**Appendix**

*A.1 South America vegetation cover in 2000 based on remote sensing (Eva et al. 2004)*

| *Vegetation type* | *Area* ($10^6$ km$^2$) |
|---|---|
| Humid Tropical Forest | 6.305 |
| Dry Tropical Forest | 1.467 |
| Temperate Forests | 0.197 |
| Agriculture | |
| Intensive | 2.0247 |
| Mosaic degraded non-forest vegetation | 0.735 |
| Mosaic degraded forest vegetation | 1.513 |
| Grass & Shrubland | 4.456 |

*A.2. Stocks*

*Inventory based estimates*

| | Woody biomass (PgC) | Organic Carbon in Soil (PgC) |
|---|---|---|
| Amazon forest in 2000 (Malhi et al. 2006) | 121-126 | 164* |

* assuming Malhi et als. forest area of 5.76 mio km$^2$, and a soil organic carbon content of 29.1 kgC m$^{-2}$ (Jobaggy and Jackson (2000))

| | | |
|---|---|---|
| Tropical forest | ~95 | |
| Extratropical forests | ~15** | |
| (Gibbs et al. 2007, their table 3) | | |

**assuming forest biomass density of 200 t ha$^{-1}$ and forest areas of Paraguay, Chile and Argentina today based on the data in Appendix A.4

| | | |
|---|---|---|
| Grass and Shrubland | ~14*** | 102**** |
| Agriculture | ~12*** | 76***** |

***rough estimates based on vegetation type areas estimated by Eva et al. 2004 (see A.1) and biomass density of 30 MgC ha$^{-1}$ for Grass and Shrubland and agriculture

**** assuming a soil carbon content of 23.0 kg m$^{-2}$ (Jobaggy and Jackson, 2000, their table 3)

***** assuming a soil carbon content of 17.7 kg m$^{-2}$ (value for crops of Jobaggy and Jackson, 2000)

*Remote sensing based estimates of forest carbon in South America (Saatchi et al. 2011)*

| Country | Area (Mha) | Total C (PgC) (AGB+BGB – i.e above and belowground) |
|---|---|---|
| Forest definition | Tree cover threshold 10% / 30% | Tree cover threshold 10% / 30% |
| Brazil | 442 / 596 | 54 / 61 |
| Peru | 73 / 80 | 12 / 12 |
| Colombia | 64 / 84 | 9 / 10 |
| Venezuela | 47 / 61 | 7 / 7 |

| | | |
|---|---|---|
| Bolivia | 61 / 74 | 6 / 6 |
| Total Latin America | 893 / 1209 | 107 / 120 |

*A.3 Population growth*

(Population division of the Department of Economic and Social Affairs of the United Nations Secretariat, World Population Prospects: The 2008 Revision, http://esa.un.org/unpp)

| Year (AD) | Population ($10^6$) | Fossil Fuel Emissions South America ($PgC\ yr^{-1}$) |
|---|---|---|
| Censuses | | |
| 1950 | 112'411 | 0.031 |
| 1955 | 129'039 | 0.046 |
| 1960 | 147'724 | 0.060 |
| 1965 | 169'238 | 0.065 |
| 1970 | 191'430 | 0.092 |
| 1975 | 214'893 | 0.112 |
| 1980 | 240'916 | 0.139 |
| 1985 | 268'353 | 0.138 |
| 1990 | 295'562 | 0.161 |
| 1995 | 321'621 | 0.192 |
| 2000 | 347'407 | 0.222 |
| 2005 | 371'658 | 0.242 |
| 2010 | 393'221 | |
| Projection (United Nations) | | |
| 2015 | 412'665 | |
| 2020 | 430'212 | |
| 2025 | 445'428 | |
| 2030 | 458'052 | |
| 2035 | 468'111 | |
| 2040 | 475'482 | |
| 2045 | 480'436 | |
| 2050 | 482'850 | |

*A.4 Deforestation*

*Decline of intact tropical forest in Brazil*

According to Fearnside 2005 the original forested area in the Brazilian Legal Amazon was $4x10^6$ $km^2$ and there was approx $0.1x10^6$ $km^2$ of 'old' (pre-1970) deforestation forest in the states of Parã and Maranhão.

| | Area remaining ($10^6$ $km^2$) | % change of area remaining |
|---|---|---|
| | 4.0 | |
| Deforestation ($km^2/yr$) (Fearnside 2005) | | |
| Pre 1970 | 4.0 | |
| Deforested area 100 $km^2$ | | |
| Pre 1978 | 3.931 | |

Deforested area 169.9 $km^2$

| | | |
|---|---|---|
| 1978 | 20.4 | 3.890 |
| 1979 | 20.4 | 3.869 |
| 1980 | 20.4 | 3.849 |
| 1981 | 20.4 | 3.829 |
| 1982 | 20.4 | 3.809 |
| 1983 | 20.4 | 3.788 |
| 1984 | 20.4 | 3.767 |
| 1985 | 20.4 | 3.747 |
| 1986 | 20.4 | 3.727 |
| 1987 | 20.4 | 3.706 |

Deforestation ($km^2$/yr) Brazilian Amazon based on remote sensing (PRODES, INPE)

| | | |
|---|---|---|
| 1988 | 21050 | 3.684 |
| 1989 | 17770 | 3.667 |
| 1990 | 13730 | 3.653 |
| 1991 | 11030 | 3.642 |
| 1992 | 13786 | 3.629 |
| 1993 | 14896 | 3.614 |
| 1994 | 14896 | 3.599 |
| 1995 | 29059 | 3.570 |
| 1996 | 18161 | 3.552 |
| 1997 | 13227 | 3.538 |
| 1998 | 17383 | 3.521 |
| 1999 | 17259 | 3.504 |
| 2000 | 18226 | 3.486 |
| 2001 | 18165 | 3.467 |
| 2002 | 21651 | 3.446 |
| 2003 | 25396 | 3.418 |
| 2004 | 27772 | 3.399 |
| 2005 | 19014 | 3.385 |
| 2006 | 14286 | 3.373 |
| 2007 | 11651 | 3.360 |
| 2008 | 12911 | 3.352 |
| 2009 | 7464 | 3.346 |
| 2010 | 6451 | 3.340 |

*Deforestation estimates of Achard et al. 2002 (Table 1) based on remote sensing*

Forest cover change Latin America Humid Tropical Forest Cover

| Date of forest cover estimate | Forest cover ($10^6 km^2$) | Time period of deforestation est. | Deforestation rate ($km^2\ yr^{-1}$) | Total forest cleared ($km^2$) |
|---|---|---|---|---|
| 1990 | 6.69+-0.57 | | | |
| 1997 | 6.53+-0.56 | | | |
| | | | 25000+-1400 | |
| rate of change | | | 0.38 % $yr^{-1}$ | |

| | |
|---|---|
| Annual regrowth area | 2800+-2200 |
| Rate of change | 0.04% |
| Annual net cover change | -22000+-1200 |
| Rate of change | 0.33% |
| Annual degraded area | 8300 +- 0.67 |
| Rate of change | |

*Deforestation estimates of humid tropical forests 2000-2005 based on remote sensing (Hansen et al. 2008)*

| | Within region forest loss as percent of year 2000 forest area | % contribution of region to forest loss in (global) biome |
|---|---|---|
| Brazil | 3.6 % | 47.8 |
| Americas sans Brazil | 1.23% | 12.8 |
| | | (i.e. brazil contributes 79% of S American humid tropical Forest loss) |

*Deforestation data for countries other than Brazil*
*Andean Amazon*

*Bolivian Amazon*

| Date of forest cover estimate | Forest cover ($10^6 km^2$) | Time period of deforestation est. | Deforestation rate ($km^2\ yr^{-1}$) | Total forest cleared ($km^2$) |
|---|---|---|---|---|
| 1984-1987 | 0.447 | | | 15532 |
| 1989-1994 | 0.437 | 1987-1993 | 1529 | 24703 |
| | | | 0.34 % yr-1 | |
| *(Steininger et al. 2001, Wall-to-Wall, Landsat image analysis)* | | | | |
| 1990-2000 | | | 1506 | |
| 2000-2005 | | | 2247 | |
| *(Killeen et al. 2007, Wall-to-Wall, Landsat image analysis)* | | | | |
| 2005/6 | 0.409 | | | |

*Peruvian Amazon*

| | | |
|---|---|---|
| 1985-1990 | | 1876 |
| *(Perz et al. 2005)* | | |
| 1999-2005 | 0.66 | 647 |
| *(Oliveira et al . 2005, Landsat, "Wall to Wall")* | | |

For explanation of Wall-to-Wall methods see Olander et al. 2008

*Colombia – no reliable data found (although see Sierra 2000)*
*Venezuela – no reliable data found*
*Ecuador – no reliable data found*

*Non-Amazon*
*Paraguay*

1973 ~ 0.624 (Atlantic forest only)

| | | |
|---|---|---|
| 1970-1990 | | 1394 assuming that Atlantic Forest region is where most forest by area is being cleared) |
| 1990-2000 | | 2546 |
| *(Huang et al. 2007)* | | |

| | | |
|---|---|---|
| *Argentina* | | |
| 1900 | ~ 0.026000 | |
| 1970-79 | | 103 |
| 1980-89 | | 138 |
| 1990-99 | | 202 |
| 2000-05 | | 208 |

*(Gasparri et al. 2008, Landsat images, Wall-to-Wall)*

*Forest area data for Andean Amazon*

| | Originally forested Area ($10^6$ km$^2$) | year AD | Region Area (Perz et al. 2005) ($10^6$ km$^2$) | Source |
|---|---|---|---|---|
| Bolivia | 0.505 | | 0.596 | Killeen et al. 2007 |
| Colombia (Amazonia & Orinoquia) | | | 0.631 | |
| Ecuador | | | 0.130 | |
| Perú | 0.66 | 2005 (?) | 0.647 | Oliveira et al. 2007 |
| Venezuela (Amazonas) | | | 0.178 | |
| Brazil, legal Amazon | 4.0 | 1970 | 5.082 | Fearnside 2005 |

*Primary forest Area Non-Amazon*

| | | | |
|---|---|---|---|
| Paraguay, Atlantic forest | 0.624 | 1973 | Huang et al. 2007 |
| Argentina | 0.265 | 1900 | Gasparri et al. 2008 |
| Chile (native forest area, i.e. not necessarily primary) | 0.184 | 1990's | CONAF, 1999 |

*A.5 Simplified Houghton style book-keeping model to estimate carbon release to the atmosphere in the vane of deforestation*

As mentioned in the main text we assume exponential decay of dead organic material left over after a deforestation event: $\Delta C = -\lambda_{decomp} C \Delta t$ where C is carbon, Δt a discrete time interval (one year), and $\lambda_{decmp}$ a decay constant. Thus the carbon release during $t$-$t_{def}$ years after the deforestation event in year $t_{def}$ is $F_{ld \to at}(t - t_{def}) = \lambda_{decmp}(1 - \lambda_{decmp})^{t - t_{def} - 1} C(t_{def})$ with

$$C(t_{def}) = \underbrace{r_{C:Bio} m_{forst} \Delta A(t_{def})}_{\text{Total dead Biomass due to clearcutting of area } \Delta A} \underbrace{(1-\alpha)}_{\text{fraction of dead Biomass not immediately released}} + r_{C:Bio} r_{soil\ relse} m_{soil\ forst}$$

where $r_{C:Bio}$ is the carbon to mass ratio of wood and $m_{forst}$ is tree biomass per area (MgC ha$^{-1}$). The total flux to the atmosphere in year $t$ caused by deforestation during previous years and subsequent decomposition of remaining dead organic material is $F^{tot}_{ld \to at}(t) = \sum_{t_{def} = -\infty}^{t} F_{ld \to at}(t - t_{def})$ thus

$$F^{tot}_{ld\to at}(t) = r_{C:Bio}\{m_{forst}\alpha\Delta A(t) + \lambda_{decmp}\sum_{ndef=1}^{N-1}(m_{forst}(1+r_{bgrd:abgrd})(1-\alpha)\Delta A(t-t_{def}) + r_{soil\ relse}m_{soil\ frst})(1-\lambda_{decmp})^{t-t_{def}}\}$$

Similarly, as already mentioned as well, carbon uptake by land due to spin-up to a new vegetation type after deforestation is assumed to asymptote following $C(t-t_{def}) = C_{steady}(1-e^{-\lambda_{rgrwth}(t-t_{def})})$ where $\lambda_{rgrwth}$ is the inverse of the spin-up time to the new vegetation type. Therefore $F_{ld\to at}(t-t_{def}) = r_{C:Bio}m_{lu}\Delta A(t_{def})(1-e^{-\lambda_{lu}})e^{-\lambda_{lu}(t-t_{def})}$.

The total flux from the atmosphere to land due to re-establishment of either forest or another vegetation type (we distinguish cultivation, secondary forest and pasture) is then given by $F^{tot}_{at\to ld}(t) = \sum_{t_{def}=-\infty}^{t}\sum_{lu}\alpha_{lu}F_{at\to ld}(t,t_{def})$, where $F_{at\to ld}(t,t_{def})$ is carbon uptake in year t in the wake of deforestation in year $t_{def}$ and $\alpha_{lu}$ is the fraction of originally deforested land being replaced by land use type $lu$, thus altogether $F^{tot}_{at\to ld}(t) = r_{C:Bio}m_{lu}(1-e^{-\lambda_{lu}})\sum_{t_{def}=1}^{t-1}\Delta A(t_{def})e^{-\lambda_{lu}(t-t_{def})}$.

The net flux to the atmosphere in year $t$ finally is $F^{net}(t) = F^{tot}_{at\to ld}(t) - F^{tot}_{ld\to at}(t)$.

For the calculations discussed in section 3.2 we use the following numbers: $\alpha = 0.28$ (following Houghton et al. 1983), $\alpha_{lu}$ we estimate based on statistics of agricultural land use of the Brazilian government (AGROPECUARIA, Brazil, 2011), ratio of below- to aboveground tree biomass $r_{blwg:abgrd}$=0.2 (Malhi et al. 2010), $m_{intact\ forest\ trees} = (1+ r_{blwgrd:abvgrd})$*220 (MgC ha$^{-1}$) based on RAINFOR forest censuses, $m_{intact\ forest\_soil}$=291 (MgC ha$^{-1}$) (Jobaggy and Jackson, 2000), $m_{pasture}$ = 8 (MgC ha$^{-1}$) (Barbosa and Fearnside, 1996), $m_{cultivation}$=50 (MgC ha$^{-1}$) (Barbosa and Fearnside, 1996), $m_{secdr\ forst} = 0.8*m_{intact\ forst}$, $r_{soil\ relse}$=0.22 fraction of soil C released on conversion of forest to agriculture (Murty et al. 2002) (while according to Murty et al. 2002 this transition of forest to pasture does not lead to significant soil carbon loss), $r_{C:Bio}$=0.5 (ratio of C to rest of tree biomass by weight), $\lambda_{prim\_forest}$ = 0.1 – 0.05 yr$^{-1}$ (Achard et al. 2002), $\lambda_{secndry\_forest}$ = 0.05 yr$^{-1}$ (Schrodt 2002), $\lambda_{cultiv}$=1 yr$^{-1}$, $\lambda_{pasture}$ = 0.5 yr$^{-1}$.

To scale our estimates from the Brazilian Amazon roughly to the full tropical South American forests we use a ratio of 100/79 based on Hansen et al. 2008, table 1.

*A.6 Carbon pool changes estimated with Dynamic Global Vgetation Models*

Net Biome Production (NBP)
(PgC yr$^{-1}$)*

| Period | DGVM name | | | | |
|---|---|---|---|---|---|
| | Hyland | LPJ | SDGVM | TRI | OCN |
| 1901-1920 | -0.27 | -0.22 | -0.13 | -0.19 | -0.14 |
| 1921-1940 | -0.23 | 0.08 | 0.02 | -0.12 | -0.12 |

| | | | | | |
|---|---|---|---|---|---|
| 1941-1960 | -0.19 | 0.34 | 0.1 | 0.03 | -0.1 |
| 1961-1980 | -0.42 | -0.29 | -0.29 | -0.34 | -0.26 |
| 1981-2000 | -0.77 | -0.41 | -0.59 | -0.47 | -0.35 |
| 2001-2010 | -0.78 | -0.26 | -0.60 | -0.47 | -0.39 |

*a negative value of NBP corresponds to a flux of carbon to the atmosphere from land vegetation.