RAPIC, The Missing Link?

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There is an increasing awareness that electronic data processing (EDP) and information retrieval (IR) can be tremendous assets in systematic biology. Many EDP projects are currently being operated in North America on a pilot basis and a few are in a production phase (see Crovello and MacDonald 1971). Interest is likewise keen in Europe and other parts of the world (Brenan 1974). Although many problems remain to be solved in data standardization, scope, nomenclature, and the like, perhaps the most pressing and recurring problem is funding for these projects. A prime example was the Flora North America (FNA) project which, although well designed, aborted due to federal budgetary problems (see discussion in *BioScience* 23: 215 and *Science* 179: 778).

The primary sources for obtaining support for EDP projects in systematic biology seem to be government funding (NSF for FNA, United Nations for Europe) and private funding (Longwood Foundation for the Plant Records Center of the American Horticultural Society). The general public or even most of the biological community have been, at best, only curious about the proposed and/or existing projects.

Why has the public shown so little interest in these projects? Perhaps the answer lies in the benefits that are usually emphasized by systematic biologists involved with EDP projects. These benefits often include the following: better nomenclature; better inventory control of herbaria and museums; automatic printing of specimen labels; easy location of type specimens; lists of synonymy; lists of collections and dates of collection; geographic distributions; information on the state of the specimen; ease of accounting for loans and exchanges; immediate access to the morphological characteristics of species (for numerical taxonomy); computer-generated keys; ecological data for taxa; and less loaning of specimens and therefore less damage to specimens. Most of these benefits are for the institution, the curator, and/or taxonomic research. Yet many people we know would like information on taxa concerning rarity, endangered status, weediness, poisonousness, edibility, allergenic properties, use by wildlife, and common names, as well as lists of organisms in countries and distribution maps.

The Rapid Access Plant Information Center (RAPIC) of Colorado is a project which seeks to bridge the gap between the systematic biologist and the public. Central to the development of RAPIC have been applied users such as the land-use planner, environmental impact assessor, farmer, rancher, teacher, veterinarian, weed control personnel, and so on. In addition, RAPIC has extensive mapping capabilities. Distribution maps may be generated for any combination of taxa onto any or any combination of 24 base maps for Colorado. These computer-generated base maps include the following:

- *physical features:* land surface forms, elevation contour maps (in 1000, 2000, or 3000 ft.[1] intervals), and watershed maps showing major rivers and basins
- *edaphic factors:* surface geology and soils
- *climatic factors:* average annual precipitation, number of frostfree days, average annual snowfall, warm season precipitation, and potential evapotranspiration
- *vegetation types:* alpine meadows barren, mountain grassland, pine-Douglas fir, plains eastern Colorado, southwestern spruce-fir, Great Basin sage, mountain mahogany-oak scrub, pinyon-juniper, sagebrush steppe, western spruce-fir
- *cultural features:* Colorado with counties shown and Colorado state boundary

Some of these computer-generated maps are shown in Fig. 1. Most of the maps were taken from the "U.S. National Atlas" (1970) to facilitate comparisons across state boundaries.

Information has been gathered on 3,500 taxa of vascular plants in Colorado using 178 descriptors for each taxon (see box). Notice the kinds of data being collected. A modified version of the Taxonomic Information Retrieval system (TAXIR) developed by David Rogers (see Brill 1971 for a summary of the development of TAXIR) is utilized.

Perhaps the simplest way to demonstrate the RAPIC's linkage with users is to give some examples of user's needs and RAPIC responses.

Suppose a rancher has some cattle which are dying. The veterinarian suspects plant poisoning. A telephone call to RAPIC, along with the symptoms, could result in the following query of the system:

> Print, genus, species, infraspecific, common name for plants with poisonous, cumulative and blindness, yes and demented action, yes*

If this species list was too large, the life cycle could be added to the query to eliminate some taxa. A stomach sample of leaves could then narrow the search to find the poisonous plants, and steps could be taken to eradicate the plants or move the cattle to a different pasture.

As another example, consider the case where two sites are being proposed for the construction of a manufacturing plant. Which of the sites is least natural or native and has the fewest rare taxa? RAPIC could be queried to show the percentage of plants which are native (to Colorado) versus non-native (not Colorado) in the area around each of the proposed sites. Another query could list the rare species reported for each area. These lists would alert planners to the

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[1]Since RAPIC gives elevations in feet, as is shown on the maps in Figs. 1 and 2, measurements in this paper have not been converted to the metric system (in accordance with usual *BioScience* style).

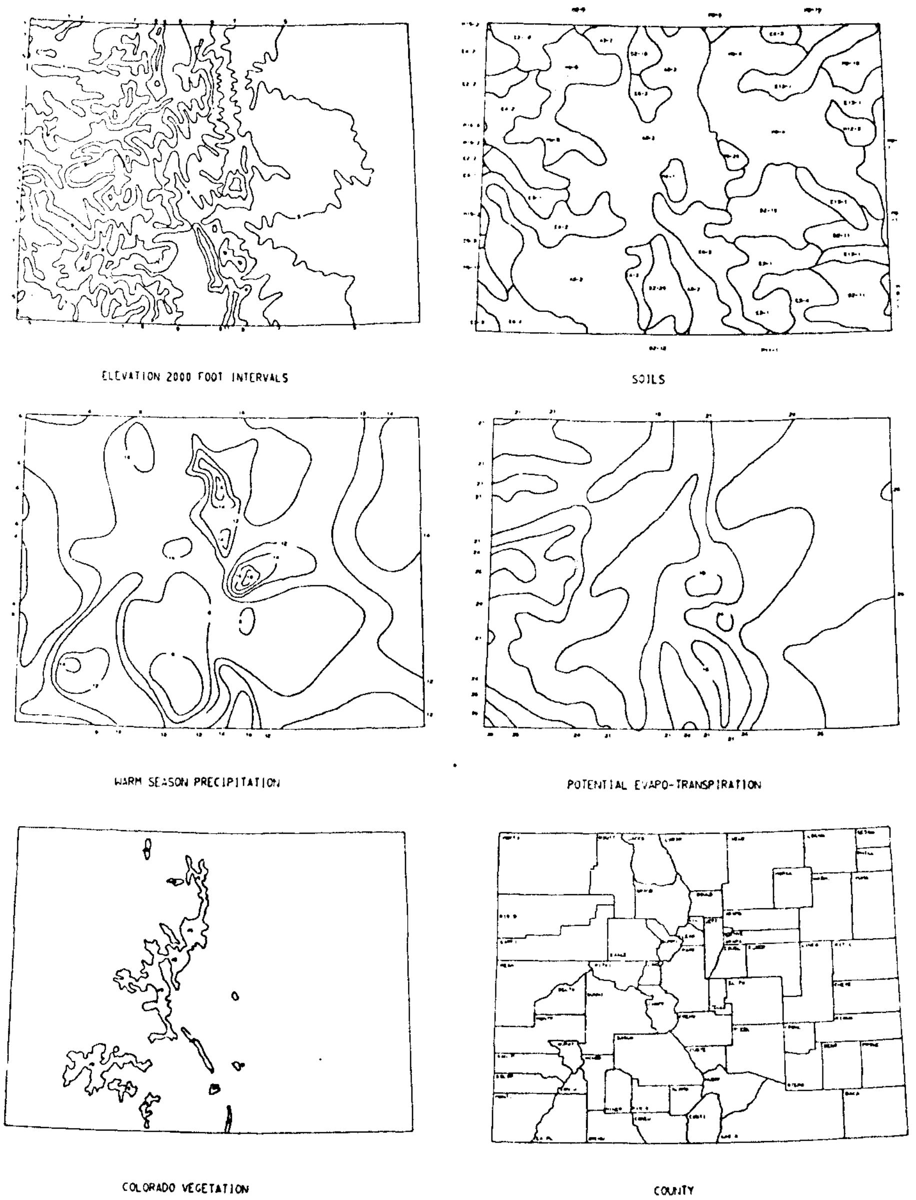

Fig. 1. Some computer-generated base maps available for distribution mapping in the RAPIC system. Any distributions or combinations of distributions can be plotted onto any or any combination of the 24 base maps currently available. See text for a list of base maps currently in the system.

need for (or scope of) an environmental impact assessment. Although these data are likely to be somewhat incomplete at present, better collections will vastly improve the information content of the system.

The spread of agricultural weeds is a continuing problem today. Weed abatement districts are common. Most herbaria are unable to answer a request for a list of weeds for a certain county, much less provide distribution maps for each species, printed onto various base maps. Noxious weeds are well defined by state law, yet the correlation of these weeds with distributional factors must be guessed at by noxious-weed control personnel. A call to RAPIC can generate noxious-weed lists for any county or the state of Colorado and also produce distribution maps to show the correlations with various factors. This could greatly aid in the prediction of the spread of a noxious weed from county to county.

The use of native plants for revegetation has received considerable impetus recently with rising environmental concerns. Unfortunately, relatively few native species have been tried on reclaimed sites. RAPIC relates to this need by entering information about the use of taxa for revegetation. Not only can RAPIC users obtain a list of taxa useful for revegetation, but they may also specify the habit, life cycle, elevation range, and the like of the taxa to be considered. For example, suppose one wanted a native shrub which naturally occurs at 12,000 feet in Colorado. The query to RAPIC would be:

> Print, genus, species for all plants with maximum elevation, from 12000 to 15000 feet and habit, shrub*

The interplay between systematic biologists and wildlife managers, big game managers, and state fish and game personnel has generally been very poor. In an effort to bridge this gap, RAPIC is collecting information concerning the use of various taxa for game forage and game cover. This area has scarcely been examined and will surely be greatly expanded in RAPIC. It should be noted that the authors do not have the expertise to answer these kinds of questions and thus we depend on other specialists to add these and other kinds of data to RAPIC.

Nomenclatural data include family, genus, species, and infraspecific scientific names. Although the common names may be of little use to a classical taxonomist, the public is quite interested in the common name of a plant. The common names were taken from the "Standardized Plant Names" (Kelsey and Dayton 1942). These names often prove inadequate in Colorado, and attention should be given to revising the names some day.

Locational data are of interest to both systematic botanists and many users. Each taxon is scored as being present in a particular county if a vouchered specimen is on deposit at one of the few regional herbaria (Colorado State University, University of Colorado, U.S. Forest Service Herbarium, U.S. Forest Service Pathology Herbarium, and University of Wyoming). Initially, we are processing specimens from these herbaria to compile county lists. RAPIC will eventually rely solely on new material, deposited at the CSU herbarium, due to the enormous curatorial problems of trying to coordinate nomenclatural changes among these herbaria. A query of the RAPIC can generate county floras in a matter of seconds. Currently, these floras have been rather incomplete for many counties. This is due to the concentration of plant collecting around the major universities in Colorado and the habits of botanists who often voucher unusual plants but seldom collect common, widespread plants due to lack of time and storage facilities.

RAPIC currently has a network of both professional and amateur botanists in Colorado in senior colleges, junior colleges, and high schools. They are interacting with RAPIC by submitting specimens which are not on their county flora list. The specimens are collected, pressed, and sent to the CSU herbarium for confirmation of new county records. If a specimen is indeed a new county record, it is mounted and accessioned into the CSU herbarium, and RAPIC is updated to show that this taxon has now been confirmed as being present in that particular county. To date, the response has been very positive, and we envision a good network of collaborators around the state. In the United States (particularly in the western states), this may be the only way to obtain good general records of the biota.

Maximum and minimum elevations for a taxon within the state were compiled from individual specimens and the "Manual of the Plants of Colorado" (Harrington 1954) and updated as new information comes into RAPIC. These data are of considerable interest when one is querying for all taxa at a certain elevation. For instance, if one wanted to know how many plants would likely occur between 5,000 and 6,000 feet in Colorado, one could query as follows:

> How many plants have minimum elevation from 3000 to 6000 and maximum elevation from 5000 to 15000*

The response is:

> No. of items in query response = 1,748
> No. of items in the data bank = 3,428
> Percentage of response/total data bank = 50.992

This tells the user that over half of the vascular plants in Colorado might be expected in this elevational interval. The first part of the above query eliminated those plants whose minimum elevation was above 6,000 feet, whereas the second part of the query eliminated those plants whose maximum elevation was below 5,000 feet (since the highest elevation in Colorado is about 15,000 feet and the lowest elevation is above 3,000 feet).

Distribution records are being gathered on each taxon on three levels of confidence: vouchered specimens, reliable reports, and unconfirmed reports. For each taxon, three computer files are maintained in which coordinate locations are accumulated as specimens or reports come in to RAPIC. This is an

Plant Attributes Used by RAPIC

Descriptors are in italics and descriptor states are in parentheses:

Names

Division (conifer, dicot, monocot, fern allies)
Family (133 family names)
Genus (785 generic names)
Species (1,947 specific names)
Infraspecific (722 infraspecific names)
Common Names (1,911 names)

Locational

63 *counties**, e.g., Baca County (present, unknown)
Maximum Elevation (from 3,000 to 15,000 in 100 feet)
Minimum Elevation (from 3,000 to 15,000 in 100 feet)
Vouchered (distribution map number)
Reliable (distribution map number)
Unconfirmed (distribution map number)
Origin (Asia, Colorado, Eurasia, Europe, North America, other, South America)

Ecological

Habitat (aquatic, emergent, wet, mesic, dry, epiphytic, halophhtic, phreatophytic)
Vegetation Type [note–80% of the range of the species must occur in a vegetation type, left blank if less than 80% correlation] (alpine, sagebrush, pinyon-juniper, subalpine, greasewood, mountain-grassland, montane, shadscale, plains-grassland, oak-bush, sandsage, riparian woodland, willow carr, disturbed area)
Abundance (rare, uncommon, common, abundant)
Endangered (Colorado, North America, World)
Threatened (Colorado, North America, World)
Vegetational Dominant (yes, no)
Endemic (yes, no)
Range Trend Indicator (upward, downward, stable, none)
Disturbance Indicator (erosion, farming, overgrazing, traffic, other, no)
Edaphic Indicator (serpentine, gypsum, very acidic, very alkaline, aluminum, boron, cobalt, copper-molybdenum, copper, diamonds, gold, iron, lead, lithium, manganese, mercury, nickel, phosphorus, selenium, selenium-uranium, silver, strontium, tin, vanadium, zinc, other, none)

Economic Attributes

Cattle Forage Value (good, fair, poor, none)
Sheep Forage Value (good, fair, poor, none)
Game Forage Value (good, fair, poor, none)
Erosion Control (good, fair, poor)
Game Cover Value (good, fair, poor, none)
Revegetation Use (good, fair, poor, none)
Aesthetic Value (good, fair poor, none)
Weediness (noxious, economic, economic-noxious, nonweedy, colonizing)
Poisonous (acute, cumulative, no)
*60 Livestock Poisoning Symptoms**, e.g., bloating (yes, unknown)
Allergenic (yes, no, maybe)
Edible (yes, no, maybe)

Life History

Life Cycle (perennial, biennial, annual)
Trophic Status (parasitic, symbiotic, saprophytic, autotrophic)
Reproduction (sexual, vegetative, apomictic, vegetative-sexual)
Anthesis (January, February, March, April, May, June, July, August, September, October, November, December)
Dispersal Agent (wind, water, gravity, birds, mammals, other, none)
Habit (tree, shrub-tree, shrub, sub-shrub, vine, grasslike, forb)
Carbon Dioxide Fixation (C3, C4, none, other, crassulaceous)

*The poisoning symptoms and county names are not included due to space limitations but are available from the authors.

area of the project that will require considerable manpower during the coming years. We are currently focusing on vouchered records only. A query of all the vouchered distribution of the parasitic plants, mapped onto a land surface forms map would be as follows:

> Find the distributions which are: vouchered for items with trophic status, parasitic* map onto, land surface forms with label parasitic plants on land surface forms*

The result of this query is shown in Fig. 2. At the time of this query the only parasitic plants with distribution maps were of the genus *Arceuthobium*. Areas of overcollecting are very apparent as well as areas of undercollecting. Even though the plants occur on trees, the distributional data may be correlated indirectly with land surface forms because the host is correlated with this factor. This is one of many examples of indirect information that could be gathered from this system.

Maps based on climatic and edaphic factors could be of tremendous benefit in predicting the spread of weeds into regions of similar habitat. If additional correlations were desired, other map statements could be used. Not only can one display species maps, but the following kinds of queries are equally valid:

> Find the distributions which are: vouchered for plants with vegetation type, pinyon-juniper*
>
> Find the distributions which are, vouchered for all plants with (life cycle, perennial and poisonous, acute or cumulative) not habitat, aquatic*

These kinds of queries are extremely powerful since one may examine distribution maps which cut across taxonomic lines.

The information gathered on origin of a taxon is important when questions arise concerning the naturalness or nativeness of an area, as previously mentioned. Under the ecological category, some of the information is very complete (such as habitat, abundance, and endangered), whereas other areas have scarcely been examined (i.e., vegetation type, when 80% of the species range is in this type; edaphic indicator; and vegetational dominant).

The economic attributes are also in various stages of completeness. The information is nearly complete on such descriptors as weediness, poisonous, and edible (for humans); incomplete for

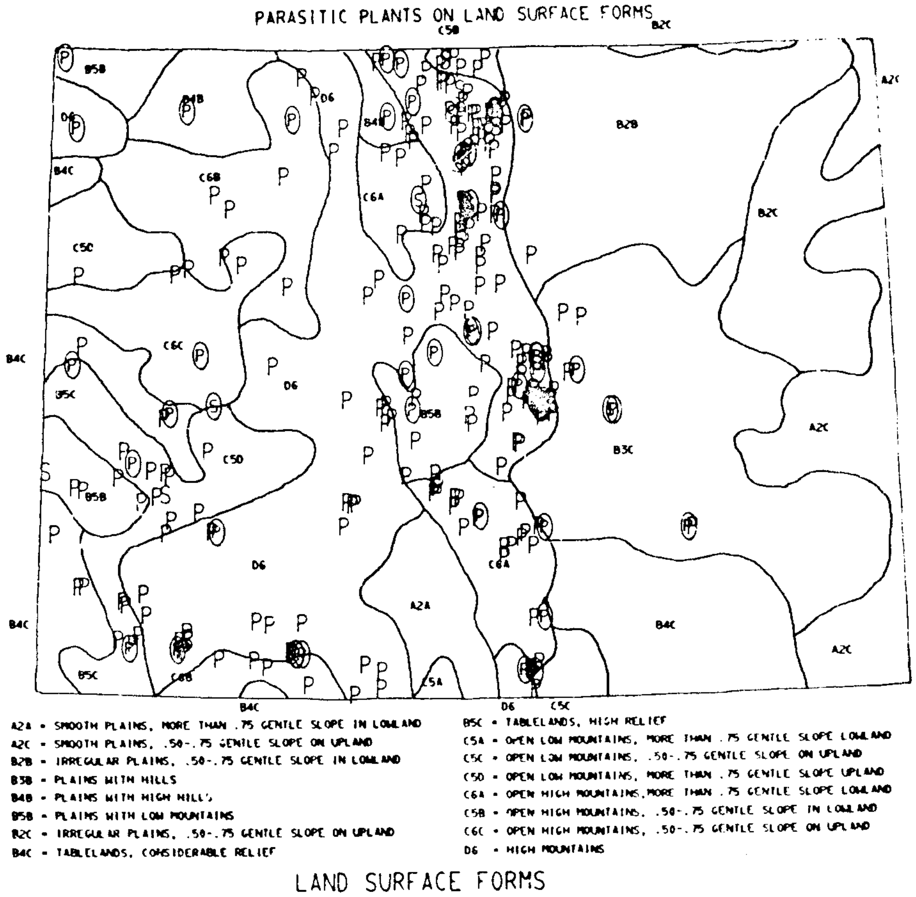

Fig. 2. The computer-generated map of all vouchered records of parasitic plants in Colorado mapped onto the land surface forms map. *P* = U.S.F.S. pathology herbarium; *S* = Colorado State University herbarium. Circled letters imply that the exact location is not known (e.g., Weld County, Grand Mesa). At the date of this query the only parasitic plants which were included in the distribution files were of the genus *Arceuthobium*.

revegetation use and allergenic; and lacking for domestic forage value, game forage value, erosion control value, game cover value, range trend indicator, and aesthetic value. Nevertheless, we do expect input from various users during the coming year(s) to complete the information in these categories.

Some of these categories will undoubtedly be subdivided as experts in various fields interact with us. It is already quite apparent in game forage value and game cover value, for instance, that plant species must be evaluated quite differently for deer, elk, song birds, fox, and the like. We envisage a growth in the number of descriptors in RAPIC to perhaps 250 eventually. New descriptors will be added as user demand increases and as expertise becomes available to contribute the information.

Information on life history is perhaps the easiest data for botanists to gather. Descriptors in this area are generally complete or soon will be.

In analyzing the manner in which RAPIC has bridged the gap between basic research interests and applied users, we feel that probably the most important problem for the authors, as "ivory tower" botanists, was to become acquainted with a wide spectrum of user needs in our state. Although the land-grant colleges of the states would likely have a considerable advantage in this respect, we see no reason why any college or university could not develop this liaison with users.

The total cost of RAPIC during the development phase and data collection to the present (four years) has been about $50,000. A considerable portion of this was spent on programming to revise and change the TAXIR program. Operation of RAPIC will likely cost $7,000 to $10,000 per year in the future. The value of the services of such a center could well run upwards from $250,000 per year, depending on use.

The passage of the Endangered Species Act of 1973, concurrent with a lack of federal funds to carry out research on endangered species, may encourage individual states to begin the task of data banking biological information. We would, therefore, propose that data banking of biological information start on the state level with a considerable portion of each project devoted to applied needs of the particular state. Although the development of state systems will undoubtedly present certain problems of compatibility, some descriptors and descriptor states could probably be easily standardized.

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IN PERSPECTIVE . . .

The AIBS Life Insurance Plan

It's always a good practice to look backward now and then to see where you've been. It helps to put the future in perspective.

The AIBS Life Insurance Plan is a good example. The program passed its 10th Anniversary in September of 1974. The question must be asked: Is the plan as good as it was ten years ago?

One measure of relative value would be to compare the AIBS Plan to other similar plans now on the market. At first glance some others may appear to be less expensive. Our comparison need go beyond gross premium cost, however. Cost and amount of insurance alone are not a true measure of value.

For example, some life insurance policies can be canceled at the option of the insurance company. Certainly, this is a negative feature because the number of years your insurance will continue is an unknown factor. The AIBS Plan cannot be canceled by the insurance company, and the policy premium rates cannot be increased. The insured member owns and controls his policy. This may not be true of other programs.

The payment of dividends is another measure of value. The AIBS Plan currently pays an 18% dividend. The insured member can use this dividend to reduce his net insurance cost, or he can assign the dividend to the association to help further projects and progress in the biological field. Again, the insured member has control.

Two additional features that have an impact on value are Waiver of Premium and Conversion Right. The AIBS Life Plan contains both of these important provisions. The phrase "You get what you pay for" may be overused, but it is certainly true of life insurance.

One final question must be asked as we look back on the progress of the life insurance plan. Is the insurance company responsive to the needs of the members? In 1974 the company reduced the premium rates for all members. In further recognition of membership needs, the insurance company increased to $100,000, the maximum amount of insurance available under the plan. We feel that both of these steps are positive responses.

On May 22nd we held our annual program review with the insurance company. It is our belief that they have successfully satisfied each criterion set down by the Executive Committee when the plan was adopted in 1964. We feel it is our responsibility to represent the 2,262 members who are currently insured. We shall continue to do so.