

Supplementary Information

S1. Calculation of NPP_{pot}

NPP_{pot} (Equation (S1)) was calculated using the multiplicative Miami Model of Zaks *et al.* [1].

$$\text{NPP}_{\text{pot}} = ((a/(1 + \exp(b - c \times T))) \times (d \times 1 - \exp(e \times P))) \quad (\text{S1})$$

Values of the constants are $a = -20.13$, $b = 9.5$, $c = 2.25$, $d = -45.83$ and $e = -3.5$. Temperature (T) and precipitation (P) represent the annual averages from the monthly observed records of the United States National Climate Data Center [2] between 1897 to 2012 for Greenville, SC, USA.

S2. LiDAR Data for Estimated Canopy Height

Shoot biomass was required to select the appropriate root:shoot ratio to convert from total NPP_{act} to aboveground NPP_{act}. We used the equation from Lefsky *et al.* [3] (see methods) to calculate shoot biomass based on average canopy height. Canopy height was determined using 2011 LiDAR data using equal area polygons (Table S1). LiDAR data was acquired from the United States Geological Survey Earth Explorer website [4].

Table S1. Average canopy height for LiDAR polygons in the Doddie Creek watershed.

Polygon	Height (m)	StdDev (m)
S1	15.76	8.71
S2	12.99	7.72
S3	14.7	8.36
S4	13.62	9.77
S5	14.9	8.07
S6	11.57	7.23
S7	13.51	8.99
S8	14.95	8.51
S10	14.75	9.69
GB	14.09	8.99
Average	14.08	8.60

Based on the results of the estimated shoot biomass of conifer and broadleaf forest (deciduous), we chose the root:shoot ratio from the bolded categories in Mokany *et al.* [5] (Table S2).

Table S2. Root:Shoot ratios from Mokany *et al.* [5].

Forest Classification	Shoot	Median
	Biomass (Mg/ha)	Root:Shoot Ratio
Conifer Forest	<50	0.403
	50–150	0.292
	>150	0.201
Broadleaf Forest	<75	0.456
	75–150	0.226
	>150	0.241

S3. Estimated Livestock Populations

Agricultural animal populations were scaled from Pickens County populations from the 1969 and 2012 USDA Census of Agriculture data [6,7] (Table S3). The scaling factor was the percentage of pasture area of Pickens County located in the watershed.

Table S3. Estimated livestock populations in Doddies Creek Watershed.

	1968		2011	
	County	Watershed	County	Watershed
Livestock Type	Population	Population	Population	Population
Cattle and Calves	9468	928	6437	981
Hogs and Pigs	1323	130	377	57
Horses	61	6	1383	211
Goats	0	0	799	122
Sheep and Lamb	244	24	176	27
Mules, Burros, & Donkeys	8	1	137	21
Poultry	194,475	19,054	3352	511
<i>Total Animals</i>	<i>205,579</i>	<i>20,142</i>	<i>12,661</i>	<i>1930</i>
<i>Total Livestock</i>	<i>11104</i>	<i>1088</i>	<i>9309</i>	<i>1419</i>

S4. Calculation of NPP_{act} and $HANPP_{harv}$ for Hay and Row Crops

NPP_{act} (Equation (S2)) for hay and row crops were calculated using the equation of Hicke *et al.* [8]. Values for variables are in Table S4. Harvest data were from the 1969 and 2012 USDA Census of Agriculture [6,7].

$$P = \Sigma((PC \times MRY \times (1 - MC) \times C)/(HI \times fAG)) \quad (S2)$$

P = total productivity in Pickens County

PC = production of crops in reported units

MRY = mass (kg) per reported yield in production units

MC = moisture content

C = carbon conversion (0.45 g C/g crop for all crops)

HI = harvest index

fAG = fraction of plant biomass above ground

Table S4. Values for crops primary production equation of Hicke *et al.* [8]

Crop	MRY^a	MC^a	HI^a	fAG^b
Hay	907.19 kg/ton	15%	1.00	0.53
Corn	25.4 kg/bushel	11%	0.45	0.85
Soybean	27.22 kg/bushel	10%	0.40	0.87
Wheat	27.22 kg/bushel	11%	0.40	0.83
Sorghum	25.4 kg/bushel	10%	0.40	0.80
Cotton	217.7 kg/bale	8%	0.40	0.80

^a Data from Lobell *et al.* [9]; ^b Data from Hicke *et al.* [8];

$NPP = P/A$, where P is production ($g \cdot C \cdot y^{-1}$) and A is the area of crop in the county;

$NPP_{act} = NPP \cdot LF$, where LF is loss factor via herbivory from Haberl *et al.* [10].

$LF = 1.14$ for all crops.

The following equations (Equations (S3)–(S5)) were used to calculate average total and aboveground NPP_{act} ($aNPP_{act}$) and $HANPP_{harvR}$ for row crop in Pickens County.

$$\text{Total } NPP_{act} = (\Sigma P / \Sigma A) \times LF \quad (S3)$$

$$aNPP_{act} = \text{total } NPP_{act} \times fAG \quad (S4)$$

$$HANPP_{harvR} = aNPP_{act} \times HI \quad (S5)$$

For hay, the calculation is straightforward. For row crops, however, the calculations were more complicated. For total NPP_{act} , we used the sum of all production and the total area of row crop area. For $aNPP_{act}$ and $HANPP_{harvR}$, we used area-weighted average of fAG and HI . For 1968, five row crops were harvested in Pickens County (corn, soybean, sorghum, wheat, cotton). For 2011, only corn and soybean were produced in Pickens County. The major assumption was that areas of each row crop in the watershed were proportional to the area in the county. Lack of data for individual farms resulted in this assumption. The results are in Table S5 below.

Table S5. Weighted average row crop harvest data in $g \cdot C \cdot m^{-2} \cdot y^{-1}$.

Parameter	1968	2011
Total NPP_{act}	278.6	657.5
$aNPP_{act}$	234.9	563.4
$HANPP_{harvR}$	82.4	197.7

Fecal return of carbon to the soil was calculated using feed intake data of Haberl *et al.* [10], and using data from Thompsen *et al.* [11] showing 14% long-term (more than a year) fecal return of the carbon ingested as feed. As for row crops, because we lack data for individual farms, we assumed livestock numbers in the watershed had the same proportion as livestock in Pickens County. The number of livestock was determined by the percentage of pasture in Pickens County located in the watershed (9.80% in 1968 and 15.2% in 2011).

S5. Calculation of Timber Harvest ($HANPP_{harvW}$)

Data for recovery rates associated with deciduous and coniferous tree harvest and wood densities for deciduous and coniferous trees were from Haberl *et al.* [10]. Wood harvest data for the watershed was assumed to be proportional to forested area located in the watershed (1.56% in 1968 and 1.52% in 2011). This likely an overestimate as most wood in Pickens County is harvested from plantations or from public forest land.

Timber harvest data from the United States Forest Service for 1968 and 2011 [12] were used to determine the total biomass harvested for the watershed (Equation (S6)).

$$\text{Forest Ecosystem Biomass Harvested (kg)} = TH \times 1/RR \times \rho \times C \times 1/PB \times 1000 \times PW \quad (S6)$$

TH = timber harvest for Pickens County for deciduous and coniferous trees (m^3)

RR = recovery rates (0.92 for coniferous, 0.89 for deciduous) from Haberl *et al.* [10]

ρ = wood density for trees in America in metric tons dry matter per cubic meter (0.43 for coniferous, 0.60 for deciduous) from Haberl *et al.* [10]

C = carbon conversion of 0.5 [13]

PB = percentage of tree biomass in forest ecosystem in South Carolina (0.952)

PW = percentage of Pickens county forest in Doddies Creek watershed

Two methods were used to estimate aboveground forest ecosystem biomass (Mg C/ha). First, based on data from the United States Forest Service for South Carolina forests [12] there are an average of 57.969 Mg·C/ha in trees and 2.941 Mg·C/ha in understory for a total of 60.910 Mg·C/ha in forest ecosystem biomass.

A second we used the LiDAR estimate mean canopy height for the watershed in the equation (Equation (S7)) from Lefsky *et al.* [14].

$$\text{Aboveground Biomass (Mg/ha)} = 20.7 + 0.98 \times \text{mean canopy height}^2 \quad (7)$$

This resulted in an aboveground forest ecosystem biomass of 40.139 Mg·C/ha.

We calculated area of timber harvest by (Equation (S8)):

$$\text{Area (ha)} = \text{kg C biomass harvested} / (\text{kg C/ha in forest ecosystem biomass}) \quad (8)$$

This resulted in an estimate of 6.8 ha of timber harvest using the average forest ecosystem biomass for South Carolina and 10.5 ha of timber harvest using the forest ecosystem biomass determined using the Lefsky *et al.* [14] equation.

We also determined the area of the watershed deforested (Figure S1) using satellite data from Hansen *et al.* [15]. The results indicated 2.7 ha of forest loss in 2011, and an average of 11.7 ha of forest loss over the three year period from 2010 to 2012.

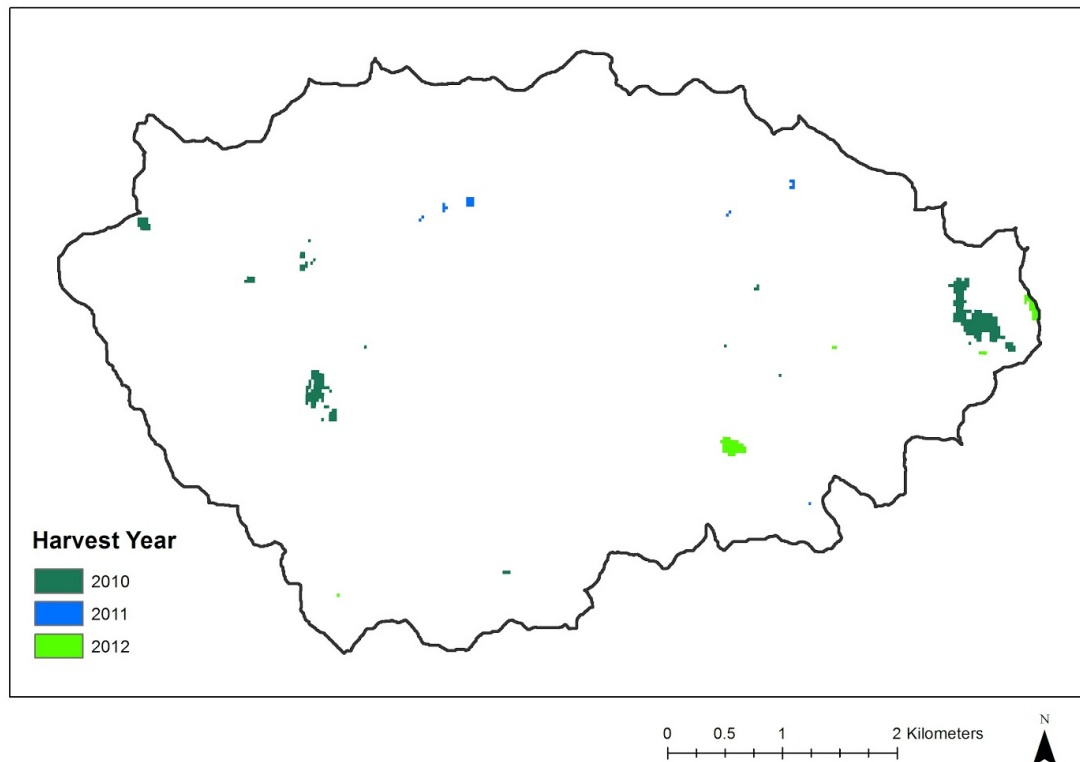


Figure S1. Area of harvest for the years 2010–2012. Data from Hansen *et al.* (2013) [15].

Percent aHANPPluc varied by land cover type and year (Figure S2, Table S6), with aHANPPluc the dominant driver of aHANPP (Figure S3). aHANPPluc was driven by row crop and pasture in 1968, but primarily pasture in 2011 (Figure S3).

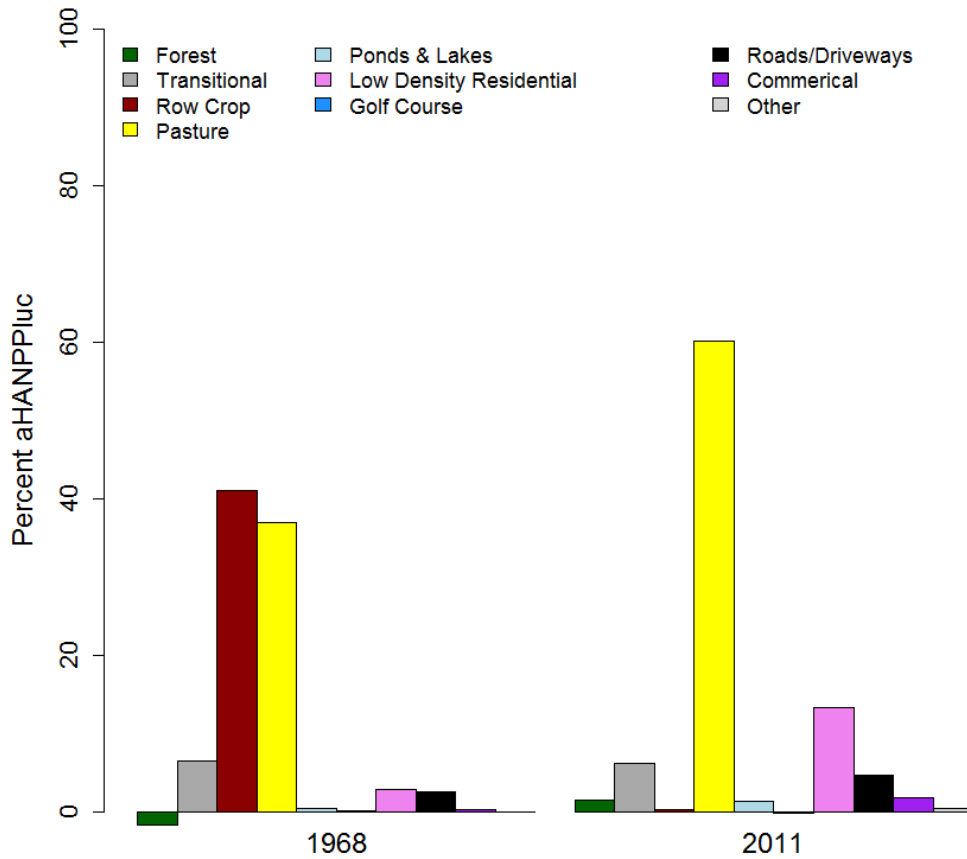


Figure S2. Percent aHANPPluc of total NPPpot in the Doddies Creek watershed for important land covers in 1968 and 2011.

Table S6. Percent aHANPPluc of total NPPpot in the Doddies Creek watershed for important land covers in 1968 and 2011.

Land Use	1968	2011
Forest	-1.68	1.43
Transitional	6.45	6.21
Row Crop	41.08	0.21
Pasture	36.87	60.19
Ponds & Lakes	0.39	1.32
Golf Course	-0.11	-0.23
Low Density Residential	2.84	13.30
Roads/Driveways	2.57	4.62
Commercial	0.24	1.74
Other	0.00	0.33

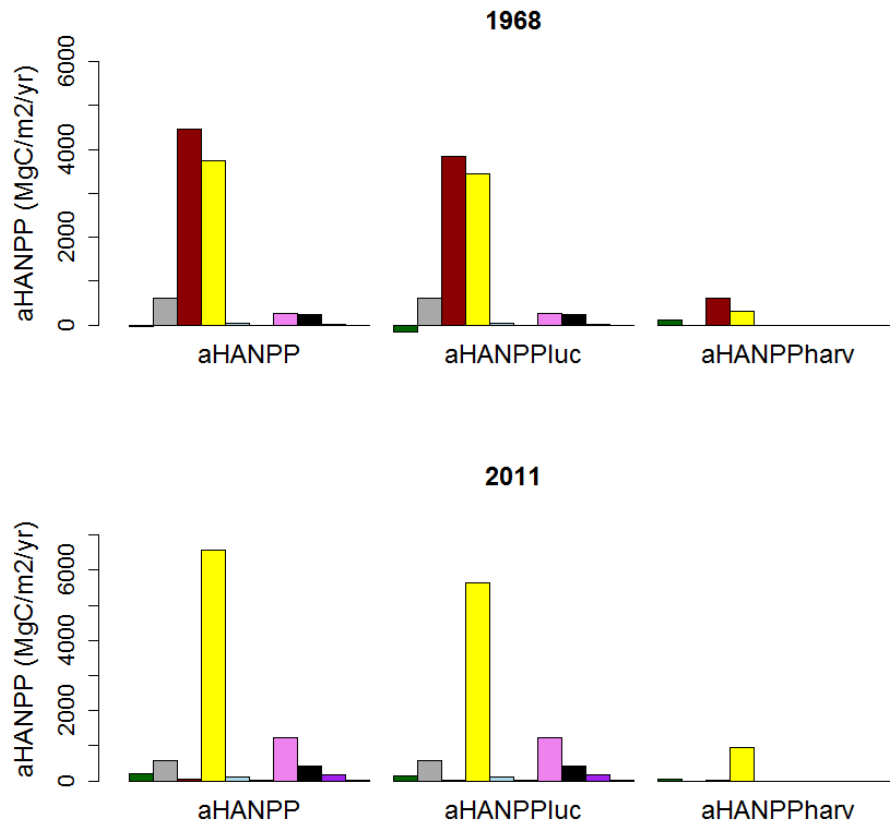


Figure S3. aHANPP, aHANPPPluc, and aHANPPPharv per important land cover in the Doddies Creek watershed in (MgC/m²/yr) for 1968 and 2011.

References

1. Zaks, D.P.M.; Ramankutty, N.; Barford, C.C.; Foley, J.A. From Miami to Madison: Investigating the relationship between climate and terrestrial net primary production. *Glob. Biogeochem. Cycles* **2007**, *21*, doi:10.1029/2006GB002705.
2. National Oceanic and Atmospheric Administration. National Climate Data Center. Available online: <http://www.ncdc.noaa.gov/cdo-web/datasets/GHCNDMS/locations/CITY:US450005/detail> (accessed on 5 December 2014).
3. Lefsky, M.A.; Cohen, W.B.; Harding, D.J.; Parker, G.G.; Acker, S.A.; Gower, S.T. Lidar remote sensing of above-ground biomass in three biomes. *Glob. Ecol. Biogeogr.* **2001**, *11*, 393–399.
4. United States Geological Survey. Earth Explorer. Available online: <http://earthexplorer.usgs.gov/> (accessed on 22 July 2013).
5. Mokany, K.; Raison, R.; Prokushkin, A.S. Critical analysis of root:shoot ratios in terrestrial biomes. *Glob. Chang. Biol.* **2006**, *12*, 84–96.
6. United States Department of Agriculture. Census of Agriculture: 1969 Census, Volume 1, Part 27, Chapters 1 and 4. Available online: http://agcensus.mannlib.cornell.edu/AgCensus/getVolumeOnePart.do?year=1969&part_id=301&number=27&title=South%20Carolina (accessed on 15 October 2014).

7. United States Department of Agriculture. Census of Agriculture: 2012 Census Volume 1, Chapter 2: County Level Data. Available online: http://www.agcensus.usda.gov/Publications/2012/Full_Report/Volume_1,_Chapter_2_County_Level/South_Carolina/ (accessed on 15 October 2014).
8. Hicke, J.A.; Lobell, D.B.; Asner, G.P. Cropland area and net primary production computed from 30 years of USDA agricultural harvest data. *Earth Interact.* **2004**, *8*, 1–20.
9. Lobell, D.; Hicke, J.; Asner, G.; Field, C.; Tucker, C.; Los, S. Satellite estimates of productivity and light use efficiency in United States agriculture, 1982–1998. *Glob. Chang. Biol.* **2002**, *8*, 722–735.
10. Haberl, H.; Erb, K.H.; Krausmann, F.; Gaube, V.; Bondeau, A.; Piutzar, C.; Gingrich, S.; Lucht, W.; Fischer-Kowalski, M. Quantifying and mapping the human appropriation of net primary production in earth's terrestrial ecosystems. *Proc. Natl. Acad. Sci. USA* **2007**, *104*, 12942–12947.
11. Thomsen, I.K.; Olesen, J.E.; Møller, H.B.; Sørensen, P.; Christensen, B.T. Carbon dynamics and retention in soil after anaerobic digestion of dairy cattle feed and faeces. *Soil Biol. Biochem.* **2013**, *58*, 82–87.
12. *USFS Forest Inventory Data Online Web-Application Version: FIDO 1.5.1.05b*; U.S. Department of Agriculture, Forest Service: St. Paul, MN, USA. Available online: <http://apps.fs.fed.us/fia/fido/index.html> (accessed on 31 January 2015).
13. Thomas, S.C.; Martin, A.R. Carbon content of tree tissues: A synthesis. *Forests* **2012**, *3*, 332–352.
14. Lefsky, M.A.; Harding, D.J.; Keller, M.; Cohen, W.B.; Carabajal, C.C.; Espirito-Santo, F.D.B.; Hunter, M.O.; de Oliveira, R., Jr. Estimates of forest canopy height and aboveground biomass using ICESat. *Geophys. Res. Lett.* **2005**, *32*, doi:10.1029/2005GL023971.
15. Hansen, M.C.; Potapov, P.V.; Moore, R.; Hancher, M.; Turubanova, S.A.; Tyukavina, A.; Thau, D.; Stehman, S.V.; Goetz, S.J.; Loveland, T.R.; *et al.* High-Resolution Global Maps of 21st-Century Forest Cover Change. *Science* **2013**, *342*, 850–853.

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