combined to consume 2.33 to 2.66 million green tonnes of biomass feedstock per year. Enviva reports that its pellet feedstock in the region is comprised of 22% pine and 78% hardwood, and with 87% coming from primary feedstock including roundwood and whole trees direct from forests with the remainder as secondary feedstock from residual material provided by sawmill and wood industry suppliers. With 78% of the feedstock being hardwood supply and 87% from primary supply, approximately 68% of the feedstock would be expected to arrive directly from recent hardwood harvests in the region. This equates to 0.78 to 0.89 million dry tonnes of pellets per year of Enviva's 3-mill cluster supply coming from hardwood deciduous and mixed forest harvests. This feedstock would consume 41% to 47% of the total biomass from deciduous forest clearings within the 3-mill area.

Table 6. Feedstock supplies for the 3-mill cluster in 2016, 2017, and 2018 from deciduous harvest as reported by Enviva in Supply Base Reports, and the percent of potential production from deciduous forest clearings detected in this study.[1]

	2016	2017	2018
Total Pellet Feedstock	[green tonnes of biomass per year]		
Ahoskie	706,675	706,675	652,083
Northampton	981,002	908,641	862,609
Southampton	970,670	862,567	814,632
Total of Three Mills	2,658,347	2,477,883	2,329,324
Pellets from Deciduous Harvesting	[dry tonnes of pellets per year]		
Ahoskie	235,988	235,988	217,757
Northampton	327,597	303,433	288,061
Southampton	324,147	288,047	272,039
Total of Three Mills	887,732	827,467	777,857
Potential Feedstock from Deciduous Clearing	1,895,914	1,895,914	1,895,914
% Potential from Deciduous Clearings	47%	44%	41%

[1] In 2019, Enviva's total pellet feedstock (including primary feedstock from forests) increased at each of the three mills from 2018 (*5-7*). As reported by Enviva, the 2019 total pellet feedstock (in green tonnes) were: Ahoskie 688,752; Northampton, 1,014,554; Southampton 915,568. For the Southampton and Northampton mills, this increase was above 2017 levels. The same is true for the Enviva Sampson mill, with total pellet feedstock increasing from 852,842 in 2017 and 879,826 in 2018 to 1,016,024 in 2019 (see Enviva Sampson SBP reports 36. Enviva, "Supply Base Report: Enviva Pellets Sampson, LLC, Fourth Surveillance Audit, available for download at https://sbp-cert.org/certificate-holders/#4619," (Sustainable Biomass Program, 2020).) .

5. Conclusions

With analysis of the GFW forest cover and forest loss data, we find that the rate of forest clearing increased markedly after the initiation of pellet mill operations at Northampton, Southampton, and Ahoskie. By 2013 to 2015, the 3-mill region saw deciduous forest clearing increase by 1.34 times over that in 2009 to 2012, and by 2016 to 2018 it increased to 1.51 times. (Table 4 and section 4.1) The reference region, prior to its pellet mill operations, saw a 2013 to 2015 increase of only 1.18 times over the 2009 to 2012 period. However, once pellet mill operations began within the reference region in 2016, deciduous forest clearing rose to 1.54 times the rate during the recession period. Together, these lines of evidence provide a clear indication that the initiation of pellet mill operations contributed to elevated rates of deciduous forest clearing beginning in the early 2010s for the 3-mill region, and in 2016 for the reference region.

With analysis of NLCD land cover data, we find a net loss of forested area within the 3-mill region, with an average annual loss of 2,313 hectares per year from 2001 to 2016. Over the 15-year period this corresponds to a loss of 2.4% of the year-2001 Deciduous, Mixed, and Woody Wetland forest areas combined. By comparison, the reference region saw a 15-year loss of only 1.1%. Despite some gains in coniferous forest types, the 3-mill region saw a combined net loss of forested area from 2001 to 2016, losing 1.5% of the year-2001 forestland. Forest loss rates were generally steady over the two time intervals of 2001 to 2011 and 2011 to 2016. Thus, pellet mill operations do not appear to have induced an increase in forestland area within the region, and in fact deciduous forestland saw a sizeable and steady decline.

Enviva's supply base reports indicate that from 2016 to 2018 the three mills consumed 2.33 to 2.66 million green tonnes of biomass feedstock per year, with 68% of the feedstock from recent hardwood harvests. This deciduous-only, direct-harvest portion of the total feedstock would support the production of 0.78 to 0.89 million dry tonnes of pellets per year from Enviva's 3-mill cluster supply. This corresponds to 41% to 47% of the total biomass extracted from deciduous forest clearings within the 3-mill area. Therefore, pellet mill operations consume a correspondingly large fraction of the total deciduous forest clearing within the region.

With declining deciduous forest cover in the 3-mill sourcing region and with Enviva consuming 41% to 47% of the total biomass extracted from deciduous forest clearings in the area, it is likely that Enviva sourcing is contributing to overall declining carbon stocks in deciduous forests in the 3-mill area. The fact that the wood pellets made from the feedstock sourced from the area's forests is burned for power generation overseas further worsens the carbon and climate profile of pellet mill operations as a whole.

6. Citations

1. K. L. Abt, R. C. Abt, C. S. Galik, K. E. Skog, Effect of policies on pellet production and forests in the US South: a technical document supporting the Forest Service update of the 2010 RPA Assessment. *Gen. Tech. Rep. SRS-202, Asheville, NC: US Department of Agriculture Forest Service, Southern Research Station. 33 p.* **202**, (2014).
2. V. H. Dale, K. L. Kline, E. S. Parish, A. L. Cowie, R. Emory, R. W. Malmsheimer, R. Slade, C. T. SMITH Jr, T. B. Wigley, N. S. Bentsen, G. Berndes, P. Bernier, M. Brandão, H. L. Chum, R. Diaz-Chavez, G. Egnell, L. Gustavsson, J. Schweinle, I. Stupak, P. Trianosky, A. Walter, C. Whittaker, M. Brown, G. Chescheir, I. Dimitriou, C. Donnison, A. Goss Eng, K. P. Hoyt, J. C. Jenkins, K. Johnson, C. A. Levesque, V. Lockhart, M. C. Negri, J. E. Nettles, M. Wellisch, Status and prospects for renewable energy using wood pellets from the southeastern United States. *GCB Bioenergy* **9**, 1296-1305 (2017).
3. E. Voegele, "USDA: US exports 7.26 million metric tons of wood pellets in 2020," (Biomass Magazine, February 05, 2021, http://www.biomassmagazine.com/articles/17712/usda-us-exports-7-26-million-metric-tons-of-wood-pellets-in-2020, 2021).
4. Drax, "Drax Group plc Annual Report and Accounts 2020," (https://www.drax.com/wp-content/uploads/2021/03/Drax_AR2020.pdf 2021).
5. Enviva, "Supply Base Report: Enviva Pellets Southampton, LLC, Fourth Surveillance Audit, available for download at https://sbp-cert.org/certificate-holders/#4435," (Sustainable Biomass Program, 2019).
6. Enviva, "Supply Base Report: Enviva Pellets Northampton, LLC, Fourth Surveillance Audit, available for download at https://sbp-cert.org/certificate-holders/#4310," (Sustainable Biomass Program, 2019).
7. Enviva, "Supply Base Report: Enviva Pellets Ahoskie, LLC, Fourth Surveillance Audit, available for download at https://sbp-cert.org/certificate-holders/#4347," (Sustainable Biomass Program, 2019).
8. SELC, "Southeast U.S. Wood Pellet Plants Exporting to Europe," (https://www.southernenvironment.org/uploads/maps/SELC_WoodPelletExportMap_2021_0701_map+table.pdf, 2021).
9. J. Scheck, in *The Wall Street Journal*. (https://www.wsj.com/articles/SB10001424127887324082604578485491298208114, 2013).
10. S. Stashwick, R. Frost, D. W. Carr. (Dogwood Alliance, Natural Resources Defense Council, and Southern Environmental Law Center, https://www.nrdc.org/sites/default/files/media-uploads/9965_nrdc_2019_booklet_05_em_-_web_version.pdf, 2019).
11. E. D. Schulze, C. Koerner, B. E. Law, H. Haberl, S. Luyssaert, Large-scale bioenergy from additional harvest of forest biomass is neither sustainable nor greenhouse gas neutral. *Global Change Biology Bioenergy* **4**, 611-616 (2012).
12. G. Zanchi, N. Pena, N. Bird, Is woody bioenergy carbon neutral? A comparative assessment of emissions from consumption of woody bioenergy and fossil fuel. *GCB Bioenergy* **4**, 761-772 (2012).
13. NRDC, "The Sustainable Biomass Program: Smokescreen for Forest Destruction and Corporate Non-Accountability," (https://www.nrdc.org/sites/default/files/sustainable-biomass-program-partnership-project-ip.pdf, 2017).

14. J. Southworth, J. Hartter, M. W. Binford, A. Goldman, C. A. Chapman, L. J. Chapman, P. Omeja, E. Binford, Parks, people and pixels: evaluating landscape effects of an east african national park on its surroundings. *Tropical Conservation Science* **3**, 122-142 (2010).
15. R. E. Kennedy, Z. Yang, W. B. Cohen, E. Pfaff, J. Braaten, P. Nelson, Spatial and temporal patterns of forest disturbance and regrowth within the area of the Northwest Forest Plan. *Remote Sensing of Environment* **122**, 117-133 (2012).
16. M. C. Hansen, High-resolution global maps of 21st-century forest cover change. *Science* **342**, (2013).
17. B. Ruefenacht, M. V. Finco, M. D. Nelson, R. Czaplewski, E. H. Helmer, J. A. Blackard, G. R. Holden, A. J. Lister, D. Salajanu, D. Weyermann, K. Winterberger, Conterminous U.S. and Alaska Forest Type Mapping Using Forest Inventory and Analysis Data. *Photogrammetric Engineering and Remote Sensing* **74**, 1379-1388 (2008).
18. C. A. Williams, N. Hasler, H. Gu, Y. Zhou. (ORNL Distributed Active Archive Center, 2021).
19. J. Fry, G. Xian, S. Jin, J. Dewitz, C. Homer, L. Yang, C. Barnes, N. Herold, J. Wickham, Completion of the 2006 National Land Cover Database for the Conterminous United States. *Photogrammetric Engineering and Remote Sensing* **77**, 858-864 (2011).
20. C. Homer, J. Dewitz, J. Fry, M. Coan, N. Hossain, C. Larson, N. Herold, A. McKerrow, J. N. VanDriel, J. Wickham, Completion of the 2001 National Land Cover Database for the Conterminous United States. *Photogrammetric Engineering and Remote Sensing* **73**, 337-341 (2007).
21. C. G. Homer, J. A. Dewitz, L. Yang, S. Jin, P. Danielson, G. Xian, J. Coulston, N. D. Herold, J. D. Wickham, K. Megown, Completion of the 2011 National Land Cover Database for the conterminous United States-Representing a decade of land cover change information. *Photogrammetric Engineering and Remote Sensing* **81**, 345-354 (2015).
22. S. Jin, L. Yang, P. Danielson, C. Homer, J. Fry, G. Xian, A comprehensive change detection method for updating the National Land Cover Database to circa 2011. *Remote Sensing of Environment* **132**, 159-175 (2013).
23. USGS. (U.S. Geological Survey data release, https://doi.org/10.5066/P955KPLE., 2018).
24. J. Eidenshink, B. Schwind, K. Brewer, Z.-L. Zhu, B. Quayle, S. Howard, A project for monitoring trends in burn severity. *Fire Ecology* **3**, 3-21 (2007).
25. D. G. Hodges, A. J. Hartsell, C. Brandeis, T. J. Brandeis, J. W. Bentley, Recession Effects on the Forests and Forest Products Industries of the South. *Forest Products Journal* **61**, 614-624 (2011).
26. C. E. Keegan, C. B. Sorenson, T. A. Morgan, S. W. Hayes, J. M. Daniels, Impact of the Great Recession and Housing Collapse on the Forest Products Industry in the Western United States. *Forest Products Journal* **61**, 625-634 (2011).
27. R. P. Dahal, J. E. Henderson, I. A. Munn, Forest Products Industry Size and Economic Multipliers in the US South. *Forest Products Journal* **65**, 372-380 (2015).
28. T. W. B. a. OECD, a. O. N. A. d. f. The World Bank national accounts data, Ed. (https://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG?end=2019&locations=US&start=1997&view=chart, 2021).
29. J. R. Townshend, J. G. Masek, C. Huang, E. F. Vermote, F. Gao, S. Channan, J. O. Sexton, M. Feng, R. Narasimhan, D. Kim, Global characterization and monitoring of

forest cover using Landsat data: opportunities and challenges. *International Journal of Digital Earth* **5**, 373-397 (2012).
30. M. Feng, J. O. Sexton, C. Huang, A. Anand, S. Channan, X.-P. Song, D.-X. Song, D.-H. Kim, P. Noojipady, J. R. Townshend, Earth science data records of global forest cover and change: Assessment of accuracy in 1990, 2000, and 2005 epochs. *Remote Sensing of Environment* **184**, 73-85 (2016).
31. Y. Li, D. Sulla-Menashe, S. Motesharrei, X.-P. Song, E. Kalnay, Q. Ying, S. Li, Z. Ma, Inconsistent estimates of forest cover change in China between 2000 and 2013 from multiple datasets: differences in parameters, spatial resolution, and definitions. *Scientific Reports* **7**, 8748 (2017).
32. M. C. Hansen, S. V. Stehman, P. V. Potapov, Quantification of global gross forest cover loss. *Proceedings of the National Academy of Sciences* **107**, 8650-8655 (2010).
33. J. O. Sexton, P. Noojipady, A. Anand, X.-P. Song, S. McMahon, C. Huang, M. Feng, S. Channan, J. R. Townshend, A model for the propagation of uncertainty from continuous estimates of tree cover to categorical forest cover and change. *Remote Sensing of Environment* **156**, 418-425 (2015).
34. S. Phillips, "Acreage required to meet projected biomass pellet demand from the European Union, 2016 – 2030," (Dogwood Alliance, https://www.southernenvironment.org/uploads/audio/BiomassAcreage_Final_20160427_(3).pdf., 2016).
35. H. Gu, C. A. Williams, N. Hasler, Y. Zhou. (ORNL Distributed Active Archive Center, 2019).
36. Enviva, "Supply Base Report: Enviva Pellets Sampson, LLC, Fourth Surveillance Audit, available for download at https://sbp-cert.org/certificate-holders/#4619," (Sustainable Biomass Program, 2020).

Appendix 1 Figures of Areas Excluded from Analysis

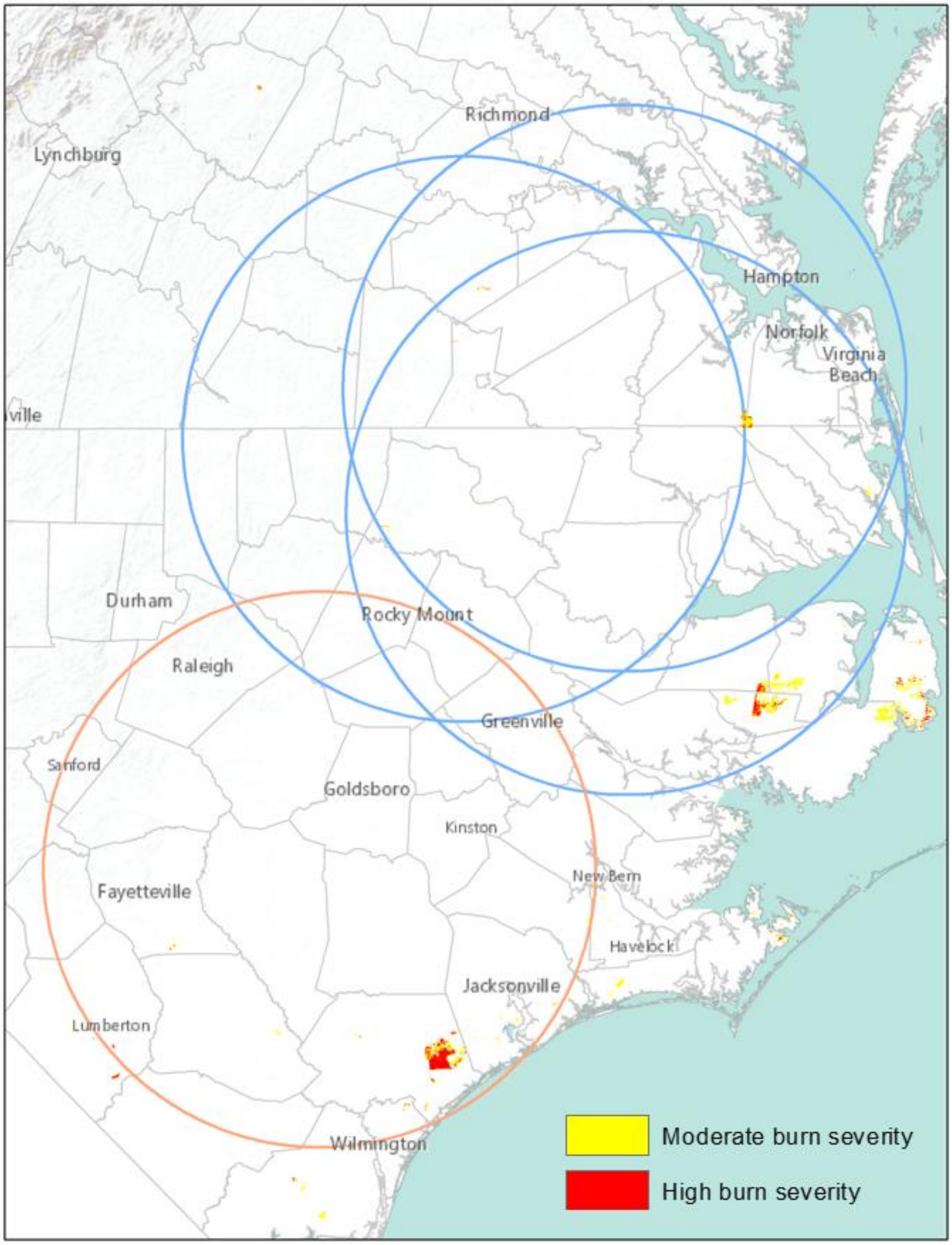

Figure A1. Burned areas of moderate and high severity fires excluded from the analysis based on the Monitoring Trends in Burn Severity dataset.

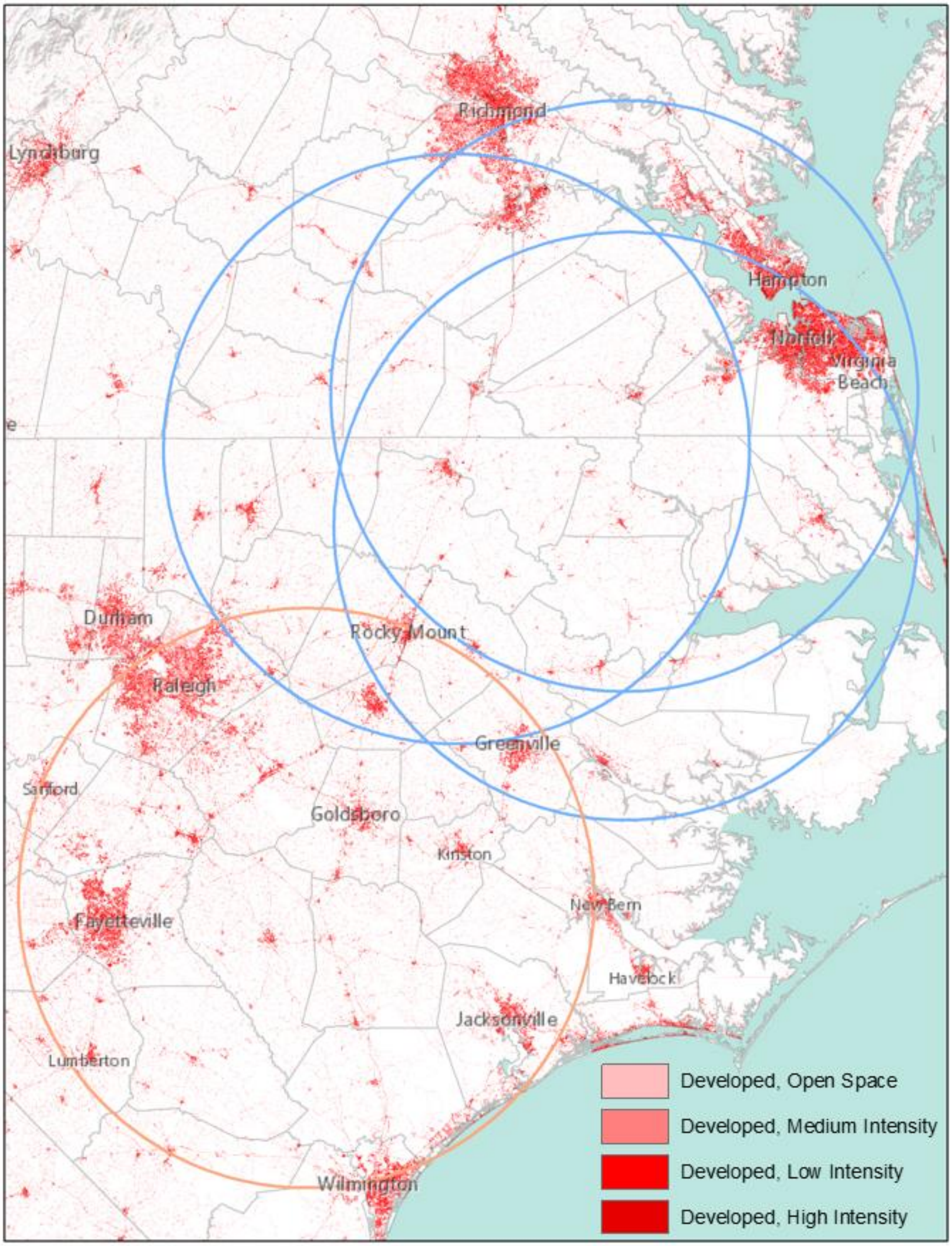

Figure A2. Developed lands in 2016 according to the National Land Cover Dataset.

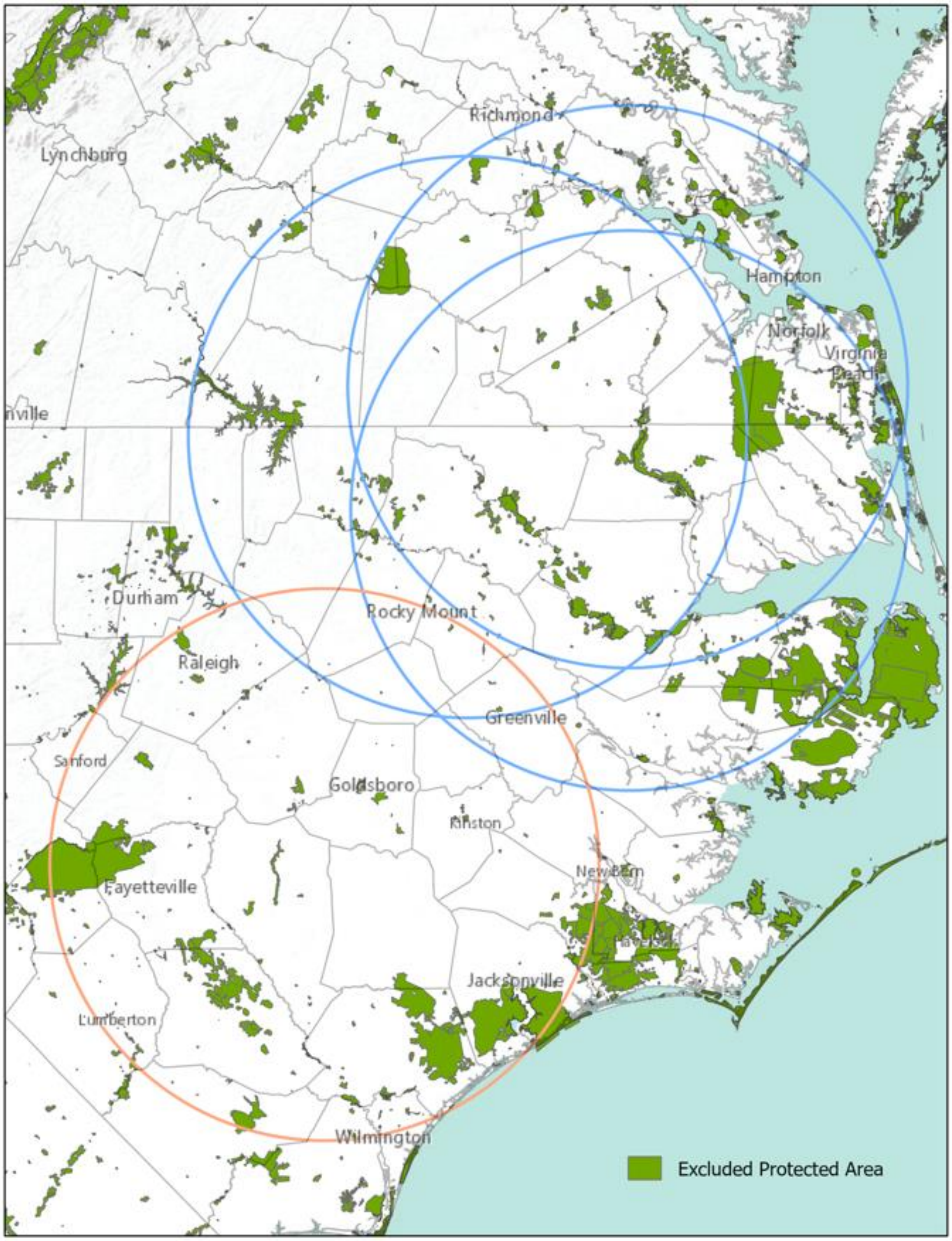

Figure A3. Protected areas from the USGS GAP PAD-US 2.0 dataset that are not prone to forest harvesting sourced for pellet mills.

Appendix 2 Datasets Provided with Report

1. Map data of forest area by forest type group in 2000.
2. Map data of forest clearing by forest type group for each year from 2001 to 2019.
3. Map data of NLCD analysis of forest area by forest type class for 2001, 2011 and 2016.
4. Map data of spatial filters applied for burned areas, developed lands, and protected areas.
5. Excel spreadsheet including:
    a. Tables and figures of the area of annual forest clearings and percentage cleared by forest type, deciduous forest types and coniferous forest types within 100 km radius of each selected pellet mill, the 3-mill region, the reference region, and the 4 cut-out regions.
    b. Tables of forest area by each forest type, deciduous, and coniferous types in 2000.
    c. Table and charts of NLCD forest area and percentage change per year from 2001 to 2011, for 2011 to 2016, and from 2001 to 2016.
    d. Table of feedstock analysis.
    e. Table of tree cover percent analysis.
    f. Tables formatted for inclusion in this final report.

Appendix 3 Area of Gross Forest Clearings

Annual Area of Gross Forest Clearing by Forest Type Group for Each Pellet Mill Source Region, the 3-Mill Combined Source Region, and the Reference Region

Area of Gross Forest Clearing [hectares]

Northampton Pellet Mill Source region

Year	Loblolly / Shortleaf Pine	Oak / Pine	Oak / Hickory	Oak / Gum / Cypress	Elm / Ash / Cottonwood	Deciduous	Coniferous
2001	14370	3370	10870	2257	159	16656	14370
2002	13678	2593	10408	2163	124	15287	13678
2003	14386	2028	6604	1085	77	9793	14386
2004	20408	2870	8003	1522	148	12542	20408
2005	22154	2968	8438	2035	130	13571	22154
2006	22722	2803	9549	2204	162	14719	22722
2007	21847	2887	8685	2209	139	13920	21847
2008	20467	2371	7959	2442	309	13082	20467
2009	18207	2167	7213	1951	162	11493	18207
2010	19378	2655	6327	1665	131	10777	19378
2011	14967	1862	6076	1448	87	9472	14967
2012	15973	2064	5791	1239	91	9185	15973
2013	20065	2746	7226	1874	170	12016	20065
2014	21442	3227	8871	2446	187	14731	21442
2015	20258	3441	9454	2305	211	15411	20258
2016	21662	3693	10140	2305	294	16432	21662
2017	23456	3400	10384	2971	261	17015	23456
2018	21186	3126	9170	2211	149	14657	21186
2019	19504	3181	8328	2520	152	14180	19504

Southampton Pellet Mill Source region

Year	Loblolly / Shortleaf Pine	Oak / Pine	Oak / Hickory	Oak / Gum / Cypress	Elm / Ash / Cottonwood	Deciduous	Coniferous
2001	12718	2531	6807	2416	106	11859	12718
2002	12176	2007	6874	2515	98	11494	12176
2003	12216	1434	3777	1331	53	6595	12216
2004	18571	2110	4326	1614	104	8154	18571
2005	20951	2136	5113	2245	130	9623	20951
2006	19006	2056	5147	2642	95	9940	19006
2007	19650	2244	4842	2510	104	9700	19650
2008	17324	1722	4835	2752	263	9572	17324
2009	15819	1562	4801	1922	131	8415	15819
2010	17123	1919	3982	1865	92	7858	17123
2011	12181	1222	3435	1163	68	5888	12181
2012	14552	1570	3608	1160	82	6420	14552
2013	17023	1768	4113	1795	168	7843	17023
2014	18429	2120	5541	2419	138	10218	18429
2015	17313	2199	5274	1965	143	9581	17313
2016	18045	2443	5299	2139	219	10101	18045
2017	19419	2207	5916	2815	224	11162	19419
2018	17007	1964	4824	1995	78	8861	17007
2019	16014	2095	4797	2466	109	9467	16014

Ahoskie Pellet Mill Source region

Year	Loblolly / Shortleaf Pine	Oak / Pine	Oak / Hickory	Oak / Gum / Cypress	Elm / Ash / Cottonwood	Deciduous	Coniferous
2001	15674	2835	4658	3370	101	10963	15674
2002	13784	2330	4757	3659	91	10838	13784
2003	14656	1828	2657	1996	56	6538	14656
2004	19878	2476	2993	2393	98	7960	19878
2005	23703	2650	3318	3179	107	9254	23703
2006	21239	2363	3696	3580	87	9726	21239
2007	21171	2514	3074	3596	103	9288	21171
2008	20313	2044	2977	3894	241	9156	20313
2009	16633	2030	3307	2705	114	8156	16633
2010	18949	2280	2885	2685	66	7917	18949
2011	12831	1583	2137	1871	60	5650	12831
2012	16662	1961	2396	1966	59	6382	16662
2013	18721	2131	2839	2676	119	7764	18721
2014	19615	2633	3761	3357	120	9872	19615
2015	18260	2953	3669	3017	123	9761	18260
2016	19199	3327	3941	3120	203	10591	19199
2017	19622	2879	4182	3843	208	11112	19622
2018	18111	2503	3585	2941	79	9109	18111
2019	17111	2759	3368	3449	95	9671	17111

Reference Region Sampson Pellet Mill Source region

Year	Loblolly / Shortleaf Pine	Oak / Pine	Oak / Hickory	Oak / Gum / Cypress	Elm / Ash / Cottonwood	Deciduous	Coniferous
2001	10636	1832	1669	4000	50	7550	10636
2002	11215	1584	1315	3947	22	6868	11215
2003	9725	1186	1033	2703	13	4935	9725
2004	12672	1581	1377	3179	10	6148	12672
2005	13445	1744	1496	4115	7	7362	13445
2006	12024	1925	1485	3767	20	7197	12024
2007	14707	1825	1689	4305	42	7861	14707
2008	13035	1576	1386	3627	13	6603	13035
2009	11375	1397	955	3707	9	6068	11375
2010	12455	1746	1383	4169	10	7307	12455
2011	11110	1476	1353	3641	16	6486	11110
2012	12392	1615	1368	3547	22	6552	12392
2013	13889	1720	1466	3995	17	7199	13889
2014	14534	1728	1781	3941	11	7460	14534
2015	13368	1939	1984	4762	10	8695	13368
2016	16382	2458	2120	5001	34	9612	16382
2017	19269	2976	2641	5893	58	11568	19269
2018	16154	2374	1913	5019	27	9332	16154
2019	14360	1907	1703	4583	18	8211	14360

3-Mill Combined Source region

Year	Loblolly / Shortleaf Pine	Oak / Pine	Oak / Hickory	Oak / Gum / Cypress	Elm / Ash / Cottonwood	Deciduous	Coniferous
2001	19776	4033	11989	3480	165	19666	19776
2002	17627	3155	11575	3748	139	18617	17627
2003	19607	2399	7464	2077	83	12022	19607
2004	26796	3395	8727	2496	155	14773	26796
2005	31017	3615	9387	3298	152	16452	31017
2006	29233	3365	10371	3677	176	17589	29233
2007	28662	3465	9633	3706	147	16951	28662
2008	28442	2844	9122	4071	325	16361	28442
2009	22626	2602	7898	2810	177	13486	22626
2010	25749	3055	7026	2821	143	13045	25749
2011	19190	2198	6629	2000	103	10930	19190
2012	21949	2591	6489	2040	104	11223	21949
2013	25789	3157	7952	2751	196	14057	25789
2014	27555	3744	9706	3514	199	17163	27555
2015	25624	4059	10276	3182	213	17730	25624
2016	27172	4384	10957	3273	317	18932	27172
2017	28382	3962	11388	4013	284	19647	28382
2018	25983	3582	10036	3086	159	16863	25983
2019	24533	3726	9265	3577	159	16728	24533

Cut-Out A region

Year	Loblolly / Shortleaf Pine	Oak / Pine	Oak / Hickory	Oak / Gum / Cypress	Elm / Ash / Cottonwood	Deciduous	Coniferous
2001	1488	885	1365	442	32	2725	1488
2002	1184	732	1303	335	38	2408	1184
2003	2378	1015	1281	171	12	2479	2378
2004	2320	983	1051	220	16	2269	2320
2005	2438	1265	1058	329	6	2657	2438
2006	2622	1131	1298	273	22	2724	2622
2007	2456	1191	1132	359	34	2716	2456
2008	2098	771	889	403	65	2128	2098
2009	1807	970	865	285	43	2162	1807
2010	2868	1153	1198	211	50	2613	2868
2011	1790	674	820	310	21	1824	1790
2012	1978	793	958	203	12	1966	1978
2013	2862	1145	1087	163	16	2410	2862
2014	2881	1506	1489	355	44	3393	2881
2015	2967	1612	1677	483	25	3797	2967
2016	3078	1908	1914	485	112	4419	3078
2017	2678	1294	1482	568	41	3384	2678
2018	2414	1135	1343	289	54	2820	2414
2019	2610	1402	1433	432	33	3300	2610

Cut-Out C region

Year	Loblolly / Shortleaf Pine	Oak / Pine	Oak / Hickory	Oak / Gum / Cypress	Elm / Ash / Cottonwood	Deciduous	Coniferous
2001	2607	324	1382	584	54	2345	2607
2002	1814	233	1285	414	30	1962	1814
2003	1994	96	544	218	14	872	1994
2004	2976	163	691	287	54	1195	2976
2005	3161	184	878	541	64	1668	3161
2006	3899	205	1307	573	40	2125	3899
2007	3669	223	996	627	33	1879	3669
2008	3582	150	881	689	33	1753	3582
2009	3291	116	871	397	25	1409	3291
2010	3269	164	840	529	20	1553	3269
2011	2242	131	650	329	21	1131	2242
2012	2409	138	564	244	9	955	2409
2013	3928	147	849	474	37	1507	3928
2014	3660	231	1129	480	56	1896	3660
2015	3009	132	983	318	69	1502	3009
2016	3248	213	815	336	63	1427	3248
2017	3156	245	1160	665	42	2112	3156
2018	3016	228	1051	428	9	1715	3016
2019	2918	176	846	656	18	1696	2918

[end of report]