NDP-017

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# CDIC NUMERIC DATA COLLECTION

# Major World Ecosystem Complexes Ranked by Carbon in Live Vegetation: A Database

*Information Resources Organization at Oak Ridge National Laboratory*
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NDP-017

# MAJOR WORLD ECOSYSTEM COMPLEXES RANKED BY CARBON IN LIVE VEGETATION: A DATABASE

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September, 1985

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for the
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# CDIC NUMERIC DATA PACKAGE-017
## ABSTRACT

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## 1. NUMERIC DATA PACKAGE NAME

Major World Ecosystem Complexes Ranked by Carbon in Live Vegetation: A Database

## 2. CONTRIBUTORS

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## 3. CITATION OF THE PACKAGE

The Carbon Dioxide Information Center (CDIC) recommends the following citation for those citing or referencing this package:

Olson, J.S., J.A. Watts, and L.J. Allison. 1985. Major world ecosystem complexes ranked by carbon in live vegetation: A Database. NDP-017, Carbon Dioxide Information Center, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

## 4. BACKGROUND INFORMATION

Available vegetation maps and resource inventories are not sufficiently detailed, accurate, and current to answer major questions about the biological "source or sink" of atmospheric $CO_2$. A number of carbon estimates were summarized and discussed in Bolin et al. (1979) and Bolin (1981), along with applications for modeling the global carbon cycle. Other inventories, however, use different methods and classification systems for estimating terrestrial carbon and are therefore difficult to compare. Regional studies, which concentrate on one area with little attention to the others, can furnish useful but limited data on types and trends. Changes in one vegetation group are sometimes offset by changes in the opposite direction in other areas. Deforestation or other landscape modifications in one region may be balanced by reversion to forests in others. But the carbon cycle must be evaluated on a global scale. While detailed, localized studies proceed, the map and data base documented in this package provide a unifying format for the continuing evaluation of changes in estimated carbon in plant mass, and eventually other components, of the whole terrestrial ecosystem.

## 5. SOURCE AND SCOPE OF THE DATA

The global ecology map (inside back cover) shows the spatial distribution of major world ecosystem complexes estimated for 1980. However, because some information sources documented here are older some of this information may not be current. Except for more drastic changes caused by humans, it also reflects the map of broad "Continental Ecosystem Patterns and Reconstructed Living Carbon Prior to the Iron Age" prepared earlier by Olson (1970), after Bazilevich and Rodin (1967). Both maps were developed after more than 20 years of field investigation and consultations, and analyses of maps and published literature. The latter are cited mainly in chapters 2 and 3 and the Appendices of the report by Olson et al. (1983), which is included in this package. The map printing was an experiment, using computer-generated color separation plates derived from a file of land-cover types.

Counting the cells of each type in each $0.5^{\circ}$ latitude band and adding their areas over latitude bands gave total area estimates for these ecosystem complexes. Some independent area estimates are brought together in Sect. 4.1 of Olson et al. (1983) and confirm the thesis that some earlier estimates of forest area and forest contribution to global carbon inventories were apparently overestimated. Current estimates of the range in density of carbon per unit area (Table 1) are discussed in Sect. 4.2 and the Appendices of Olson et al. (1983). Multiplying the low medium, and high density estimates by ecosystem area gives corresponding estimates of the global total carbon by ecosystem complexes (Sect. 4.3 of Olson et al., 1983).

Only the mass of green plants is considered here, since the amounts of animal biomass are small in comparison. The mass of fungi and bacteria is not necessarily negligible, but evaluating it was beyond the scope of the 1983 report. This mass of decomposers varies greatly with time and space. It is important for controlling flux or recycling rates rather than for its own inventory. The recycling rate of $CO_2$ by respiration is usually expressed relative to the substrates of standing, fallen, and incorporated soil residues. The range of uncertainty about total plant carbon and its component parts reveals where more attention could reduce the uncertainty. Implications of these data are discussed briefly by Olson et al. (1983).

Estimation of the inventory of carbon in major world ecosystems and of the exchanges with the atmosphere and other major reservoirs has thus been approached in two ways. In the first approach, development of broad global patterns uses potential vegetation maps, or associates vegetation types with climatic or other environmental factors independent of local disturbance. The distributions described by Bazilevich and Rodin (1967), Lieth (1975), Kuchler (1978), and Bailey (1978) are examples of this approach. In the second approach, development of modern regional or stand-type estimates is based on analyses of current vegetation and land-use practices. This method uses updated resource maps of natural vegetation, forestry surveys, agricultural yields, and human and economic as well as geopolitical considerations. Both approaches were applied in the development of the ecosystem map. The personal judgment of experts about ecosystem types, their locations and extent, and likely biomass or carbon in landscape complexes representative of different parts of the world is crucial in either approach.

## 6. APPLICATIONS OF THE DATA

The rates of $CO_2$ release to the atmosphere and its removal are controlled differently by factors affecting photosynthesis, respiration, and burning as well as by shifts in land use and climate. Understanding these relations together with increased knowledge of the plant pools undergoing change will enhance our ability to integrate information from biology and geography into geophysical modeling of element cycles and climate.

1. The map of Major World Ecosystem Complexes provides a current reference base for interpreting the role of vegetation in the global cycling of $CO_2$ and other gases. It combines improvement in available ecological data and techniques for computer generation of maps.

2. The data provide a basis for improved estimates of vegetation and soil carbon, of natural exchanges of $CO_2$, and of net historic shifts of carbon between the biosphere and the atmosphere.

3. Landscape areas inferred from the map and other sources and weighted averages of carbon in various kinds of vegetation suggest significantly lower carbon in global vegetation than has been sometimes used in recent analyses of global geochemical cycles.

4. Tabulations still show tree formations holding most of the plant carbon. Yet decreases in area and mass of closed forest have already been so extensive that hundreds of petagrams (billion metric tons) of carbon were probably released over centuries or millenia before recent industrialization and human population growth.

5. The remaining plant pool is still large enough to contribute a few petagrams of carbon per year to atmospheric $CO_2$, if conversion as well as harvesting of massive tropical forests continues (a significant fraction of recent releases of 5 petagrams of carbon per year is from burning of fossil fuels). The problem remains, however, to infer how much of that release is offset by renewed storage in untilled areas of the tropics. In temperate or Boreal zones, even more forests are regrowing after earlier harvesting and clearing and because of recent fire protection.

## 7. RESTRICTIONS AND LIMITATIONS

The broad ranges given on the map legend for the carbon content in the major groups probably span all the type means in each ecosystem group and most of the stand averages for each mapping cell within an ecosystem group. At the present stage of development of this methodology, a carbon density based on the ranges and means as given cannot be assigned to each cell. Such an effort requires local assessments of vegetative cover, land use, soils, topography, and climatic factors.

Uncertainties for regions known poorly or inferred indirectly (by analogy) will remain for additional refinements. The digitized map offers a systematic way of locating future revisions of boundaries and ecosystem areas. As amounts of carbon per unit area or their transfer rates are analyzed in more locations, then the mean estimates, which are currently applied as "default" values for each place a given type occurs, can be suitably adjusted for variations among nations, among climatic or soil regions of a given ecosystem type, or for particular map cells. Remote sensing on a continental or world-wide basis (e.g., with Advanced Very High Resolution Radiometry) is one approach to this next stage of analysis. If the climate itself changes significantly, whether due to $CO_2$ or to other possible interacting causes (Manabe and Wetherald 1967, 1975, 1980; WMO 1979; Clark 1982), then the relation of the present patterns of vegetation and climate can be used in helping to project the impacts on change of vegetation and related resources.

Because forests, open woodlands, and complexes in which these ecosystems alternate with nonwooded communities (so-called "Interrupted Woods"), constitute most of the carbon in live vegetation, present uncertainties (about 20 percent) still center on these types. Where investigated most recently, tropical woods have been identified with even lower biomass and carbon estimates than were expected in 1982.

Some coniferous forests of moist regions like the northwestern coast of North America are identified with even higher biomass than the tropical rain forests.

A major uncertainty exists in the "nonwoods" ecosystem concerning the amount of carbon that should be added for scattered trees or woody inclusions not counted in the "woods" ecosystems. There is considerable allowance from judgment and experience in using the sampled averages differently.

As closer refinements are made, the future estimates for carbon density in ecosystems will more likely be revised downward from the medium estimate of 560 $\pm$ 100 petagrams (Pg).

The database in this package may not duplicate exactly the world ecosystems complexes map that is part of this package. Revisions to about 200 cells (0.8% of all cells) were made to the plates used to print the map. Some of these revisions were not recorded and may not have been incorporated into the database.

## 8. DESCRIPTION OF DATA PROCESSING ROUTINE

A retrieval routine written in FORTRAN IV for the IBM 3033 is provided along with a sample of the output generated from the execution of this retrieval routine. The output lists latitude, longitude, vegetation codes, and corresponding vegetation complexes for land only. Water bodies, represented by a vegetation code 0 (zero), were omitted to minimize the length of the output but are included in the data file (File 3) provided on magnetic tape so that the database can be used to produce line printer maps. The shoreline codes 65-68 are used to indicate the quadrant of a cell that is land. The area of land used for calculating the carbon density is 35 percent for these codes. The deciduous forest complex is subdivided into codes 25 and 26; the forest/field complex represented by 56 and 57; and farm, grass, or scrub with woods defined by 55 and 58 representing cool and warm climates respectively. The tropical seasonal forest (29) and evergreen equatorial forest (33) are subdivisions of the broader complex-tropical/subtropical broad-leaved humid forest. The mangroves along the coastal strips are indicated by red outlines along the coastal outlines, and were drawn using the mapping file of coastal outlines as defined in the cartographic software. They are not coded as a part of this file; a task that remains to be done. Codes 53 and 54 are used to define tundra, with 53 being used consistently throughout this version. The southern taiga is divided into midcontinental (60) and east-continental (61) categories. The entire listing of the land output are provided in the package on microfiches. The data include 360 latitude bands with vegetation codes for each $0.5^\circ$ x $0.5^\circ$ cell represented as two-digit integers (Table 1). The format of the vegetation code data (File 3) is:

```
      READ(5,8001)NP,(SURF(IP,1),SURF(IP,2),IP=1,15)
      IF(NP .LE. 15) GO TO 30
10    READ(5,8002) (SURF(IP,1),SURF(IP,2),IP=16,30)
      IF(NP .LE. 30) GO TO 30
11    READ(5,8002) (SURF(IP,1),SURF(IP,2),IP=31,45)
      IF(NP .LE. 45) GO TO 30
12    READ(5,8002) (SURF(IP,1),SURF(IP,2),IP=46,60)
      IF(NP .LE. 60) GO TO 30
13    READ(5,8002) (SURF(IP,1),SURF(IP,2),IP=61,75)
      IF(NP .LE. 75) GO TO 30
14    READ(5,8002) (SURF(IP,1),SURF(IP,2),IP=76,90)
      IF(NP .LE. 90) GO TO 30
15    READ(5,8002) (SURF(IP,1),SURF(IP,2),IP=91,105)
      IF(NP .LE. 105) GO TO 30
16    READ(5,8002) (SURF(IP,1),SURF(IP,2),IP=106,120)
      IF(NP .LE. 120) GO TO 30
17    READ(5,8002) (SURF(IP,1),SURF(IP,2),IP=121,135)
      IF(NP .LE. 135) GO TO 30
18    READ(5,8002) (SURF(IP,1),SURF(IP,2),IP=136,150)
      IF(NP .LE. 150) GO TO 30
19    READ(5,8002) (SURF(IP,1),SURF(IP,2),IP=151,165)
8001  FORMAT(I3,15(I3,I2))
8002  FORMAT(3x,15(I3,I2))
30    CONTINUE
```

The variable NP denotes the number of pairs of vegetation codes that will be found in a latitudinal band; SURF(IP,1) denotes the number of consecutive $0.5^\circ$ grids a particular vegetation code is found; and SURF(IP,2) denotes the vegetation code number. For example, the latitudinal band 1720 0 means that only one pair of codes is found and that 720 consecutive 0.5° grids have the vegetation code 0, which is water.

## 9. KEYWORDS

BIOSPHERE; TERRESTRIAL ECOSYSTEMS; GLOBAL CARBON RESERVOIRS; CARBON CYCLE; VEGETATION FORMATIONS; BIOGEOGRAPHY; CLIMATE REGIONS; MAPPING; HUMAN IMPACTS

## 10. CONTENTS OF THE PACKAGE

The package contains the referenced documents (a), and three files of information written in EBCDIC on magnetic tape as card images: tape information, the retrieval code, and one set of data. Total records: 1723.

a. Included in the package:

Olson, J. S. 1982. Earth's vegetation and atmospheric carbon dioxide, IN: Carbon Dioxide Review: 1982. Ed. W. C. Clark. Oxford University Press, New York. p. 388-398.

Olson, J. S., J. A. Watts, and L. J. Allison. 1983. Carbon in live vegetation of major world ecosystems, Report ORNL-5862, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

b. Background information:

Bazilevich, N. I. and L. Ye Rodin. 1967. Maps of productivity and the biological cycle in the Earth's principal terrestrial vegetation types, Izv. Vses. Geogr. Obschestva. 99: 190-194.

Bolin, B., E. T. Degens, S. Kempe, and P. Ketner (eds.). 1979. The Global Carbon Cycle, SCOPE 16, John Wiley & Sons, New York.

Bolin, B. (ed.). 1981. Carbon Cycle Modelling, SCOPE 16, John Wiley & Sons, New York.

Olson, J. S. 1970. Continental ecosystem patterns and reconstructed living carbon prior to the Iron Age, Back flyleaf. IN: D. E. Reichle (ed.), Analysis of Temperate Forest Ecosystems, Ecological Studies No. 1. Springer-Verlag, New York.

## 11. HOW TO OBTAIN THE PACKAGE

The documentation of NDP-17 contains a sample printed listing of the data retrieved by the output routine and a complete listing of the output on microfiches for the use of requesters who may not need the automated data. If the requester does not have access to a microfiche reader, a complete, hard-copy listing of the output is available at the address listed below.

Requests for computerized data should be accompanied by a reel of tape and special instructions for transmitting the data. Tape requests not accompanied by a tape or instructions will be filled with a standard labeled, 6250 BPI, 9-track density tape with files formatted as listed in the Tape Contents Section.

Requests should be addressed to:

Carbon Dioxide Information Center
Oak Ridge National Laboratory
Post Office Box X
Oak Ridge, Tennessee 37831-2008
Telephone (615) 574-0390
FTS 624-0390

## 12. DATE OF ABSTRACT

September 1985

Each numeric data package (NDP) assembled by CDIAC goes through a process of assuring the quality of the data. This process includes document review(s) by the contributors of the data to ensure that, in compiling and documenting the data, CDIAC does not misrepresent or inaccurately describe the data. NDPs are not distributed without the written consent of the contributors. In addition to review by the contributors, CDIAC also performs some quality checks on the data. For this data set, the following checks were done using SAS (SAS Institute Inc., Cary, North Carolina):

(1) frequency checks were done on all latitude bands to ensure the presence of 720 grid cells

(2) cumulative frequency checks were done on all grid cells to ensure that 259,200 were defined and that no vegetation codes other than documented existed in the database

## Magnetic Tape Contents

Tape Identification __________
Density _______ 9 Track

Package NDP-017
Date Packaged: 09-85
Most Recent Update:

*****************************************************************

| Description | | Mode | Logical Records | DCB Parameters | | |
|---|---|---|---|---|---|---|
| File 1. | Descriptive Information | EBCDIC | 54 | FB | 8000 | 80 |
| File 2. | Retrieval Program | EBCDIC | 124 | FB | 8000 | 80 |
| File 3. | Global Vegetation Complexes Data | EBCDIC | 1545 | FB | 8000 | 80 |
| | | Totals | 1723 | | | |

*****************************************************************

A listing of the FORTRAN retrieval and output program and descriptive information is included in the documentation. Tabular listings of the data file (3), as printed by the retrieval program, are provided on the microfiches included in the package or can be obtained as a hard copy by request.

## NDP-17 TAPE INFORMATION

**Dataset Title:** Major World Ecosystem Complexes Ranked by Carbon in Live Vegetation: A Database

**Contributors:** Jerry S. Olson, Julia A. Watts and Linda J. Allison
Environmental Sciences Division
Oak Ridge National Laboratory
Oak Ridge, TN 37831

**Scope of the Data:** A computerized database used to generate a global vegetation map of 44 different land ecosystem complexes comprising seven broad groups are provided. The database and accompanying map provides a basis for making improved estimates of vegetation areas and carbon quantities, of natural biological exchanges of $CO_2$, and eventually of the net historic shifts of carbon between the biosphere and the atmosphere. The map is derived from patterns of preagricultural vegetation, modern areal surveys, and intensive biomass data from research sites.

**Data Format:** The database, defining the Major World Ecosystem Complexes map provided in the package has a matrix format of 360 rows and 720 columns, where the rows are the latitude bands and the columns are the longitude bands. Element (1,1) is centered on 89.75°N, 179.75°W. The matrix elements have an increment of 0.5°. Two-digit numeric codes (Table 1) were assigned to each vegetation type. There is no special significance to these code numbers. This open-ended approach to assigning vegetation codes was done to facilitate addition of new categories or subdivision of previously defined categories without having to reassign or restructure the codes when regroupings were made. Each row of data consists of NP data pairs, where NP is the total number of pairs required to define the land or water cover for a given latitude band. The data pair is composed of the number of consecutive elements (left to right) for a given cover category [SURF(IP,1)] and the vegetation code [SURF(IP,2)] assigned to that element. The formats used in reading the data are:

```
      READ(5,8001)NP,(SURF(IP,1),SURF(IP,2),IP=1,15)
      IF(NP .LE. 15) GO TO 30
10    READ(5,8002) (SURF(IP,1),SURF(IP,2),IP=16,30)
      IF(NP .LE. 30) GO TO 30
11    READ(5,8002) (SURF(IP,1),SURF(IP,2),IP=31,45)
      IF(NP .LE. 45) GO TO 30
12    READ(5,8002) (SURF(IP,1),SURF(IP,2),IP=46,60)
      IF(NP .LE. 60) GO TO 30
```

```
13      READ(5,8002) (SURF(IP,1),SURF(IP,2),IP=61,75)
        IF(NP .LE. 75) GO TO 30
14      READ(5,8002) (SURF(IP,1),SURF(IP,2),IP=76,90)
        IF(NP .LE. 90) GO TO 30
15      READ(5,8002) (SURF(IP,1),SURF(IP,2),IP=91,105)
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        IF(NP .LE. 120) GO TO 30
17      READ(5,8002) (SURF(IP,1),SURF(IP,2),IP=121,135)
        IF(NP .LE. 135) GO TO 30
18      READ(5,8002) (SURF(IP,1),SURF(IP,2),IP=136,150)
        IF(NP .LE. 150) GO TO 30
19      READ(5,8002) (SURF(IP,1),SURF(IP,2),IP=151,165)
8001    FORMAT(I3,15(I3,I2))
8002    FORMAT(3x,15(I3,I2))
30      CONTINUE
```

## REFERENCES


Olson, J. S. 1982. Earth's Vegetation and Atmospheric Carbon Dioxide, pp. 388-398. In W. C. Clark (ed.), Carbon Dioxide Review : 1982. Oxford University Press, New York.

Olson, J. S., J. A. Watts, and L. J. Allison. 1983. Carbon in Live Vegetation of Major World Ecosystems, ORNL-5862, Environmental Sciences Division Publication No. 1997, Oak Ridge National Laboratory, Oak Ridge, Tennessee.

Table 1. Summary of carbon estimates by map legend for major world ecosystem complexes (Source Olson et al., 1983). Revised current estimates in parentheses as determined by Olson.

| Category | Ecosystem Code(s) | Carbon Potentials ($kg\ C/m^2$) Medium | Range |
|---|---|---|---|
| **TREE FORMATIONS (WOODS)** | | | |
| Major FOREST and WOODLAND | | | |
| Mostly taiga and other conifer | | | |
| Main Taiga | 20, 21 | 8 (6) | 4-11 |
| Southern Taiga | 60, 61 | 11 (8) | 6-14 |
| Other Conifer | 22, 27 | 16 (13) | 12-20 |
| Mostly mid-latitude broad-leaved and mixed | | | |
| Temperate broad-leaved forest | 25, 26 | 10 (9) | 8-14 |
| Mixed Woods: deciduous to evergreen broad-leaved, often with conifer | 23, 24 | 10 (7) | 6-14 |
| Main Tropical/Subtropical Forest | | | |
| Broad-Leaved Humid Forest | 29,33,73 | 15 (12) | 4-25 |
| Dry Forest and Woodland | 32 | 7 (6) | 5- 9 |
| INTERRUPTED WOODS | | | |
| Tropical savanna or montane | | | |
| Tropical Savanna and Woodland | 43 | 3 (3) | 2- 5 |
| Tropical Montane Complexes | 28 | 5 (5) | 1-15 |
| Tall or dwarfed forest | | | |
| Grass, scrub, paramo, rock | | | |
| Other dry woods mosaics | | | |
| Woods/Scrub/Grass Complexes | | | |
| Succulent and thorn woods | 59 | 4 (3) | 2- 6 |
| Mediterranean types | 46 | 4 (3) | 2- 8 |
| Other dry or highland woods | 47 | 4 (3) | 2- 8 |
| Semiarid Woodland or Low Forest | 48 | 5 (4) | 2-10 |
| Northern or Maritime Taiga, subalpine | 62 | 5 (5) | 2- 8 |
| Second Growth Woods & Field Mosaics | | | |
| Forest/Field (allocations) | 56, 57 | 5 (4) | 4- 8 |
| Tropical/subtropical humid forest | | | |
| Temperate/boreal forest | | | |

Table 1 (continued)

| | | | |
|---|---|---|---|
| INTERRUPTED WOODS (continued) | | | |
| Field/woods (allocations) | 55, 58 | 4 (3) | 2- 5 |
| Tropical woods | | | |
| Temperate woods | | | |
| Fields, grass, scrub | | | |
| **NONWOODS** (trees planted, sparse, low, or absent) | | | |
| MAINLY CROPPED, RESIDENTIAL, COMMERCIAL, PARK and associated marginal lands | | | |
| Irrigated land and surroundings | | | |
| Paddyland | 36 | 3 (3) | 2- 4 |
| Other Irrigated Dryland | 37,38,39 | 2 (2) | 1- 3 |
| Other Crop, Settlements, and Marginal Lands | | | |
| Cool or cold farms, towns | 30 | 1 (0.7) | 0.4- 2 |
| Warm or hot farms, towns | 31 | 1 (0.8) | 0.6- 2 |
| GRASS AND SHRUB COMPLEXES | | | |
| Main Grassland or shrubland | | | |
| Warm or hot shrub and grassland | 41 | 1.3 (0.9) | 0.5- 3 |
| Cool grassland/scrub | 40 | 1 (0.8) | 0.6- 2 |
| Heath and moorland | 64 | 1.5 (1.0) | 1- 2 |
| Cold Grass or Stunted Woody Complex | | | |
| Tibetan, Siberian | 42 | 1 (1) | 0.5- 4 |
| Wooded tundra | 63 | 2 (2) | 1- 5 |
| TUNDRA AND DESERT | | | |
| Tundra, artic desert, and ice | | 0.5 (0.5) | 0-1.2 |
| Tundra | 53, 54 | | |
| Polar or Rock Desert | 69 | | |
| Ice | 70 | | |
| Nonpolar desert or semidesert | | | |
| Cool Semidesert Scrub | 52 | 0.6 (0.6) | 0.3- 1 |
| Sand Desert | 50 | 0.05 (0.05) | 0- 0.2 |
| Other Desert and Semidesert | 51, 71 | 0.4 (0.3) | 0.2- 1.0 |
| Sparse (rocky) vegetation | 49 | | |

Table 1 (continued)

| | | | |
|---|---|---|---|
| **WETLAND** and/or **COASTAL** | | | |
| MAJOR WETLANDS | | | |
| Bog/Mire of Cool or Cold Climates | 44 | 2 (2) | 1- 6 |
| Warm or Hot Wetlands | 45, 72 | 3 (2) | 1- 6 |
| (Mangrove/Tropical Swamp Forest) | | | 1-20 |
| Other COASTAL, AQUATIC, AND MISCELLANEOUS | | | |
| Shore and Hinterland Complexes | 65, 66, 67, 68 | 3 (3) | 0-10 |
| Water Bodies | 0 | | |
| Antarctica (not shown on map) | 17 | | |

The program will read the vegetation complexes data (File 3 on the tape) as partially shown in Table 2 and output the data as shown in Table 3. A complete listing of the output shown in Table 3 is provided on the microfiches provided on the inside of the back cover.

```
       REAL*16 VTYP(720),VN(47)
       INTEGER SURF,SYM
       DIMENSION SURF(200,2),SYM(720),LAT(360),X(720),Y(720)
      DIMENSION XF(720),YF(720),ISYM(720)
       DATA VN/'ANTARCTICA          ','MAIN TAIGA          ',
     1 'COOL CONIFER        ','COOL MIXED          ','WARM DECIDUOUS      ',
     2 'WARM MIXED          ','WARM CONIFER        ','TROPICAL MONTANE    ',
     3 'TROP. SEASONAL      ','EQ. EVERGREEN       ','COOL CROPS          ',
     4 'WARM CROPS          ','TROPICAL DRY FOR    ','PADDYLANDS          ',
     5 'WARM IRRIGATED      ','COOL IRRIGATED      ','COLD IRRIGATED      ',
     6 'COOL GRASS/SHRUB    ','WARM GRASS/SHRUB    ','HIGHLAND SHRUB      ',
     7 'MED. GRAZING        ','SEMIARID WOODS      ','SIBERIAN PARKS      ',
     8 'HEATHS, MOORS       ','SUCCULENT THORNS    ','NORTH. TAIGA        ',
     9 'TROP. SAVANNA       ','COOL FIELD/WOODS    ','WARM FIELD WOODS    ',
     1 'WARM FOR./FIELD     ','COOL FOR./FIELD     ','SOUTH. TAIGA        ',
     2 'E. SOUTH. TAIGA     ','TROP. MONTANE       ','MARSH, SWAMP        ',
     3 'MANGROVES           ','LOW SCRUB           ','BOGS, BOG WOODS     ',
     4 'HOT DESERT          ','COOL DESERT         ','WOODED TUNDRA       ',
     5 'TUNDRA              ','SAND DESERT         ','POLAR DESERT        ',
     6 'ICE                 ','WATER               ',
     7 'COASTAL EDGES       '/
C   STARTING LATITUDE AND LONGITUDE POINTS CENTERED ON CELL
        DO 55 ILO=1,720
55      XF(ILO)=-179.75+(0.5*(ILO-1))
C   READ IN DATA FOR EACH 0.5 DEGREE LATITUDE BAND
C   NP=NO. OF PAIRS OF POINTS AND VEGETATION CODE
C   SURF(IP,1) IS NO. OF CONSECUTIVE CELLS HAVING VEGETATION TYPE
C    DEFINED IN SURF(I,2)
C    SURF(I,2) IS VEGETATION CODE
        DO 1 IROW=1,360
          YLAT=89.75-(0.5*(IROW-1))
        READ(5,8001) NP,(SURF(IP,1),SURF(IP,2),IP=1,15)
        IF(NP .LE. 15) GO TO 30
10      READ(5,8002) (SURF(IP,1),SURF(IP,2),IP=16,30)
        IF(NP .LE. 30) GO TO 30
11      READ(5,8002) (SURF(IP,1),SURF(IP,2),IP=31,45)
        IF(NP .LE. 45) GO TO 30
12      READ(5,8002) (SURF(IP,1),SURF(IP,2),IP=46,60)
        IF(NP .LE. 60) GO TO 30
13      READ(5,8002) (SURF(IP,1),SURF(IP,2),IP=61,75)
        IF(NP .LE. 75) GO TO 30
14      READ(5,8002) (SURF(IP,1),SURF(IP,2),IP=76,90)
        IF(NP .LE. 90) GO TO 30
15      READ(5,8002) (SURF(IP,1),SURF(IP,2),IP=91,105)
        IF(NP .LE. 105) GO TO 30
16      READ(5,8002) (SURF(IP,1),SURF(IP,2),IP=106,120)
        IF(NP .LE. 120) GO TO 30
17      READ(5,8002) (SURF(IP,1),SURF(IP,2),IP=121,135)
        IF(NP .LE. 135) GO TO 30
18      READ(5,8002) (SURF(IP,1),SURF(IP,2),IP=136,150)
        IF(NP .LE. 150) GO TO 30
19      READ(5,8002) (SURF(IP,1),SURF(IP,2),IP=151,165)
8001    FORMAT(I3,15(I3,I2))
8002    FORMAT(3X,15(I3,I2))
30      CONTINUE
C   SET UP COUNTERS TO LOOP THRU TO DEFINE ECOSYSTEM COMPLEX
C   FOR EACH CELL ON A LAT-LONG BASIS
C   LOOP FOR NP PAIRS
        IK=0
        IC=1
        DO 2 I=1,NP
        I2=SURF(I,2)
        I1=SURF(I,1)
        IK=IC+I1-1
        DO 3 J=IC,IK
        SYM(J)=I2
3       CONTINUE
        IC=IC+I1
2       CONTINUE
```

```
          DO 5 IKT=1,720
           YF(IKT)=YLAT
           ISYM(IKT)=SYM(IKT)
         IF(ISYM(IKT) .EQ. 0) VTYP(IKT)=VN(46)
           IF(ISYM(IKT).EQ. 17) VTYP(IKT)=VN(1)
           IF(ISYM(IKT).EQ.20 .OR. ISYM(IKT) .EQ. 21)
     1    VTYP(IKT)=VN(2)
           IF(ISYM(IKT) .EQ. 22) VTYP(IKT)=VN(3)
           IF(ISYM(IKT) .EQ. 23) VTYP(IKT)=VN(4)
           IF(ISYM(IKT) .EQ. 24) VTYP(IKT)=VN(5)
           IF(ISYM(IKT) .EQ. 25 .OR. ISYM(IKT) .EQ. 26)
     1    VTYP(IKT)=VN(6)
           IF(ISYM(IKT) .EQ. 27) VTYP(IKT)=VN(7)
           IF(ISYM(IKT) .EQ. 28) VTYP(IKT)=VN(8)
           IF(ISYM(IKT) .EQ. 29) VTYP(IKT)=VN(9)
           IF(ISYM(IKT) .EQ. 33) VTYP(IKT)=VN(10)
           IF(ISYM(IKT) .EQ. 30) VTYP(IKT)=VN(11)
            IF(ISYM(IKT) .EQ. 31) VTYP(IKT)=VN(12)
           IF(ISYM(IKT) .EQ. 32) VTYP(IKT)=VN(13)
            IF(ISYM(IKT) .EQ. 36) VTYP(IKT) =VN(14)
           IF(ISYM(IKT) .EQ. 37) VTYP(IKT)=VN(15)
           IF(ISYM(IKT) .EQ. 38) VTYP(IKT)=VN(16)
           IF(ISYM(IKT) .EQ. 39) VTYP(IKT)=VN(17)
           IF(ISYM(IKT) .EQ. 40) VTYP(IKT)=VN(18)
           IF(ISYM(IKT) .EQ. 41) VTYP(IKT)=VN(19)
           IF(ISYM(IKT) .EQ. 47) VTYP(IKT)=VN(20)
           IF(ISYM(IKT) .EQ. 46) VTYP(IKT)=VN(21)
           IF(ISYM(IKT) .EQ. 48) VTYP(IKT)=VN(22)
           IF(ISYM(IKT) .EQ. 42) VTYP(IKT)=VN(23)
           IF(ISYM(IKT) .EQ. 64) VTYP(IKT)=VN(24)
           IF(ISYM(IKT) .EQ. 59) VTYP(IKT)=VN(25)
           IF(ISYM(IKT) .EQ. 62) VTYP(IKT)=VN(26)
           IF(ISYM(IKT) .EQ. 43) VTYP(IKT)=VN(27)
           IF (ISYM(IKT) .EQ. 55) VTYP(IKT)=VN(28)
           IF(ISYM(IKT) .EQ. 58) VTYP(IKT)=VN(29)
           IF(ISYM(IKT) .EQ. 56) VTYP(IKT)=VN(30)
           IF(ISYM(IKT) .EQ. 57) VTYP(IKT)=VN(31)
           IF(ISYM(IKT) .EQ. 60) VTYP(IKT)=VN(32)
           IF(ISYM(IKT) .EQ. 61) VTYP(IKT)=VN(33)
           IF(ISYM(IKT) .EQ. 28) VTYP(IKT)=VN(34)
           IF(ISYM(IKT) .EQ. 45) VTYP(IKT) =VN(35)
           IF(ISYM(IKT) .EQ. 72) VTYP(IKT)=VN(36)
           IF(ISYM(IKT) .EQ. 49) VTYP(IKT)=VN(37)
           IF(ISYM(IKT) .EQ. 44) VTYP(IKT)=VN(38)
           IF(ISYM(IKT) .EQ. 51 .OR. SYM(IKT) .EQ. 71)
     1     VTYP(IKT)=VN(39)
           IF(ISYM(IKT) .EQ. 52) VTYP(IKT)=VN(40)
           IF(ISYM(IKT) .EQ. 63) VTYP(IKT)=VN(41)
           IF(ISYM(IKT) .EQ. 53 .OR. ISYM(IKT) .EQ. 54)
     1     VTYP(IKT)=VN(42)
           IF(ISYM(IKT) .EQ. 50) VTYP(IKT)=VN(43)
           IF(ISYM(IKT) .EQ. 69) VTYP(IKT)=VN(44)
          IF(ISYM(IKT) .EQ. 70) VTYP(IKT)=VN(45)
           IF(ISYM(IKT) .GE. 65 .AND.
     1    ISYM(IKT) .LE. 68) VTYP(IKT)=VN(47)
5        CONTINUE
           WRITE(6,200)
          DO 15 NCT=1,720,2
            IF (MOD(NCT,120) .EQ. 0) WRITE(6,200)
200         FORMAT(1H1,'LATITUDE',3X,'LONGITUDE',3X,
     1    'ECOSYSTEM CODE',3X,'ECOSYSTEM COMPLEX',10X,'LATITUDE',3X,
     2    'LONGITUDE',3X,'ECOSYSTEM CODE',3X,'ECOSYSTEM COMPLEX')
         WRITE(6,230) YF(NCT),XF(NCT),ISYM(NCT),VTYP(NCT),
     1    YF(NCT+1),XF(NCT+1),ISYM(NCT+1),VTYP(NCT+1)
230        FORMAT(1H ,F8.2,3X,F9.2,9X,I2,8X,A16,10X,F8.2,3X,
     2    F9.2,9X,I2,8X,A16)
15        CONTINUE
1        CONTINUE
         STOP
         END
/*
```

Table 2. Sample listing of the vegetation complexes data file. File 3 on the magnetic tape contains the complete file used to generate the map provided in the package.

```
 1720 0
 1720 0
 1720 0
 1720 0
 1720 0
 1720 0
 1720 0
 1720 0
 1720 0
 1720 0
 1720 0
 1720 0
 1720 0
 5272 0  769 2270   569414 0
11195 0 1969  470   169  370 1069 34 0 1069 2870 1169405 0
13188 0 1069 1870   369  370  969  370  469  7 0  969  3 0 5870405 0
20181 0  469 1970   269  870 1869  170  4 0 1569 5670  2 0  270  369 10 0  370
   269  470142 0  153243 0
24173 0  369  3 0 1369 1170  469  570 1869  7 0 1169 5970  769  2 0  869  470
   369  270140 0  453 10 0  353 61 0  1 0168 0
31172 0  669  4 0 1469  470  2 0  669  270  469  870  269  5 0 1569 6970  869
   670  269  170121 0  670  2 0  370  7 0  770  3 0  670 61 0  469  270  369
  165 0
34162 0  1 0  7 0  469  570  369  1 0  269  2 0  669  1 0 1669  670  369  6 0
  1569 7370  269  970  369 69 0 1870 40 0  670  5 0  270  6 0  470 66 0  469
   570  169  170166 0
29161 0  369  5 0  569  770  469  4 0 1469 1170  369 14 0  569 8270  569  170
    58 0  269  870  169 2070130 0  170  169  370  169  470  369  470160 0
25149 0  569 19 0  869  270  769  1 0 1069  370  769 18 0  369 8670  369 61 0
   753  369  653  7 0  453140 0 1069  3 0  569153 0
28151 0  369  653  4 0  369  6 0  469  270  369  170  269  2 0 1253  370  869
     7 0  569  370  469 8870  369 63 0 1070  169  970158 0  970150 0
26133 0  869 11 0  853  4 0  653  5 0  769  3 0 1553  470  569  5 0  769 9670
   169 70 0  370  269  570  3 0  269  270154 0 1069151 0
23130 0  269  1 0  769  9 0  153  9 0  2 0  6 0  753 10 0  653  270 1253 15 0
  1069 8670  669 67 0  970  6 0  670311 0
18120 0  969 20 0  353 32 0  553  370  353  870 16 0 1069 8870  669 66 0  670
   169 0  769149 0
27118 0 1069 12 0  253 15 0  553  5 0  653  8 0 1453  870  153 18 0  269 9170
   369 74 0  270 98 0  470  269 61 0 1069  553  2 0  553139 0
32114 0  769  6 0  853  4 0  653  6 0  453  1 0  853 10 0  653  9 0  153  7 0
   353 22 0  769 8670  269166 0  269  670  569  170 56 0  153  4 0 1953  470
   653133 0
31121 0  353  1 0 1253  3 0  953  4 0 1153 11 0  653  9 0  953 41 0 7670  469
   157 0  169  570  469  270 55 0 1953  569  153  469  453  969  253 47 0 1569
    70 0
37125 0  653  1 0 1653  3 0  153  6 0  653  4 0  453  4 0 2453 44 0 7770  1 0
   253149 0  370  569  370 53 0  953  969  153  469  353  469  953  869  353
    48 0 1469  5 0  569  153  269 58 0
30132 0  653 31 0  453  3 0  753  570  453  1 0  753 46 0 7070  369  2 0  1 0
   149 0  169  570  369 53 0  653 3369  253  669  453 52 0  469 19 0  269 59 0
19112 0 1353122 0 7570148 0  153  470  353 55 0  253 1069  853  269 2553  4 0
   253 55 0  169 78 0
37112 0 1653 19 0  353  7 0  953  3 0 1053  6 0  553  4 0  353  2 0  153 48 0
   153 6670  453149 0  253  369  353 53 0 1753  569  153  269 2253  3 0  553
     2 0  153  4 0  1 0 50 0  470 74 0
37111 0 1653  3 0  153 14 0  653  7 0  653  5 0  953  4 0  653  3 0  653  2 0
   853 42 0  153 6470  253151 0  253  269  353 26 0  353 18 0 1353 1669 2353
     3 0 2153  9 0 1253 25 0  469 73 0
36111 0 1253  3 0 1753  1 0  653  5 0 1253  2 0  753  5 0  653  2 0  953  6 0
   153 44 0  170  153 6170  453149 0  353  269  253 26 0  853  3 0  253 11 0
   153 1869 7853 23 0  253 76 0
```

Table 3. Sample listing of the output generated by the execution of the retrieval program (File 2) in reading the vegetation complexes data (File 3). Positive latitude values represent points north of the equator while negative values correspond to points south of the equator. Positive longitude values represent eastern points; negative values represent western points.

| LATITUDE | LONGITUDE | ECOSYSTEM CODE | ECOSYSTEM COMPLEX |
|---|---|---|---|
| 89.75 | -179.75 | 0 | WATER |
| 89.75 | -178.75 | 0 | WATER |
| 89.75 | -177.75 | 0 | WATER |
| 89.75 | -176.75 | 0 | WATER |
| 89.75 | -175.75 | 0 | WATER |
| 89.75 | -174.75 | 0 | WATER |
| 89.75 | -173.75 | 0 | WATER |
| 89.75 | -172.75 | 0 | WATER |
| 89.75 | -171.75 | 0 | WATER |
| 89.75 | -170.75 | 0 | WATER |
| 89.75 | -169.75 | 0 | WATER |
| 89.75 | -168.75 | 0 | WATER |
| 89.75 | -167.75 | 0 | WATER |
| 89.75 | -166.75 | 0 | WATER |
| 89.75 | -165.75 | 0 | WATER |
| 89.75 | -164.75 | 0 | WATER |
| 89.75 | -163.75 | 0 | WATER |
| 89.75 | -162.75 | 0 | WATER |
| 89.75 | -161.75 | 0 | WATER |
| 89.75 | -160.75 | 0 | WATER |
| 89.75 | -159.75 | 0 | WATER |
| 89.75 | -158.75 | 0 | WATER |
| 89.75 | -157.75 | 0 | WATER |
| 89.75 | -156.75 | 0 | WATER |
| 89.75 | -155.75 | 0 | WATER |
| 89.75 | -154.75 | 0 | WATER |
| 89.75 | -153.75 | 0 | WATER |
| 89.75 | -152.75 | 0 | WATER |
| 89.75 | -151.75 | 0 | WATER |
| 89.75 | -150.75 | 0 | WATER |
| 89.75 | -149.75 | 0 | WATER |
| 89.75 | -148.75 | 0 | WATER |
| 89.75 | -147.75 | 0 | WATER |
| 89.75 | -146.75 | 0 | WATER |
| 89.75 | -145.75 | 0 | WATER |
| 89.75 | -144.75 | 0 | WATER |
| 89.75 | -143.75 | 0 | WATER |
| 89.75 | -142.75 | 0 | WATER |
| 89.75 | -141.75 | 0 | WATER |
| 89.75 | -140.75 | 0 | WATER |
| 89.75 | -139.75 | 0 | WATER |
| 89.75 | -138.75 | 0 | WATER |
| 89.75 | -137.75 | 0 | WATER |
| 89.75 | -136.75 | 0 | WATER |
| 89.75 | -135.75 | 0 | WATER |
| 89.75 | -134.75 | 0 | WATER |
| 89.75 | -133.75 | 0 | WATER |
| 89.75 | -132.75 | 0 | WATER |
| 89.75 | -131.75 | 0 | WATER |

| LATITUDE | LONGITUDE | ECOSYSTEM CODE | ECOSYSTEM COMPLEX |
|---|---|---|---|
| 89.75 | -179.25 | 0 | WATER |
| 89.75 | -178.25 | 0 | WATER |
| 89.75 | -177.25 | 0 | WATER |
| 89.75 | -176.25 | 0 | WATER |
| 89.75 | -175.25 | 0 | WATER |
| 89.75 | -174.25 | 0 | WATER |
| 89.75 | -173.25 | 0 | WATER |
| 89.75 | -172.25 | 0 | WATER |
| 89.75 | -171.25 | 0 | WATER |
| 89.75 | -170.25 | 0 | WATER |
| 89.75 | -169.25 | 0 | WATER |
| 89.75 | -168.25 | 0 | WATER |
| 89.75 | -167.25 | 0 | WATER |
| 89.75 | -166.25 | 0 | WATER |
| 89.75 | -165.25 | 0 | WATER |
| 89.75 | -164.25 | 0 | WATER |
| 89.75 | -163.25 | 0 | WATER |
| 89.75 | -162.25 | 0 | WATER |
| 89.75 | -161.25 | 0 | WATER |
| 89.75 | -160.25 | 0 | WATER |
| 89.75 | -159.25 | 0 | WATER |
| 89.75 | -158.25 | 0 | WATER |
| 89.75 | -157.25 | 0 | WATER |
| 89.75 | -156.25 | 0 | WATER |
| 89.75 | -155.25 | 0 | WATER |
| 89.75 | -154.25 | 0 | WATER |
| 89.75 | -153.25 | 0 | WATER |
| 89.75 | -152.25 | 0 | WATER |
| 89.75 | -151.25 | 0 | WATER |
| 89.75 | -150.25 | 0 | WATER |
| 89.75 | -149.25 | 0 | WATER |
| 89.75 | -148.25 | 0 | WATER |
| 89.75 | -147.25 | 0 | WATER |
| 89.75 | -146.25 | 0 | WATER |
| 89.75 | -145.25 | 0 | WATER |
| 89.75 | -144.25 | 0 | WATER |
| 89.75 | -143.25 | 0 | WATER |
| 89.75 | -142.25 | 0 | WATER |
| 89.75 | -141.25 | 0 | WATER |
| 89.75 | -140.25 | 0 | WATER |
| 89.75 | -139.25 | 0 | WATER |
| 89.75 | -138.25 | 0 | WATER |
| 89.75 | -137.25 | 0 | WATER |
| 89.75 | -136.25 | 0 | WATER |
| 89.75 | -135.25 | 0 | WATER |
| 89.75 | -134.25 | 0 | WATER |
| 89.75 | -133.25 | 0 | WATER |
| 89.75 | -132.25 | 0 | WATER |
| 89.75 | -131.25 | 0 | WATER |