



Hunt Institute for Botanical Documentation
5th Floor, Hunt Library
Carnegie Mellon University
4909 Frew Street
Pittsburgh, PA 15213-3890
Telephone: 412-268-2434
Email: huntinst@andrew.cmu.edu
Web site: www.huntbotanical.org

The Hunt Institute is committed to making its collections accessible for research. We are pleased to offer this digitized item.

Usage guidelines

We have provided this low-resolution, digitized version for research purposes. To inquire about publishing any images from this item, please contact the Institute.

Statement on harmful and offensive content

The Hunt Institute Archives contains hundreds of thousands of pages of historical content, writing and images, created by thousands of individuals connected to the botanical sciences. Due to the wide range of time and social context in which these materials were created, some of the collections contain material that reflect outdated, biased, offensive and possibly violent views, opinions and actions. The Hunt Institute for Botanical Documentation does not endorse the views expressed in these materials, which are inconsistent with our dedication to creating an inclusive, accessible and anti-discriminatory research environment. Archival records are historical documents, and the Hunt Institute keeps such records unaltered to maintain their integrity and to foster accountability for the actions and views of the collections' creators.

Many of the historical collections in the Hunt Institute Archives contain personal correspondence, notes, recollections and opinions, which may contain language, ideas or stereotypes that are offensive or harmful to others. These collections are maintained as records of the individuals involved and do not reflect the views or values of the Hunt Institute for Botanical Documentation or those of Carnegie Mellon University.

About the Institute

The Hunt Institute for Botanical Documentation, a research division of Carnegie Mellon University, specializes in the history of botany and all aspects of plant science and serves the international scientific community through research and documentation. To this end, the Institute acquires and maintains authoritative collections of books, plant images, manuscripts, portraits and data files, and provides publications and other modes of information service. The Institute meets the reference needs of botanists, biologists, historians, conservationists, librarians, bibliographers and the public at large, especially those concerned with any aspect of the North American flora.

Hunt Institute was dedicated in 1961 as the Rachel McMasters Miller Hunt Botanical Library, an international center for bibliographical research and service in the interests of botany and horticulture, as well as a center for the study of all aspects of the history of the plant sciences. By 1971 the Library's activities had so diversified that the name was changed to Hunt Institute for Botanical Documentation. Growth in collections and research projects led to the establishment of four programmatic departments: Archives, Art, Bibliography and the Library.

May 15, 1973

Dr. D. L. Jennings
Scottish Horticultural Research Institute
Ivergowrie
Dundee DD2 5DA

Dear Derek:

Thank you very much for the excellent paper on The Utilization of Cassava Variability on an International Basis. It is a fine job, and my comments are only intended to add something useful.

First, I think it would be nice to recognize that FAO/IBP are much interested in the conservation of genetic resources on an international basis. I will probably be involved in setting up the information systems to be used for documentation of genetic resources, so your comments on the use of computers as a means to handle the data and information on genetic resources of cassava are much appreciated. I am sure that the international system will want to cooperate with the Cassava Breeder's Association you recommend, and with any other group so designated. Clearly I will be interested to work on some aspect of the crop (or wild species) as I can.

Some specific comments on the papers:

Page 3, re diseases in Africa. You have rightly emphasized the over-riding importance of viruses on that continent. Do you want to add something of the following: "Bacterial (and possibly, fungus) diseases are also significant in central Zaire. Recent outbreaks of a bacterial wilt, of devastating effects in localized areas indicate that, given the proper circumstances, cassava suffers a wide range of diseases, as might rationally be expected."

Pages 4-7, on Yield and Labour Saving: I am hesitant to bring it up, but I feel very insecure on recommendations of one type or another as an over-riding of any other recommendation, made by breeders in isolation from other disciplinary types. There are good reasons for increased yield and labour-saving, but to emphasize these out of context of a larger set of objectives which may be much more significant for one country or another is or can be disastrous. To determine objectives, breeders themselves need the advice and consent of the decision-makers for a particular setting (or country). By such means, the breeding objectives can be brought into more precise focus, and very likely, some of the major goals you have emphasized will be the most likely ones in many areas. However, I believe that the breeder would have more chance of getting the necessary funds for his work if he brings the aforementioned "decision-makers" into the act before he starts in on one or more programs.

Perhaps what I have said in the preceding paragraph is more in the realm of "philosophy" for casseava breeding than in actual breeding, which your paper is clearly intended to be, but I can't help but feel that we will succeed to goals more rapidly by adopting this type of philosophy, and stating it, at the beginning of these discussions.

The same general type of comment can be made for "Labour saving" as for yields. I would agree that in certain countries, or in certain parts of certain countries, it is important to emphasize modern, mechanized systems to produce greater quantities with smaller numbers of people. However, a number of economists have been recently stating that we need to maintain labour-intensive agricultural systems in certain parts of the underdeveloped countries (almost all of which are important cassava producers) because there is a labour surplus in these countries, and manual systems of cassava culture can be important places to employ the labour. A mix of breeding objectives for such countries as Nigeria, for example might be more important than to bend our efforts specifically towards breeding a modern-design, totally mechanically-oriented cultivar.

I hope that what I have said isn't too far from the point here. Obviously I think that they are important considerations, and ones that need to be emphasized to the readers of such a paper as this one.

Other than these, I have nothing but praise for it, and really, I don't want to act too much like a foreign missionary. I'm sending a copy to Frank, because he is already familiar with my take-off point, and he might even secretly agree with some of them!

Sincerely,

David J. Rogers
Professor of Biology

cc.: Dr. Frank Martin

Scottish
Horticultural
Research
Institute

INVERGOWRIE DUNDEE DD2 5DA Telephone INVERGOWRIE 441

Director C. E. Taylor BSc, PhD

Secretary N. D. Anderson

DLJ/MC

8th May, 1973

To: Members of the Cassava Study Group

Sr Milton de Albuquerque

Dr E. V. Doku

Dr Brown A. C. Enyi

Dr William O. Jones

Prof. Alvaro Montaldo

Dr David Rogers

(cc to F. W. Martin)

Dear *David*

I enclose a revision of our study on Cassava variability compiled by F. W. Martin and myself. Please send any further comments to either of us as soon as possible, so that a final version can be prepared for presentation at Ibadan.

Yours sincerely,

D.L.J.

D. L. Jennings

THE UTILIZATION OF CASSAVA VARIABILITY ON AN INTERNATIONAL BASIS

The Report of a Study Group^{*} compiled by

D. L. Jennings

Scottish Horticultural Research Institute, Dundee, United Kingdom

and

F. W. Martin

United States Department of Agriculture, Mayaguez,
Puerto Rico 00708

INTRODUCTION

The importance of cassava as one of the world's most efficient producers of carbohydrate is being increasingly recognised in many parts of the world. With this recognition has come an increase in research aimed at improving the crop by breeding. This is therefore an opportune time to take stock of the potential offered by the available germplasm, and to consider how it can be best utilised. The need to acquire and maintain collections of germplasm becomes increasingly apparent as the wide range of variation in cassava and its related species is recognised. This range must be preserved in full for future generations of breeders, whose requirements might well differ from ours. But germplasm collections are notoriously expensive to maintain and it is essential to organise them efficiently. Moreover, two problems must be

^{*}Acknowledgement: The contributions of M. de Albuquerque, E. V. Doku, E. A. O. Enyi, W. O. Jones, A. Montaldo and D. J. Rogers are gratefully acknowledged.

solved before efficient, world-wide exchange of germplasm can occur: one is the problem of avoiding the spread of viruses to countries where they do not occur, and the other is the problem of standardizing evaluatory procedures and assembling information on germplasm in such a way that breeders have ready access to it, and are able to choose the most useful material for their purpose.

For these reasons, the committee of the International Society for Tropical Root Crops set up a study group to draw up recommendations for the utilization of cassava variability on an international basis, and to present them at the present symposium. It was realised, of course, that first priority must go to actual breeding work in progress or being started, and we do not suggest any diversion from this work or diminution of its impetus. Rather, we wish to ensure that full impetus is maintained, because as breeding progresses it will become increasingly desirable to consider how to organise the germplasm so that its full potential becomes available to the breeders. It is to this question that our recommendations are directed, and, as a preliminary to this we first attempt to define the short and long term goals of cassava breeding.

Goals in cassava breeding

Local problems. The immediate objectives of cassava breeding are always to solve problems that limit production or

utilization, but since these differ in different parts of the world the breeding goals vary too. Furthermore, because cassava is used for different purposes in different regions, the breeding goals frequently reflect the different priorities given to cassavas for home consumption, for fresh and processed foods and for industrial starches etc.

Each area also has particular diseases and pests which limit production. It is important to identify these and to identify

sources of resistance to them. Resistance to mosaic disease is essential for most parts of Africa. It is said to be moderately severe but still serious in inland areas, while its severity makes it an overriding factor in many coastal regions. More careful selection of planting material may be achieved with large-scale management, but this is unlikely to solve the problem. The available resistant cultivars are not immune but highly field resistant, apparently through an ability to restrict virus multiplication and to localise virus. The goal should be to breed cassavas with a level of resistance adequate for the areas where they are to be grown. Further species should be tested for forms of resistance which are easier to select, such as immunity or vector resistance. Resistance to the vector (Bemisia tabaci) has the attraction that it may confer protection against other virus diseases, possibly including undescribed ones.

Resistance to brown streak disease is important only in East Africa. The disease reduces yield and renders the roots inedible, but new cultivars possess adequate resistance. The goal should be to maintain this while introducing further improvements. The virus diseases important in South America also differ from those important elsewhere, but, in general, virus diseases are probably less important than bacterial diseases in this continent. (at least in part)
Sources of resistance to these are known too and the problem is therefore one for plant breeders.

Bacterial (and possibly, fungus) diseases are also significant in central Zaire. Recent outbreaks of a bacterial wilt, of devastating effects in localized areas, have been reported. Bacterial wilt is a disease which suffers a wide range of diseases, as might rationally be expected.

Scale insects, red mites and thrips are occasionally important, especially under sub-optimal conditions such as drought, when they increase rapidly, damage the foliage, and cause the plants to dry out. The reported sources of resistance should be utilised. Drought itself is a major threat in areas of marginal rainfall, and selection for tolerance of these conditions merits high priority in some breeding programs. New sources of drought resistance are needed.

Yield

^{One-}
A major goal is to produce cultivars capable of yielding the maximum number of calories per unit area. Since advances in growing practices are likely to parallel advances through breeding, ^{could (or might)} one objective ~~should~~ be to select cultivars capable of responding to high fertility and improved agronomic practice. But selection must also be done on soils of average or below average fertility, because these too will be used for cassava in the future.

High-Intensity cultivation requires a plant architecture that permits close spacing and efficient use of light. The following characteristics for the ideal plant have been suggested: (a) only one shoot arising from its cutting, (b) a high ratio of root to stem, (c) a leaf area index of about 3.5, (d) about 8 tubers, (e) large tubers, (f) early maturity and high bulking rate, (g) leaves placed at a small angle to the stems so that they are held vertically rather than horizontally, and permit greater penetration of light to

the lower leaves, (h) narrow leaf laminae, also to permit light penetration, and (i) disease resistance. Another view is that mechanical harvesting will almost certainly require short, compact roots, and that there should be an adequate number of them to compensate for reductions in their size. Tuberous roots form within the first 6 months of growth and all subsequent yield increases are due to their increase in size. Hence restriction of root size for mechanized management will place a ceiling on yield if there is not an adequate number of roots.

Yield is not merely weight at harvest. The starch content of roots, for example, varies significantly among cultivars, and is a factor affecting absolute yield. Rough skins and irregular shapes reduce the portion of useful yield, while easy-to-peel outer skins give minimal root loss. ^(in mechanical processing) Cassava marketed for human consumption is usually limited to roots attaining 20 cm length and 5 cm diameter. Various changes in the root which lead to necrosis, darkening or liquefaction of the starch can be attributed to low tolerance of sub-optimal soil conditions - soils with impeded drainage, for example. These problems are aggravated by fungal pathogens, but sources of resistance to the pathogens are known and should be given special attention when breeding for regions where peasant smallholders 'store' their roots for long periods in the ground.

Yield is also related to time to maturity. Root yield during

the second season is usually achieved more efficiently than in the first, and thus for starch and industrial purposes a requirement is for cultivars capable of giving high yields in about 20 months. For these situations, the concept of yield per hectare per month may be more valuable than simple yield measurement, but for other situations the requirement is for cultivars which give an economic return in 6 to 10 months, as these fit better into agricultural rotations and local needs.

In summary, breeding for high yield necessitates studies of the components of yield, but the relative importance of factors which affect yield varies in different regions and thus breeding goals must vary too.

Labour saving

comment over →

The need to produce more ^{starch} food with fewer hands requires the production of staples which utilize mechanical devices for many steps in their production. In some cases the development of such devices must await the breeding of suitable cultivars, but breeding for characters which facilitate mechanical planting and harvesting would probably yield cultivars suitable for more simple agricultural systems as well. Cassava cultivation on peasants' small-holdings will certainly continue to be of major importance for the foreseeable future, but there seems little need to breed especially for small-holding situations, as none of the special characteristics of cultivars bred for plantation work should make them

While saving of labour sounds attractive to developed countries, there is not so much attractiveness in labour-surplus areas. You really should read the works of economists whose most recent idea is that you should not substitute labour-saving devices in areas where there is a tendency for migration to urban centers. (Which is very nearly universal in the world today!)

Since cassava must be centered in areas with labour surplus, to put other barriers in the way of labour utilization is really anti-development. This is a complex subject, requiring input from all disciplines, but we (as plant breeders) must be knowledgeable of all thinking rather than put our blinders on to real needs of people and to their economies.

unsuitable for growing on small-holdings.

Almost all present-day cultivars produce a few large cylindrical tubers which grow deeply into the soil. This makes both hand and mechanical harvest difficult. The need is for cultivars with larger numbers of smaller and more spherical tubers which do not penetrate so deeply. It is uncertain whether the ideal plant habit is one with erect stems and minimal branching, or one where the stems are of medium height and moderate branching. The former produce material ideal for mechanized planting, but they lodge more easily and are less effective for shading out weeds; ^{while} the more profusely branched ones have disadvantages for the application of crop-protection chemicals and for harvesting.

They are also
much more
susceptible
to wind
damage.

Quality

Except where cassava is used exclusively for industrial purposes, the lowest possible hydrocyanic acid (HCN) content is the most important quality to be sought. Even where HCN is at present dealt with by wellknown procedures it is probable that it is not completely removed, and that cumulative ill-effects on health occur due to its regular intake at low levels.

Cassava owes its claim for advancement to its capacity for producing very high yields of calories, and it is said that its roots are organs for starch storage and not adapted physiologically for protein storage. Clearly, improvement in protein content is

acceptable only if it is achieved without diminution of this primary function. Nevertheless, the existence of cultivars with higher than average protein contents and of related species with high protein contents justifies further studies of the feasibility of combining high calorie yield with improved protein content. Attention should also be paid to the specific amino acids present. In these respects our knowledge of the potential of the available germplasm is still limited.

Good cooking quality (floury texture), high contents of sugar, vitamins and minerals, and suitability for processing into numerous local foods are additional qualities required. Processed foods such as tapioca require large starch grains. Developments in the use of cassava flour for bread might introduce other requirements. The industrial usage of cassava will increase both in quantity and in variety. This, too, may lead to variation in the kind of starch required, possibly in grain size or in characteristics such as amylose content. Large grains are required for most purposes but differences in requirement may call for specialized cultivars.

The need for new germplasm

Cassava improvement requires new germplasm for two main reasons: to introduce specific characters and to broaden the genetic base. Specific characters such as disease resistance or quality attributes are usually transferred to locally adapted types by repeated backcrossing. However, it is often difficult

to recognize the usefulness of a new specific trait in a 'wild' background, even though it could be revolutionary and give a major breakthrough if incorporated into an adapted cultivar. This difficulty can only be met by careful study of germplasm collections by people representing a wide range of interests and competence.

Where the transfer of a specific character from a related species by backcrossing has been attempted, benefits have frequently occurred over and above those predicted from the specific improvement alone. This is because 'fringe' benefits occurred from general improvements associated with broadening the genetic base. Prolonged backcrossing is not as effective for taking advantage of these as a system which allows intercrossing after the first or second backcross. The objective should be to recover most of the adapted parents' germplasm plus all the useful new germplasm. Large segregating populations will be required, especially where negative correlations occur between a desirable character and an objectionable one.

The wide morphological variation among cassava cultivars suggests that cassava had a polyphyletic origin and hence has a fairly wide genetic base already. Nevertheless, further broadening of the genetic base may possibly be achieved dramatically by 'starting again', that is to say, by selecting over several generations among wild species of Manihot for forms productive of good roots. The selections obtained might then be used to

produce productive hybrids with cassava cultivars. This idea is stimulated by success recently reported for a similar project with potatoes, where material of Solanum andigenum has been successfully selected with greatly improved tuber yield and then crossed with potato cultivars to give hybrids with 50% more yield than typical S. tuberosum progenies. Obvious candidates for improvement prior to crossing with cassava are species with tuberous roots and low HCN content. Another objective is to widen the area where cassava can be grown successfully, for which task the introduction of germplasm from other Manihot species is particularly desirable, as the ecological range that they cover is considerable.

The acquisition of germplasm

A start has been made in the development of germplasm collections, but these are not yet extensive. Four categories of germplasm should be preserved: elite cultivars, breeding material carrying genes for special characteristics, ordinary cultivars, and wild species. The four categories are not of equal importance and merit different consideration. The most important are cultivars or hybrids which are elite because they have given outstanding performance in trials, have proved themselves outstanding parents or contain rare combinations of genes such as genes transferred by interspecific crossing. Comprehensive collection of the other categories is of lower priority, and is a long-term task which should be done as an organized operation sponsored by an

international body. Collections should be made on an adequate scale and with adequate objectives, and isolated expeditions with specialized objectives should be replaced by systematic collecting aimed at including as many ecological variants as possible of each species, especially those closely related to M. esculenta. This implies a major study based on knowledge in depth and a thorough ecological appreciation of the areas explored. The preparatory work will require just as much time and labour as any major investigation.

The maintenance of germplasm (a) Manihot species

It is desirable to maintain the germplasm in germplasm centres, whose responsibility should be to locate and acquire it, and then to maintain and rejuvenate it as necessary. Only seed maintenance need be considered for wild species, which do not propagate easily from cuttings. Research is required to determine the optimum storage conditions for Manihot seeds in terms of moisture content, temperature and gaseous content of the storage atmosphere. In other genera, reduction in water content and attention to these other factors has permitted seed storage for 20 years, but this has not always been achieved for species whose seed has a high oil content. Success with Manihot would enable germplasm to be maintained entirely as seed, only a small proportion being grown for rejuvenation at one time. The maintenance of a living collection would not be a primary require-

ment, as material required for particular projects would be grown especially in the most appropriate areas. For example, studies concerned with pathology or with adaptation to an environment must necessarily be done in areas where the particular disease or particular problem of adaptation occurs. Where individual breeders prefer to maintain their own collections the material would also be received from a germplasm centre. None of these purposes would require the complete collection, and material grown for short to medium term projects could later be discarded, because the centres provide continuity.

The maintenance of germplasm (b) Cultivars

A very large number of cassava cultivars exist in most tropical countries. They often represent variants evolved from a relatively narrow base of germplasm and perpetuated by clonal propagation. A serious erosion of germplasm could occur when existing cultivars recede in the face of superior ones produced by breeding, and efforts should be made to prevent such losses. Analyses of the variation would probably show groupings which reflect the origins of the cultivars, and it may simplify the situation if such groups were regarded as populations. Their basic germplasm could probably be adequately maintained in the form of seed, as the cultivars are really no more than the elite individuals of a population. Again, a big advantage of this would be achieved if long-term storage of the seed became possible, as only a fraction

of the material would then be grown at one time. The facilities of a central seed bank would be used, and all the disadvantages of collections maintained by cuttings avoided. Collections of cuttings are more difficult to acquire for reasons concerned with plant health. They can be based on fewer plants than collections maintained by seed, but the total collection must always be maintained as living plants. Experiments with storage of cuttings may show how the work could be reduced slightly.

Problems arise in ensuring the maintenance of germplasm in seed mixtures: ^d Different genotypes within a seed sample may have different abilities to survive, especially when the germination capacity of a sample is reduced by long storage; ^t There may ~~also~~ be differential survival or capacity to reproduce during the rejuvenation phase, possibly due to differences in inflorescence production or in capacity to set seed; ~~isolation must be sufficient to prevent out-~~
might occur if isolation is insufficient, while p crossing with other populations; ~~Practicalities~~ may dictate small sizes of population, and ~~this may~~ lead to "genetic drift", i.e., fixation of particular alleles at the expense of others, which will be lost. Fixation of deleterious genes often occurs in small populations, as it occurs independently of adaptive value.

Some of these problems are aggravated because the capacity of cassava to reproduce by seed is so variable. Indeed, the variation is so wide that it precludes the use of large panmixia of material, because they would become dominated by the more

fertile kinds. Possibly a fairly large number of groups should be started and then combined progressively as evidence of similarity is obtained. Use of a small number of large groups would be easier and would also minimise genetic drift, since in a large population few if any genes tend to be eliminated.

The maintenance of germplasm (c) Elite breeding material

In the case of very select cultivars and hybrids the individual clones are outstanding for their particular combination of genes, and they are usually so heterozygous that only a small proportion of their seedling progeny adequately represent them. Breeders therefore prefer to breed from the cultivar itself, which therefore has to be maintained clonally. Outstanding breeding stocks and sources of disease resistance fall into this category.

For these materials, expensive measures to satisfy quarantine requirements are justified in order to make elite material from all regions available to all breeders. Thus, material which had been exposed to virus infection could first be grown in quarantine, and then possibly cured by heat therapy or by propagation from apical meristems. Where the risks are high, quarantine should be enforced in the country of origin and repeated in the importing country. No effort should be spared to keep the collections virus-free, so that recipient countries can accept material with minimal delays and restrictions.

The evaluation of germplasm

Material in the germplasm centres must be rigorously tested,

and its attributes and characteristics documented in detail if it is to be used effectively to attain the breeding goals defined. This will entail testing under a range of conditions to evaluate genotype-environment interactions for important plant characters. Indeed, testing at several centres will be necessary to obtain all the requisite facilities for testing the many qualities being sought. The aim should be to identify material not only by its number and place of origin, but also by its test ratings for as many characteristics as possible. Information on such characters as resistance to diseases, quality of roots and their suitability for various purposes, growth pattern in terms of characters likely to affect yield and adaptation to particular environments should accumulate, and be added to a store of information. Computerized procedures for processing this data should then be used. Such a record in a central file with facility for rapid retrieval of information would greatly facilitate the use of germplasm collections by providing speedy information about new accessions and discoveries of special characters. The record system would allow for revision and alteration as information accumulates, as this would happen as studies of a general nature were followed by an increasing number of studies by specialists. The specialists involved may not all be primarily concerned with plant breeding, as basic studies in such disciplines as taxonomy, cytogenetics and pathology are also facilitated by germplasm collections.

The standardization of testing and evaluatory procedures

The high cost of experimental work means that experiments must be planned to give a maximum of information that is useful in any geographical area to which it is relevant. Good experiments accurately reported make unnecessary the continuous repetition of similar experiments in distinct regions. But only if investigators all over the world use similar reporting techniques will they be able to use each other's results.

The general problem of experimental design has been handled admirably in "A Guide for Cassava Field Trials" printed by the Centro Internacional de Agricultura Tropical (CIAT), Cali, Colombia. The information given is too extensive to include here, but should be consulted by persons interested in the agronomy of cassava. Of particular value are a series of standard forms for planning experiments, recording background information, maintaining a diary of experimental procedures, recording economic data, information on climate ^{and} plant diseases and preserving samples. Such information makes it possible to compare the details of experimental results from diverse regions. Permission is given in the manual to reproduce and use these forms. In this report, standard procedures are considered only for the purpose of cultivar testing, and the measurement of yield under a given set of conditions is emphasized.

Trials are managed at several levels, only some of which

allow the possibility of international co-operation, but it is highly desirable that tests involving exchanges of material be standardized. Selection frequently occurs in the following stages, and will usually be for many factors besides yield:

1. Preliminary screening among seedlings or new accessions, based on single plants.
2. Unreplicated comparisons of short rows of preliminary selections, to reduce the selections to a workable number.
3. Replicated trials to select a small number of genotypes for trial under well-defined conditions.
4. Final trials in replicated large blocks at several locations.

Duplication for assessments of genotype x environment interactions in respect of planting time, high and low fertility, or high and low rainfall should be introduced at stage 3 or 4, to indicate a genotype's 'stability' or 'responsiveness'.

Much of the material moved internationally will be of sufficient merit to be tested directly in replicated trials, once sufficient material is available. New rapid propagation methods must be perfected to facilitate this. Some recommendations for standardized experiments are:-

1. Randomized block design. Alternatively, a balanced lattice, especially where computerized analyses are possible.
2. Four to six replications.
3. Where material is abundant, each plot should have 3 rows of 36 plants each, the middle row to serve as test plants.

Shorter rows could be used when material is limiting.

4. Uniform planting material, spacing, fertilizer, insecticidal, fungicidal and other treatments, providing that the standardized procedure does not conflict with the local practices under which the selected cultivars will be grown.

Although recording can be managed most effectively on the forms in the CIAT manual, it is unlikely that these will always be used, because they are very extensive. A shortened form has therefore been devised. Many important items are clearly omitted from it, but other information can always be added. It is appropriate to consider here some standardized methods of measuring certain other variables:

Dry matter content. Dry matter determinations of sufficient accuracy for most purposes can be made by drying cassava chips to a constant weight in an oven at 55-60°C and expressing this weight as a percentage of the fresh weight.

Starch content (Mechanical method). Duplicate 50 gm samples of fresh roots are placed in a blender containing 500 ml of water and macerated for 5 minutes. The starch is then washed out of the pulp through a 200-mesh screen with 500 ml of water, dried in a suitable pan in a forced-draught oven at 65°C, and its dry weight determined and expressed as a percentage of its fresh weight.

Starch content (Root density method). The starch content of a sample of roots can be estimated from its specific density. The latter is determined by dividing its weight in air by the difference

samples of 5-10 kg should be used. The CIAT manual gives a table to convert specific densities into starch contents, but it may be desirable to verify these conversions locally.

shelling? HCN content. Gulguard's test is suitable for rapid primary screening. For this test, sodium picrate paper is first prepared as follows: prepared filter paper is dipped into 1% picric acid, dried, dipped into 10% sodium carbonate and dried again. For the test, a few grams of finely chopped root are placed in a test-tube, a few drops of chloroform added, a moist strip of the sodium picrate paper inserted and the tube tightly stoppered. After 3 or 4 hours the amount of free HCN released will be indicated by the intensity of red coloration on the paper, which can be scored on a 0-5 scale. A more exact quantitative method should then be used for selections giving negative responses. The method described by Wood (J.Sci.Fd.Agric., 1965, 16, 300) seems suitable.

HCN content is influenced by many variables which should always be noted: plant age and soil fertility, for example. Account must also be taken of variation within a plant. All of its roots should be peeled and cut into transverse sections to take account of variation between roots, and these sections should be sampled with a cork borer to take account of variation within them. Disease resistance. For assessment of disease resistance it is important to choose a locality and management system which maximises the discrimination between genotypes. Preliminary

experiments to determine the best system are often needed and details of factors such as climate, time of planting and soil fertility should ^{always} be reported. For maximum discrimination, records of the proportion of plants infected, the proportion of branches infected (since for many diseases branches are infected independently) and the intensity of symptoms ~~present~~ are often desirable, particularly when computerized techniques can be used to combine them into a single figure which is more discriminating than any one of them alone.

Facilitating international exchange of materials

Two factors facilitate international exchange more than any others. The first is the provision of adequate information for recipients to know exactly what is available so that they receive precisely what they require, and the second is the establishment of procedures which permit germplasm exchange with minimal delay and with minimal risk of spreading diseases or pests.

We have described how information should be accumulated and incorporated into a computer system at the germplasm centres. In an ideal situation a breeder applies for material of a particular type which fulfils particular requirements. The computer then lists the materials available which meet the stated requirements, and the breeder selects from the list: success depends on the completeness of the information available ~~and on the completeness of the information available~~ and on the extent to which its form is meaningful to all

readers.

Quarantine controls must be rigorous, but the delays caused by them can be minimised by choosing ways of exchanging materials which have minimal risks of spreading disease. Certain centres, possibly the germplasm centres, should maintain a nucleus of material at such a high health standard that foreign countries will accept it with minimal restriction. But more study should be given to the possibility of exchange of seeds or pollen, for which risks of spreading disease are less. There are many possibilities: 1) A breeder may exchange open-pollinated seed. This may be satisfactory for supplying germplasm for a particular character whose inheritance is not complex, but it is not a good way of distributing an elite genotype. 2) A breeder may repeat a cross which has produced a progeny containing elite individuals, and distribute the seed. Since it is often particular combinations which give overall superiority, this method gives other breeders the opportunity to test superior combinations and to select for local adaptation as well. 3) A breeder may make a cross between a superior parent and parents known to be adapted to a recipient country. This is useful where the contribution of the superior parent is inherited in a simple or additive way, and could be used in a back-crossing program following interspecific hybridization. For such a program, one center may proceed as far as the first or second backcrosses, and then distribute second or third backcross seed, the seed for

each situation being obtained by crossing with parents chosen for that particular situation. 4) A breeder may attempt to produce improved populations by recurrent selection, and distribute seed to be tested for local adaptation after successive cycles of selection.

Modifications are possible if pollen exchange is considered. Prolonged pollen storage is possible in other genera and studies are needed to determine the optimum conditions for storage of cassava pollen. If successful, this method would allow a donor center to store pollen of superior parents for long periods pending requests for its use. Small quantities could then be sent to recipients at the most opportune time for crossing.

These methods have other advantages over the exchange of cuttings. They remove the delay caused by quarantine and the time required for establishment and flowering of the imported clone prior to its use in making crosses.

CONCLUSIONS

We conclude that there are considerable benefits to be gained from organising cassava variability on an international basis. Broad breeding goals, including the acquisition of materials and the screening for certain basic traits, can best be handled ^{at} in large international centres, while local needs must be handled locally, though individual breeders should make increasing use of germplasm supplied by the larger centres. We propose a system of international germplasm centres, possibly one each for Africa, the Americas and Asia.

These should not only facilitate the acquisition and maintenance of what is potentially a vast reservoir of germplasm, but should also fulfil the functions of collecting and distributing the information gained from it. We realize that the creation of such centres are long-term projects, but in the meantime, some of their objectives can be achieved by collaboration between breeders in a less organised way. Indeed, closer informal contacts between breeders is needed whatever formal organisations are eventually set up, because some of the procedures advocated here call for a degree of co-operation not as yet achieved. Developments at the International Research Centres already call for greater co-operation, particularly between breeders at these centres and breeders in individual countries. We therefore advocate the creation of a Cassava Breeders' Association, preferably within the International Society for Tropical Root Crops, whose role should be to promote informal contacts and exchange⁵ of information, especially on germplasm and on techniques, and to facilitate the planning of collaborative projects in the field of cassava breeding.

April 23, 1973

Dear Dr. Emsley:

I started treating the enclosed manuscript as though it were a term paper, and made a number of marks on the paper before I remembered that it was not a student thesis. I trust that you have other copies which are not so marked up.

As stated, the paper is not suitable for Biotropica. I think the hypothesis is interesting, and probably the author should use this paper as the basis for an application to NSF to test it, but it is in notsense a finished piece of work. It is the sort of thing that might be useful to place in a newsletter such as it put out by Dr. Frank Martin, USDA, Mayaguez, Puerto Rico, for all tropical root and tuber crops.

Sincerely,

David J. Rogers

REVIEWER'S EVALUATION SHEET

Title of paper: Herbivores and the Ecology and Evolution of Sweet and Bitter Manioc
Cultivation in Indian America
 Author(s): Doyle McKey

The paper is (please check):



Suitable for publication as it stands.



Suitable for publication, but changes should be made as noted below.



Unsuited for publication in BIOTROPICA for reasons stated below.

The major hypothesis of this paper is very interesting, and should be pursued. However, the author has apparently done no field work on it, and his literature citations on the major hypothesis are limited to reports that are, at best, secondary evidence. This crop has suffered from too many gratuitous hypotheses, and now needs some really first-hand investigations.

There are alternative hypotheses which have been suggested for the larger proportion of the more highly toxic cultivars: greater starch production being the most frequent one. Another untested hypothesis is that the HCN serves as an additional nitrogen source for the fermenting microorganisms. Neither of these has been given adequate tests, but they are as attractive as the one presented in this paper.

The paper has a number of small, but significant, incorrect statements and inferences, as follows:

1. No biologist should confuse a root and a tuber. Manihot esculenta has tuberous roots.
2. The word "variety" is not applicable as used by the author.
3. Manihot esculenta contains HCN in all parts--roots, stems, leaves.
4. In all my field experience in Latin America and Africa, I have not seen any differentiation by animals between the variations designated "sweet" or "bitter". I do not think an animal could make the distinction, because even in the sweet cultivars, the phelloderm, or bark, of the root contains significant concentrations of HCN.
5. On page 3, the author states that herbivory of the stems and leaves will not affect the size and quality of the roots as much as herbivory of the root, and in a sense he is certainly correct, but in context, one gains the impression that little or no damage would be done if the herbivore did chew up the leaves. Statement should be clarified.
6. Author states that no studies have correlated leaf-root HCN content and that is true, but informal studies have been made which indicate a close relation between the two, and those plants with high HCN in roots generally have high HCN in the leaves. One experience of my own comes to mind: I had a collection of over one hundred twenty five cultivars, mixed bitter and sweet, in a garden in Jamaica, and cattle accidentally got into the plot. They mowed down every single cultivar there!

Date: April 20, 1973

NATIONAL SCIENCE FOUNDATION
PROPOSAL RATING SHEET

Reviewer

Proposal No. P3B2748
Investigator GILMARTIN
Institution Monterey Peninsula Coll
Please return to Systematic Biology
If possible by May 1, 1973

Comments (Continue on additional sheet if necessary)

Upon first examination of this proposal, one is impressed with the objectives of the principal investigator. However, further examination of the Materials and Methods section indicates that there are too many discrepancies for the PI to fulfill the objectives.

(1) The PI intends to compare the flora as sampled 80 years ago with the present day flora. On page 10 (last paragraph) the PI indicates intention of concentration of collecting on the high mountain peaks, which areas have not been previously well collected. If the comparison is to be made, it seems essential to collect in the exact same localities of the earlier collections. The PI intends to employ Mexican Government land-use surveys. But there is no indication of the completeness of these surveys, and it is doubtful that the surveys are very complete, and probably do not include the high mountain peaks where the PI intends to concentrate collections. Are the surveys complete for both the earlier periods and the present periods?

(2) The PI intends to use Crovello's computer program to capture "specimen and label" information (p. 12), but points out (p. 13) that the system is not complete for purposes of correction techniques. Also on page 13, the PI intends to build various programs for retrieving information using students in a computer class. But the methods to be employed in building retrieval programs and the necessary concepts underlying the design of the information retrieval programs are not given. Why does the author not also use the information retrieval systems for capturing all the data, including the data to be used in the comparisons of the character lists for each family? But more fundamentally, why should the PI develop new information retrieval systems when several general purpose systems are already well developed and available? This type of endeavor falls under the category of "reinventing the wheel." If the PI wishes to develop information retrieval systems, this should be listed under objectives, and does not contribute to this proposal.

(3) The PI intends to use several numerical taxonomy programs, including a distance (or similarity value) developed in her own shop, plus those developed under Rohlf. These include some type of clustering procedure. The PI is certainly capable to use the programs indicated in the proposal, but she has not indicated how any of the computer-aided systems will actually be used to solve the problems which are inherent in the objectives of the study. Until such connections or indications are given, the reviewer cannot determine the validity of any of them.

In general, then, the procedural aspects of this proposal are poorly worked out, and more effort must be given to indicate how the computer methods are useful before the proposal should be funded.

Date:

OVERALL RATING

- ☐ EXCELLENT
☐ VERY GOOD
☐ GOOD
☐ FAIR
☐ POOR

Signature of Reviewer

Other suggested reviewers (optional):

NSF Form 173, January 1968

"Reviewers' comments are solicited and received in confidence by the National Science Foundation, an agency of the U.S. Government, and will be given maximum protection from disclosure permitted under applicable laws, including 5 U.S.C. 522 (The Freedom of Information Act) "

NATIONAL SCIENCE FOUNDATION

WASHINGTON, D.C. 20550

April 3, 1973

Dr. David J. Rogers
Taximetrics Laboratory
Department of Biology
University of Colorado
Boulder, Colorado 80302

Dear Dr. Rogers:

Ref: P3B2748

We should appreciate your assistance in evaluating the enclosed proposal. The Foundation strives to ensure that every proposal is fairly and critically reviewed. To achieve this goal, we rely heavily on experts in each field.

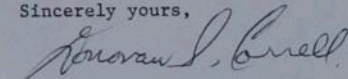
Your critical review of the merits of the proposal thus will be of great value. Aspects which may enter into such an evaluation include the relative importance, feasibility, and conceptual framework of the project. You may also wish to consider the capacity of the investigator to conduct successfully the contemplated project, as shown in his description of developments in the field, his presentation of the proposed project, and his training and research contributions. The adequacy of the facilities available to the investigator should be noted.

Please rate the proposal at the bottom of the evaluation sheet according to the scientific merit of the project. Budgetary aspects should not enter into the rating, but general or specific comments on the budget are welcome. A guideline to the rating system we use is enclosed for your convenience.

Your comments on the project will be treated as confidential. The proposal and one copy of the evaluation sheet may be retained for your file. The proposal itself should be considered as a privileged document.

We should like to thank you in advance for the valuable assistance you are providing in making our proposal review process a judicious one.

Sincerely yours,



Donovan S. Correll
Program Director
Systematic Biology

Enclosure

SYSTEMATIC BIOLOGY PROGRAM

GUIDELINES TO NUMERICAL RATING SYSTEM FOR PROPOSALS

- | | |
|---------------|---|
| 1 = EXCELLENT | Highly meritorious and deserving of top priority for funding. This rating should be reserved for truly excellent proposals, but should be used without hesitation when warranted. |
| 2 = VERY GOOD | Proposals considered superior, both for the intrinsic merit of the project and the ability or potential of the investigator, but with secondary priority. |
| 3 = GOOD | Quality sufficiently high to warrant consideration for support, but definitely with tertiary priority. When funds are scarce, such a proposal will seldom be funded. |
| 4 = FAIR | Unsupportable in present form; might merit consideration for support if resubmitted with major changes. |
| 5 = POOR | Unsupportable. |

Important Note: Ratings range from 1.0 through 5.0, but you are encouraged to use fractional ratings in your evaluation; e.g., 1.2 indicates a rating just below the very top, 1.5 indicates an evaluation halfway between first and second priority, etc. When using fractions, please indicate by writing in the number as well as by location of your "X" in the rating column.

A Proposal to the
National Science Foundation

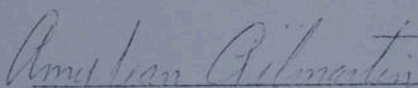
For Research Entitled:

EFFECTS OF RECENT HISTORY OF LAND-USE
UPON THE FLORISTIC SPECIES ASSEMBLAGE IN THE CAPE DISTRICT OF BAJA CALIFORNIA

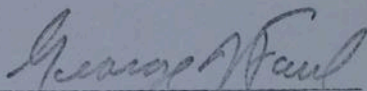
Covering the Period from 1 August 1973 to 31 July 1976

Requesting Support in the Amount of \$60,990

SUBMITTED BY



Amy Jean Gilmartin, Principal Investigator
Department of Biology, Monterey Peninsula
College, Monterey, California



George J. Faul, President and
Superintendent, Monterey Peninsula
College, Monterey, California

Submitted: March, 1973

Abstract

At the tip of the peninsula of Baja California lies a small area with a tropical, xeric, insular type of flora. This flora was the subject of several intensive biological expeditions around the turn of the century. The proposed study will produce an up-to-date account of the assemblage of vascular species now within the region and will employ modern computer techniques for sampling within-group variation and for information retrieval. The work is significant to the entire problem of the ecological and evolutionary effects of land-use. Data and results will make it possible to test interesting hypotheses concerning intrapopulational variability and the putative fragility of species from insular floras.

The Cape District, Baja California Sur, is an important geographic area. It contains a variety of xeric, tropical habitats as well as elements of an insular flora. As a result of several biological expeditions to the area and intensive work by botanists around 1900, much information and many plant specimens have been accumulated which provide data on the presence of species and botanical notes such as are not available for many tropical regions. Comparisons of these data with detailed information on the current flora will help to elucidate evolutionary trends and are particularly valuable for testing the hypothesis of relative and discriminatory robustness of tropical, arid, assemblages of plant species.

The proposed research has three related goals. Firstly, to establish the current assemblage of vascular plant species within a defined, tropical, arid region. Secondly, to examine the qualitative differences and similarities between this assemblage and that which is known to have existed 80 years previously. Thirdly, to qualitatively evaluate the effects of the past three quarters of a century of land-use practices on the flora within the area.

The study area (Fig. 1) is the 7,500 square km at the tip of the Peninsula between 22° 52' and 24° 10' north latitudes astride the Tropic of Cancer. This tropical region includes elevations to nearly 2,200 meters and has been isolated intermittently as an island during Pleistocene times.

The hypothesis will be tested that, with certain specific exceptions, the xeric species assemblage of the area is a particularly robust one, in the sense of many species having shown a high degree of tenacity to withstand the past 70 to 80 years of land-use by man and his ungulate grazers. It is hypothesized that most, though not all, of the same plant species remain today as were observed and collected by the several expeditions mentioned below around the turn of the century. The data base for comparison to the present situation was established about 80 years ago when the Cape District attracted numerous biological expeditions. The plant specimens and data which were gathered from these are available in herbaria and in the publications of Brandegee (1891, 1892a, b, 1894, 1903), Nelson (1921) and

Goldman (1916, 1951) and cover their respective expeditions near the turn of the century. There were also other less intensive collections made during the latter half of the past century such as those of Xantus (Gray, 1861), and Vasey and Rose (1890) and Bentham (1846).

Initially an account of the vascular plants currently found in the Cape District will be produced and compared with an annotated species list extracted from previous expeditions to compare the 1970's and the period around 1900. Valuable as it would be to be able to also make comparisons between the present species assemblage and that of earlier centuries, the limits of this proposal are dictated by the paucity of detailed information on the flora prior to the late 1800's. Some accounts as described below are available from the years during the transition from Indian populations to the mestizo but these accounts were basically descriptive of the overall appearance of the vegetation at that time. However, information provided by early settlers such as Father Kino (Rudkin, 1952), Ignacio Tirsch (Nunis, 1972) and Lassepas (1859) and the translations of Bagert's observations of 1772 (Brandenburg and Baumann, 1952) will be utilized whenever it is possible.

As a by-product of the systematic work, specimen and label data which must be gathered for floristic purposes (e.g., collector, number, date, altitude, state of plant, etc.) will also be prepared in machine readable form for use with computer programs similar to those developed by Crovello (1972) in order to index and retrieve specimen label data. These electronic data processing applications will facilitate retrieval of the taxonomic information requisite to this proposal's goals and will also make the information more accessible to other biologists who are working in neighboring regions and with related taxa. The PI spent a year at the Smithsonian (1969-70) with the Flora North America Program then in the planning stages of computerization. The experience with specimen data and information retrieval is especially applicable to this portion of the proposed work (Gilmartin, 1970). The specimen and label data which must be gathered in any case are very

amenable to being converted to machine readable form for use with indexing and information retrieval programs.

The proposed study builds upon the previous research of the Principle Investigator with the application of computers to information retrieval in botany (Gilmartin, 1970) and previous research in the geographical study area and with estimates of within-group variation: The Flora in the Vicinity of La Paz (supported by the National Geographic Society) and the PI's research "Quantification of Population Variability" (supported by NSF Grant GB 28104). During the course of trips (Gilmartin, 1964a,b, 1965, 1969c) it became evident to the PI that the Cape District vegetation did not appear, even in the vicinity of various ranches, to be denuded and over-grazed by cattle and goats. This was in sharp contrast to some other arid, tropical areas, for example, the scrub forests of the Santa Elena Peninsula in coastal Ecuador (Gilmartin, 1964a) which did appear to be obviously denuded.

In the Cape District it may be found that the land-use practices have undergone a dramatic increase during the 1940's with the improved roads and the increase in number of motor vehicles (Carter, 1973, personal communication). It is Carter's view that during the years between approximately 1840 and 1940 there may have been only minor changes in land-use practices but that starting just prior to the mid-point of the present century, many changes took place with the consequent depletion or loss of populations, for example of Alvordia and Castela species.

Between 1950 and 1960 the population of La Paz, the center of human population for the district, nearly doubled and again nearly doubled between 1960 and 1970 (Gerhard and Gulick, 1967). Currently the desire for expanded tourism within the Cape District, particularly La Paz in the northern portion and San Jose del Cabo at the tip, has engendered political pressure for doubling the number of head of cattle in order to supply the burgeoning human population. Apparently, governmental engineers have been asked by the Territorial Government to study the feasibility of doing this from the point of view of the Cape District's water resources.

The trend in doubling time of the human population suggests that by 1985 there may well be 100,000 people in the Cape District. Thus, even if the current flora, with exceptions, is robust - the hypothesis is to be tested by the proposed study - it seems likely that land-use may significantly alter the species composition. It is therefore, particularly important to establish now what changes have occurred between 1900 (the time of Brandegee's studies, before the upsurge in population around 1950) and the 1970's today.

At present the domestic grazing animals within the district are mostly cattle, however, there are goats and burros locally and these were even more prevalent previously, particularly near the sites of the past mining operations. The resulting decades of plant-ungulate interaction must have encouraged some introduced plant species thus affecting the species assemblage. These too, of course, will be included in the proposed account of the vascular plants. Information concerning the numbers of ungulate grazers and the numbers of head of cattle present now and in past years will be gathered from records of the Mexican Instituto Nacional de Investigaciones Forestales and extracted from historical accounts such as those of Brown (1887). In essence, information will be gathered on land-use history in the sense of Mooney et al. (1972) and plant evolution in response to man's activities will be examined as suggested by Baker (1972).

Plant introductions (e.g., the genus Hypericum) which are now present in the District, have a way of usurping certain habitats while some native species may be found to be much more rare today than they were during the times of Brandegee's field work there. For example, Dryopetalon crenatum (Brand.) Rollins (Cruciferae) was collected several times by Brandegee and noted by him (1891) to be common at moderate elevations and collected by Purpus in 1902 from near the Cape, but rarely subsequently. Other somewhat fragile species may be revealed by the proposed research. Examples of the opposite situation are also evident in even a cursory

examination of the available collections. Sarcostemma clausem (Jacq.) Schlect. (Asclepiadaceae) was collected by several botanists and noted by Brandegee to be a conspicuous component of the flora in the vicinity of San Jose del Cabo around the turn of the century and is very much evident there today. Several recently collected specimens of this species are housed in the herbarium of the University of California at Berkeley and in the PI's own collection. The same could be said for several different species of Bursera common then and today and perhaps for many other genera as well.

Since the time of Brandegee there has been no thoroughly systematic effort to sample the vegetation of the Cape Region itself although the Belvedere Foundation and the California Academy of Science have launched many expeditions into the Peninsula (Johnson, 1958). Carter has been systematically working in the Sierra de Giganta region to the north of the Cape District for many years (e.g., Carter, 1964). Some expeditions have included the proposed study area as a relatively minor part of more general studies. More collecting, therefore, must be carried out in order to test the aforementioned hypothesis concerning the discriminatory robustness (i.e. robustness of some species) as well as to determine if the putatively less robust ones are in fact on their way out and if so, which introduced species are becoming established.

The putative fragility of some of the species is likely to be related to the insularity of the flora. That the District has in fact been an island during parts of the Cenozoic era is well established. Durham and Allison (1960) and Hammond (1954) summarize some of the evidence for the existence of several periods of subsidence and emergence of the land of the District relative to sea level, and of several intervals of insular isolation of the Cape District from the remainder of the Peninsula during the Cenozoic.

An insular type of flora tends to have a low ratio of species to families,

while a continental flora has more species per family. For example, Gilmartin (1968a) found while examining dioecism in Hawaii, that the flora of Hawaii had a ratio of 8 species per family whereas continental floras have higher ratios, such as 19, e.g., Southern California. In the Galapagos Islands, Wiggins (1971) found 642 species divided among 107 families which represents a ratio of 6.

The Cape District thus seems to follow this trend for insular floras, for according to Brandegee (1892b) there were 98 families (excluding the ferns) with 730 species which produces a ratio of about 7. The insular nature of the District's flora seems evident and the relative fragility of insular floras throughout the world and especially of their endemic components is well established (Carlquist, 1965). These facts would have to be reconciled with this project's findings if, as hypothesized, relative overall robustness is the case.

In addition to obtaining qualitative information about the species assemblage, the attempt will be made to describe the kind and the present extent of each vegetation subtype. Among these are the subtropical strand, the Sonoran Desert and the Gulf Coast subflora (Wiggins, 1960; Shreve and Wiggins, 1964). The arid, tropical scrub forest is the community within which the majority of the cattle are grazed. The other vegetation subtypes will also be sampled, including those of the high mountain and the few arroyos which remain moist through the year. As described in the Methods section, several vegetation sampling methods will be employed by the PI and the Faculty Associate (Robinson, 1968, 1971) in order to establish (in permanent study areas) the present vegetation's composition in different regions subject to varying amounts of grazing and usage. From these data gathered from different areas at one point in time, extrapolations can be made to changes through time in past decades and a secondary and more quantitative baseline is created for comparison during the coming decades.

Intensive herbarium studies will be required to verify determinations. The San Francisco Bay Area is especially rich in herbarium specimens from the study area, housed in the herbaria at the University of California at Berkeley, the Dudley Herbarium at Stanford University and the California Academy of Sciences in San Francisco. Previous work on the PI's collections from the vicinity of La Paz revealed that a great deal of nomenclatural-taxonomic work will need to be done before it will be possible to reasonably and accurately compare the historical species listings with the annotated list to be produced.

The climatic regime for the entire Peninsula including the Cape District is currently being monitored by the U. S. Government. Hastings (1964) and Hastings and Turner (1965) summarize some of these data. This work and the vegetation maps of Hastings et al. (1972) will aid in relating the flora to physical factors and to neighboring floras with somewhat different species components. Hastings and Turner have distribution data for some 2,000 mostly woody species available on punch cards which enables multi-indexing of these with computer programs.

The collections and work of Carter (1964) in the Sierra Giganta to the North of La Paz and separate from the District, as well as hers, Wiggins', Moran's, Thomas', and Porter's excellent collections from within the Cape District, all will be invaluable for the proposed study. The PI has been in contact with Carter at the University of California Berkeley Herbarium and has received much advice and help and plans to remain in contact with her expertise.

The PI has for some time been using techniques of numerical taxonomy to aid in difficult determinations, to sample taxonomic circumscriptions in terms of within-group variation (Gilmartin, 1969a, b), and to sample variation within populations (Gilmartin, in preparation). These numerical taxonomic tools will be very suitable for the current proposed work and the deliniation of taxa necessary for the study just as they applied to the PI's work in Ecuador (Gilmartin, 1972).

During the course of obtaining quantitative estimates of intra- and inter-population variability the PI has obtained some quantitative evidence¹ that species whose various populations have narrow ecological distributions (e.g., Cassia emarginata L., from the District) show strikingly less intrapopulation variability as estimated by mean phenetic distance with a large number of characters than do those species whose populations are found in a variety of habitat-types. Thus it is hypothesized that the within-population variation can be used to predict between population variation (intraspecific variation). It is predicted that species which are endemic to particular subhabitats will evidence significantly lower intrapopulation variation than species found in areas within several subhabitat types. For example, Hypericum schaffneri S. Wats, mostly restricted to the high mountains within the study area should have lower intrapopulation variation than species such as Calliandra brandegeei (B. & R.) Gentry which, while endemic to the Cape District and nearby areas, still grows in a variety of altitudinal subhabitats.

¹Gilmartin, A. J., 1973. Up the Hierarchy, Classification Categories as Related to Variability Within Populations. Contributed paper accepted for presentation by the First International Congress of Systematics and Evolutionary Biology, August 1973.

MATERIALS AND METHODS

The materials for the proposed research are the living representatives of the present flora in the Cape District of the Peninsula of Baja California plus the herbarium specimens that have previously been collected from the area. Together with these specimens is Brandegee's copy of his published list (Brandegee, 1891) annotated in his own hand. The majority of the specimens from the Cape are housed in the three major herbaria in the San Francisco Bay area. In addition, in order to complete the taxonomic work it will be necessary to obtain loans of herbarium specimens and photographs of type specimens from various other herbaria and to obtain additional specimens and data in regard to the current flora.

During the field work in so far as is possible, four sets of specimens will be collected. One set will be deposited in the Instituto Forestales and one at the Jardín Botánico in Mexico City as the PI's collection permit stipulates. One set will be deposited at the U. S. National Museum and one at Berkeley, for it is the latter institution where the bulk of Brandegee's collections are housed including many of his type specimens.

From Brandegee's publications and annotations and from other sources, tabulations will be made of the degrees of abundance and these tabulations will be compared with the situation currently. Five categories of degrees of abundance as noted by Brandegee will be employed: (1) very common; (2) moderately common; (3) rare; (4) collected but without any notes as to abundance; (5) not collected during Brandegee's time. For example, on page 110 of Brandegee (1891) under Clematis, sp., the published account states: "Common in the hedges of irrigated fields and damp localities, between Miraflores and Triunfo". An example of Brandegee's annotations in his own hand is on page 124 referring to Rhus laurina Nutt., "Saw plenty in March". Approximately 20 percent of the species in Brandegee's publications seem to include notes on relative amounts observed.

For those species included in historical records for which no information is available on abundance, the fact of their presence will simply be compared with the presence or apparent absence during subsequent years.

Field trips for collecting will be planned keeping in mind the past collecting record and the seasonal changes in flowering times. The climatic regime (Hastings and Turner, 1965) shows a wet period usually occurring from July to November of December and a dry period from December or January through June. Many plants flower during rainy periods and a few flower during the dry season.

Four field trips of varying durations are planned. As mentioned previously the PI has collected in the study area during two summers, July and August of 1969, a very dry year, and during June and July of 1972, a wet summer. The flora will be sampled at different times of the year with two collecting trips during the winter months, one in December or January of 1973-74 and another in December or January of 1974-75. One collecting trip will be undertaken during the spring of 1974, a time when a few plants flower exclusively and a fourth trip during the late summer of 1974 after the summer rains have commenced and when Brandegee did much of his field work. In this way it is hoped to complete a good sample of the vascular plants including the grasses and in condition suitable for identification. Field trips will be made with assistants in order to more thoroughly cover the terrain. The Faculty associate will have the opportunity during the field work to concentrate on the ecological aspects of vegetation sampling as described below as well as to give special attention to the family Gramineae. In addition, the PI is in contact with Frank Gould who collected grasses in one part of the Peninsula several decades ago and who has been working systematically with the family throughout the Baja Peninsula.

The geographical areas to be concentrated upon for collections are the high mountain peaks, particularly in the southern half of the Peninsula which have been less well collected in recent years; the area near Cabo San Lucas which was

well collected by Brandegee; the Pacific slopes of the mountain ranges, again not much collected and the eastern slopes around Santiago, Miraflores and Caduano, also well collected by both early and more recent collectors.

The field work and collections of biologists around the turn of the century plus the more recent work of Wiggins, Thomas, Porter, Moran, and Carter, as well as those of a few others during the past 25 years in particular, all afford valuable information concerning the existence of many of the species which are seldom collected and the distributions of these and of recently introduced species. Examination of these collections will offer an indication of the relative abundance through the last quarter of a century of these species and of some of the ones which are more common today.

Records of land-use practices as recorded by the Mexican Government publica- tions and noted in newspapers will be examined together with local knowledge from ranchers who have been living in the District for many years. These together with information on local presence and absence of species, estimates of their abundance and growth in various localities within the district now subject to different amounts of land-use, afford the opportunity to interpret some of the effects of land-use upon the species assemblage.

Prior to each of the four field studies, an aerial reconnaissance flight will be made of the Cape District to plan collecting strategy for the field work. In addition, the aerial reconnaissances will help determine the current vegetation and land-use patterns and will aid in selecting the several areas for community sampling.

Since it is the intent of this research to establish the relative robust- ness of species within the Cape flora through comparisons of that now extant with what is presumed to have been present at the time of Brandegee's visits there, it is felt that statistically valid, yet reasonably rapid community sampling techniques must be used to establish with some degree of precision the present

phytosociological relationships. Further, permanently marked study areas (cement posts embedded in soil and flush with the surface) will provide a basis for precise analyses of vegetative trends through the years to come.

Because there is a variation in the nature of the vegetation from place to place, two sampling techniques will be used. In those areas most aptly described as tropical scrub the point-centered quarter of Cottam and Curtis (1956) will be used. Though originally designed for forest sampling, it has been used with success in the warm desert communities of Southern California. In those areas where grasses and low herbs are dominant, a point frame as modified by Becker and Crockett (in press) will be employed. It offers the advantages of speed in surveying and statistical validity. The faculty associate is experienced with both techniques and well qualified to supervise this particular aspect of the research program.

It is estimated that there will be approximately 9,000 specimens of vascular plants representing the entire collection record from the study area. The electronic data processing necessary for indexing and retrieval of specimen and label information for these specimens will be carried out similarly to the computerization of the Greene Herbarium as described by Crovello (1972). Although there may be some changes made as work progresses, the essential field (classes of information occupying proscribed columns) for each of the approximately 9,000 specimens for the proposed work are seven and as follows: (1) Family, (2) the binomial and author, (3) the state of the specimen, i.e., in flower, bud or fruit or none, or any combination; (4) collector's name and collection number; (5) herbarium in which the specimen is housed; (6) altitude in meters; (7) locality (in terms of distance and direction from nearest center of population or historic point). In addition, whenever known the following information will also be coded: (1) the name of an authority who may have determined the specimen and date of determination, (2) type if it has ever been so designated (no decision will be made as to which kind of type), (3) the

plant species with which the specimen was noted to be associated, (4) name of species folder in which specimen is located if different from the specimen label, (5) common name in Spanish.

The above fields will be subject to trial after coding about 100 specimens in order to ascertain what changes in format or what additions may be necessary, if any. The various programs for retrieving information will be written by students in a class in computer programming at the Monterey Peninsula College Computing Center at no charge and under the direction of instructor Bela Banathy (1968). The computer to be used for this processing is a Burroughs 1714 and up to two hours of free time per week is available to the PI. Advice will be obtained from Crovello at Notre Dame who has experience with this type of EDP (1967, 1970) including the computerization of the Greene Herbarium (1972). The experience of Crovello and co-workers will be sought especially in regard to matters of error correction procedure, a necessary and sometimes difficult portion of information retrieval systems.

Specimen and label data for some of the Cape District specimens at the Herbarium of the University of California at Berkeley have been prepared on typed 5 X 8 cards by the PI and these are ready to be coded and punched on IBM cards now. It is planned to utilize IBM punch cards for coding data. While paper tape is an alternate possibility it is thought that use of the punch cards may be the simpler method for the proposed work.

The proposal also requests funds for employing the methods of numerical taxonomy which are applicable to the study. These methods which are based upon scoring species or individual specimens using defined and coded character-lists are described in many publications including Sokal and Sneath (1963) and Gilmartin (1968b, 1969) and many others as for example, in the described modifications of Legendre and Rogers (1972). Basically the first step in an application of numerical taxonomy for aiding identifications and quantifying circumscriptions such as previously carried out by

the PI involves the development of a character-list. A character-list of 264 characters for the plant family Leguminosae has been coded with states. This family is particularly well represented in the District's flora. The list has been used and tested with specimens of several different species and will be used during the summer of 1973 for scoring individuals of species of Hymenaea (Caesalpinoideae) in conjunction with the work of Langenheim and co-workers on the taxonomy of species Hymenaea and related genera currently under investigation by them.

Character-lists for three other families have also been prepared during the course of prior work, the Asclepiadaceae, Bromeliaceae and Umbelliferae and individuals have been scored and submitted to the PI's DISTA program for computing mean phenetic distance. Additional character-lists will be developed for other families as sufficient data are gathered to verify that numerical phenetic comparisons would be helpful. Data gathered in this study will be prepared in machine readable form of scored characters when it appears to be desirable to estimate variability (the mean phenetic distance of Gilmartin, 1969a) within populations and within and between putative species.

The computer programs for this numerical taxonomic portion of the proposed research have been written and have been running smoothly at the Stanford Computation Center on the IBM 360-67 for over a year. In addition, recently the tapes for the most recent version of NT-SYS prepared by James Rohlf and associates at Stonybrook have been received by the PI, and are currently being adapted to the installation at the Stanford Computation Center. These programs will also be used when deemed appropriate for standard types of cluster analysis and phenogram printouts.

SUMMARY

The Cape District, Baja California Sur, is an important geographic study area. It contains a variety of xeric habitats in a tropical environment and includes elements of an insular tropical flora. Because of the information and the specimens accumulated from the region around 1900 and because of the region's accessibility and the insularity (which provides basic data for illuminating trends and rates of evolution) the area is particularly suited for study and for testing the hypothesis of relative and discriminatory robustness of tropical, arid assemblages of plant species. The area was subjected to some intensive qualitative biological work about 80 years ago which provides data on presence of species and botanical notes on their abundance such as are not commonly available for many tropical areas.

The hypothesis of relative robustness of this flora is a testable one and the results will bear on land-use practices not only locally but throughout much of the arid, tropics today. The work is significant to the entire problem of the effects of land-use in the arid tropics of which much of the world's tropical areas consist. However, robustness is a relative term and the current plans of the Mexican government and of industry for development of this small tropical area may rapidly reduce the flora to one no longer having the present dramatic variability. Ecological methods of vegetation sampling will be employed at various permanently marked points within the district in order to help interpret current and future land-use practices and their effects on the species assemblage.

The proposed study is important to plant systematics as it will utilize the results of previous botanists' efforts which are available in herbarium specimens, making this more easily accessible, and will summarize this information as well as completing it with needed, further selective collections. Knowledge of this flora with its low species to family ratio and its many endemics, can help to elucidate rates of evolution and provide biologists with additional baseline data on xeric, tropical biota. The study will synthesize data from many sources and will utilize

modern computer techniques which the PI has previously employed for retrieval of specimen and label data and for estimating within group variability.

LITERATURE CITED

- BANATHY, Bela. 1968. Instructional Systems. Fearon Publ., Inc. Palo Alto.
- BRANDEGEE, T. S. 1891. Flora of the Cape District of Baja California. Proc. Calif. Acad. Ser. 2, 3:108-182.
- _____. 1892a. Additions to the Flora of the Cape Region of Baja California. Proc. Calif. Acad. Ser. 2, 3:218-227.
- _____. 1892b. Distribution of the Flora of the Cape Region.
- _____. 1894. Additions to the Flora of the Cape Region of Baja California. II. Zoe 4:398-408.
- _____. 1903. Notes and New Species of Lower California Plants. Zoe 5(9): 155-177.
- BAKER, H. G. 1972. Human Influences on Plant Evolution. Econ. Bot. 26(1):32-43.
- BECKER, D. A., and J. J. Crockett. 1973(?). Evaluation of Sampling Techniques on Tall-Grass Prairie. In Press.
- BENTHAM, G. 1846. The Botany of the Voyage of the Sulphur. London. 195 pp.
- BRANDENBURG, M. M. and Carl L. Baumann. 1952. (Translation of Johann J. Bagaert, 1772.) Observations in Lower California, 1772. Univ. Calif. Press, Berkeley, Calif. pp. 1-218.
- BROWN, J. Ross. 1887. Resources of the Pacific Slope. New York. 678 + 200 pp.
- CARTER, A. 1964. The Genus *Alvordia* (Compositae) of Baja California, Mexico. Proc. Calif. Acad. Sci. 30(8):157-174.
- CARLQUIST, S. 1965. Island Life. Natural History Press, Garden City, N.Y. 451 pp.
- COTTAM, G. and J. T. Curtis. 1956. The Use of Distance Measures in Phytosociological Sampling. Ecology 37:451-460.
- CROVELLO, T. J. 1967. Problems in the Use of Electronic Data Processing in Biological Collections. Taxon 16:481-494.
- _____. 1970. Standards for Recording Specimen Label Data for Electronic Data Processing. Amer. J. Bot. 57:752.
- _____. 1972. Computerization of Specimen Data from the Edward Lee Greene Herbarium (ND-G) at Notre Dame. Brittonia 24(2):131-141.
- DURHAM, J. W. and E. C. Allison. 1960. The Geologic History of Baja California and Its Marine Faunas. Syst. Zoo. 9(2):47-91.

- GERHARD, P. and H. E. Gulick. 1967. Lower California Guidebook. Arthur Clark Co., Glendale, Calif. 243 pp.
- GILMARTIN, A. J. 1964a. Algunas especies leñosas xerofilosas en el litoral del Ecuador, especialmente en La Península de Sta. Elena, Adial (Ecuador) 1:14-19.
- _____. 1964b. La expedición internacional a las Galápagos. Ciencia (Ecuador) 7(1):3-4.
- _____. 1965. Las Bromeliaceas de Honduras. Ceiba 11(2):1-82.
- _____. 1968a. Baker's Law and dioecism in the Hawaiian flora. Pac. Sci. 22(3):285-292.
- _____. 1968b. The Bromeliaceae of Ecuador, an alpha-numerical taxonomic study. Ph.D. Thesis, Univ. Hawaii. Univ. Microfilms, 30(1) 732 pp. (order No. 69-10,598).
- _____. 1969a. The quantification of some plant-taxa circumscriptions. Amer. J. Bot. 56(6):654-663.
- _____. 1969b. Numerical phenetic samples of taxonomic circumscriptions in the Bromeliaceae. Taxon 18:378-392.
- _____. 1969c. An hypothesis concerned with evolution in the tropics. Amer. Philos. Soc. 1969:302-304.
- _____. 1970. Flora North America: work in progress on the Genus Carex. 63 pp. Mimeo. Smithsonian, Washington, D. C.
- _____. 1972. The Bromeliaceae of Ecuador. Phaner. Monog. IV, 255 pp.
- GOLDMAN, E. A. 1916. Plant Records of an Expedition to Lower California. Contr. U. S. Nat. Herb. 16(14):309-371.
- _____. 1951. Biological Investigations in Mexico. Smithsonian Misc. Collections. Vol. 115, 476 pp.
- GRAY, A. 1861. Enumeration of a collection of dried plants. Proc. Amer. Acad. Arts and Sci. 5:153-173.
- HAMMOND, E. H. 1954. A geomorphic study of the Cape Region of Baja California. Univ. Calif. Publ. in Geography 10:45-112, 16 figs., 4 maps.
- HASTINGS, J. R. 1964. Climatological Data for Baja California. Tech. Rpts. Met. and Climatology of Arid Regions. No. 14. Univ. Arizona Inst. Atmospheric Physics. 132 pp.
- HASTINGS, J. R. and R. M. Turner. 1965. Seasonal Precipitation Regimes in Baja California, Mexico. Geogr. Ann. 47A:204-223.

- JOHNSON, B. H. 1958. The botany of the California Academy of Sciences Expedition to Baja California in 1941. *Wasmann Jour. Biol.* 16(2):217-315.
- LASSEPAS, U. U. 1859. De la Colonización de la Baja California y Decreto de 10 de Marzo de 1857. Primer memorial Mexico. 250 pp.
- LEGENDRE, P. and D. J. Rogers. 1972. Characters and clustering in taxonomy: A synthesis of two taximetric procedures. *Taxon* 21(5/6):567-606.
- MOONEY, H. A., E. L. Dunn, F. Shropshire, L. Song, Jr. 1972. Land-use history of California and Chile as related to the structure of the sclerophyll scrub. *Madroño* 21(5):305-319.
- NELSON, E. W. 1921. Lower California and Its Natural Resources. *Mem. Nat. Acad. Sci.*, Vol. 16, 194 pp.
- NUNIS, D. B. Jr. 1972. The Drawings of Ignacio Tirsch, A Jesuit Missionary in Baja California. Dawson's Book Shop, L. A. 125 pp.
- ROBINSON, R. H. 1968. An Analysis of the Ecological Factors Limiting the Distribution of a Group of Stipa pulchra Associations. Ph.D. Dissertation, Oklahoma State University.
- _____. 1971. An analysis of some ecological factors limiting the distribution of Stipa pulchra. *Kor. J. Bot.* 14(4).
- RUDKIN, C. 1952. Father Kino at La Paz - April 1683. (A translation of the *Relación Puntal de 1683*.) Glen Dawson, L.A.
- SHREVE, F. and I. W. Wiggins. 1964. Vegetation and Flora of the Sonoran Desert. Stanford Univ. Press, Stanford, Calif., 1740 pp. in two volumes.
- SOKAL, R. R. and P. H. A. Sneath. 1963. Principles of Numerical Taxonomy. W. H. Freeman and Co., San Francisco, 359 pp.
- VASEY, G. and J. N. Rose. 1890. List of plants collected by Dr. Edward Palmer in Lower California in 1889. *Contr. U. S. Nat. Herb.* 1(3):63-92.
- WIGGINS, I. 1960. The origin and relations of the land flora. Symposium: The Biogeography of Baja and Its Adjacent Seas. *Syst. Zoo.* 9(3/4):148-165.
- WIGGINS, I. and D. M. Porter. 1971. Flora of the Galapagos Islands. Stanford Univ. Press, Stanford, California. 998 pp.



Figure 1. Cape District, Baja California.

CURRICULUM VITAE

Amy Jean Gilmartin

Biographical Summary:

- 1932 Born at Red Bluff, California
- 1941-50 Early schooling in Hawaii, graduated from Hilo High School
- 1950-54 Pomona College, California, B.A. in botany
- 1954 Married
- 1954-56 University of Hawaii, M.Sc. in botany
- 1956-58 University of British Columbia, additional graduate course work, mathematics
- 1957-61 Gave birth to three children
- 1961-64 Residence in Latin America
- 1965-68 University of Hawaii, Ph.D. in botany (June 1968)
- 1969-70 Smithsonian Institution
- 1970- Monterey Peninsula College

Research Interests and Experience since 1968:

- 1967-68 Flowering time and differentiation in tropical species; 1967 (summer) field work in southern Sierra Madre Occidental of Mexico; further field work 1968 (May); living bromeliads maintained and studied in Monterey, California.
- 1968-69 Intra-taxon and intra-population variability in ultra-xeric, xeric and mesic tropical populations; the effects of the activities of human populations upon tropical xeric vegetation; summer field work Cape District, Baja California. National Geographic Society research grant.
- 1969-70 Taxonomic studies on the Bromeliaceae and Asclepiadaceae, at the Smithsonian Institution; Research Associate (1/2) with AIBS Flora North America Project; adapted the Morse matrix system for computer-assisted identification and key-generation and tested with genus Carex; National Science Foundation Research Grant.
- 1970-71 Epidermal characteristics and habitat type in Ecuadorian Bromeliaceae; population studies in the Asclepiadaceae of California floristic studies on the flowering plants of the Cape District, Baja California. National Geographic Society and National Science Foundation research grants.

- 1970-71 Epidermal characteristics and habitat type in Ecuadorian Bromeliaceae; population studies in California, variability within and between populations, National Science Foundation research Grant; flora in the vicinity of La Paz, Cape District, Baja California Sur, National Geographic Society Grant.
- 1971-72 Floristic studies of portions of the Cape District; variability within and between populations of temperate and tropical species, National Geographic and National Science Foundation Grants.
- 1972- Variability within and between populations; identifications of Bromeliaceae from Panama; flora of the Monterey Peninsula; local environmental impact studies; National Science Foundation Grant.

BIBLIOGRAPHY

Amy Jean Gilmartin

Minor Publications and Abstracts Since 1968:

- GILMARTIN, A. J. 1968. The Bromeliaceae of Ecuador, an alpha-numerical study. Ph.D. thesis, Univ. Hawaii, Univ. Microfilms, Ann Arbor. Dissert. Abstr. 30(1)
- GILMARTIN, A. J. 1968. Biology in Central America. Assoc. Trop. Biol. Newsletter 13:4-6.
- GILMARTIN, A. J. 1969. The sex life of bromeliads. Bromeliana 50:37-44.
- GILMARTIN, A. J. 1969. Historical note on the Palau Islands. Assoc. Trop. Biol. Newsletter. 16:8-9.
- GILMARTIN, A. J. 1969. Current foreign exchange programs which include tropical biology. ibid. 18:2-6.
- GILMARTIN, A. J. 1969. Tropical Island Biogeography Symposium. ibid. 19:2-4.
- GILMARTIN, A. J. 1969. An Hypothesis Concerned With Evolution In The Tropics. Amer. Philos. Soc. 1969:302-304.
- GILMARTIN, A. J., and M. J. HARVEY. 1970. Alpha taxonomy, bio-systematics and numerical phenetics: the essential fusion. Amer. J. Bot. 57(6) abstract.
- GILMARTIN, A. J. 1970. XI International Botanical Congress: tropical research papers. Assoc. Trop. Biol. Newsletter 20:4-11.
- GILMARTIN, A. J. 1970. First Colloquium on Rare and Endangered Species of Hawaii. ibid. 22:1-4.
- GILMARTIN, A. J. 1971. A prerequisite for numerical phenetics estimates of intra-taxon distance. Proc. 5th Numerical Taxonomy Conference, Toronto. abstract.
- GILMARTIN, A. J. 1971. Plants and People of Ecuador. Jour. Bromel. Soc. 21(6):125-134.

Scientific Papers Since 1968:

- GILMARTIN, A. J. 1968. Taxonomic notes on some Bromeliaceae of Ecuador. Phytologia 16(2):153-167.
- GILMARTIN, A. J. 1968. Baker's Law and dioecism in the Hawaiian flora. Pacif. Sci. 22(3):285-292.

- GILMARTIN, A. J. 1969. Numerical phenetic samples of taxonomic circumscriptions in the Bromeliaceae. *Taxon* 18:378-392.
- GILMARTIN, A. J. 1969. Test of a hypothesis concerned with evolution in the tropics. *Amer. Phil. Soc. Yr. Bk.* 1969: 302-304.
- GILMARTIN, A. J. 1969. The quantification of some plant-taxa circumscriptions. *Amer. J. Bot.* 56(6):654-663.
- GILMARTIN, A. J. 1970. Flora North America: Work-in-progress on the genus Carex. 63p. mimeo. Smithsonian, Washington, D.C.
- GILMARTIN, A. J. 1971. Family Bromeliaceae. in Wiggins, Ira and D. Porter (eds.) *Flora of the Galapagos*. Stanford Univ. Press, Stanford.
- GILMARTIN, A. J. 1972. Trichomes of some Ecuadorian Bromeliads. *Morris. Arbor. Bull.* 23(2):19-23.
- GILMARTIN, A. J. Transandean Distributions of Bromeliaceae in Ecuador. Accepted, Ecology.
- GILMARTIN, A. J. Phenetic distance estimates and the problem of missing data. draft typescript. *Syst. Zool.*
- GILMARTIN, A. J. Variability Within Populations As Related to the Hierarchy of Classification. In preparation.

Books:

- GILMARTIN, A. J. 1972. The Bromeliaceae of Ecuador. *Monogr. Phaner.* vol. V. J. Cramer, Lehre, Germany. Vol. V, 255 pp. 18 pls.

RESUME OF RESEARCH ASSOCIATE

Richard H. Robinson

Biographical summary:

- 1924 Born, Atascadero, California
- 1942 Forest Service, U.S. Department of Agriculture
- 1942-46 Military service, Infantry, U.S. and S.E. Asia, 1st Lieutenant
- 1946-48 Naturalist, National Park Service, summers
- 1949 B.A. zoology, University of California, Berkeley
- 1950 Naturalist, National Park Service
- 1951-52 Military service, Infantry, Japan and Korea, 1st Lieutenant
- 1952-53 Biologist, California Department of Fish and Game
- 1954 M.A. Biology, Fresno State College
- 1954-55 Biology Teacher, Roosevelt High School, Fresno, California
- 1955-67 Instructor in Biology, Monterey Peninsula College
- 1968 Ph.D. Botany (ecology), Oklahoma State University
- 1968-70 Chairman, Life Science Division, Monterey Peninsula College
- 1970-72 Visiting Professor Kon Kuk University and Graduate Lecturer in Ecology, Seoul National University, Korea
- 1972- Monterey Peninsula College, Department of Biology

Research interests:

Ecology, population and environmental biology, and grassland research from the management point of view.

Awards, fellowships and offices:

Forbes Ripley Military Scholarship
National Science Foundation Summer Fellowships
Sigma Xi Grant-in Aid of Research
Treasurer California Native Plant Society, local chapter
Board of Directors, Nature Conservancy, local chapter
President Academic Senate, Monterey Peninsula College

Publications:

- ROBINSON, R. H. 1958. A size record for the common garter snake. *Herpetologica* Vol. 13.
- ROBINSON, R. H. 1958. Use of nest boxes by wood ducks in the San Joaquín Valley, California. *Condor*, Vol. 60, No. 4.
- ROBINSON, R. H. 1971. Science Education - Impressions of a foreign professor. *Science Education*, Vol. 76, No. 1.
- ROBINSON, R. H. 1971. An analysis of some ecological factors limiting the distribution of *Stipa pulchra*. *Kor. J. Bot.* Vol. 14, No. 4.
- ROBINSON, R. H. and I. K. Lee. The tall grass prairie of Cheju Island, Korea. In preparation.

BUDGET

	1973/74	1974/75	1975/76
A. Wages and Salaries			
1. Senior Personnel			
a. Principal Investigator			
academic year (20%)	\$3,034	\$3,186	\$3,345
summer (2/9's)	3,370	3,539	3,717
b. Faculty Associate			
summer (1/18th)	916	962	
2. Other Personnel			
a. Graduate Assistant (summer)	600	630	662
b. Prebaccalaureate Student Assistant			
(1/2 time, 9 months at \$2.00/hr.)	1,440	1,512	1,588
c. Key Punch Operator (\$2.50/hr.)	938	1,973	1,020
B. Fringe Benefits (16, 16.5, 17%)	1,648	1,947	1,756
C. Total Salaries, Wages and Fringe Benefits (A + B)	11,946	13,749	12,088
D. Permanent Equipment			
1. Two herbarium cabinets	345		
E. Expendible Equipment and Supplies			
1. Field supplies	360	200	150
2. Film and film processing	75	150	75
F. Travel			
1. Domestic R/T Economy			
a. National Meeting, PI	340	360	380
b. National Meeting, Faculty Associate		360	
2. International			
a. Mexico - field work (R/T tourist)	570	980	420
G. Publication Costs		200	210

BUDGET (CON'T.)

	1973/74	1974/75	1975/76
H. Computer Costs			
1. IBM 360-67 at \$9/min (SCC)	360	388	204
2. Burroughs 1714 at \$45/hr (MPC)	No cost	No cost	800
3. Program consulting, interfacing with computer at \$15/hr (SCC)	150	79	83
4. Disc cartridges	195	195	
I. Other Costs			
1. Field expenses, pack animals food, local assistance	504	600	364
2. Aircraft charter at \$20/hr.	80	168	88
3. Shipping and communication	70	100	50
4. Surface transportation to San Francisco Bay Area herbaria.	100	105	110
J. Total Direct Costs (C through I)	15,095	17,634	15,022
K. Indirect Costs (34.61, 35, 35.5% of salaries and wages)	4,134	4,812	4,291
L. Total Costs	19,229	22,446	19,313
M. Total Budget Rounded	19,230	22,445	19,315
Grand Total			\$60,990

DATE RECEIVED:

11/15/74

Routing:

		Initial
April		
Abbott		
Bailey		
Hersh	2	sh
Hanley		
Rogers, Dave	1	✓
Rogers, Connie		
Louis		✓
McArthur		
von Borstell		
Jose Saldana		
Secretary		

Filing:

Original

?

Copies:

In

✓ ok

Out

Internal

Administration

Fiscal/Contract

Organization

Project

Proposal

COMMENTS:

shall we start
a file for this
kind of thing? yes

There is already a file
somewhere with
recipients of proposals
in it.

NOV 15 1974

cc: John Marr,
Dave Rogers

NATIONAL SCIENCE FOUNDATION
PROPOSAL RATING SHEET

Reviewer: Charles C. Slater
Professor of Business

Proposal No. BMS-7502010
Investigator HANNON, Bruce M.
Institution Univ. of Illinois
Please return to: Ecosystem Analysis
If possible by: 10/1/74

Comments (to be typed on additional sheet if necessary)

Dr. Hannon's proposal has some very attractive features and is concerned with a significant problem. However, the proposal suffers from a serious shortcoming. It appears to focus on the equilibrium problem and as such seems to be drawn to utilizing economic theories from the tradition of neo-classical micro-economic analysis. The problem is that much of this tradition of analysis is in the nature of an ideal construct which does not yield testable propositions. The apparent dependence on non-testable economic doctrine is exemplified by Figure 4 in the paper, "Marginal Product Pricing in the Ecosystem," where the diagram does not indicate any feedback loops.

The equilibrium situation whether biological or economic is subject to perturbation. Control theory has emerged as a mean of describing the interaction processes of dynamic systems. It seems to this reviewer that a more useful model to assess the performance of ecosystem would be one of the more dynamic control theory designs rather than the neo-classic economics which has the not too well hidden traps of the ideal construct of transitivity of wants and other non-testable behavioral assumptions.

OVERALL RATING

- ☐ EXCELLENT
☐ VERY GOOD
☒ GOOD
☐ FAIR
☐ POOR

Signature of Reviewer:

Other suggested reviewers (optional):

msc?

UNIVERSITY OF COLORADO
Taximetrics Laboratory
Department E.P.O. Biology
Boulder, Colorado 80302
Phones: 492-6909
492-8598

February 27, 1975

Editor
Science
American Association for
the Advancement of Science
1515 Massachusetts Avenue, N.W.
Washington, D. C. 20005

Gentlemen:

I won't bore you with details (such as sickness, absence from the country, etc.) which have prevented me from an earlier return of this manuscript. But since we do not feel that the paper merits printing in Science, I do not feel that the delay is serious.

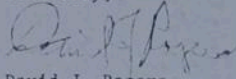
I asked one of our experts in the computing center, whose specialty is computer graphics, to read the paper to add to my opinion. If you like, I can supply his name.

In content, the paper is interesting and informative, but not unique. The filtering and smoothing techniques employed are commonplace and their extension to graphics display is not new. The specific application of these techniques shed no new light on the ability to screen and massage data to establish "spatial and temporal" trends.

In form, the paper is somewhat verbose, with run-on sentences. The outlines is good, but the presentation needs considerable editing.

In summary, the paper is interesting, but not unique in methods, nor is it at the forefront of the graphics area.

Sincerely,



David J. Rogers
Professor of Biology

DJR:jkb

Enclosure