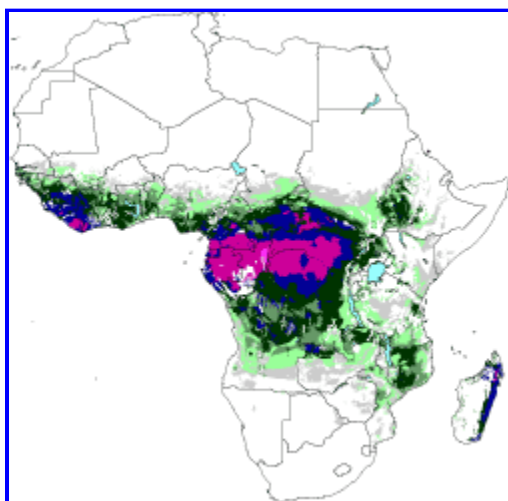# NDP-055

Tropical Africa: Land Use, Biomass, and Carbon Estimates for 1980

Contributed by

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- Abstract
- Access data and ASCII documentation files
- The user may view and print a breakdown by country of the amount of land and biomass in open and closed forest in 1980, and the reclassification scheme used to obtain the four land use cateogries used in NDP055 using the free Adobe® Acrobat® Reader software.
- Users may also review an abstract representing pertinent literature.

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ABBREVIATIONS

CDIAC = Carbon Dioxide Information Analysis Center
FTP = file transfer protocol
NDP = numeric data package
QA = quality assurance
GCM = General Circulation Model
UNEP = United Nations' Environmental Program
FAO = United Nations' Food And Agriculture Organization
GIS = geographic information system
PBD = potential biomass density
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ABSTRACT

Brown, S, and Greg Gaston. 1996. Tropical Africa: Land Use, Biomass, and Carbon Estimates for 1980. NDP-055, Carbon Dioxide Information Center, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

This document describes the contents of a digital database containing maximum potential aboveground biomass, land use, and estimated biomass and carbon data for 1980. The biomass data and carbon estimates are associated with woody vegetation in Tropical Africa. These data were collected to reduce the uncertainty associated with estimating historical releases of carbon from land use change. Tropical Africa is defined here as encompassing 22.7 x 10^6 km^2 of the earth's land surface and is comprised of countries that are located in tropical Africa (Angola, Botswana, Burundi, Cameroon, Cape Verde, Central African Republic, Chad, Congo, Benin, Equatorial Guinea, Ethiopia, Djibouti, Gabon, Gambia, Ghana, Guinea, Ivory Coast, Kenya, Liberia, Madagascar, Malawi, Mali, Mauritania, Mozambique, Namibia, Niger, Nigeria, Guinea-Bissau, Zimbabwe (Rhodesia), Rwanda, Senegal, Sierra Leone, Somalia, Sudan, Tanzania, Togo, Uganda, Burkina Faso (Upper Volta), Zaire, and Zambia).

The database was developed using the GRID module in the ARC/INFO^{TM} geographic information system. Source data were obtained from the Food and Agriculture Organization (FAO), the U.S. National Geophysical Data Center, and a limited number of biomass-carbon density case studies. These data were used to derive the maximum potential and actual (ca. 1980) aboveground biomass values at regional and country levels. The land-use data provided were derived from a vegetation map originally produced for the FAO by the International Institute of Vegetation Mapping, Toulouse, France.

Analyses conducted with this database found that 18% of Tropical Africa was classified as closed forest and 36% was classified as open forest in 1980. Forested lands contained over 138×10^9 Mg of aboveground live biomass, which is equivalent to 69×10^9 Mg of carbon. Closed forests and open forests had mean aboveground biomass values of 209 Mg/ha and 67 Mg/ha, respectively, in 1980. These values are down from maximum potential aboveground live biomass values of 296 Mg/ha for closed forest and 108 Mg/ha for open forest.

Keywords: Carbon release, climate change, deforestation, forestry, population.

NDP-055 includes the following data and documentation files:

- descriptive text file (ndp055.txt)
- ARC/INFO projection file (trop_africa.prj) with parameters for the ARC/INFO grids and coverages included in this NDP.
- ARC/INFO exported integer grid (biomax.e00) containing maximum potential biomass density data in Mg/ha.
- ASCII format of BIOMAX grid (biomax.asc)
- ARC/INFO exported integer grid (lakes.e00) containing the location of all non-seasonal lakes.
- ASCII format of LAKES grid(lakes.asc)
- ARC/INFO exported integer grid (land.e00) containing land-use information.
- ASCII format of LAND grid (land.asc)
- FORTRAN code (intgrid.for) to read and print the ASCII data files (biomax.asc, lakes.asc, and land.asc)
- SAS retrieval program (intgrid.sas) to read and print the ASCII data files biomax.asc, lakes.asc, and land.asc.
- ARC/INFO exported floating point grid (bio1980.e00) containing the calculated actual aboveground live biomass in open and closed forests for 1980 in Mg/ha.
- ASCII format of BIO1980 grid (bio1980.asc)
- ARC/INFO exported floating point grid (pd80.e00) containing population density data for 1980.
- ASCII format of PD80 grid (pd80.asc)
- FORTRAN code (realgrid.for) to read and print the ASCII files pd80.asc and bio1980.asc.
- SAS retrieval program (realgrid.sas) to read and print the ASCII datafiles pd80.asc and bio1980.asc.
- ARC/INFO exported coverage (africa.e00) containing the amount and biomass in open and closed forest by country.
- ARC/INFO exported coverage (t_afr.e00) containing population data for 1960, 1970, 1980 and 1990 for the subnational political units used in this NDP.
- ASCII file (africa.asc) containing the attribute information associated with africa.e00.
- FORTRAN code (africa.for) to read and print africa.asc.
- SAS retrieval program (africa.sas) to read and print africa.asc.
- ASCII file (t_afr.asc) containing the attribute information associated with t_afr.e00.
- FORTRAN code (t_afr.for) to read and print t_afr.asc.
- SAS retreival program (t_afr.sas) to read and print t_afr.asc.
- Graphic Map, "Maximum Potential Biomass Density" (africa_biomax.gif)
- Graphic Map, "Land use" (africa_lc.gif")
- Graphic Map, "Area of Closed Forests (By Country)" (areaclsdforest.gif)
- Graphic Map, "Area of Open Forests (By Country)" (areaopnforest.gif)
- Graphic Map, "Mean Biomass of Closed Forests (By Country)" (clsdforestbio.gif)
- Graphic Map, "Mean Biomass of Open Forests (By Country)" (opnforestbio.gif)
- Graphic Map, "Percent Forest Cover (By Country)" (pctforest.gif)
- Graphic Map, "Total Forest Biomass (By Country)" (totforestbio.gif)
- Graphic Map, "Population Density - 1990" (pop1990.gif)
- Graphic Map, "Population Density - 1980" (pop1980.gif)
- Graphic Map, "Population Density - 1970" (pop1970.gif)

- Graphic Map, "Population Density - 1960" (pop1960.gif)
- text file of data tables (table.txt)

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1. BACKGROUND INFORMATION

This database was developed by Sandra Brown, Louis Iverson, Ariel Lugo, Anantha Prasad, Greg Gaston, and others between 1990 and 1994. The primary contract that supported the collection of the data was the U.S. Department of Energy, Office of Health and Environmental Research, contract DEFG02-90ER61081. Additional support was obtained from the U.S. Environmental Protection Agency through its post doctoral fellowship program, which is administered by the National Research Council.

Human-induced changes in the Earth's land cover may influence ecological and climatic systems. The potential for these changes to have regional or global implications makes the task of developing an all-inclusive general circulation model (GCM) with predictive capabilities essential. However, to accurately predict the effects of long-term increases in the number and concentration of greenhouse gases on climate, GCMs require information on the timing and magnitude of past releases of CO_2, methane, nitrous oxide, water vapor, and a host of other anthropogenic gases. An understanding of all of the major processes leading to the release (sources) and storage (sinks) of these gases over time is also essential.

The prediction of regional trends in climate will be problematic until a well- documented understanding of the past, present, and possible future usage of fossil fuels and land is reached. Such an understanding is possible only with the concerted effort of many investigators from a diverse set of disciplines. The perspectives of ecologists, biologists, historians, geographers, foresters, mathematicians, physicists, and others are needed if a multifaceted examination of the causes and consequences of land-cover change and human population growth on the world's climate is to be conducted.

Reductions in the amount of carbon stored in terrestrial ecosystems are partially responsible for the increase in the concentration of atmospheric CO_2 that has occurred since 1850 (Houghton 1993). For example, live vegetation in terrestrial ecosystems is estimated to have contained over 900 Pg of carbon, with 90% of this being in forests, prior to any intentional land clearing on Earth (Olson et al. 1985, Dale et al. 1991).

A decline in the amount of carbon sequestered in vegetation has been associated with the rapid increase of human population that began during the industrial revolution. This population growth created demands for food and forest products that were fulfilled through the clearing and conversion of large tracts of forest to agriculture and other uses. This land-cover change has direct impacts on the concentration of atmospheric CO_2. For example, a 1% change in the total amount of carbon stored in living vegetation would release about 21 Pg of carbon to the atmosphere, almost four times the present annual emission from fossil fuels (Houghton 1993).

2. SOURCE AND SCOPE OF THE DATA

This numeric data package (NDP-055) describes a land-use and biomass database for Tropical Africa that contains 1980 land cover, maximum potential aboveground biomass, and biomass estimates for woody vegetation in 1980. In addition, the database includes information on human populations in each nation and sub-national political unit in Tropical Africa for the years 1960, 1970, 1980, and 1990. These data were collected to reduce the uncertainty associated with the possible magnitude and time course of historical releases of carbon from land-cover change and may be used by demographers, historians, geographers, and other researchers interested in the relationship between land cover change, land degradation, climate, and anthropogenic activities.

For purposes of this NDP, Tropical Africa is defined as encompassing nearly 22.7×10^6 km^2 of the world's surface and includes the following countries: Angola, Botswana, Burundi, Cameroon, Cape Verde, Central African Republic, Chad, Congo, Benin, Equatorial Guinea, Ethiopia, Djibouti, Gabon, Gambia, Ghana, Guinea, Ivory Coast, Kenya, Liberia, Madagascar, Malawi, Mali, Mauritania, Mozambique, Namibia, Niger, Nigeria, Guinea-Bissau, Zimbabwe (Rhodesia), Rwanda, Senegal, Sierra Leone, Somalia, Sudan, Tanzania, Togo, Uganda, Burkina Faso (Upper Volta), Zaire, and Zambia. As defined here Tropical Africa does not include countries in Mediterranean and southern Africa (i.e., Egypt, Libya, Tunisia, Algeria, Morocco, Western Sahara, South Africa, Lesotho, and Swaziland).

The major effort in the compilation of this database involved the acquisition and processing of the source data sets. Most of these data sets were acquired from the United Nations Environmental Program's (UNEP) Global Resources Information Database (Jaakkola 1990) or from the United Nation's Food and Agriculture Organization (FAO 1993). These data, in turn, were input, georeferenced, and converted into a raster format as needed using an ARC/INFO^{TM} geographic information system (GIS). The spatial data sets used in the development of this NDP are as follows:

1. National boundaries were derived from the U.S. Defense Mapping Agency's *Digital Chart of the World* at a scale of 1:1,000,000. Boundaries for subnational political units were derived from *The New International Atlas*, the *Encyclopedia of the Nations*, and the FAO's Tropical Forest Resources Assessment Program 1990 population data (Worldmark Press 1984, Rand McNally 1980). Boundaries for large water bodies (e.g. Lake Victoria) were copied from the *Digital Chart of the World*; moderate sized lakes (>20 km in length in any direction) were digitized from the *UNESCO Vegetation Map of Africa*, scale 1:5,000,000 (UNESCO/AETFAT/UNSO 1981, White 1983).

2. Population density data for 1960, 1970, 1980, and 1990 for national and subnational political units were provided by M. Lorenzini and K.D. Singh, FAO, Tropical Forest Resources Assessment Program 1990 (FAO 1993).

3. Elevation data were derived from a global digital elevation database originally developed by the U.S. Defense Mapping Agency (ETOPO5). The elevation data were reclassified into 15-m increments, and all bathymetry data were set to zero.

4. Soils data were derived from the FAO *Soils Map of the World* (FAO 1971-81). The soils data were reclassified into five soil texture classes, five slope classes, and two soil depth classes and were used in calculating the maximum potential biomass values included with this database. These soil data are not included with this NDP.

5. Climatic data were obtained from the FAO agro-meteorology database and two maps were developed using the spatial coordinates for each station and the mean monthly precipitation, maximum temperature, minimum temperature, day-night temperature differential, evapotranspiration rate, and vapor pressure. The first map is a isopleth map of annual precipitation and the second is of an integrated climate index that provides a measure of the growing season length based on five climatic variables (Weck 1970).

6. Vegetation data represent conditions in 1980 (approximate date) from the FAO *Vegetation Map of Africa* (Lavenu 1987).

3. DATA MANIPULATION AND INTERPOLATION

The methodology described in Iverson et al. (1994) and Brown and Gaston (1995) (Abstract) was used to compute degradation ratios. These degradation ratios were applied to a map of maximum potential aboveground biomass density to develop a map of current (ca. 1980) aboveground biomass. Since the linear regression models used to estimate the degradation ratios were calibrated for woody vegetation only, this map was masked using a land cover map (1980). All

areas not in a forested or wooded class were deleted. This process resulted in a map showing the amount of aboveground biomass in woody vegetation for 1980. The change (emission) of carbon resulting from land use change and land degradation between the 1880s and 1980 can be estimated for closed and open forests by comparing the aboveground biomass map with the maximum potential aboveground biomass density map.

Two of the data sources used in calculating the maximum potential aboveground biomass values needed additional processing before they could be used in the biomass estimation model. First, the meteorology data were used to calculate a climatological index for each station based on a modified version of Weck's (1970) methodology. Second, these climatological indices (point data) were interpolated into a thematic map using a thin-plate spline technique (Iverson et al. 1994). Lastly, the FAO vegetation map used (Lavenu 1987) was reclassified from over 64 ecosystem types into a map showing closed forest, open forest, grassland savanna, and other non-forested lands. See Appendix C for a description of the reclassification scheme used.

The source data were then projected into a cylindrical equal-area projection using a central meridian of 15° East and a standard parallel of 0°. The data were then converted into grids (cellsize 5km) using the ARC/INFO ^{TM} POLYGRID command.

4. MODELING BIOMASS

The maximum potential biomass density of woody vegetation is assumed to be the product of a combination of the prevailing climatic and geomorphic conditions in an area. To estimate the maximum potential biomass for each grid cell, each input layer (i.e., mean annual precipitation, climate index, elevation/slope, and soil quality/texture) was recoded and assigned values ranging from 1 to 25 based on the perceived importance of the layer to the growth of woody vegetation. A weighted overlay of the four layers was then performed to create a biomass index with a minimum possible value of 4 and a maximum value of 100 (in Tropical Africa the values ranged from 40 to 100).

The climate-related layers (mean annual precipitation and climate index) account for 50% of the possible index value. The soil layer accounts for 25% and the elevation and slope layer [formed by combining the elevation data (maximum value 13) with the slope data (maximum value 12)] accounts for the remaining 25%. Iverson et al. (1994) used the same weighting scheme for Tropical Asia. This scheme was found to give satisfactory results for Africa when compared to available literature for the region (Graham et al. 1990, Martin 1991, Lavenu 1987).

Potential biomass density (PBD) indices for forests, woodlands, and woody savannas were calibrated by assigning aboveground biomass density estimates (obtained from the literature) to the range of index values. This task posed a challenge because few measurements of mature forest biomass have been taken in this region (Brown and Lugo 1982). The highest reported biomass densities were about 500 Mg/ha (Huttel and Bernhard-Reversat 1975, Huttel 1975) for tropical moist forests in western Africa. Western Africa is also associated with the highest range of PBD indices (>96). A PBD index value of 51 was assumed to represent the lower limit for tree or shrub savannas and was assigned a biomass density of 15 Mg/ha based on data in Lamotte (1975), Lamotte and Bourliere (1983), and Menaut et al. (1991). It was then assumed that biomass density exhibited a logistic-shaped function between the PBD index and biomass. Biomass values (in Mg/ha) were assigned to the PBD values as shown in Table 2. The lower index value (i.e., ~40) and upper index value (i.e., 100) for Tropical Africa were equated with 1Mg/ha and with 500 Mg/ha, respectively. Between these two bounds the potential biomass index was divided into twelve ranges. Intermediate values of biomass density were obtained or estimated from Greenland and Kowal (1960), Pierlot (1966), Feson et al. (1974), and Brown et al. (1994).

The remainder of this methodology is designed for woody vegetation only. Thus, the next step in determining the biomass in forests for 1980 was to remove non-woody vegetation associations from the map of maximum potential biomass density that is distributed with this database. This was done by taking the reclassified FAO vegetation map for 1980 (Lavenu 1987) [i.e., with four classes: closed forest, open forest (woodland/wooded savanna), grassland savanna,

and other] and setting those grid cells with closed forest or open forest to a value of 1. All other cells were set to NODATA. This temporary map was multiplied by the potential biomass density map. This process set or masked most grid cells that were not classified as woody vegetation (as of 1980) to NODATA. The resulting maximum potential biomass density map, therefore, is of forested areas only. The only non-wooded areas remaining in this map are grid cells located within lakes.

To estimate the actual biomass remaining in live woody vegetation in 1980, researchers developed degradation ratios based on population data and applied them to the maximum potential biomass density map for forested lands. The degradation ratios were based on the assumption that the degree to which forests are reduced from their potential biomass is a function of the population density and forest type or ecofloristic zone. For example, high population densities will result in low degradation ratios (i.e., highly degraded forests), and drier regions will be degraded more severely than moist regions because of the ability of moist forests to replace biomass faster (Brown and Lugo 1982).

Other socioeconomic factors such as the ratio of rural to urban population, the importance of subsistence versus export-oriented agriculture, and the state of industrialization affects the rate of biomass reduction. In developed countries a population density and a stage of industrial development have been reached at which no further biomass loss occurs and other factors come into play, which may actually lead to increases in biomass (Flint and Richards 1994).

In most of Tropical Africa this threshold has not been reached, as exemplified by the fact that 90% of the population in Africa still uses wood for cooking. The average amount of wood used for cooking per family is equivalent to about 1.5 tons of fuel oil per year. It has been estimated that the annual addition to the fuelwood supply through the growth of biomass was less than consumption in 1980 and that the half-life of tree stocks (the time it would take for stocks to decline by 50%) averaged about 25 years in 1980. Furthermore, tree stocks are declining at accelerating rates because consumption is increasing exponentially with population growth (Anderson and Fishwick 1984).

Degradation equations have been estimated for two forest types (closed forest and woodland/wooded savanna) by comparing the potential biomass density in 1980 with biomass densities obtained from forest inventories for the same location. This process produced unitless factors that indicate the reduction from potential biomass to actual biomass as a function of population density. Eight reliable forest inventories for Tropical Africa were used to develop the degradation equations (Clement and Nouvellet 1978, Development and Resources Corporation 1967, Republique de Cote d'Ivoire 1975, United Nations 1972, FAO 1989). Due to the limited number of suitable forest inventories of tropical Africa, 27 additional inventories from tropical South and Southeast Asia were also included in the analysis (Iverson et al. 1994).

The data for the closed forest zone of Tropical Africa were combined with the moist forest data from South and Southeast Asia, while data for the woodland/wooded savanna zone were combined with the dry forest data from South and Southeast Asia. A least-squares regression was conducted for each zone, and the following degradation equations were produced.

The equations, sample sizes, and correlation results for closed forest are:

```
PD  > 12:      DR = 0.847 - 0.091 ln (PD), (n = 25, r² = 0.72),      (1a)
PD < 12:      DR = 1 - 0.032 PD,                               (1b)

where DR is the degradation ratio and PD is the population density in people per
km².
```

The equations, sample sizes, and correlation results for open forest (woodland/wooded savanna) are:

```
PD  > 7:      DR = 0.866 - 0.118 ln (PD), (n = 10, r² = 0.54),      (2a)
PD < 7:      DR = 1 - 0.050 PD,                                (2b)
```

```
where DR is the degradation ratio and PD is the population density in people
per km2.
```

Equation 1a and 2a for each forest type is based on the range of available data, and the minimum PD for which it is applicable. For PDs less than these minimums, simple linear equations (Eq. 1b and 2b) were developed between the DR at zero PD (assumed to be one), and the value of DR from equation 1a and 2a at the minimum PD. A linear function of PD was then calculated for each land cover class between these DR values.

Use of the natural logarithm in equations 1a and 2a allows negative DR values to occur for PDs greater than 11,022 for closed forest and 1,539 for the open forest (woodland/wooded savanna) land cover classes. This was not a problem in most cases, however, since forest lands tend to have lower population densities. For this reason, calculated DR values less than 0.1 were reset to 0.1.

The actual-biomass-density map for 1980 is the product of the potential-biomass- density map for woody vegetation, the population density map for 1980 stratified by land cover type (closed forest and open forest), and the calculated degradation ratios. The map of actual biomass densities for 1980 was calculated on a cell-by-cell basis. All cells within a political unit were assigned the same population density value. The forest strata, however, may vary within a political unit causing the degradation equation used to vary. Thus, the map of actual biomass density for woody vegetation in 1980 reflects the predicted maximum potential biomass, the forest type stratification, and the population density in 1980.

Due to the coarse scale of the input data used in generating the potential biomass density map, some large water bodies within Africa were not represented. Boundaries for large water bodies (e.g., Lake Victoria) and moderate sized lakes (>20 km in length in any direction) were digitized and entered into a lake coverage (map). Following a process similar to that used for the land cover data, those grid cells within a lake (i.e., > 50%) were given a value of NODATA, and the remainder were set to one. This coverage was multiplied by the grid cells in the map of actual biomass density for 1980 to set all "wet" grid cells to NODATA.

This final map of actual live aboveground biomass density only contains lands that were in closed forest (moist forest and seasonal forest) or open forest (woodland/wooded savanna) in 1980 (per Lavenu 1987). The final map contains 4,025,275 km^2 of closed forest land with a mean biomass density of 208.7 Mg/ha and 8,156,575 km^2 of open forest land (woodland/ wooded savanna) with a mean biomass density of 67.1 Mg/ha. As expected, the minimum biomass densities were located in lowland dry zones to the north and south, maximum values were located in the humid lowlands in southwest and south central Africa (i.e., Congo, Gabon, Zaire), and highland areas had slightly less biomass than their lowland counterparts. The presence of these known patterns increased our confidence in this methodology and its ability to generate reasonable estimates of biomass density for Tropical Africa.

The primary product of this GIS methodology is the actual biomass density information for woody vegetation in 1980. Actual biomass density in year X may be determined (as described for 1980) using a land-cover map and population data for year X (e.g., 1990). The results may then be compared to determine the change in biomass (carbon) of woody vegetation in the intervening years.

The biomass for 1980 may also be compared to the maximum potential aboveground biomass for the region. The difference between the mean maximum potential biomass density for closed forest lands and the mean actual biomass density in 1980 is 86.9 Mg/ha (40.5 Mg/ha for open forest). On the basis of the average biomass to carbon conversion factor of 1 kg of wood to 0.5 kg of carbon (Smith 1991), and the assumption that the removed wood was eventually burned, the amount of CO_2, CO, CH_4, and other gases emitted from this per ha reduction in biomass may be estimated for closed and open forests. Table 3 shows the estimated emission of CO_2, CO, and CH_4 that would have occurred if

86.9 (40.5) Mg of dry biomass were burned using traditional West African stoves, based on emission factors calculated by Brocard et al. (1995). (If forest fire based emission factors were used the emission of CO_2 and CO would increase while the amount of CH_4 and carbon in the "other" category would decrease.)

Africa had an estimated total population of 100 million people in 1650 (density of 0.03 people per km^2). Two hundred years later (1850) the population was still around 100 million (Udo 1982). Thus, it may be assumed that prior to the colonial period, which began in the mid to late 1800s, the amount of land in forests had remained relatively stable for over two hundred years. Since the land in the closed forest and open forest (woodland/wooded savanna) land-cover classes in 1980 were located in the interior of larger forests in 1880, it can be assumed that they were at or near their maximum potential biomass density at the beginning of the colonial period. If this was the case, the emission of CO_2 due to the degradation of these forested lands (i.e., reduction of biomass from the maximum potential to the "actual" biomass in 1980) would total 27.21×10^{12} kg/C. If this CO_2 had been emitted at a constant rate since 1880, 272.1×10^6 Mg C per year would have been released into the atmosphere. To put this figure into perspective, Houghton and Hackler (1995) calculated that the regional net flux of carbon in Tropical Africa from all land-use changes was 238.69×10^6 Mg C in 1980 and had increased to 341.5×10^6 Mg C by 1990.

5. LIMITATIONS AND RESTRICTIONS OF THE DATA

The following paragraphs list the limitations and caveats that should be considered when using this database. Failure to consider these limitations could result in erroneous interpretations of the data.

1. All data coverages (maps) in this database have been resampled into 5 x 5 km grid cells. This cell size and the small cartographic scale of most of the input data used preclude the use of these data for site-specific studies.

2. The soil texture, slope, and elevation data used in the development of the map of maximum potential aboveground biomass densities were based on small-scale data sources (1:1,000,000 to 1:5,000,000).

3. The climate data were extrapolated into areas with little or no data. Consequently, effects of local topography on precipitation and temperature patterns are not considered in the map of maximum potential aboveground biomass.

4. The population data used to calculate the degradation ratios are based on national internal political subdivisions as of 1980. The population data provided with this database (i.e., for 1960, 1970, 1980, and 1990) are keyed to these 1980 divisions.

5. The limited number of forest inventories in Tropical Africa makes verification of the final map of actual biomass density for woody vegetation in 1980 difficult. However, average biomass densities were obtained for Guinea, Gambia, Mozambique, and Burkina Faso from national level forest inventories and compared to those calculated here. The values for Guinea, Gambia, Mozambique, and Burkina Faso were within 3%, 19%, 3%, and 38%, respectively, of the inventory values (Brown and Gaston 1995).

6. DATA CHECKS PERFORMED BY CDIAC

An important part of the data packaging process at the Carbon Dioxide Information Analysis Center (CDIAC) is the quality assurance (QA) of the data before its distribution. The QA process is an important component of the value-added concept of ensuring accurate, usable information. The complete QA of a data set can be a time-consuming process, since data received by CDIAC are rarely in condition for immediate distribution, regardless of source. The following summarizes the QA checks performed on the various data groups presented in this document.

1. The map of maximum potential aboveground biomass density is derived from an index calculated from six climatic and geomorphic variables. The index values were associated with the known upper and lower limits of biomass density in Africa, and the range was divided into 12 density groupings (Table 2). The maximum potential aboveground biomass density map (5x5 km grid cells) was correlated with a 1x1 degree map of carbon in live vegetation (Olson et al. 1983). The analysis obtained an r^2 value of 0.4, n = 1195611, and α = 0.0001. Because of cell size differences, a higher correlation value should not be expected; however, the significance of the correlation (>99%) implies that the two independently derived data sources are measures of the same variable.

2. The map of maximum potential aboveground biomass (5x5 km grid cells) and the Olson et al. (1983) 1 x 1 degree map of carbon in live vegetation were printed and visually compared to ensure that the location of low and high carbon/biomass densities matched.

3. The land-use map for 1980 derived from Lavenu (1987) was printed and compared to a similar map prepared by the United Nations (White 1983).

4. On the basis of QA steps 2 and 3, it was determined that neither the land cover nor potential-biomass-density map had accounted for internal water bodies in Tropical Africa. A new map was created for use with this database that contains all permanent (versus seasonal) lakes larger than 20 km in length in any direction.

5. The population data for 1960, 1970, 1980, and 1990, were aggregated by country and compared to secondary data sources (e.g., WorldMark Press 1984, Udo 1982, and Goode 1992).

6. The final actual-biomass-density map for 1980 was aggregated on a cell-by-cell basis to obtain the mean biomass density by country (see

```
PD  > 12:  DR = 0.847   0.091 ln (PD), (n = 25, r^2 = 0.72), (1a)
PD <= 12:  DR = 1 - 0.032 PD .                              (1b)
```

The equations, sample size, and correlation coefficient for open forest (woodland/wooded savanna) are:

```
PD  > 7:   DR = 0.866   0.118 ln (PD), (n = 10, r^2 = 0.54), (2a)
PD <= 7:   DR = 1 - 0.050 PD .                              (2b)
```

Where DR is the degradation ratio and PD is the population density in people per km^2.

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7. HOW TO OBTAIN THE DATA AND DOCUMENTATION

These data may be used with a vector or raster geographic information system (GIS) or non-GIS database systems. This database (NDP-055) is available free of charge from CDIAC. The files are available, via the Internet, from CDIAC's World-Wide-Web site (**http://cdiac.esd.ornl.gov**), or from CDIAC's anonymous file transfer protocol (FTP) area (**cdiac.esd.ornl.gov**) as follows:

1. FTP to cdiac.esd.ornl.gov (128.219.24.36).
2. Enter "ftp" as the user id.
3. Enter your electronic mail address as the password (e.g., fred@zulu.org).
4. Change to the directory "pub/ndp055" (i.e., use the command "cd pub/ndp055").
5. Set ftp to get ASCII files by using the ftp "ascii" command.
6. Retrieve the ASCII database documentation file by using the ftp "get ndp055.txt" command.
7. Retrieve the ASCII data files by using the ftp "mget *.asc" command.
8. Retrieve the ASCII FORTRAN files by using the ftp "mget *.for" command.
9. Retrieve the ASCII SAS[TM] files by using the ftp "mget *.sas" command.
10. Set ftp to get BINARY files by using the ftp "binary" command.
11. Retrieve the binary ARC/INFO[TM] export files by using the ftp "mget *.e00" command.
12. Exit the system by using the ftp "quit" command.

For **non-Internet data acquisitions** (e.g., floppy diskette or CD-ROM) or ifor additional information, contact:

Carbon Dioxide Information Analysis Center
Oak Ridge National Laboratory
P.O. Box 2008
Oak Ridge, Tennessee 37831-6335, U.S.A.

Telephone: 1-865-574-3645
Telefax: 1-865-574-2232
E-mail: cdiac@ornl.gov

8. LISTING OF FILES PROVIDED

This database consists of 36 files: two *.txt files, seven *.e00 GIS data files, one *prj projection file, seven *.asc data files, four FORTRAN input statement files, and four SAS input statement files, and 13 *.gif graphics files. See Table 1 for a complete listing and description of these files.

9. DESCRIPTION OF THE DOCUMENTATION FILE

The ndp055.txt (File 1) file is an ASCII text equivalent of this document.

10. DESCRIPTION, FORMAT, AND PARTIAL LISTINGS OF THE DATA FILES

Table 1 lists and describes the files included in this numeric data package.

FLAT ASCII DATA FILES:

Eight flat ASCII data files are provided with this data package. These files contain the same information as the ARC INFO grids and coverages included in this NDP. The ASCII files were either created directly from the ARC/INFO grids of the same name using the GRIDASCII command or are ASCII versions of ARC/INFO attribute tables associated with polygon coverages included in this NDP. SAS and FORTRAN programs designed to read and print the contents of each ASCII data file are also provided. The information within these files will allow the user to ascertain population densities, the amount of land remaining in forests in 1980, the maximum potential aboveground biomass densities within Africa, and the biomass in aboveground woody vegetation in Tropical Africa in 1980. What follows is a description of the contents and formats (e.g., variable names, widths) of the eight flat ASCII data files distributed with this data package.

The flat ASCII files BIOMAX.ASC (File 4), LAKES.ASC (File 6), and LAND.ASC (File 8) are formatted as shown in the following FORTRAN code and may be read using the input/output programs INTGRID.FOR (File 9) or INTGRID.SAS (File 10).

```
        READ (5,100) NCOLS
        READ (5,100) NROWS
        READ (5,110) XLLCORNR
        READ (5,110) YLLCORNR
        READ (5,100) CSIZE
        READ (5,100) NODATA
        DO 10 ROWS = 1, NROWS
            READ (5,120)  (VALUE(ROWS,COLS), COLS=1, NCOLS)
 10     CONTINUE
C
 100    FORMAT(14X,I5)
 110    FORMAT(14X,F15.5)
 120    FORMAT(1534(1X,I5))
```

BIOMAX.ASC contains maximum potential biomass density data in Mg/ha; LAND.ASC contains land-use information classified into four land-use categories; and LAKES.ASC contains the location of all non-seasonal lakes >20 km in any direction in Tropical Africa. Each file of these three files contains header information containing a set of key words followed by cell (i.e., data) values in row-major order. The first six lines of BIOMAX.ASC, LAKES.ASC, and LAND.ASC (header information) are:

```
ncols 1534
nrows 1502
```

```
xllcorner -3616156.5
yllcorner -3644063.04465
cellsize 5000
NODATA_value -9999
```

The data are in a normal (type 1) cylindrical equal-area projection with a central meridian of 15 degrees East longitude and a standard parallel of 0 degrees latitude. Data are provided for 1,502 rows and 1,534 columns, with the first cell being located in the upper-left corner. Each data cell covers a 25 km^2 square area, 5,000 m per side. The area covered by the data is bounded by a box with the following coordinates: lower-left -3616156.500, -3644063.04465; upper-right 4053843.500, 3865936.955.

The variables in BIOMAX.ASC (File 4), LAKES.ASC (File 6), and LAND.ASC (File 8) are formatted as listed in Table 4 and are shown in the same order as they would appear in the files.

The flat ASCII files PD80.ASC (File 14) and BIO1980.ASC (File 12) are formatted as shown in the following FORTRAN code and may be read using the input/output programs REALGRID.FOR (File 15) or REALGRID.SAS (File 16).

```
        READ (5,100) NCOLS
        READ (5,100) NROWS
        READ (5,110) XLLCORNR
        READ (5,110) YLLCORNR
        READ (5,100) CSIZE
        READ (5,120) NODATA
        DO 10 ROWS = 1, NROWS
             READ (5,130)  (VALUE(ROWS,COLS), COLS=1, NCOLS)
 10     CONTINUE
C
 100    FORMAT(14X,I5)
 110    FORMAT(14X,F15.5)
 120    FORMAT(14X,F8.2)
 130    FORMAT(1534(1X,F8.2))
```

PD80.ASC contains population-density data for 1980 in people/km^2 and BIO1980.ASC contains the calculated "actual" aboveground live biomass in open and closed forest for 1980 in Mg/ha. Each of these two files contains header information with a set of key words followed by cell values in row-major order.

The first six lines of PD80.ASC, and BIO1980.ASC (header information) are :

```
ncols 1534
nrows 1502
xllcorner -3616156.5
yllcorner -3644063.04465
cellsize 5000
NODATA_value -9999
```

The data are in a normal (type 1) cylindrical equal-area projection with a central meridian of 15 degrees East longitude and a standard parallel of 0 degrees latitude. Data are provided for 1,502 rows and 1,534 columns with the first cell located in the upper-left corner. Each data cell covers a square area, 5,000 m per side. The area covered by the data is bounded by a box with the following coordinates: lower-left -3616156.500, -3644063.04465; upper-right 4053843.500, 3865936.955.

The variables in PD80.ASC (File 14) and BIO1980.ASC (File 12) are formatted as listed in Table 5 and are shown in the same order as they would appear in the files.

The flat ASCII file T_AFR.ASC (File 22) contains population density data for 1960, 1970, 1980, and 1990 for the subnational political units used in this database. The data were provided by M. Lorenzini and K. D. Singh (FAO, Tropical Forest Resources Assessment Program 1990). The file is formatted as shown in the following FORTRAN code and may be read using the input/output programs T_AFR.FOR (File 23) or T_AFR.SAS (File 24).

```
 10      READ (5,100,END=999) COUNTRY, COUNTRY_NO, ADMP, ADMP_NM,
    1                      PD60, PD70, PD80, PD90, LANDAREA
         GOTO 10
C
 100     FORMAT(A30,I5,I4,A40,4F8.3,I10)
```

The variables in T_AFR.ASC (File 22) are formatted as listed in Table 6 and are shown in the same order as they appear in the file.

The first ten data records of t_afr.asc are:

```
Water         0    0                    0      0      0      0       0
Mauritania 136   287   TIRIS_ZEMOUR   0.058  0.077  0.106  0.148   252900
Mali       133   275   TOMBOUCTOU      -1     -1     1.215  1.236   408977
Water         0    0                    0      0      0      0       0
Niger      158   306   AGADEZ          -1     0.111  0.196  0.334   714790
Chad        39    74   BET            0.119  0.138  0.147  0.17    600350
Mauritania 136   283   ADRAR          0.326  0.301  0.253  0.161   215300
Mauritania 136   278   HODH_CHARKI    0.986  0.953  0.877  0.71    182700
Sudan      206   387   NORTH_REGION    -1     1.942  2.176  2.339   477405
Sudan      206   388   EAST_REGION     -1     4.28   5.952  8.273   334331
```

The last ten data records of t_afr.asc are:

```
Mozambique 144   296   INHAMBANE                 9.594 12.542 14.517 17.591    68615
Botswana    20    18   KGALAGADI                 0.142  0.157  0.217  0.286   106940
Botswana    20    20   KWENENG                   1.9    2.027  3.096  4.419    35890
Botswana    20    19   KGATLENG                  3.57   4.295  5.445  6.757     7960
Botswana    20    23   NGWAKETSE                 2.246  2.812  3.863  5.237    27370
Mozambique 144   298   CID_MAPUTO_MAPUTO_PROV   18.545 34.664 47.177 69.288    26358
Botswana    20    24   BAROLONG_SOUTH_EAST      10.397 21.905 40.573 71.489     2880
Mozambique 144   298   CID_MAPUTO_MAPUTO_PROV   18.545 34.664 47.177 69.288    26358
Zimbabwe   181   337   MATABELELAND_NORTH        -1     8.159 11.329 15.806    73537
Zimbabwe   181   339   MIDLANDS                  -1    13.191 17.577 23.54     58967
```

The flat ASCII file AFRICA.ASC (File 19) contains the amount of land and biomass in open and closed forest by country for 1980. The file is formatted as shown in the following FORTRAN code and may be read by using the input/output programs AFRICA.FOR (File 20) or AFRICA.SAS (File 21).

```
 10      READ (5,100,END=999) COUNTRY, CNTRY_NO, TOTCELL,
    1         TOTAREA, CFAREA, OFAREA, CFBIO, OFBIO,
    1         TOTBIO, FOREST
         GOTO 10
```

```
C
 100     FORMAT(A30,I5,I11,I10,2I9,2F12.1,F12.4,F12.1)
```

The variables in AFRICA.ASC (File 19) are formatted as listed in Table 7 and are shown in the same order as they appear in the file.

The first ten data records of africa.asc are:

```
Angola                      7 50127 1253175   66750  1063775  109.4  69.7  8144.76   90.2
Botswana                   20 23195  579875       0   101800      0  13.1   133.36   17.6
Burundi                    29  1021   25525    2575     6900   57.1  40.3    42.51   37.1
Cameroon                   32 18529  463225  221750   182500  297.5 120     8787.06   87.3
Central African Republic   37 24856  621400  105425   515850  262.9 185.7 12350.96  100
Chad                       39 50635 1265875       0   316825      0  38     1203.94   25
Congo                      46 13841  346025  247675      375  344.9  36.4  8543.68   71.7
Benin                      53  4664  116600    4325   103675   75.6  56.4   617.42   92.6
Equatorial Guinea          61  1072   26800   24725        0  318      0    786.26   92.3
Ethiopia                   62 49920 1248000  375450   325400   65.3  35.6  3610.11   56.2
```

The last ten data records of africa.asc are:

```
Senegal       195  7916  197900   13500    63975   52.8   25.8   236.34   39.1
Sierra Leone  197  2899   72475   30875    28400  220.6  174.9  1177.82   81.8
Somalia       201 25573  639325     350   165675   11.4   12.4   205.84   26
Sudan         206 99743 2493575    5425   737150  134     63     4716.74   29.8
Tanzania      215 35629  890725    5550   529800   73.5   48.6  2615.62   60.1
Togo          217  2297   57425     725    49575   40.9   71.7   358.42   87.6
Uganda        226  8204  205100   12075   131825  124    101.7  1490.39   70.2
Burkina Faso  233 10957  273925       0    97375    0     34     331.08   35.5
Zaire         250 92433 2310825 1860300   378175  223.9  118.2 46122.15   96.9
Zambia        251 29846  746150   47250   579650   45.9   52.3  3248.45   84
```

ARC/INFO (Version 7.2.1) EXPORT FILES

Seven ARC/INFO export files (*.e00) are provided with this NDP. These files contain the same data as the flat ASCII data files described previously. The ARC/INFO export (*.e00) files were produced using the EXPORT command with the NONE option in ARC/INFO Version 7.2.1. These files are in an uncompressed, fixed-block format that may be moved across computer systems. The coverages are in a normal (type 1) cylindrical equal-area projection with a central meridian of 15 degrees East longitude and a standard parallel of 0 degrees latitude. All units are in meters and the spheroid is a sphere with a radius of 6,370,997 meters (vs. the Clark 1866 spheroid).

The following files (BIOMAX.E00, LAND.E00, PD80.E00, LAKES.E00 and BIO1980.E00) should be imported with the GRID option and contain 1,502 rows and 1,534 columns, with each data cell covering a square area with 5,000 m per side. The remaining files (T_AFR.E00 and AFRICA.E00) are ARC/INFO polygon coverages and should be imported using the COVER option. The polygon coverage AFRICA contains regions. The region subclass within AFRICA is named SUM1980. These regions were built using countries within Tropical Africa as unique identifiers. The AFRICA.PAT.SUM1980 INFO file contains summary information by country for the amount of land and biomass in open and closed forests in 1980. The area covered by the data is bounded by a box with the following coordinates: lower-left -3616156.500, -3644063.04465; upper-right 4053843.500,

3865936.955. A listing of the variable names and data formats for these last two export (E00) files are shown in Tables 6, and 7.

The first ten data records of BIOMAX.E00 are:

```
EXP  0 /DATA4/OZ1/CDIAC/NDP-055/NEW_E00/BIOMAX.E00
GRD  2
       1534       1502 1-0.21474836470000E+10
 0.50000000000000E+04 0.50000000000000E+04
-0.36161565000000E+07-0.36440630446500E+07
 0.40538435000000E+07 0.38659369553500E+07
          -9999          -9999          -9999          -9999          -9999
          -9999          -9999          -9999          -9999          -9999
          -9999          -9999          -9999          -9999          -9999
          -9999          -9999          -9999          -9999          -9999
```

The last ten data records of BIOMAX.E00 are:

```
           42          90055
           75          91074
          150          99339
          250          81883
          350          64032
          425          37550
          475          17970
          500           2264
EOI
EOS
```

The first ten data records of LAND.E00 are:

```
EXP  0 /DATA4/OZ1/CDIAC/NDP-055/NEW_E00/LAND.E00
GRD  2
       1534       1502 1-0.21474836470000E+10
 0.50000000000000E+04 0.50000000000000E+04
-0.36161565000000E+07-0.36440630446500E+07
 0.40538435000000E+07 0.38659369553500E+07
          -9999          -9999          -9999          -9999          -9999
          -9999          -9999          -9999          -9999          -9999
          -9999          -9999          -9999          -9999          -9999
          -9999          -9999          -9999          -9999          -9999
```

The last ten data records of LAND.E00 are:

```
LAND.VAT                      XX   2   2   8          5
VALUE          4-1  14-1 10-1 50-1  -1  -1-1                   1I
COUNT          4-1  54-1 10-1 50-1  -1  -1-1                   2-
       -9999    1105588
           1     175811
           2     346001
           3     157539
```

```
          4       519129
EOI
EOS
```

The first ten data records of PD80.E00 are:

```
EXP  0 /DATA4/OZ1/CDIAC/NDP-055/NEW_E00/PD80.E00
GRD  2
       1534        1502 2-0.34028234663853E+39
 0.50000000000000E+04 0.50000000000000E+04
-0.36161565000000E+07-0.36440630446500E+07
 0.40538435000000E+07 0.38659369553500E+07
-0.9999000E+04-0.9999000E+04-0.9999000E+04-0.9999000E+04-0.9999000E+04
-0.9999000E+04-0.9999000E+04-0.9999000E+04-0.9999000E+04-0.9999000E+04
-0.9999000E+04-0.9999000E+04-0.9999000E+04-0.9999000E+04-0.9999000E+04
-0.9999000E+04-0.9999000E+04-0.9999000E+04-0.9999000E+04-0.9999000E+04
```

The last ten data records of PD80.E00 are:

```
IFO  2
PD80.STA                      XX   4   4  32          1
MIN                8-1   14-1  15 3 60-1  -1  -1-1                    1-
MAX                8-1   94-1  15 3 60-1  -1  -1-1                    2-
MEAN               8-1  174-1  15 3 60-1  -1  -1-1                    3-
STDV               8-1  254-1  15 3 60-1  -1  -1-1                    4-
-9.99900000000000000E+03 2.19550610351562500E+03-4.78676211358813089E+03 5.00127
655918892469E+03
EOI
EOS
```

The first ten data records of LAKES.E00 are:

```
EXP  0 /DATA4/OZ1/CDIAC/NDP-055/NEW_E00/LAKES.E00
GRD  2
       1534        1502 1-0.21474836470000E+10
 0.50000000000000E+04 0.50000000000000E+04
-0.36161565000000E+07-0.36440630446500E+07
 0.40538435000000E+07 0.38659369553500E+07
           -9999          -9999          -9999          -9999          -9999
           -9999          -9999          -9999          -9999          -9999
           -9999          -9999          -9999          -9999          -9999
           -9999          -9999          -9999          -9999          -9999
```

The last ten data records of LAKES.E00 are:

```
STDV               8-1  254-1  15 3 60-1  -1  -1-1                    4-
-9.99900000000000000E+03 4.00000000000000000E+00-9.95541616610273741E+03 6.58839
540326123597E+02
LAKES.VAT                     XX   2   2   8          2
VALUE              4-1   14-1  10-1 50-1  -1  -1-1                    1I
COUNT              4-1   54-1  10-1 50-1  -1  -1-1                    2-
       -9999    2294029
```

```
        4       10039
EOI
EOS
```

The first ten data records of BIO1980.E00 are:

```
EXP  0 /DATA4/OZ1/CDIAC/NDP-055/NEW_E00/BIO1980.E00
GRD  2
     1534      1502 2-0.34028234663853E+39
 0.50000000000000E+04 0.50000000000000E+04
-0.36161565000000E+07-0.36440630446500E+07
 0.40538435000000E+07 0.38659369553500E+07
-0.9999000E+04-0.9999000E+04-0.9999000E+04-0.9999000E+04-0.9999000E+04
-0.9999000E+04-0.9999000E+04-0.9999000E+04-0.9999000E+04-0.9999000E+04
-0.9999000E+04-0.9999000E+04-0.9999000E+04-0.9999000E+04-0.9999000E+04
-0.9999000E+04-0.9999000E+04-0.9999000E+04-0.9999000E+04-0.9999000E+04
```

The last ten data records of BIO1980.E00 are:

```
IFO  2
BIO1980.STA                      XX   4   4  32          1
MIN              8-1   14-1  15 3 60-1  -1  -1-1                    1-
MAX              8-1   94-1  15 3 60-1  -1  -1-1                    2-
MEAN             8-1  174-1  15 3 60-1  -1  -1-1                    3-
STDV             8-1  254-1  15 3 60-1  -1  -1-1                    4-
-9.99900000000000000E+03 4.66339996337890625E+02-7.86027052510779868E+03 4.13001
816239345681E+03
EOI
EOS
```

11. SAS AND FORTRAN CODES TO ACCESS THE DATA

BIOMAX.ASC (File 4), LAKES.ASC (File 6), and LAND.ASC (File 8) may be read using the input/output programs INTGRID.FOR (File 9) or INTGRID.SAS (File 10).

INTGRID.FOR (File 9):

```
  real xllcornr, yllcornr
      integer ka
      integer ncols, nrows, csize, nodata
      dimension ka(2304068)
      open(unit=5,file='biomax.asc',status='old',access='sequential')
      open(unit=6,file='biomax.out',status='new',access='sequential')
      read (5,100) ncols
      read (5,100) nrows
      read (5,110) xllcornr
      read (5,110) yllcornr
      read (5,100) csize
      read (5,120) nodata
      write (6,200) ncols, nrows, xllcornr, yllcornr,
    1              csize, nodata
      do k=1,1502
      read (5,*) (ka(j),j=1,1534)
```

```
       write(6,*) (ka(j),j=1,1534)
       enddo
       continue
100    format (14x,i5)
105    format (14x,f10.1)
110    format (14x,f14.5)
120    format (14x,i5)
200    format (1x,i5,/,1x,i5,/,1x,f10.1,/,1x,f15.5,/,1x,i5,/,1x,i5)
999    close(unit=5)
       close(unit=6)
       stop
       end
```

INTGRID.SAS (File 10):

```
data in;
infile 'path and file name' firstobs=7 linesize=9203;
input varname@@;
run;
```

The flat ASCII files PD80.ASC (File 14) and BIO1980.ASC (File 12) may be read using the input/output programs REALGRID.FOR (File 15) or REALGRID.SAS (File 16).

REALGRID.FOR (File 15):

```
 real xllcornr, yllcornr, xa
       integer ncols, nrows, csize, nodata
       dimension xa(2304068)
       open(unit=5,file='bio1980.asc',status='old',access='sequential')
       open(unit=6,file='bio1980.out',status='new',access='sequential')
       read (5,100) ncols
       read (5,100) nrows
       read (5,110) xllcornr
       read (5,110) yllcornr
       read (5,100) csize
       read (5,120) nodata
       write (6,200) ncols, nrows, xllcornr, yllcornr,
     1               csize, nodata
       do x=1,1502
       read (5,*) (xa(j),j=1,1534)
       write(6,*) (xa(j),j=1,1534)
       enddo
       continue
100    format (14x,i5)
105    format (14x,f10.1)
110    format (14x,f14.5)
120    format (14x,i5)
200    format (1x,i5,/,1x,i5,/,1x,f10.1,/,1x,f15.5,/,1x,i5,/,1x,i5)
999    close(unit=5)
       close(unit=6)
       stop
       end
```

REALGRID.SAS (File 16):

```
data in;
infile 'path and file name' firstobs=7 linesize=13805;
input varname@@;
run;
```

The flat ASCII file T_AFR.ASC (File 22) may be read using the input/output programs T_AFR.FOR (File 23) or T_AFR.SAS (File 24).

T_AFR.FOR (File 23):

```
     character cntry*30, aname*40
         integer cntryn, admp, larea
         real pd60, pd70, pd80, pd90
         open(unit=5,file='t_afr.asc',status='old',access='sequential')
         open(unit=6,file='t_afr.out',status='new',access='sequential')
5        read (5,100, end=999) cntry, cntryn, admp, aname, pd60, pd70,
      1 pd80, pd90, larea
10       write (6,100) cntry, cntryn, admp, aname, pd60, pd70,
      1 pd80, pd90, larea
         goto 5
100      format (a30,1x,i5,1x,i4,1x,a39,1x,f8.3,1x,f8.3,
      1          1x,f8.3,1x,f8.3,1x,i8)
999      close(unit=5)
         close(unit=6)
         stop
         end
```

T_AFR.SAS (File 24):

```
data in;
infile 't_afr.asc';
input country $ 1-30 cntry_no 32-36 admp 38-41
      admp_nm 43-82 pd60 84-91 pd70 93-100
      pd80 102-109 pd90 111-118 landarea 120-129;
proc print;
run;
```

The flat ASCII file AFRICA.ASC (File 19) may be read by using the input/output programs AFRICA.FOR (File 20) or AFRICA.SAS (File 21).

AFRICA.FOR (File 20):

```
     character cntry*30
         integer cntryn, tcell, tarea, carea, oarea
         real cbio, obio, tbio, forest
         open(unit=5,file='africa.asc',status='old',access='sequential')
         open(unit=6,file='africa.out',status='new',access='sequential')
```

```
5       read (5,100, end=999) cntry, cntryn, tcell, tarea, carea,
     1 oarea, cbio, obio, tbio, forest
10      write (6,100) cntry, cntryn, tcell, tarea, carea,
     1 oarea, cbio, obio, tbio, forest
        goto 5
100     format (a30,1x,i5,1x,i11,1x,i10,1x,i9,1x,i9,
     1          1x,f12.1,1x,f12.1,1x,f12.2,1x,f12.1)
999     close(unit=5)
        close(unit=6)
        stop
        end
```

AFRICA.SAS (File 21):

```
data in;
infile 'africa.asc';
input country $ 1-30 cntry_no 32-36 tcell 38-48
      tarea 50-60 carea 62-70 oarea 72-80
      cbio 82-95 obio 97-110 tbio 112-126
      forest 128-41;
proc print;
run;
```

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