THE USDA ECONOMIC BOTANY LABORATORY'S DATA BASE ON MINOR ECONOMIC PLANT SPECIES

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The world is fed mainly by a dozen plant species, and most agricultural countries have specialists for their country's major crops. The world also has thousands of minor economic species, which potentially are as important ecologically and economically as the big dozen, but there are not enough specialists to study them. There is an overwhelming number of climatological, pedological, anthropological, latitudinal, and biological variables associated with these minor species. The Economic Botany Laboratory (EBL) of the U.S. Department of Agriculture (USDA) is trying to gather data on these potentially economically useful species.

In 1971, USDA asked me to develop an information system on potential alternative crops for narcotics. With no computers available, I set up a manual information retrieval system of transparencies for screening 1,000 economic plants as potential substitutes. In 1972, I was encouraged to abandon the transparencies for computers. Now, 10 years later, there are many data in the computer. However, the computer bill for 1981 was over $50,000, and with the loss of our support from the National Cancer Institute, we can no longer afford to keep the data bases online.

Data Base Files and Subsets

Some of our files and their subsets are listed below, subjectively ranked in decreasing order of importance to USDA's Beltsville Agricultural Research Center.

1. ECOSYSTEMATICS
   - Germ Plasm Donor Subset (mailing list)
   - Monthly Temperature
   - Monthly Precipitation
   - Soil pH
   - Soil Type [limited)
   - Salinity (more limited)
   - Tolerances (not computerized)
2. YIELD
   - Phytomass Subset
   - Cultural Subsets
3. CLIMATE
   - Wernstedt
   - Questionnaires
   - Publishing Experiment Stations
4. NUTRITION
   - Food Composition Tables
   - Watt and Merrill
   - Wealth of India
   - Miller (1958)
   - Gohl (1981)
   - ZERO-MOISTURE SUBSET
5. AGROFORESTRY
   - Ecology Subset
   - Germination Subset
   - Cultural Subset
   - Nutrition Subset
   - Utilization Subset
   - Yield Subset
   - Wood Characterization Subset
   - Pest Subset
   - INTERCROPPING
6. PEST (fungi and insects only)
7. ETHNOMED
   - Colloquial Name Subset
   - Pesticide Subset
   - Pharmacologically Proven Subset
   - Cancer Subset
   - Malaria Subset
   - Geography Subset
   - Ailment Subset
   - Source

Methods and Results

Ecosystematic File

One of our most productive activities was mailing over 1,000 questionnaires worldwide to scientists and extension people, intentionally emphasizing developing countries. Within 2 years, over 500 people had responded, sending published and unpublished ecosystematic data (annual rainfall, annual temperature, soil type, soil pH, elevation, etc.) on economic plants and some weeds and nitrogen-fixing species. These data, related to about 1,000 species, now are incorporated in the Ecosystematic File (fig. 1) and are tabulated in The *Quest for Tolerant Germplasm (4).*

A success story addressing the multimillion-dollar problem of iron-efficient sorghum germ plasm illustrates the potential value of the ecosystematic file in seeking germ plasm for extreme environments (6). Scientists from the Plant Stress Laboratory were incredulous at the high soil pH reported for *Sorghum bicolor* in the file. Most sorghums are chlorotic and nonproductive on alkaline soils. The scientists asked for more information on the high pH sorghum. Since each species in the file is recorded with the name and address of the reporting scientist(s), the computer was able to provide a mailing list of 14 correspondents who reported sorghum at pH 7.5 or higher. Letters were sent to 10 of the correspondents. Four responded with seed, two lots of which were iron-efficient sorghum which grows and produces without chlorosis on alkaline soils in the Western United States. Now we are cooperating with the USDA Plant Physiology Institute in a search for soybeans tolerant to aluminum toxicity.

Figure 1 .—Sample Page From "The Quest For Tolerant Germplasm"

Sesamum radiatum	Wild sesame		T'm	P,H	4.3-5.0	25-40	25-27	AF	64
Sesbania bispinosa	Canicha	Wm	Tvm	A,S	4.3-7.5	6-33	16-29	HI	12,24
Sesbania exalt ala	Hemp sesbania	Wm	Tdm	P,A,H	4.5-7.3	7-25	13-27	NA	12
Setaria italica	Italian millet	Cmw	Tvw	A,G	5.0-8.3	3-42	6-27	CJ	18
Setaria sphacelata	Golden timothy	Cdm	Tvm	P,G	4.3-7.1	7-33	11-27	AF	18,36,54
Sicana odorifera	Casabanana	Sdm	Tvm	P,V	5.0-8.0	7-28	21-25	SA	
Simarouba glauca	Aceituna	Sm	Tdm	P,S,T	5.3-8.0	11-25	21-27	MA	
Simmondsia chinensis	Jojoba	Wxt	Td	P,S,T	7.3-8.2	2-11	16-26	MA	56,*100
Sinapis alba	White mustard	Bmw	Td	A,H	4.5-8.0	4-18	5-24	ME	24
Smilax aristolochiifolia	Sarsaparilla	Wm	Sm	P,S,L		17	18-23	MA	
Solarium *aethiopicum*	Mock tomato	Cm	Tm	P,S	(3.2-6.2	9-40	9-25	AF	24
So*lanum aviculare*	Australian nightshade	Crnw	Wdm	P,S,T	5.5-8.2	7-13	12-17	AU	46,48,92
Solarium *ferox*	Ram-begun	Cm	Tw	P,H	4.5-5.0	7-42	83-27	HI,II	24
Solarium *gilo*	Gilo		Tm	P,S	4.3-4.8	27-33	26-27	AF	24
Solanum hyporhodium	Cocona		Sdw	P,S	6.5-7.3	7-31	21-23	SA	
Solarium *incanum*	Sodom apple		Sdm		5.5-7.8	8-17	19-23	AF,HI	24
Solarium *indicum*	Indian nightshade	Sdm	Txw		4.3-7.8	2-42	1'3-27	HI,II	24
Solanum khasianum	Solarium khasianum	Cw	Wm	H	5.0-6.0	9-13	13-15	HI	24
Solanum laciniatum	Kangaroo apple	Cmw	Wd	P/A,S,T	5.6-8.2	7-11	12-15	AU	48,92
Solanum macrocarpon	Native eggplant	Ww	Tdm	11,s	4,3-5.2	13-37	18-27	AF	36
Solanum melongena	Eggplant	Csw	Txw	P/A,H	4.3-8.7	2-42	7-28	CJ,HI	24,36,48
Solanum muricatum	Melon-pear	Sdm	Td	1',s	5.7-7.3	7-15	18-25	SA	24
Solanum nigrum	Black nightshade	Bw	Txw	A,H	4.3-8.4	2-42	5-27	AF,ES	24,36,48
Solanutn q uitoense	Lulo	Cmw	Td	P,H S	5.8-8.0	7-31	11-25	SA	24
Solanum torvum	Terongan	Cm	Tvw		*4.3-8.7*	*7-42*	*9-29*	MA HI	24
Solanum tuberosum	Potato	Bmw	Tvw	A,H	4.2-8.3	3-46	4-27	SA,MA,ES	24,36,48
Solenostemon rotundifolius	Hausa potato	Sm	Td	P,H	5.0-5.0	13-17	23-26	AF	±84
Sorghastrum avenaceum	Indian grass	Wm	Td	P,G	5.6-7.1	11-17	12-26	NA	
Sorghum X *almum*	Almum sorghum	Csw	Tvd	P,G	5.0-8.3	3-25	9-26	SA	40
Sorghum bicolor	Sorghum	Csw	Ttw	A,G	4.3-8.7	4-41	8-27	CJ,HI,ME	20

† For authorities on most of these species, see Duke and Terrell (1974).

‡ Following Holdridge (1947); T-Tropical, S-Subtropical, W-Warm Temperate, C-Cool Temperate, B-Boreal; x-Desert, t-Thorn, s-Steppe, v- Very Dry, d-Dry, m-Moist, w- Wet and r-Rain.

§ A-Annual, B-Biennial, P-Perennial, P/A-Perennial treated as an annual, H-Herb, G-Grass, L-Liana (woody vine), S-Shrub, T-Tree, V-Herbaceous vine.

¶ Average of monthly means with values below 0°C treated as 0.

\# Center of diversity, based largely on Zeven and Zhukovsky (1975) and Plant Taxonomy files. The first symbol cited is possibly a center of origin. , CJ-China-Japan, II-Indochina-Indonesia, AU-Australia, HI-Hindustani, CE-Central Asia, NE-Near East, ME-Mediterranean, AF-Africa, ES-Eurosiberian, SA-South America, MA-Middle America, NA-North America. For space conservation, no more than three centers are listed.

†† Diploid chromosome numbers based largely on Fedorov (1969), Zeven and Zhukovsky (1975), and unpublished compilation by MacHenry Stiff. Only three counts are listed here, but many more mny have been reported.

SOURCE: Duke, J. A., "The Quest For Tolerant Germplasm," ch. 1, pp. 1-61, *ASA Special Symposium 32* "Crop Tolerance to Suboptimal Land Conditions" (Madison, Wis.: American Society of Agronomy, 1978).

Yield File

In addition to data from the questionnaires, data from publications of experiment stations have been entered into the Yield File. We regret that we cannot keep up with this literature; the entries probably account for less than 1 percent of the yield data published annually by experiment stations, By increasing the data included in this file, which is impossible at our current level of fundin,g people could be told the yield of exotic crops (with various cultural inputs) grown in areas ecologically similar to theirs. The Yield File is clean and useful now, though off-line. With major backing, it could help strategists predict yields of new crops in particular areas.

For a brief period, funding was available to promote one subset of the file, the Phytomass File (fig. 2). (Phytomass is defined as aboveground dry-matter yields of plants.) Department of Energy (DOE] support for that file has been discontinued but some institutions such as DOE or Oak Ridge may have similar files. Data from the Phytomass File support our early contention that C_4 grasses are roughly twice as productive as C_3 grasses, which are in turn roughly twice as productive as legumes. Availability of this kind of information could save

Figure 2.–Sample Page From Phytomass File

PHYTOMASS FILE
ECONOMIC BOTANY LABORATORY

SPECIES	AGE (YEAR)	LOCATION	STANDING PHYTOMASS (MT/HA)	ANNUAL PRODUCTIVITY (MT/HA)	LEAF AREA INDEX	SOURCE
PANICUM MAXIMUM	X	TAIWAN	X	14	X	DUKE YIELDFILE 1979
PANICUM MAXIMUM	X	TAIWAN	X	24	X	DUKE YIELDFILE 1979
PANICUM MAXIMUM	X	THAILAND	X	20	X	BOGDAN 1977
PANICUM MAXIMUM	X	UGANDA	X	8	X	BOGDAN 1977
PANICUM MAXIMUM	X	UGANDA	X	12	X	BOGDAN 1977
PANICUM MAXIMUM	X	UGANDA	X	11	X	BOGDAN 1977
PANICUM REPENS	X	RHODESIA	X	6	X	BOGDAN 1977
PANICUM REPENS	X	RHODESIA	X	8	X	BOGDAN 1977
PANICUM REPENS	X	RHODESIA	X	21	X	BOGDAN 1977
PANICUM VIRGATUM	X	X	X	9	X	DUKE 1978
PASPALUM COMMERSONII	X	QUEENSLAND	X	1	X	BOGDAN 1977
PASPALUM COMMERSONII	X	QUEENSLAND	X	4	X	BOGDAN 1977
PASPALUM CONJUGATUM	X	SARAWAK	X	3	X	BOGDAN 1977
PASPALUM CONJUGATUM	X	SARAWAK	X	6	X	BOGDAN 1977
PASPALUM CONJUGATUM	X	SARAWAK	X	14	X	BOGDAN 1977
PASPALUM CONJUGATUM	X	SURINAM	X	58	X	BOGDAN 1977
PASPALUM CONJUGATUM	X	X	X	29	X	DUKE YIELDFILE 1979
PASPALUM CONJUGATUM	X	X	X	140	X	DUKE YIELDFILE 1979
PASPALUM DILATATUM	X	FIJI	X	44	X	BOGDAN 1977
PASPALUM DILATATUM	X	FIJI	X	62	X	BOGDAN 1977
PASPALUM DILATATUM	X	QUEENSLAND	X	1	X	BOGDAN 1977
PASPALUM DILATATUM	X	QUEENSLAND	X	5	X	BOGDAN 1977
PASPALUM DILATATUM	X	RHODESIA	X	26	X	BOGDAN 1977
PASPALUM DILATATUM	X	X	X	24	X	DUKE 1978
PASPALUM GUENOARUM	X	RHODESIA	X	6	X	BOGDAN 1977
PASPALUM NICORAE	X	GEORGIA(ATHENS)	X	4	X	BOGDAN 1977
PASPALUM NICORAE	X	GEORGIA(ATHENS)	X	7	X	BOGDAN 1977
PASPALUM NICORAE	X	GEORGIA(ATHENS)	X	9	X	BOGDAN 1977
...PALUM NICORA		...RGIA(ATHENS)	X	11	X	BOGDAN 1977
PASPALUM NOTATUM	X	AUSTRALIA	X	17	X	BOGDAN 1977
PASPALUM NOTATUM	X	CUBA	X	14	X	BOGDAN 1977
PASPALUM NOTATUM	X	[illegible]	X	5	X	BOGDAN 1977
PASPALUM NOTATUM	X	INDIA	X	4	X	BOGDAN 1977
PASPALUM NOTATUM	X	RHODESIA	X	21	X	BOGDAN 1977
PASPALUM NOTATUM	X	RHODESIA	X	37	X	BOGDAN 19[illegible]
PASPALUM NOTATUM	X	TAIWAN	X	18	X	DUKE YIELDFILE 1979
PASPALUM NOTATUM	X	TAIWAN	X	24	X	DUKE YIELDFILE 1979
PASPALUM NOTATUM	X	UGANDA	X	5	X	BOGDAN 1977
PASPALUM NOTATUM	X	US	X	2	X	BOGDAN 1977
PASPALUM NOTATUM	X	US	X	4	X	BOGDAN 1977
PASPALUM NOTATUM	X	X	X	24	X	DUKE 1978
PELARGONIUM GRAVEOLENS	X	ALGERIA	X	30	X	DUKE YIELDFILE 1979
PENNISETUM AMERICANUM	X	AUSTRALIA	X	20	X	BOGDAN 1977
PENNISETUM AMERICANUM	X	AUSTRALIA	X	13	X	BOGDAN 1977
PENNISETUM AMERICANUM	X	AUSTRALIA	X	22	X	BOGDAN 1977
PENNISETUM AMERICANUM	X	AUSTRALIA	X	10		BOGDAN 1977
PENNISETUM AMERICANUM	X	INDIA	X	21	X	HA 03344(036)
PENNISETUM AMERICANUM	X	INDIA	X	58	X	BOGDAN 1977
PENNISETUM AMERICANUM	X	RHODESIA	X	51	X	BOGDAN 1977
PENNISETUM AMERICANUM	X	RHODESIA	X	45	X	BOGDAN 1977
PENNISETUM CLANDESTINUM	X	AUSTRALIA	X	25	X	BOGDAN 1977
PENNISETUM CLANDESTINUM	X	AUSTRALIA	X	10	X	BOGDAN 1977
VTA(TROPIC MONTANE SAVANNA)	X	WORLD	40	12	X	RODIN & BAZILEVICH 1967
VTA(TROPIC PSAMMOPHYTE,SAND)	X	WORLD	1.0	0.1	X	RODIN & BAZILEVICH 1967
VTA(TROPIC SAVANNA,BLACK SOIL)	X	WORLD	30	11	X	RODIN & BAZILEVICH 1967
VTA(TROPIC SAVANNA,FERRALITIC)	X	WORLD	40	12	X	RODIN & BAZILEVICH 1967
VTA(TROPIC SAVANNA,SOLONETS)	X	WORLD	20	7	X	RODIN & BAZILEVICH 1967
VTA(TROPIC SEASONAL EVERGREEN,BLACK SOIL)	X	WORLD	80	15	X	RODIN & BAZILEVICH 1967
VTA(TROPIC SEASONAL EVERGREEN,FERRALITIC)	X	WORLD	200	16	X	RODIN & BAZILEVICH 1967
VTA(TROPIC SEASONAL MONTANE,FERRALITIC)	X	WORLD	450	22	X	RODIN & BAZILEVICH 1967
VTA(TROPIC SWAMP SAVANNA)	X	WORLD	60	14	X	RODIN & BAZILEVICH 1967
VTA(TROPIC XEROPHYTIC FOREST,FERRALITIC)	X	WORLD	250	17	X	RODIN & BAZILEVICH 1967
VTA(TROPIC XEROPHYTIC MONTANE)	X	WORLD	200	15	X	RODIN & BAZILEVICH 1967
VTA(TUNDRA)	X	WORLD	X	1	X	LIETH 1978
VTA(WARM TEMPERATE)	X	WORLD	X	10	X	LIETH 1978
VTA(WOODLAND)	X	WORLD	X	6	X	LIETH 1978
VT(LAWN-BOG)	X	[illegible]	[illegible]	X	X	DUKE YIELDFILE 1979
ZEA MAYS	X	INDIA	X	5	X	BOGDAN 1977
ZEA MAYS	X	INDIA	X	15	X	BOGDAN 1977
ZEA MAYS	X	ISRAEL	36	36	X	WESTLAKE 1963
ZEA MAYS	X	KENYA	X	4	X	BOGDAN 1977
ZEA MAYS	X	MINNESOTA	X	25	X	DUKE YIELDFILE 1979
ZEA MAYS	X	SURINAM	X	2	X	BOGDAN 1977
ZEA MAYS	X	SURINAM	X	6	X	BOGDAN 1977
ZEA MAYS	X	TRINIDAD	X	69	X	BOGDAN 1977
ZEA MAYS	X	TROPICS	X	2	X	BOGDAN 1977
ZEA MAYS	X	TROPICS	X	23	X	BOGDAN 1977
ZOYSIA MATRELLA	X	X	X	23	X	DUKE 1978

VT = Vegetation Type, VTA = Vegetation Type Average
X = Assumes Dry Matter
(DM) = 10% Wet Weight. All data reported as DM
X = No data available
Under Source, HA - Herbage Abstract

SOURCE: Duke, J. A. "The Gene Revolution," paper No. I, pp. 89-150, Office of Technology Assessment, Background papers for Innovative Biological Technologies For Lesser Develped Countries (Washington, D.C; U.S. Government Printing Office, 1981) countless hours and dollars in screening projects where maximum biomass production is a priority.

Climate File

The easiest file acquired was the Climate File. It is the computer tape to Wernstedt's World *Climatic Data (1972)* and was purchased for less than $200. USDA colleagues have converted the temperature data from Fahrenheit to centigrade, and the rainfall and elevation to metric units. The monthly means for these 18,000 stations now are compatible with hundreds of climatic figures gathered through questionnaires and publications. Monthly precipitation and temperature data for about 20,000 stations now are integrated into the Climate File. A species' ecological amplitude can be determined by using this file in conjunction with ecological data for geographical areas from which the species is reported. For example, if one wanted to know the ecological amplitudes of a species that is not in the Ecosystematic File, one could consult herbaria and publications for locales where the plant grows, choose those that occur in the Climatic File and, using the computer, obtain climatic highs, lows, and means of these areas. Further, one could pick potential germ plasm sources that are most similar ecologically to the germ plasm recipient. This important germ plasm matching capability applies not only to minor, underused economic plants but to cultivars and varieties of the big dozen. A sample page from an early version of an economic amplitude paper appears in figure 3. This file has been used in the USDA Plant Physiology Institute at Beltsville by colleagues who are interested in the tropicality of members of the Malvaceae. They are studying the distribution of malvalic acid, an acid possibly involved in responses to temperature stress in cold- and heat-tolerant mallows.

In a seminar at Beltsville on March 17, 1982, Dr. G. L. Stebbins introduced a list of cold-tolerant to heat-tolerant legumes, speculating that the greater the DNA volume, the greater the cold tolerance. Without consulting the *Handbook of Legumes of World Economic Importance (5),* wherein the ecosystematic amplitudes of species are published, I predicted that the legumes' mean annual temperatures would line up inversely with Stebbins' DNA prediction. The lineup was almost perfect, as depicted:

	DNA volume (from Stebbins seminar)	*Mean temperature °C (from Handbook of Legumes)*
Vicia faba ————————	26.7	12.1
Pisum sativum ., ., ...	9.8	12.9
Phaseolus vulgaris	3.7	19.3
Glycine max	2.2	18.2
Lablab purpureus.	0.7	21.9

The Climatic File can be used to address problems in the global carbon cycle. Tropical forests play an important role in the global carbon cycle because they store 46 percent of the world's terrestrial carbon pool (1). Brown and Lugo presented data for each of several Holdridge Life Zones, projecting total forest biomass, soil carbon content, net carbon content, net primary production, wood production, and leaf litter production. The EBL has formulae for converting its 20,000 climatic data sites into Holdridge Life Zones and, using a computer,

Figure 3.—Sample Page Showing Ecosystematic Data For Malvaceae

GENUS Species	PRECIP (dm) Min	Mean	Max	(No.)	Temp °C Min	Mean	Max	(No.)	pH Min	Mean	Max	(No.)
GREWIA ASIATICA L.	6.6	20.2	42.9	(4)	14.7	22.4	27.4	(4)	6.8	7.2	7.[illegible]	([illegible])
TRIUMFETTA CORDIFOLIA A. Rich.	9.0	[illegible]	27.8	(6)	[illegible]	[illegible]	26.6	(6)	4.5	5.6	7.1	(4)
TRIUMFETTA RHOMBOIDEA Jacq.	8.7	20.1	42.9	(11)	18.7	24.6	27.4	(11)	5.0	6.0	7.1	(9)
TRIUMFETTA TOMENTOSA Boj	8.7	11.1	42.9	(6)	18.7	23.4	27.4	(6)	5.0	6.3	7.1	(4
FAMILY MALVACEAE	2.6	14.1	42.9	(313)	7.0	22.6	29.9	(312)	4.3	6.3	8.7	(211)
ABELMOSCHUS ESCULENTUS (L.) Moench.	2.6	14.3	41.0	(107)	11.1	24.4	Ins	(106)	4.3	6.7	8.7	(42)
ABELMOSCHUS MOSCHATUS Medik.	6.1	15.6	40.3	(10)	11.1	22.8	26.5	(10)	5.0	6.9	8.7	(7)
ABUTILON THEOPHRASTI Medik.	6.1	10.5	13.2	(6)	10.2	14.1	21.0	(6)	4.9	6.0	Liz	(6)
GOSSYPIUM ANOMALUM Wawra ex Wawra & Peyr.	5.1	11.2	[illegible]	(3)	17.6	22.4	26.2	(3)	[illegible]	[illegible]	8.3	([illegible])
GOSSYPIUM ARBOREUM L.	5.1	15.8	42.9	(12)	11.5	23.1	27.8	(12)	5.5	6.9	8.4	(8)
GOSSYPIUM BARBADENSE L.	4.9	13.5	40.3	(2S)	8.4	22.6	27.6	(25)	4.S	6.S	8.4	(19)
GOSSYPIUM HERBACEUM L.	5.1	11.9	42.9	[16)	11.5	20.7	27.[illegible]	(16)	5.5	6.9	8.4	(13)
GOSSYPIUM HIRSUTUM L.	2.9	11.3	27.8	(36)	7.0	[illegible]	27.8	(36)	4.5	6.6	8.4	(3[illegible]
HIBISCUS CANNABINUS L.	[illegible]	14.9	[illegible]	(26)	[illegible]	21.3	27.5	(26)	4.3	6.1	8.2	(24)
HIBISCUS SABDARIFFA L.	6.4	17.9	42.9	(22)	12.5	23.2	27.5	(22)	4.5	6.1	8.0	(18)
URENA LOBATA L.	[illegible]	[illegible]	[illegible].9	(17)	16.[illegible]	2[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	(15)
FAMILY BOMBACACEAE	4.8	16.9	42.9	(136)	18.0	25.3	28.S	(135)	4.3	6.3	8.7	(64)
BOMBAX CEIBA L.	13.2	26.1	42.9	(7)	22.0	25.1	27.4	(7)	4.5	5.2	6.3	(4)
CEIBA PENTANDRA (L.) Gaertn.	4.8	15.3	42.9	(108)	18.0	25.3	28.5	(10[illegible])	4.3	6.6	8.7	(45
DURIO ZIBETHINUS Murr.	13.5	[illegible]	[illegible].0	(7	25.[illegible]	[illegible]	[illegible].0.4	(7)	4.3	5.6	6.0	1
FAMILY STERCULIACEAE	4.8	16.8	42.9	(141)	18.0	25.4	29.9	(140)	4.3	6.2	8.7	(66)
COLA ACUMINATA (Beauv.) Schott & Endl.	6.4	19.B	40.3	(12)	21.S	2S.2	26.6	(12)	4.5	5.5	1.0	(7,
COLA NITIDA (Vent.) Schott & Endl.	1S.6	22.0	27.8	(6)	23.3	2S.4	26.6	(6)	4.s	4.9	5.3	(4)
THEOBROMA BICOLOR Humb. & Bonpl.	[illegible]	[illegible]	[illegible].3	(3)	25.7	[illegible].5	20.5	(>. I	4.8	6.4	8.0	(3)
THEOBROMA CACAO L.	4.8	16.3	42.9	(109)	11.0	25.3	28.S	(108)	4.3	6.4	6.7	(43)

SOURCE: Duke, J. A., "**Ecosystematic** Data on Economic Plants," ***Quart. J. Crude Res.*** 17, No. 3-4, 1979, pp. 91-110, can generate Holdridge Life Zone maps for countries not now mapped in the Holdridge system. We then could project standing biomass, total carbon, and annual productivity of the zonal forests, based on Brown and Lugo's numbers or refinements thereof, and give real or projected yield figures for high-biomass grasses, energy-tree plantations, or conventional crops for these Holdridge Life Zones. This could provide some guidelines for choosing the best crop-agroforestry combinations for agricultural development in Third World countries.

We believe that the climate of some remote area can be deduced by checking the ecological amplitudes of dozens of perennials growing there better than by measuring the rainfall and temperature for 1 year. The fig, scuppernong, and pecan at my Howard County farm are near their northern productive limits; the ginseng, rhubarb, and sugar maple near their southern productive limits. Based on these species, the mean temperature at my farm can be predicted to be between 110 and 130 C.

Dr. Peter Raven, director of the Missouri Botanical Gardens, asked us at what locations in the world the climate was most similar to that of the Missouri Botanical Garden. If asked simply for annual temperature and annual precipitation, the computer would indicate many places that do not have the temperature extremes of St. Louis' continental climate. Introductions from maritime climates with identical mean temperatures might be killed by the summer heat and/or winter cold of St. Louis. A continentality variable, which will differentiate among climates with similar mean annual temperatures but different vegetational potential, has been added to the Climate File.

In October 1982, EBL was asked to name locales in Latin American where date palm would grow. As a test case, Dr. Atchley at USDA and I each devoted no more than 4 hours to this query (app. I and II). The difference in conclusions reached is due to Dr. Atchley's assuming rainfed conditions and basing his projection on actual reports for date palm, and my assuming an irrigated situation because artifical or subsurface irrigation is implicit in most of the good date-growing areas I cite. The computer provided lists of possible sites for date palm under both irrigated and rainfed conditions, and eliminated hours of searching through 20,000 climatic data points.

The narcotic-replacement program led us to the *coqueros,* the cocaine-leaf chewers of the Andes. The coca leaves chewed by these Andean Indians are high in calcium and iron, more so than any plant food in the Food Composition Table for Latin America (fig. 4a). Calcium and iron, as well as certain vitamins and proteins, often are deficient in diets of the farmers we were trying to divert from cultivating the coca ("cocaine") bush. The problem, therefore, was one of both nutrition and crop substitution. What commercial food crops could the farmer grow as substitutes for coca? To answer this, we needed to know their climate. However, they might be 100 miles and 10 mountain ranges away from the nearest climatic recording station (that ceased recording 10 years ago). This quandary spawned our Ecological Amplitudes of Weeds program. We added weeds to our questionnaires to help predict climate in remote areas (fig. 5). Another use of the Ecological Amplitudes of Weeds program is in mapping the potential for an alien weed to spread in the United States. Determining ecological amplitudes of a weed by consulting its distribution and extracting climatic data from the Climate File, we can determine where in the U.S. the climate is most closely and least closely matched.

Nutrition File

For the Nutrition File, we used at least one credible entry for each plant species in Food Composition Tables for East Asia, Africa, and Latin America, from Watt and Merrill's Composition *of Foods* (Agriculture Handbook No. 8) and from The *Wealth of India* (C. S. I. R., 1948-76), computerizing the proximate analyses of hundreds of botanical. I scored the plants' nutritive contents (elements, vitamins, calorie and fiber content) as extremely low (E), low (L), high (H), or very high (V), relative to USDA's recommended dietary allowance (RDA) (fig. 4b). Unfortunately, I had overlooked Miller's Composi*tion of Cereal Grains and Forages (1958),* which consolidated thousands of forage plant analyses, No sooner had I finished adding this information than another massive compilation with numerous new data on forage analyses was published (7). My colleagues at USDA and I are entering these data into the computer file which we hope will be tabulated and published by CRC next year.

We devised a computer program to convert our as-purchased proximate analysis file to a zero-moisture basis (fig. 6). To ensure that only complete proximate analyses are used, the computer uses only those columns for which the sum of water, protein, carbohydrates, fibers, and ash is 100 percent (±1). The computer then multiplies **all** columns except water by 100 ÷ (100=X), where x

Figure 4A.—Nutritional Composition of Coca

Nutritional comparison per 100 g of Coca Leaves with other Latin American Plant Foods

FOOD ITEM	# in sample	Cal	H_2O g	Prot. g	Fat g	Carb. g	Fiber g	Ash g	Ca mg	p mg	Fe mg	Vit A IU	Thia mg	Rib mg	Nia mg	Vit C mg
San Francisco coca	(1)	305	6.5	16.9	5.0	46.2	14.4	9.0	1540	911	45.8	11,000	0.35	1.91	1.29	1.4
Bolivia coca	(3)	—	8.8	—	1.6	42.4	8.0	53	—	—	—	—	—	—	—	—
Peru coca	(3)	—	103	18.7	—	—	17.5	4.6	2038	363	7.9	9,000	0.81	1.55	6.17	—
COCA AVERAGE	(7)	—	8.5	18.8	33	44.3	13.3	6.3	1789	637	26.8	10,000	0.58	1.73	3.7	1.4
PLANT FOOD AVERAGE	(50)	279	40.0	11,4	9.9	37.1	3.2	2.0	99	270	3.6	135	0.38	0.18	2.2	13.0
Nuts & Seeds	(10)	521	9.9	16.8	36.0	28.2	3.6	3.1	273	522	4.3	17	0.78	0.28	5.2	2.1
Pulses	(10)	354	11.3	25.4	5.0	55.1	5.5	33	102	398	7.1	20	0.58	0.24	2.25	1.9
Cereals	(10)	352	11.5	11.7	3.7	71.0	4.0	2.1	74	346	4.8	13	0.41	0.25	2.7	0.8
Vegetables	(10)	74	87.3	1.8	0.4	16.9	1.5	0.9	26	52	12	595	0.09	0.05	1.0	31.0
Fruits	(10)	93	79.6	12	4.5	14.1	1.4	0.7	20	33	0.8	35	0.05	0.06	0.08	29.0

SOURCE" Duke, J. A., Aulik, D., and Plowman, T. "Nutritional Value of Coca," Botanical Museum Leaflets, vol. 24, No. 6, (Boston, Mass.: Harvard University, 1975), pp. 113-119.

equals water percentage. The completely new and unique table has hundreds of species compared on a zero-moisture basis. The Nutrition File (as purchased or zero-moisture) can be linked through a species' scientific name to the Yield File to convert yields to protein per hectare instead of grain per hectare, and to the Ecosystematic File to show which will yield the most leaf protein per hectare under any specified combination of annual temperature, annual precipitation, soil pH, etc.

Before the National Cancer Institute discontinued its support for the EBL data base, we started a file on biologically active compounds to parallel the Nutrition File. It indicated the toxic compounds and their LD50's for plant genera (fig. 7). We regret that other quantitative data were omitted, Dr. Farnsworth's comprehensive NAPRALERT program dwarfs our attempt at computerizing biologically active compounds in plants. Since he also uses plants' scientific names, his pharmacological data could be sorted against any one or all of our data files, using the scientific names to link the two data bases.

Ethnomed File

It is ironic that the Ethnomed File (fig. 8), with which I worked most closely for nearly 5 years, is now the lowest priority file. The file was built to encourage Third World countries to supply medicinal and poisonous plants for a collaborative screening program with the U.S. National Cancer Institute. With 88,000 entries, the Ethnomed File is probably the largest extant computerized data base for folk cancer remedies and is quite good for general folk remedies. Pesticidal activities, of greater current interest to USDA, also are included (see fig. 9 for insecticide subset sample). This file can interact with any other file through the same scientific name.

Ethnomed is not dead; it lives on as a much consulted printout. For example, we have been asked to help an NIH contractor prepare a prioritized list of Nigerian species for antimalarial screening (fig. 8). The malaria entries marked with an asterisk contain compounds with proven antimalarial activity. The species marked with a double asterisk correct or alleviate malaria. Unfortunately, the common name file is incomplete. It would be useful to many agencies, since many plants are recorded by common rather than scientific name. Interlocking scientific names with the name of a country from the Ecosystematic File should show not only which antimalarial species occur in that country but should give the names and addresses of the people who reported them, Using the ecosystematic amplitudes of the target species, the computer could indicate the country's climatic stations within the ecological ranges of the target species. For example, the computer could name many antimalarial species occurring in Nigeria and list villages suitable as staging areas to search for the species.

Figure 4B.—Sample Page From Vegetarian Vitachart

Common Name and plant part[1]	Scientific Name[2]	Calcium	Calories	Fiber	Iron	Magnesium	Niacin	Phosphorus	Potassium	Protein	Riboflavin	Sodium	Thiamin	Vitamin A	Vitamin C
wild grape (f)	Vitis tiliifolia	L	L	H	H	L	L			L	L		L	E	H
wild lettuce (l)	Lactuca taraxacifolia	H	L	H				L		L					
wild mango (f)	Irvingia gabonensis	L	L	L	H			L		L					v
wild plus (f)	Bequaertiodendron magalismontanum	L	L	H	L		L	L		L	L		L		H
wild rice	Zizania aquatica	L	H	H	H	H	H	H	L	H	H	E	H	E	E
willowleaf lucuma	Lucuma salicifolia	L	L	H	L		H	L		L	E		H	L	H
wine palm	Mauritia vinifera	H	L	V	H		L	L		L	H		L	V	H
winged yam	Dioscorea alata	L	L	L	L		L	L	H	L	L	E	L	E	H
winged yam	Dioscorea alata	L	L	H	L	L		L		L	L		L	E	H
wintersquash (f)	Cucurbita maxima	L	L	L	L		L	L	H	L	L	E	L	H	H
wintersquash (l)	Cucurbita maxima	H	L	H	L		L	H	H	L	H	E	L	H	H
wintersquash (fl)	Cucurbita maxima	H	E	L	H		L	L	L	L	L	E	L	L	H
wolfberry (d, f)	Lycium chinensis	L	H	V	V		H	H	H	H	V	L	H	V	V
wolfberry (l)	Lycium chinensis	H	L	H	H		L	L	H	L	H	L	L	V	H
wood oil nut	Ricinodendron heudelotii	H	H	H	L		E	V		H	E		E	E	E
wooly manzanita	Arctostaphylos tomentosa		L	H			L	L		L	E		L	H	V
wormseed (l)	Chenopodium ambrosioides	H	L	H	H		L	L		L	H		L	H	H
yam	Dioscorea sp.	L	L	L	L		L	L	H	L	L		L	E	H
yambean (r)	Pachyrrhizus angulatus	E	L	H	L		L	L		L	L		L	E	H
yambean (tuber)	Sphenostylis stenocarpa	L	L	L				H		L					
yambean (r)	Pachyrrhizus sp.	L	L	L	L		L	L		L	L		L	E	H
yardlong pea (pod)	Vigna unguiculata	L	L	H	L		L	L	L	L	L	E	L	L	H
yardlong pea (l)	Vigna unguiculata	H	L	H	H		L	H	H	L	H	E	H	H	H
yautia (l)	Xanthosoma sp.	H	L	H	H			H		L				V	H
yautia (r)	Xanthosoma sp.	L	L	H	L			L		L					H
yebbnut (s)	Cordeauxia edulis	L	H	H	H			H		H					
yellow hogplum (f)	Spondias mombin	E	L	L	E		L	L		E	L		L		V
yellow mombin (f)	Spondias mombin	L	L	H	H		L	L		L	L		L	L	H
yellow mombin (nut)	Spondias mombin	L	L	L	H		L	L		L	L		L	L	H
yellowtaper candletree	Parmentiera dcata	L	L	V			L	H		L	L		H	L	H
yellow vein (l)	Pseuderanthemum reticulate		L	H			L	L		L	L		L	H	V
yergan	Cucumeropsis edulis	H	H	H				H		H					
yucca (fl)	Yucca elephantipes	L	L	L	L		L	L		L	L		H	E	V
yucca (sh)	Yucca elephantipes	H	L	H	L		L	L		L	L		H	E	H

[1] d = dry, f = fruit, fl = flower, g = green, l = leaf, m = mature, r = root, s = seed, sh = shoot (or bud).

SOURCE: Duke, J. A., "Vegetarian Vitachart, *Quart. J. Crude Drug Res* 15, 1977, pp. 45-46.

We receive daily inquiries from all over the world asking what herbs are used for what ailments. One Senator asked us for opinions on various quack herbal medicines. Another Senator has shown an interest in the so-called "petroleum nut" ***Pittosporum resiniferum*** (fig. 10), an energy plant endemic to the Philippines.

Thanks to three professors in the Philippines, we now have seed and a fairly good idea of the ecosystematic amplitudes of the ***Pittosporum.*** One professor indicated where ***Pittosporum resiniferum*** was growing prior to widespread relocations in the Philippines for potential energy studies. This information was paired with climate stations in the Climate File to yield ecosystematic amplitudes. Ranging from Tropical Dry to Moist through Subtropical Forest Life Zones, the petroleum nut grows where annual precipitation ranges from 15 to over 50 dm (mean = 27 din), annual temperature from 18-28° C (mean = 26° C). Of 17 cases where both temperature and rainfall data were available to us, 13 were found in the Tropical Moist Forest Life Zone, three in the Tropical Dry Zone, and one in the Subtropical Rain Forest Life Zone. A similar approach could be used to determine the ecological amplitudes of a medicinal plant, weed, or promising new economic species from the thousands of species not among the thousands already in our computer.

Prototypes

We have developed the following three data base prototypes which could be expanded readily if priorities dictated.

Agroforestry File: This program was developed for several species being considered for **agroforestry**. Different subfiles contain information on **eco-**

Figure 5.—Ecological Amplitudes of 100 Perennial Weeds

Ecological amplitudes of 100 perennial weeds*

SCIENTIFIC NAME	COMMON NAME	LIFE ZONE	pH	ANN. PRECIP. (DM)	ANN. TEMP. (°C)	WARM WET MONTHS
ACACIA FARNESIANA	HUISACHE	h'd Txm	4.2-8.0	6-40	15-[illegible]	0-11
ACER SACCHARUM	SUGAR MAPLE	Cmw Sm	4.5- 7.3	5-15	7-21	0-5
ACORUS CALAMUS	SWEETFLAG	Cmw Tvw	5.5-7.5	5-42	7-27	3-12
AGAVE LECHEGUILLA	LECHEGUI LLA	Wt Ttv	7.0- 7.7	3-6	15-21	2-5
AGROPYRON REPENS	QUACKGRASS	Bmr St	4.2-8.3	3-1J	5-23	0-9
AGROSTIS STOLONIFERA	CREEPING BENTGRASS	Bm Wm	4.5-8.3	3-17	6-13	0-6
ALOPECURUS PRATENSIS	MEADOW FOXTAIL	Bw Wt	4.5-7.8	3-17	5-13	0-6
ALYSICARPUS VAGINALIS	ALYCE CLOVER	Sm Tdw	4.2- 4.8	10-42	23-29	9-12
AMMOPHI LA ARENARIA	EUROPEW BEACHGRASS	Cmw	4.5-6.2	5-11	7-19	2-6
ANDROPOGON GERARDI I	BIG BLUESTEM	Bm Csm	6.3- 7.5	5-11	7-27	0-11
ARCTIUM L4PPA	GREAT BURDOCK	Cmw Wtm	4.5- 7.8	3-13	6-19	0-6
ARRHENATHERUM ELATIUS	TALL OATGRASS	Bmw Wtm	4.5- 8.3	3-16	5-19	0-6
ARTEMISIA ABSINTHIUM	ABSINTH WORMWOOD	Cmw Sd	6.3- 8.2	3-1J	7-21	0-6
ARUNDO DONAX	GIANT REED	Cw Tdw	5.5-8.5	3-40	9-25	0-11
ATRIPLEX CANESCENS	FOURWING SALTBUSH	Wt	7.3- 8.0	3-5	15-19	--
AXONOPUS COMPRESSUS	TROPICAL CARPETGRASS	Sm Tmw	5.8	11-40	19-27	5-12
BOEHMERIA NIVEA	RAMIE	Wdm Tvw	4.5- 7.3	7-40	15-27	1-12
BRACHIARIA MUTICA	PARAGRASS	Sdw Tvw	4.3- 7.9	8-37	19-27	5-12
BROMUS INERMIS	SMOOTH BROME	Bmw Wtd	5.3- 8.2	3-17	5-19	0-5
CALTHA PALUSTRIS	MARSHMARIGOLD	Cmw Wdm	4.8- 7,5	4-14	4-17	0-6
CARYA ILLINOENSIS	PECAN	Wtm Sm	5.8-8.3	3-13	13-19	0-7
CASSIA AURICULATA	AVARAM	Sdm Tvw	4.3- 7.3	7-42	19-27	5-12
CASTANEA DENTATA	AMERICAN CHESTNUT	Csm Wm	5. 8-7.3	5-11	9-15	3-5
CHENOPODIUM AMBROSIOIDES	MEXICANTEA	Cw Tdw	5.5-8.3	3-42	7-27	0-12
CHLORIS GAYANA	RHODESGRASS	Cs Tvw	4.3- 8.3	3-40	9-26	0-12
CICHORIUM INTYBUS	CHICORY	Bm Tvm	4.5- 8.5	3-40	6-27	0-12
CLITORIA TERNATEA	BLUE PEA	Sdm Tvw	5.8-8.0	7-42	21-29	5-12
COCCOLOBA UVIFERA	SEAGRAPE	Sdm Tvm	5.8-8.0	11-25	21-26	5-12
CORONILLA VARIA	TRAILING CROWNVETCH	Cmw Wdm	5.8- 6.8	6-40	7-25	2-11
CORYLUS CORNUTA	BEAKED HAZEL	Bm Cw	5.8- 7.5	4-9	6-15	0-5
CYNARA CARDUNCULUS	CARDOON	Cmw Wtm	5.0-8.3	3-12	7-19	0-7
CYNODON DACTYLON	BERMUDAGRASS	Csw Txw	4.3- 8.5	3-42	9-29	0-12
C}' PERUS ROTUNDUS	PURPLE NUTSEDGE	Bm Txw	4.5-8.5	3-42	6-27	0-12
DACTYLIS GLOMERATA	ORCHARDGRASS	Bmw Sm	4.5- 8.3	3-21	5-23	0-9
DICHANTHIUM ANNULATUM	DIAZ BLUESTEM	Sdm Txm	5.7-7.5	2-8	19-25	0-6
DICHONDRA REPEM	DICHONDRA	Wdm Stm	5.0-8.3	3-15	13-23	0-9
DIGITARIA DECUMBENS	PANGOLAGRASS	Sd Tdw	4 .:-7.8	9-26	17-27	4-12
DIOSPYROS VIRGINIANA	PERS IMMON	Wdw Sm	5.8-8.0	7-17	15-25	1-9
ECHINOCHLOA CRUSGALLI	BARNYARDGRASS	Bmw Tvw	5,0-8.3	3-23	6-29	0-12
ELEOCHARIS DULCIS	WATERNUT	Sdm Td	5.5-5.7	8-23	19-29	5-10
EQUISETUM ARVENSE	FIELD HORSETAIL	Bmw Tw	4,5-7.5	3-25	6-23	0-9
ERAGROSTIS CURVULA	WEEPING LOVEGRASS	Csw Td	4.3- 8,3	3-15	11-25	0-9
FAGUS GRANDIFOLIA	AMERICAN BEECH	Cw Sm	4.5- 6.8	3-13	7-19	3-7
FESTUCA ARUNDINACEA	TALL FESCUE	[illegible]	[illegible]	3-[illegible]	[illegible]	[illegible]
FOENICULUM VULGARE	COMMON FENNEL	Cmw Tvm	5.7-8.3	3-26	4-27	0-12
FRAGARIA VIRGINIANA	VIRGINIA Strawberry	Bmw Sdm	5.3- 7.5	4-17	5-23	1-9
GENISTA TINCTORIA	DYERS GREENWOOD	Cmw h'd	4.5-7.5	7-11	9-17	1-6
GENTIANA LUTEA	YELLOW GENTIAN	Cmw Wdm	5.8- 6.8	7-11	7-17	1-6
GLYCYRRHIZA GLABRA	COMMON LICORICE	[illegible] Wt	[illegible]	3-7	3-19	[illegible]
HELIANTHUS TUBEROSUS	JERUSALEM ART ICHOKE	Cmw Tm	4.5- 8.5	3-28	7-27	0-12
HORDEUM BULBOSUM	BULBOUS BARLEY	Cs Sd	5.8-8.2	3-9	7-19	0-5
HYPARRHENIA RUFA	JARAGUA GRASS	Sdw Tdw	4.5-6.2	8-40	19-27	4-12
INULA HELENIUM	ELECAMPANE	Cmw Wdm	4.5-7.5	5-13	7-19	1-6
JUGLANS NIGRA	BLACK WALNUT	Cmw Sm	5.8-8.3	3-13	7-19	0-6
JUNIPERUS CO!MUNIS	COMMON JUNIPER	Bmw Td	4.5- 7.5	4-11	6-21	0-6
LESPEDEZA STRIATA	JAPANESE LESPEDEZA	Wdm Sm	5.0-8.8	5-17	9-23	3-9
LESQUERELLA GORDONII	GORDON BLADDERPOD	Wt	7.3- 7.8	3-9	15	--

*For explanation see text.

SOURCE: Duke, J. A., "Perennial Weeds as indicators of Annual Climatic Parameters," *Agricultural Meteorology*, 16:291-294, (Amsterdam: Elsevier Scientific Publishing Co., 1976).

Figure 6.—Proximate Analysis

16:55 THURSDAY, SEPTEMBER 30 1982

PLCO	VARNT	REFCO	PARTCODE	CALORIES	WATER	PROTEIN	FAT	CARBO	FIBER	ASH	CALCIUM
0000010o Equisetum arvense		2	L	20	93.7000	1	0.200000	4.40000	1.10000	0.700000	58

PLCO	PHOSPHO	IRON	SODIUM	POTASS	CAROT	THIAMINE	ASCORBIC	Z-u v-z	RIBOFLAV
00000 oo	93	4.40000	.		300	0	50	5 6000 o	0.0700090

z≤R° MOISTURE

(all values except water multiplie< by $\frac{100}{100-\underline{x}}$ where $\underline{x}$ = % H_2O)

PLCO	VARNT	REFCO	PARTCODE	CALORIES	WATER	PROTEIN	FAT	CARBO	FIBER	ASH	CALCIUM
000001001 Equisetum arvense		2	L	317.460	0	15.8730	3.17460	69.8413	17.4603	.1111	920.635

PLCO	PHOSPHO	IRON	SODIUM	POTASS	CAROT	THIAMINE	ASCORBIC	RIBOFLAV	Z-u u-z
000001001	147<. 9	69.8413	.	.	476 90	0	793.651	. 1 1	88.8889

SOURCE: *Nutrition*, PLCO Economic Botany Laboratory.

Figure 7.— Pertinent Pages From Phytotoxin Tables

Toxins: Their Toxicity and Distribution in Plant Genera

Chemical	Toxicity[a,b]	Plant genera
Quinaldine	orl rat LD_{50}, 1,230 mg skn rbt LD_{50}, 1,870 mg	*Galipea*
Quinazoline	skn mus TDLo, 4,000 mg/Y1 h'EO	*Dichroa*?
Quinic acid	scu mus LD_{50}, 10,000 mg	*Aconitum, Angelica, Arctostaphylos, Cinchona, Daucus, Eucalyptus, Illicium, Linum, Malus, Medicago, Nicotiana, Pistacia, Prunus, Rosa, Terminalia, Vaccinium*
Quinidine	orl rat LD_{50}, 1,000 mg orl mus LD_{50}, S94 mg ipr rat LDLo, 114 mg ipr mus LD_{50}, 190 mg	*Cinchona, Coutarea, Enantia, Remijia, Strychnos*
Quinine	orl wmn TDLo, 20 mg (4-5 W preg) TER orl rbt LDLo, 800 mg orl gpg LDLo, 300 mg unk gpg TDLo, 200 mg preg TER	*Cinchona, Cornus, Coutarec, Enantia, Ladenbergia, Picrolemma, Remijia, Strychnos*
Quinoline	orl rat LD_{50}, 460 mg ipr mus LDLo, 64 mg skn rbt LD_{50}, 540 mg	*Citrus*
Raton	scu rat TDLo, 31 g/61 W1NEO	*Gliricidia*
Red squill	orl rat LD_{50}, 200 mg	*Scilla*
Red thyme oil	orl rat LD_{50}, 4,700 mg	*Thymus*
Rescinnamine	orl mus LD_{50}, 1,420 mg	*Rauwolfia, Tonduzia*
Reserpine	orl hmn TDLo, 14 µg PSY ims hmn TDLo, 357 µg PSY unk rat TDLo, 1.500 µg (9- 10 D preg) TER	*Alstonia, Aspidosperma, Bleekeria, Excavatia, Ochrosia, Rauwolfia, Tonduzia, Vallesia, Vinca, Voacanga*
Retronecine	ivn rat LD_{50}, 1,311 mg ivn mus LD_{50}, 634 mg	Usually combined. *Amsinckia, Brachyglottis, Crotalaria, Echium, Emilia, Erechtites, Heliotropium, Petasites, Senecio, Trichodesma, Tussilago*
Retinol	orl rat TDLo, 55 mg	Widespread?

TABLE 2 (continued)

Higher Plant Genera and Their Toxins

Genus[a]	Family	Toxin
Cinchona	Rubiaceae	Cinchonidine, cinchonine, quinic acid, quinidine, quinine, s.apc..ln
Cinnamomum	Lauraceae	Acetaldehyde, benzoic acid, borneol, caproic acid, caprylic a&, carvacrol, cassia oil, cineole, cinnamaldehyde, cinnamyl alcohol, citronellol, coumarin, cuminic alcohol, cuminic aldehyde, cymene, decanal, eugenol, eugenol methyl ether, formic acid, furfural, geraniol, hydrocyanic acid, isobutyric acid, isoeugenol, isovaleraldehyde, isovaleric acid, lauric acid, limonene, Wool, myristic acid, myristicin, nonlyl alcohol, phellandrene, piperonal, propionic acid, safrole, salicylaldehyde, salicylic acid, shikimic acid, tannic acid, terpineol
Cirsium[b]	Asteraceae	Hydrocyanic acid
Cissus[b]	Vitaceae	Hydrocyanic acid
Cistus	Cistaceae	Acetophenone, formic acid

SOURCE: Duke, J.A., "Phytotoxin Tables," *CRS Critical Reviews in Toxicology 5(3): 189-237, 1977,*

Figure 8.—Sample Ethnomed Printout

USE	PLANT	COMMON	COUNTRY	SOURCE
MALARIA	TRACHELOSPERMUM LUCIDUM	NC	INDIA	WOI .10.
MALARIA	TRICHILIA HAVANENSIS	NC	GUATEMALA	STANDLEY. STEYERMARK
MALARIA	TRICHOSANTHES CUCUMERINA	YILANKABAGI	TURKEY	STEINMETZ
MALARIA	TRILISA ODORATISSIMA	NC	US	KROCHMAL
MALARIA	TROPIDIA CUCURLIGIOIDES	NC	ELSEWHERE	WOI .10
MALARIA	TURNERA DIFFUSA	NC	MEXICO	STANDLEY
MALARIA	URARIA LAGOPODIOIDES	NC	INDIA (AYURVEDIC)	WOI .10
MALARIA	URARIA PRUNELLAEFOLIA	NC	ELSEWHERE	WOI .10
MALARIA	URERA BACCIFERA	NC	MEXICO	STANDLEY
MALARIA	VERBASCUM THAPSUS	NC	US (COLONIAL)	KROCHMAL
MALARIA	VERBENA CAROLINA	NC	MEXICO	ALTSCHUL
MALARIA	VERBENA LITORALIS	NC	MEXICO	ALTSCHUL
MALARIA	VERBENA OFFICINALIS	LUNG YATS'AO	CHINA	BLISS
MALARIA	VERBENA OFFICINALIS	NC	MEXICO	MARTINEZ
MALARIA	VERNONIA CINEREA	NC	ELSEWHERE	WOI .10
MALARIA	VETIVERIA ZIZANIOIDES	NC	INDIA (SANTAL)	EB24: 244
MALARIA	VIBURNUM OBOVATUM	NC	ELSEWHERE	WOI .10
MALARIA	VIBURNUM NUDUM	NC	US	KROCHMAL
MALARIA	VICIA HIRSUTA	CH'IAO YAO	CHINA	BLISS
MALARIA	VINCETOXICUM ATRATUM	PAI WEI	CHINA	BLISS
MALARIA	VISCUM ALBUM	NC	ELSEWHERE	WOI. SYRIA
MALARIA	VITEX NEGUNDO	NC	CHINA	HUNAN
MALARIA	VITEX PEDUNCULARIS	NC	ELSEWHERE	WOI .10
MALARIA	XANTHIUM SPINOSUM	NC	ELSEWHERE	WOI. SYRIA
MALARIA	XANTHIUM SPINOSUM	NC	INDIA	WOI .11
MALARIA	XANTHIUM SPINOSUM	PITRAK	TURKEY	STEINMETZ
MALARIA	XANTHIUM SPINOSUM	CLOTWEED	US	UPHOF
MALARIA	XANTHIUM STRUMARIUM	HSI ERH	CHINA	BLISS
MALARIA	XANTHIUM STRUMARIUM	NC	ELSEWHERE	WOI. SYRIA
MALARIA	XANTHIUM STRUMARIUM	NC	ELSEWHERE	WOI .11
MALARIA	ZANTHOXYLUM PIPERITUM	SHU CHIAO	CHINA	BLISS
MALARIA	ZINGIBER MIOGA	JANG HO	CHINA	BLISS
MALARIA	ZINGIBER OFFICINALE	NC	TRINIDAD	WONG
MALARIA	ZINGIBER OFFICINALE	NC	TRINIDAD	EB30: 114
MALARIA*	ANDIRA INERMIS	NC	MEXICO	MARTINEZ
MALARIA*	BRUCEA JAVANICA	NC	CHINA	NAS
MALARIA*	BUPLEURUM CHINENSE	NC	CHINA	LI
MALARIA*	BUPLEURUM FALCATUM	NC	ELSEWHERE	KEYS
MALARIA*	CINCHONA OFFICINALIS	NC	ELSEWHERE	WOI .2
MALARIA*	DICHROA FEBRIFUGA	NC	CHINA	NAS
MALARIA*	DICHROA FEBRIFUGA	NC	CHINA	KEYS
MALARIA*	Eucalyptus SP	EUCALIPTO	HAITI	LIOGIER
MALARIA*	LEONOTIS NEPETAEFOLIA	NC	ELSEWHERE	EB30: 136
MALARIA*	LEONOTIS NEPETAEFOLIA	NC	TRINIDAD	WONG
MALARIA*	POPULUS ALBA	HUR	IRAQ	AL-RAWI
MALARIA*	SALIX BABYLONICA	AL BAKI	IRAQ	AL-RAWI
MALARIA*	SALIX FRAGILIS	NC	ELSEWHERE	WOI. SYRIA
MALARIA*	TAMARIX CHINENSIS	NC	ELSEWHERE	KEYS
MALARIA*	TINOSPORA CORDIFOLIA	NC	ELSEWHERE	WOI .10
MALARIA*	TRICLISIA GELLETII	BAHOT 07	ZAIRE	UPHOF
MALARIA**	CINCHONA LEDGERIANA	NC	MEXICO	MARTINEZ
MALARIA**	CINCHONA OFFICINALIS	NC	MEXICO	MARTINEZ

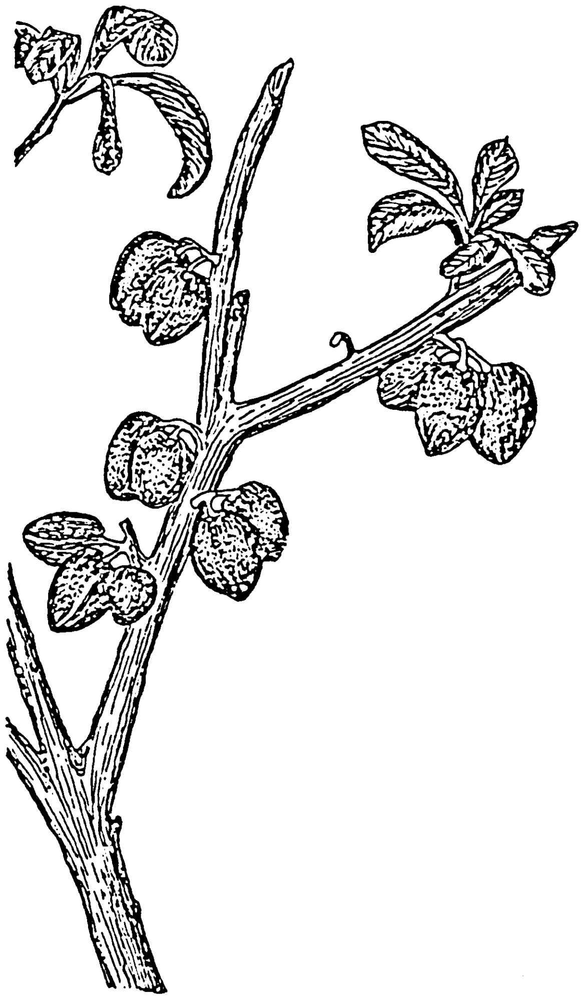
SOURCE: Duke, J. A., and Wain, K. K., "Medicinal Plants of the World," computer Index with more than 85,000 entries, 3 vols., 1981.

Figure 9.–Sample of insecticide Subset of ETHNOMED

USE	PLANT	COMMON	COUNTRY	SOURCE
INSECTICIDE	ZANTHOXYLUM ARMATUM	NC	ELSEWHERE	WO1.11
INSECTICIDE	ZANTHOXYLUM NITIDUM	NC	ELSEWHERE	WO1.11
INSECTICIDE (VET)	DELPHINIUM BRUNONIANUM	NC	ELSEWHERE	UPHOF
INSECTICIDE (VET)	GARDENIA LUCIDA	NC	ELSEWHERE	UPHOF
INSECTICIDE*	ACORUS CALAMUS	NC	ELSEWHERE	WO1.1
INSECTICIDE•	ADHATODA VASICA	NC	INDIA	WO1.SYRIA
INSECTICIDE,	ANNONA CHERIMOLA	CHERIMOYA	LA	LEWIS
INSECTICIDE*	CINCHONA OFFICINALIS	NC	ELSEWHERE	WO1.2
INSECTICIDE*	ECLIPTA ALBA	NC	ELSEWHERE	NAS
INSECTICIDE*	GALPHIMIA GLAUCA	NC	NL	LEWIS
INSECTICIDE*	GYNOCARDIA ODORATA	NC	INDIA	WO1.4
INSECTICIDE*	MAMMEA AMERICANA	NC	ELSEWHERE	EB30: 132
INSECTICIDE*	MAMMEA AMERICANA	MAMEY	LA	LEWIS
INSECTICIDE*	MAMMEA AMERICANA	NC	TRINIDAD	WONG
INSECTICIDE?	NERIUM INDICUM	NC	INDIA	WO1.7
INSECTICIDE'	OCIMUM BASILICUM	NC	ELSEWHERE	WO1.SYRIA
INSECTICIDE	OCIMUM SANCTUM	NC	ELSEWHERE	WO1.7
INSECTICIDE*	PACHYRRHIZUS EROSUS	YAMBEAN	LA	LEWIS
INSECTICIDE*	PHELLODENDRON AMURENSE	NC	ELSEWHERE	NAS
INSECTICIDE'	PICRASMA EXCELSA	NC	ELSEWHERE	WO1.8
INSECTICIDE*	PIMPINELLA ANISUM	NC	ELSEWHERE	WO1.SYRIA
INSECTICIDE"	PISCIDIA PISCIPULA	NC	ELSEWHERE	WO1.8
INSECTICIDE	PSEUDOTSUGA MENZIESII	NC	ELSEWHERE	WO1.8
INSECTICIDE*	QUASSIA AMARA	NC	ELSEWHERE	WO1.8
INSECTICIDE*	RYANIA SPECIOSA	NC	ELSEWHERE	EB26: 233
INSECTICIDE'	SALVIA OFFICINALIS	NC	ELSEWHERE	WO1.SYRIA
INSECTICIDE*	SAUSSUREA LAPPA	NC	CHINA	NAS
INSECTICIDE*	SOPHORA TOMENTOSA	NC	ELSEWHERE	WO1.9
INSECTICIDE?	SPHAERANTHUS AFRICANUS	NC	ELSEWHERE	WO1.10
INSECTICIDE*	SPILANTHES ACMELLA	NC	ELSEWHERE	WO1.10
INSECTICIDE*	SPILANTHES OLERACEA	NC	ELSEWHERE	WO1.10
INSECTICIDE*	TAGETES PATULA	NC	ELSEWHERE	WO1.10
INSECTICIDE'	TEPHROSIA BRACTEOLATA	NC	INDIA	WO1,10
INSECTICIDE"	TEPHROSIA CANDIDA	NC	INDIA	WO1.10
INSECTICIDE*	TEPHROSIA NOCTIFLORA	NC	INDIA	WO1.10
INSECTICIDE	TEPHROSIA PROCUMBENS	NC	INDIA	WO1.10
INSECTICIDE*	TEPHROSIA VOGELII	NC	INDIA	WO1.10
INSECTICIDE"	TRACHYSPERMUM AMMI	NC	ELSEWHERE	WO1.SYRIA
INSECTICIDE*	TRIANTHEMA PORTULACASTRUM	NC	ELSEWHERE	WO1.10
INSECTICIDE*	TRICHODESMA ZEYLANICUM	NC	ELSEWHERE	WO1.10
INSECTICIDE*	VERATRUM VIRIDE	NC	US	WO1.10
INSECTICIDE*	ZANTHOXYLUM OXYPHYLLUM	NC	ELSEWHERE	WO1.11
INSECTICIDE**	DERRIS ELLIPTICA	NC	INDIA	WO1.3
INSECTICIDE**	DERRIS FERRUGINEA	NC	INDIA	WO1.3
INSECTICIDE**	DERRIS MALACCENSIS	NC	ELSEWHERE	WO1.3
INSECTICIDE**	DERRIS ROBUSTA	NC	ELSEWHERE	WO1.3
INSECTICIDE**	EUCHRESTA HORSFIELDII	NC	INDIA	WO1.3
INSECTICIDE'*	HURA CREPITANS	NC	ELSEWHERE	WO1.5
INSECTICIDE**	MAMMEA AMERICANA	NC	ELSEWHERE	WO1.6
INSECTICIDE**	MELIA TOOSENDAN	NC	CHINA	LI
INSECTICIDE**	SPERGULA ARVENSIS	NC	ELSEWHERE	WO1.SYRIA
INSECTIFUGE*	CARAPA GUIANENSIS	NC	ELSEWHERE	EB30: 127

SOURCE: Duke, J.A., and Wain, K. K., "Medicinal Plants of the World," computer Index wlthmorathsn 85,000 entries, 3 vols., 1981.

Figure 10.—Pittosporum *resiniferum*



SOURCE: @Peggy Duke,

logical parameters, germination requirements, nutrition values, cultural requirements, yields, wood characteristics, use, and plant pathology. A sample of the Agroforestry File is given in figure 11. Perhaps the greatest impact of the prototype was to show that almost no data were available on most nonconventional economic plants. The Agroforestry File is most applicable to Third World countries.

Pest File: This prototype has only about 2,500 entries. It lists the scientific name of the host plant, the plant part affected by the disease or the insect, and the name and type of pest. The scientific name enables this file to communicate with any other file, such as the Agroforestry File (fig. 11).

Our ecosystematic file has helped locate herbs important to nematode taxonomy. Nematodes should be included in any pest prototype, Several years ago, Russian workers reported a most unusual nematode from a limited area of Russia on Mentha *longifolia*. Soon afterwards Dr. Morgan Golden found a nematode similar to *Meloidoderita kirjunovae,* the Russian species, on a polygonum at Beltsville. Without Russian specimens or a better description of M. *kirjunovae,* it was impossible to make a final identification of the Beltsville specimen. After testing true *Mentha longifolia* with this *Melodidoderita* specimen, Golden found that his nematode did not attack M. *longifolia,* the type host for the Russian nematode. With this information and further morphological study, Golden proved that the Beltsville specimen represented an undescribed *Meloidoderita* species. Without testing with *Mentha,* the identification and classification of the *Meloidoderita* would have been much less conclusive.

For years I have campaigned for a program that would record the ecological amplitudes of pests and diseases as we have done with economic plants and weeds, Knowledge of the ecological amplitudes of crops and their pests could launch a new phase in biological control of pests' "biological evasion" (4). Where the host tolerates more cold than the pests, planting in the colder area might be advantageous. For example, in Chowan County, N. C., near the northern limits of the cotton plant and the boll weevil, the cotton grows well but the weevil does not. This lack of crop and pest overlap may be used to good advantage by the USDA (2).

Intercropping: Because of our involvement with the Agroforestry project, we had a greater interest in intercropping than most conventional farming units in the USDA. My colleague at USDA, Dr. Atchley, setup a prototype Intercropping file. Now on tape but not on-line, it lists major and minor crop combinations, all species in pasture mixes, yield data, yield differentials, cultural variables, etc. Using the scientific names to link this and other files, one could find out which crops have been tried around the world as intercrops. In densely populated Third World areas, intercropping clearly promises more quality, quantity, and/or variety of crops per hectare than monocropping.

Limitations

In intermediate ecotypes, the effects of factors such as slope, soil porosity, soil type, vegetation cover, cultural conditions, insolation, prevailing winds, etc. on plant characteristics may be significant. Few data are available and we have entered some of these variables for only a few places. This is a major limitation of our program.

Figure 11.—Agroforestry Pest File

PLANTS THAT ARE POTENTIAL FUEL SOURCES
COMPUTERIZED BY THE ECONOMIC BOTANY LABORATORY
ALAN A. ATCHLEY AND ERIC S. MATHIS

PLNA	PLCO	AUTHOR	VALID	PEST	PESTTYPE	PARTAFEC	BIOCNTL	CODE
EUCALYPTUS CAMALDULENSIS	453046001	SCHLECHT.	N	TRICENTA ARGENTATA	I	WS		114
EUCALYPTUS CITRIODORA	453046003	HOOK.		TRAMETES CUBENSIS	F	HEA		000
EUCALYPTUS GLOBULUS	453046004	LABILL.		FUNGUS	F			114
EUCALYPTUS GLOBULUS	453046004	LABILL.		MOTH	I			114
EUCALYPTUS GLOBULUS	453046004	LABILL.		PSYLLID	I			114
EUCALYPTUS GLOBULUS	453046004	LABILL.		SCALE	I			114
EUCALYPTUS GLOBULUS	453046004	LABILL.		SNOUT BEETLE	I			114
EUCALYPTUS GLOBULUS	453046004	LABILL.						
EUCALYPTUS GOMPHOCEPHALA	453046005	OC.						
EUCALYPTUS GRANDIS	453046002			PAROPSIS DILATATA	I	OK		114
EUCALYPTUS GRANDIS	453046002			CHRYSOPHTHARTA SP.	I	BK		114
EUCALYPTUS MARGINATA	453046010	SM.		BORERS	I			114
EUCALYPTUS MARGINATA	45304GO1O	SM.		MOTHS	I			114
EUCALYPTUS MARGINATA	453046LI1O	SM.		TERMITES"	I			114
EUCALYPTUS MICROTHECA	453046006	F.MUELL.						
EUCALYPTUS OCCIDENTALS	453046007	ENOL.						
EUCALYPTUS SP.	453046000		Y	2&3016001				
EUCALYPTUS TERETICORNIS	453046006	SM.						
GLEDITSIA TRIACANTHOS	283110002							
GLIRICIDIA SEPIUM	283300001	(JACQ.)STEUD.		PSEUDOCOCCUS VIRGATUS	I			102
GMELINA ARBOREA	533056001	ROXB.						
GREVILLEA ROBUSTA	129030001	A. CUNN.	N					
GUAZUMA ULMIFOLIA	300026001	L.						
HALOXYLON PERSICUM	150057002	BUNGE EX BOISS.						
INGA BOURGONI	283002006	SCOP.						
INGA SP.	283002000							
INGA URAGUENSIS	283002007	HOOK.&ARN.						
INGA VERA	283002003	WILLD.	N					
LESPEDEZA BICOLOR	203386004							
LESPEDEZA CAPITATA	203386005							
LESPEDEZA CUNEATA	283386001							
LESPEDEZA CYRTOBOTRYA	282386006							
LESPEDEZA HIRTA	283386013							
LESPEDEZA HOMOLOBA	283386007							
LESPEDEZA PILOSA	203386009							
LESPEDEZA PROCUMBENS	283386014							
LESPEDEZA REPENS	283386015							
LESPEDEZA SP.	283386000							
LESPEDEZA STIPULACEA	203386002							
LESPEDEZA STRIATA	283306003							
LEUCAENA LEUCOCEPHALA	283013001	(LAM.) DE WIT		SEED WEEVIL	I	FR		119
LEUCAENA LEUCOCEPHALA	203013001	(LAM.) DE WIT		TWIG BORERS	I	TW		119
LEUCAENA LEUCOCEPHALA	283013001	(LAM.) DE WIT		TERMITES	I			119
LEUCAENA LEUCOCEPHALA	283013001	(LAM.) GE WIT		FUNGUS	F	SD		119
LEUCAENA LEUCOCEPHALA	203013001	(LAM.)DE WIT		WEEVILS	I			000
LEUCAENA LEUCOCEPHALA	283013001	(LAM.) DE WIT		FUSARIUM SOLANI(E.&G.MART.)JONES&GROUT				137
MELIA AZEDARACH	312021001	L.						
MIMOSA SCABRELLA	283015013	BENTH.						
MUNTINGIA CALABURA	371008001	L.						
PHYLLANTHUS EMBLICA	328014002			RAVENELIA EMBLICAE	F		000	283117
PITHECELLOBIUM DULCE	203007003	(ROXB.)BENTH.		PHYLLOSTICTA INGRA-DULCIS	F	LF		102
PITHECELLOBIUM DULCE	203007003	(ROXB.) BENTH.		COLLETOTRICUM SPP.	F	LF		102
PITHECELLOBIUM DULCE	203007003	(ROXB.) BENTH.		BORING INSECTS	I			102

SOURCE: Economic Botany Laboratory.

We need to get soil taxonomic units from a unified soil classification system for all 20,000 locales for which we have climatic data. This would require a major cooperative venture. Much more of the world is mapped in the FAO system than in the USDA Soil Conservation Service's Soil Taxonomy. The Benchmark program is using the USDA rather than the FAO system for site management.

There is a tendency of some soil scientists to assert that soil is THE determinant in the distribution and yield of economic plants, of some climatologists to believe the climate is the determinant, and of some plant ecologists to believe the vegetation type is the determinant. I suspect that all plant distributions are determined by interaction of all three and other factors as well, Unfortunately, the computer cannot identify the most important factors affecting a given species. For some species, vegetation will be the most definitive determinant; for others, soil; for others, climate. We need a major program to collate the FAO and/or USDA soil units with the 20,000 climatic data sites, soil pH, weeds, crops, yields, diseases, insect pests, native perennials, etc. This should be done for a sufficiently large number of the 20,000 sites to develop ecological (including both climatological and pedological data) amplitudes and means and determine optimal conditions for all the economic species of the world and their pests and pathogens. This system, which could be called the International Plant Utilization Data Base (IPUD), would answer a multitide of questions and avoid many costly problems.

For example, with this one-time multimillion dollar project, one could prevent many multimillion dollar mistakes made in introducing the wrong species in developing countries. It could help developing countries develop import substitution programs which might save them million of dollars. This might make the country more self-sufficient and decrease its need for transporting goods.

The perennials growing in remote areas can help one assess the plants best grown there. The IPUD could help one map the areas in a country where a plant introduction is most likely and least likely to succeed. Ancillary to this should be the development of an economic data base (such as is hinted at in fig. 12), which includes transportation costs, shelf life, world demand, trends in production, and current price of a species, Crops that make the most sense economically then could be chosen from the many crops ecologically adapted to the remote area. All should be tried experimentally before planted on a large scale. Experimental data resulting from trials would be used to select the right species for that particular area and to augment and refine the data base.

We have developed several prototype files that could attack big problems systematically. Currently these files are undersupported; we have not yet convinced international authorities of the value of an International Plant Utilization Data Base. Such a data base could reduce international agricultural trade while improving internal trade deficits accordingly. It could reduce the petroleum used in international transport of agricultural goods. The IPUD could select species best adapted to a given climate for whole-plant utilization schemes in which food, oilseeds, leaf-proteins, chemurgics, drugs, etc. would be the main products and biomass would be an energy-producing or commercial fiber byproduct. Greater plant use becomes more important as petroleum supplies become more scarce and expensive.

Implications

Without funding, our data bases now have a life expectancy of no more than 3 years. The **cost** of maintaining our files online is more than $10,000 a year, even before any programs are run on the data. Are they worth the cost? Who can use them? The data bases' contribution to the quest for sorghum tolerant of high alkali soils, a multimillion dollar problem, already has been cited. Similar searches for germ plasm suitable to marginal environments might be made for any of the hundreds of economic species and thousands of medicinal species. USDA is a constant user; daily it consults the hard copy generated by the EBL data base to answer questions on agronomy, agroforestry, climate, ecology, ethnomedicine, nutrition, pathology, and utilization.

Many other agencies have benefitted from the files and could reduce future costs by consulting them, Some examples are given below.

Agency	*Questions We Can Help Answer*	*File(s)*
AID	What crops are best adapted to Lesotho?	ECOSYSTEMAT
	What trees can you recommend for reforestation in Haiti?	AGROFOREST
	USDA, in collaboration with NAS and NIFTAL, is setting up some provenance trials. What species would you suggest?	ECOSYSTEMAT
APHIS	Where in the U.S. is niger seed, an ingredient of birdseed, most likely to become a weed?	ECOSYSTEMAT
	Which of the Chinese medicinal plants-e.g., honeysuckle, kudzu, and perilla-are most liable to become weeds around the various ports of entry?	ECOSYSTEMAT CHINA CLIMATE
CIA	Where in South America can ***Erythroxylum*** be grown?	CLIMATE ECOSYSTEMAT

	Do the trees in the background behind these maneuvers indicate that this is a tropical, temperate, or subarctic area?	CLIMATE ECOSYSTEMAT
	What trichothecene-like compounds are produced by species tolerant of the Laotian climate?	CLIMATE
DOD	If our supplies of atropine were cut off, what would be the best places in the United States to grow the various species that contain atropine?	PHYTOTOXIN
	Give us addresses of seed sources from our allies.	ECOSYSTEMAT CLIMATE
	Which herbs grown in Teheran are good sources of vitamin C?	NUTRITION
	List the edible and medical species of Iran.	GEOGRAPHY UTILIZAT
DOE	What phytomass yields have been reported from Panama? What species is the highest biomass producer reported in your file?	
	What is the standing biomass of the Republic of Panama?	PHYTOMASS YIELDS
	List the major crops and energy potential of their residue for 66 developing countries.	ECOSYSTEMAT PHYTOMASS YIELDS
FDA	What species contain safrole?	PHYTOTOXIN
	We need 100 lb of comfrey root from different latitudes to check out variability in carcinogenicity.	ECOSYSTEMAT
NAS	What is the nutritional value of the neglected legume species of the world?	NUTRITION
NIDA	Assuming Bolivia, Colombia, and Peru all phase out coca, where else in Latin America can it best be grown? What about ***Cannabis? Papaver somniferum?*** What tree crops can be grown around Chipiriri, Bolivia, where cocaine production is being discouraged? What herbs can be grown in the Golden Triangle where they are phasing out poppy production?	
	What crops can be grown in the peat swamps of Jamaica, where the ganja is being grown?	ECOSYSTEMAT CLIMATE
NIFTAL	What legumes, other than caesalpinoid legumes, can you recommend for tropical moist forest, elfin forest, subtropical thorn forest, and warm temperate rain forest?	ECOSYSTEMAT CLIMATE
	What are the medicinal uses of our 44 major nitrogen-fixing species?	ETHNOMED
NIH	Where can we get several tons of winged bean?	ECOSYSTEMAT
	What are the folk anticancer plants of China?	ETHNOMED
NIOSH	What carcinogenic compounds are found in the herbs and spices processed here in the United States?	PHYTOTOXIN
OTA	List in order of decreasing protein content the top 100 leaf-protein producers on a zero-moisture basis.	NUTRITION
	Which would do best in the tobacco belt of the Carolinas?	
	Which species could give the most leaf protein per hectare?	YIELDS
SBA	What commercial crops can you recommend for the Lake Miragone region of Haiti?	CLIMATE ECOSYSTMAT
VITA	What firewood trees can you recommend for our site in Ecuador, with a climate identical with that in Quito?	AGROFOREST CLIMATE
	What natural pesticide species—such as neem, pyrethrum, and ryania—can you recommend for the San Jose area of Costa Rica?	ETHNOMED
	What living-fence post trees produce the best firewood for Columbia?	AGROFOREST CLIMATE
VISTA	What esoteric culinary herbs can you recommend for the climate in Oregon?	ETHNOMED
WHO	List contraceptive plants. List molluscicidal plants.	ETHNOMED
WRAR	What are the medicinal uses of ***Polygonum alpinum?***	ETHNOMED
	What antimalarial species grow in Nigeria?	ETHNOMED

AID – Agency for International Development
APHIS – Animal and Plant Health Inspection Service
CIA – Central Intelligence Agency
DOD – Department of Defense
DOE – Department of Energy
FDA – Food and Drug Administration
NAS – National Academy of Sciences
NIDA – National Institute of Drug Abuse
NIFTAL — Nitrogen Fixation By Tropical Agricultural Legumes
NIH – National Institute of Health
NIOSH – National Institute of Occupational Safety and Health
OTA – Office of Technology Assessment
SBA – Small Business Administration
VITA – Volunteers in Technical Assistance
VISTA — Volunteers in Service to America
WHO – World Health Organization
WRAR – Walter Reed Army Research

There are partial or complete answers to these questions in the files of the data base, now off-line. These are samples representing only a few of the innumerable possible questions, many of which have not even been asked, much less answered. The development and maintenance of an International Plant Utilization Data Base, an on-line interlocking system with agronomic, biochemical, climatological, ecological, economic, entomological, geographic, pathological, pedological, and use data on the thousands of economic plant species, could help answer present and future questions.

Appendix I: Latin American Localities Suitable for Date Palm Cultivation

by Alan A. Atchley*

"The date palm must have its feet in water and its head in fire, " goes an old Arab saying. The familiar image of a desert oasis supporting a grove of these palms surrounded by barren dunes seems to fulfill this proverb, for the trees are "naturally irrigated" by the waters of the oasis and their crowns are exposed to some of the hottest weather in the world. But the oasis draws its water from the natural rainfall over a wide expense, and the palms are not independent of the rainfall component of the climate as they would be under artificial irrigation.

Can modern data processing techniques reveal the climatic tolerances of this important palm species and suggest where it might be introduced successfully? The Economic Botany Laboratory's methods were applied to find sites in Latin America where, based on the computerized information in AEGIS (Agricultural, Ecological, Geographic Information System), date palms might grow successfully. (AEGIS is handled with the SAS programing

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Figure 12.-Sample Page From Botanical Price Lists

Abies siberica oil	$ 8.50 -	9.00/lb
Allspice	$ 1.02 -	1.19/lb
Allyl isothiocyanate	$?.25 -	7.80/lb
Almond oil	$ 1.20 -	4.00/lb
Aloe	$ .51 -	1.50/lb
Aloin	$ 5.75 -	6.00/lb
Amyris	$	9.50/lb
Anethole	$	2.50/lb
Angelica root oil	$	800.00/lb
Anise oil	$ 11.50 -	13.00/lb
Anise seed	$ 1.40 -	1.60/lb
Apricot kernel oil	$ -	2.00/lb
Arabic gum	$ .89 -	1.44/lb
Avocado oil	$ 4.00 -	4.85/lb
Bay oil	$ 10.75 -	12.50/lb
Bayberry wax	$ 2.70 -	3.00/lb
Belladonna leaf	$ 2.40 -	2.45/lb
Benzaldehyde	$ 1.24 -	1.28/lb
Caffeine	$ -	4.50/lb
Calamus oil	$ -	55.09/1?s
Camphor	$ 3.63 -	3.70/lb
Camphor oil	$ 1.00 -	2.25/lb
Cananga oil	$ 22.00 -	23.00/lb
Candelilla wax	$ 1.?0 -	2.10/lb
Capsicum oleoresin	$ 8.40 -	16.50/lb
Caraway oil	$ 29.00 -	30.00/lb
Caraway seed	$ .55 -	.69/lb
Cardamon	$ 3.00 -	4.50/lb
Carnauba wax	$ ~.1~ -	2.05/lb
d-Carvone	$ -	8.00/lb
l-Carvone	$ ~.5Q -	9.75/lb
Cascara sagrada	$	1.00/lb
Cassia	$ .67 -	.80/lb
Castor oil	$ .46 -	.68/lb
Castor pomace	$ -	135.50/ton
Catechol	$ 2.94 -	7.48/kilo
Cedarleaf oil	$ 1.90 -	2.10/lb
Cedarwood oil	$ 2.35 -	3.00/lb
Celery seed	$ .46 -	.47/lb
Celery seed oil	$ 29.50 -	45.35/lb
Chamomile flowers	$ 3.35 -	4.94/lb
Chamomile oil	$ -	370.90/lb
Chenopodium oil	$ -	11.00/lb
Cherry kernel oil	$ 1.00 -	1.40/lb
Cinnamon	$ .50 -	1.35/lb
Cinnamon bark oil	$ 240.00 -	250.00/kilo
Cinnamon leaf oil	$ 2.90 -	3.00/lb
Citral, Natural	$	6.25/lb
Citronella oil, Ceylon	$ 2.20 -	2.60/lb
Citronella oil, Java	$ 3.45 -	4.75/lb
Citronella oil, China	$ -	8.75/lb
Citronellal	$ 4.00 -	6.20/lb

Citronellol	$ 4.90 -	in.on/1~
Clove leaf oil	$ 1.95 -	4.00/lb
Clove bud oil	$ 19.50 -	28.00/lb
Cloves	$ 5.00 -	5.10/lb
Cocaine hydrochloride	$ -	900.00/kilo
Cocillana bark	$ .40 -	.45/lb
Codeine	$ -	900.00/kilo
Coriander oil	$ 25.00 -	37.00/lb
Coriander seed	$ .34 -	.41/lb
Corn oil	$ .13½ -	.14/lb
Cottonseed oil	$ -	.13/lb
Coumarin	$ -	6.20/lb
Cube root	$ -	.60/lb
Cumene	$ -	.23½/lb
Cumin seed	$ -	1.03/lb
Cyclamen aldehyde	$ -	6.00/lb
Digitoxin	$ 2.60 -	3.00/gram
Dillweed oil	$ 9.00 -	13.75/lb
Ephedrine	$	1.25/oz
Epinephrine	$	.58/gram
Eucalyptol	$ -	4.00/lb
Eucalyptus oil	$ 2.00 -	3.10/lb
Eugenol	$ 3.90 -	4.00/lb
Fennel oil	$ -	10.00/lb
Fennel seed	$ .57 -	1.07/lb
Foenugreek seed	$ -	.37/lb
Garlic oil	$ -	35.00/lb
Geraniol	$ 5.00 -	1200()/lb
Geranium oil	$ 21.50 -	69.75/lb
Ginger	$ .46 -	.88/lb
Ginger oil	$ 24.00 -	40.00/lb
Ginger oleoresin	$ -	22.00/lb
Grapefruit oil	$ 1.15 -	2.00/lb
Guaiacol	$ -	2060/15
Guaiacwood oil	$ -	2.60/lb
Guar gum	$ .79 -	1.24/lb
Heliotropin	$ 8.25 -	9.00/lb
Hemlock oil	$ -	8.00/lb
Henbane leaves	$ -	.55/lb
Inositol	$ -	24.00/kilo
Ipecac root	$ -	40.00/lb
Jojoba oil	$ 90.00 -	100.00/gal
Juniper berry oil	$ 55.00 -	65.00/lb
Karaya gum	$ 1.75 -	2.00/lb
Kola nuts	$ .60 -	.65/lb
Laurel leaves	$ .52 -	.86/lb
Lavandin oil	$ 5.25 -	7.50/lb
Lavender flowers	$ .65 -	.75/lb
Lavender flower oil	$ 11.75 -	15.45/lb
Lemon oil, Argentina	$ 6.50 -	7.00/lb
Lemongrass oil	$	8.15/kilo
Licorice root	$ .40 -	.95/lb

SOURCE: Chemical Marketing Reporter, 1992.

language on the computer facilities of the Washington Computer Center.)

First, locations for which date palm has been reported were retrieved and their climate parameters analyzed. The result is the range of climates which would be searched for; only 13 locations report date palm at present and the application of statistical methods is only suggestive of the palm's ecological tolerances and not definitive.

The arithmetic means of several climatic parameters for our small sample of stations suggest that ecological optima for date palm are approximately: average annual precipitation ca. 1,000 mm, average annual temperature ca. 23 "C. Seasonality of the infrared optimal climate is not apparent from arithmetic means, but the minimum values for monthly rainfall and temperature suggest a sustained warm summer (temperature 21°C or higher for each month) and a coldest month with an average temperature not less than 8°C. Precipitation peaks in the spring and autumn and a driest-month average precipitation of 4 mm suggests that a dry period is required, and appears to coincide with the temperature minima.

To select candidate climates from our climate file which contains data for more than 18,000 meteorological stations around the world, several assumptions were made based on the information above. This illustrates how AEGIS can be used to approximate the potential range of a given crop based on some knowledge of the crop and within the limits of reliability of the data from the file containing known distributions. First, stations were selected that had an average June temperature figure in excess of 20 "C, a January temperature figure not less than 8°C, a July precipitation figure not less than 6 mm, and a continentality (Conrad's index) between —8 and 31 mm (the range found for those stations reporting date palm), This yielded 862 stations, many in Latin America. As some of these were found to be characterized by sustained rainfall throughout the year, additional constraints were added to improve the seasonality match: either the February or July precipitation was not to exceed 10 mm (for Southern and Northern Hemispheres, respectively), and the annual average precipitation was not to exceed 1,500 mm. (The minimum reported for date palm was 140 mm.) This generated a printout of 125 stations, including the following in Latin America:

Brazil: Araquai. Ecuador: Milagro, San Cristobal, Portoviejo. Guatemala: Amatitlan, Castaneda, Guatemala City. Honduras: Comayagua, Tegucigalpa. Mexico: Abasolo, Acaponeta, Ahome, Alcozauca, El Burro, Calaya, Carbo, Carrillo, Cerritos, Chiautla, Cintalapa, Colima, Comonfort, Concordia, Coguimatlan, Cuautla, Cuernavaca, Dolores Hidalgo, Ejutla, La Esperanza, Etla, Flor de Jimulco, Gongorron, Guayamas, Huajuapan, Ixmiquilpan, Jonacatepec, Lagos, Lerdo, Manual Doblado, Mezcala Isla, Miahuatlan, Monte Puerta, Moroleon, Motozintla, Nazas, Piaxtla, La Providencia, Puente de Ixtla, Rioverde, El Rodeo, San Bias, S. J. de Guadelupe, San Marcos, San Carlode de Yautepec, San Miguel Allende, Santiago Vane, Sierra Mojada, Tamazula Giordano, Taxco, Tehuacan, Tlacolula, Toliman, Topolo Bampo, Tuxtla Gutierrez, Union de Tula, Ures, Zimapan, Zinapecuaro, Ameca, Guadalajara, Leon, Oaxaca, Penjamo, Salvatierra, Zamora. Venezuela: *Barquisimeto,* Guigue, Valencia.

If more time were available for this quest, the selection process could be refined by entry of more data on the actual occurrence of date palms correlated with weather stations, and particularly on the yield of the palms at such places. At present AEGIS has no yield data at all on date palms, though published reports surely exist. Such data would help decide whether the palms would do well, rather than merely survive, at the stations indicated above. Other refinements, such as better attention to the reversal of seasonality in the southern hemisphere, could improve this kind of approximating retrieval and, in the present case, probably increase the listing for Brazil.

Appendix II: Rating American Localities Suitable for Date Palm

by James Alan Duke

Rather tardily, I am responding to a request to identify localities in Latin America best adapted to the date palm. I am passing on some of the data to demonstrate methodology (with a copy to OTA, which requested that I prepare a paper on applications and uniqueness of our data base here in EBL).

First the caveats! I have intentionally devoted less than 4 hours to this question. I have asked Dr. A.A. Atchley of this lab to devote a similar amount of time but to use his own devices. I hope that some of our conclusions will be the same! One should devote 4 months, not 4 hours, to a feasibility study such as this. What we will both send you are approaches at climatic analogues, very crude ones at that,

Once analogous climatic stations are uncovered, soils, availability of water for irrigation, peculiar atmospheric conditions (such as the fogs in the Chilean-Peruvian desert), and many other factors must be assessed as well.

Here is a thumbnail sketch of some of the date palm's peculiar ecological "whims":

> It is very tolerant of alkali soils and can grow in soils containing 3 to 4 percent white alkali, but to bear well, the palm's roots must be in a stratum with less than 1 percent of alkali silts.
>
> Grown ideally where the permanent water table is within 9 to 16 of the soil surface. At least 8 to 9 acre feet of irrigation water per year is necessary for good production on bearing palms.
>
> Daytime temperatures of 50° C are tolerated. For proper ripening of fruit, the mean temperature between the period of flowering and ripening should be above 21.20 C rising to 26,70 C for at least a month.
>
> Finest date varieties require 3,300 units of heat, a unit being defined as a degree above a daily mean of 64.40 F between the flowering, fruit development, and ripening periods.

Israelis blame some of their problems on inability to control flowering time (it takes 6 months for fruits to ripen). There can be some control by withholding irrigation during fall and winter. There must be no rain during flowering time. An average temperature of 30° C is good for proper ripening. Winter temperatures below –80 C (ca 170 F) are harmful.

Any good soil that is not too heavy will do. In clean soil, a little hard water is acceptable; but a combination of alkaline soil and salty water is too much. Dates do well even where there is a crust of salt on the soil surface. If, in the top 2 to 2.5 m, there is a 30 cm layer or strata with 1 percent alkalinity, the date roots will "find" the strata and flare out there.

Indio, Calif., has long been a center for study of American plant introductions of the date palms. The Indio station is rumored to be in jeopardy, considered by some as excess government property, at least in part. Jim Carpenter (714-347-3414) should be consulted. He is one of America's leading experts on date palms. He could probably point out flaws in this 4-hour document. However, we are proud of our ability to identify rough climate analogues, once the specialists tell us what is required.

The following places are reported to produce good date palms:

Place	ECOSYSTEMATIC Code	Place	ECOSYSTEMATIC Code
Aswan, Egypt	0026	Yuma, Ariz.	0122
Fayum, Egypt	0021	Beer Sheba, Israel	0219
Ciza, Egypt	0020	Bagdad, Iraq	0123
Thermal, Calif.	0123	Basra, Iraq	0224
Mecca, Calif.	0121	Alexandria, Egypt	0220
Indio, Calif.	0123	Tempe, Ariz.	0220

The first two digits of the ecosystematic code correspond to annual precipitation rounded off to the nearest decimeter. The second two digits correspond to annual mean temperature rounded off to the nearest °C. Monthly totals should also be consulted in a more refined feasibility study,

One can then look for comparable examples in a Table of Ecosystematic Values for Mexico and see that Baja, California, has several localities with identical ecosystematic codes to those for some of the better date producing localities–e.g., Comondu is analogous to Bagdad and Indio, Magdalena to Yuma, etc. Based on annual climatic averages alone, one might consider Comondu or any other place in Latin America with a ecosystematic code of 0123 to be a possible target for date palm cultivation. Several places in Peru (e.g., El Alto, Bededero, Campo de Marte, Cayalti, Talera, Trujillo, Zorritos, etc.) have ecosystematic codes similar to some of those listed above and could be investigated as date palm targets,

This is just a superficial sketch. While I would bet on the Baja, California, stations, I would be leary of fog in Peru (unless hand pollination were guaranteed) and in all cases I would question the availability of irrigation water equivalent to 2,300 mm / year.

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