FOREIGN TRAVEL REPORT

WESTERN AUSTRALIA AND TASMANIA

August 20 - November 8, 1981

OBJECTIVES

To procure plant samples for the National Cancer Institute's (NCI) anticancer screening program: (a) 750 general samples (3 to 5 pounds each) represented by 47 genera new to the program at $28 per sample; and (b) 150 pounds of *Notelaea ligustrina* root (Oleaceae) at $7.00 per pound.

SUMMARY

Procurement of general samples was discontinued in early October as a result of NCI budget cuts. In winding down an ARS-NCI cooperative program of 21 years, FY 82 funds were provided for only re-collections; therefore, work in Australia continued for a re-collection of *Notelaea ligustrina*. During a five-week period in Western Australia, 758 general samples were obtained at $18 per sample, and 60 of 180 genera represented are new to the screen. *Notelaea ligustrina* was re-collected from Tasmania that included 398 pounds of root and 50 pounds of stembark for only about $2.00 per pound. Thus, travel to Australia exceeded original expectations in terms of quantity, quality and cost.

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DETAIL

Introduction

Plant procurement for the National Cancer Institute's (NCI) anticancer screening program follows a three-step process. (1) The initial objective is to sample a broad diversity of plants. General samples, consisting of root, bark, twig, leaf or any combinations of these, weigh 3 to 5 pounds and undergo standardized extraction and testing procedures; (2) Depending on antitumor activity criteria, 1 to 10% of the general samples later need to be re-collected in amounts of 100 to 500 pounds for isolation of active agents. Pure compounds undergo further testing against a panel of five mouse tumor lines and three human tumor lines (carried in athymic mice)*. Those that meet panel criteria may be scheduled for preclinical and/or clinical studies in humans; and (3) Massive samples usually one or more tons, are then required.

This stepwise elimination (screening) process is generally regarded as the NCI screen. About one in every thousand species initially tested become candidates for preclinical studies. The term 'screening' is also used in synonomy with testing at any one stage of the evaluation.

Field exploration requires different strategies for each of the three types of samples (small, large and massive). Small samples are collected as species are encountered: a random approach that taxes one's experience in utilizing mnemonics to acquire the greatest diversity with the least amount of duplication. Locating species in large populations for a re-collection can present a deductive challenge in putting together field observations, ecological information from floras, and knowledge of local geography and

*M. Suffness and J. Douros, 1982. "Current Status of the NCI Plant and Animal Product Program." Lloydia 45(1):1-14. A "bypass" panel is also used in certain cases.

vegetation. Massive samples demand extensive literature research, field reconnaissance and much attention to logistical details in organizing labor, transportation, drying and shipping arrangements. Field work in Australia was targeted for small and large samples.

An estimated 1/4 million species of higher plants are distributed in 12,000 genera and 350 families. In a hierarchial classification, it is felt that genera, more than species or families, best reflect chemical/ morphological diversity. My experience in studying antitumor/medicinal-folkloric relationships suggest a closer correlation between the genus and species level. Infrataxonomic categories, such as subgenera and sections, may correlate better but are rarely used in general taxonomic or floristic works. One alternative is to follow a splitter's approach in a classification of genera rather than the more traditional conservative viewpoint. In screening, emphasis has been placed on collecting genera new to the program and also to exclude those on the basis of 100 or more extracts tested.

It might seem worthwhile to apply the average size of a genus to screening guidelines; however, when numbers of species per genus are plotted, one discovers a hollow curve. This is exemplified in Table 1 with data I compiled in 1975 for numbers of species tested per genus. Note that genera with only a single species tested include 1,672 genera which represents about 47% of all genera screened in the program (higher plants). Near the end of the table, one can calculate that probably less than 39 genera account for more species. The hollow curve is not an unusual pattern, but a very important concept overlooked by many scientists. It applies not only to taxa, such as plant genera, but to area and abundance distributions of all living organisms.

The available number of species for screening depends on quantities of plant material to be collected. Keeping a hollow curve distribution in mind, I estimate only about 20% (50,000 species) of the world flora is readily available to the NCI screen. With intensive procurement efforts, this might be stretched to 75,000 species. Recent advances in tissue culture techniques could lead to 'plant culture screens' that utilize only fragments instead of populations of plants. This would increase availability to many more species*.

Since the program's inception (1957), about 35,000 species in 5,000 genera have been tested. This vast screening experience has led to preclude about 1/4 of the world flora from further screening, an estimated 66,000 species distributed in about 300 common genera. As previously indicated, these are genera excluded on the basis of 100 or more extracts tested. Additionally, several thousand common species are also excluded on the basis of 6 or more extracts tested. Together, the unwanted taxa (genera and species) are regarded as 'SLOP' for "Species Low On Priority." Extracts are used as a data base for SLOP because of economical reasons; it would be preferable to use collections and species data. We estimate that an extensively screened genus is represented by at least 15 species and those species with six or more extracts tested are equivalent to having been collected on two or more occasions.

SLOP guidelines evolved in 1979 and have added a new dimension to plant procurement. Figure 1 shows the world divided into 58 floristic regions with each color-coded into one of three zones. In terms of cost effectiveness, with good planning and some knowledge of the local flora, field exploration is considered counter-productive in the red zone ('stop'), but can be

*One might visualize emphasis on rare genera that are threatened or endangered of becoming extinct.

effective in the yellow zone ('caution') and highly productive in the green zone ('go'). Africa has good examples of all three. Zambia (yellow) has Marquesia forest (seasonally dry-sclerophyllous) where about half of the samples collected at random would meet NCI guidelines and include 7% of the genera as new to the program. Brachystegia-Julbernardia (Miombo) Woodland is also common in Zambia but less than 30% of the samples obtained (randomly) in this vegetation type would be accepted. Nearby Malawi (red zone) has primarily Afro-montane forests and derived grassland types where 80% of the samples would represent SLOP. On the west coast, Cameroun has both red Afro-montane and green lowland rain forests. In the latter, I would expect 80% or more of the samples to meet the guidelines and at least one-third of all genera represented to be new to the NCI screen.

Planning: Western Australia #1 Region for General Samples

Travel to distant areas has become attractive as a result of SLOP guidelines. Although SLOP evolved in 1979, Dr. Robert Perdue, Jr. (Chief, Plant Taxonomy Laboratory) included Australia on his world-wide travel early in 1978. Western Australia was one of many places he targeted for new procurement contracts. Except for already established firms that supply botanical products, new potential suppliers are sometimes reluctant and often lack sufficient time and capital for investment. On the other hand, it should also be realized that BARC has a large investment in experienced field personnel.

Planning for Western Australia (WA) began 14 months in advance with communications to Dr. Paul G. Wilson, Senior Botanist, Western Australian Herbarium and to the American Embassy in Canberra. Dr. Wilson kindly forwarded my letter to the Department of Fisheries and Wildlife for a collecting permit and provided information needed to evaluate costs. In a memorandum to Dr. James Duke (Chief, Economic Botany Laboratory), dated November 12, 1980, I indicated that I could collect up to 700 samples, represented by 30 to 60 new genera, at a cost of $28 per sample (then figured at $24 plus 15% for inflation). Later, I refined the expected number of new genera to 47 (memorandum dated January 14, 1981) and raised my overall goal to 750 samples (memorandum dated July 23, 1981). Dr. Matthew Suffness (Acting Chief, Natural Products Section, NCI), was quick to recognize the potential value in screening WA samples and gave a strong endorsement of the proposed WA trip in his memorandum dated January 16, 1981. (Memoranda cited are included with this report).

Based on a letter to the American Embassy, The American Consulate in Perth assisted by obtaining various references on vegetation and road maps which I needed to better define prospective collecting areas. They also made reservations for 4 x 4 trucks and lodging in Perth before my arrival.

Letters were also sent to the University of Western Australia for solicitation of student help.

About a month before my departure, I proposed re-collecting Notelaea ligustrina root at $7 to $10 per pound. The American Embassy made the initial contacts with C.S.I.R.O. who in turn suggested that I contact the Tasmanian Forestry Commission since Tasmania appeared to be the best place to collect Notelaea (also in Victoria and New South Wales). Communications concerning permission and assistance from the Tasmanian Forestry Commission continued until mid-October, long after my arrival in WA. The Perth Consulate assisted in the typing of correspondence.

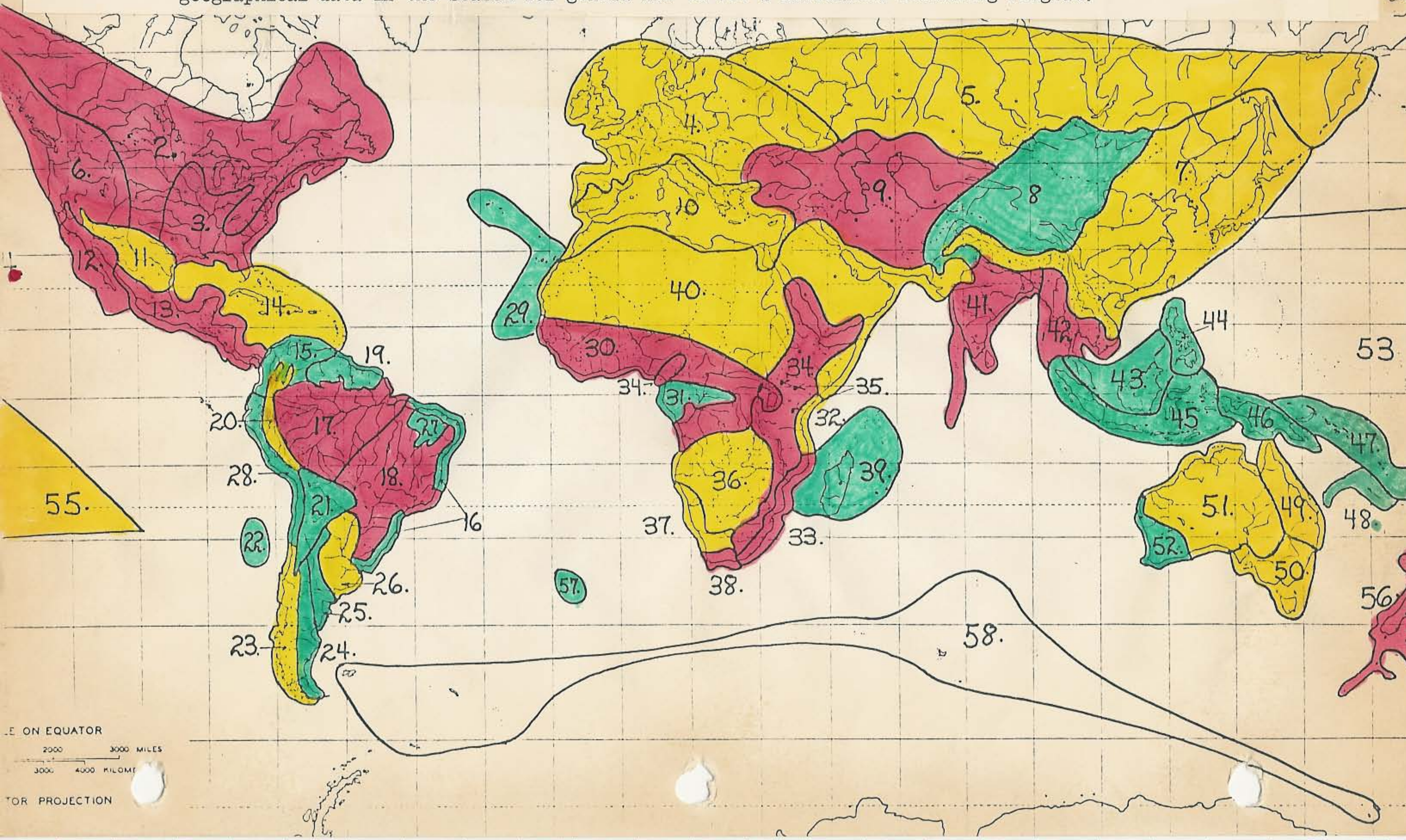
FIGURE 1. FLORISTIC REGIONS OF THE WORLD COLOR CODED TO SHOW COST EFFECTIVENESS FOR PROCUREMENT OF GENERAL SAMPLES

RED = STOP (COUNTERPRODUCTIVE)

YELLOW = CAUTION

GREEN = GO (MOST PRODUCTIVE)

Random Sampling most productive in W. Australia (#52), New Caledonia (#48), Equatorial African Rain Forest (#31), Madagascar (#39), Patagonia (#24) and Monte (#25). Yellow transition zones expected between red and green where not shown. Designed by R. Spjut for Jim Duke's Computer Program to code geographical data in the search for genera new to NCI's Anticancer Screening Program.



KEY TO THE FLORISTIC REGIONS OF THE WORLD

1. ARCTIC & SUBARCTIC
2. BOREAL AMERICA
3. SOUTHEASTERN U.S.
4. EUROPE
5. BOREAL ASIA
6. PACIFIC NORTHWEST AMERICA
7. SINO-JAPANESE REGION
8. CENTRAL ASIA
9. SOUTHWEST ASIA
10. MEDITERRANEAN
11. CHIHUAHUAN & GREAT BASIN DESERTS
12. SONORAN & CALIFORNIAN DESERTS & CHAPARRAL
13. CENTRAL AMERICA
14. WEST INDIES
15. NORTH COLOMBIA & VENEZUELA
16. COASTAL BRAZILIAN RAIN FOREST
17. AMAZON
18. BRAZILIAN HIGHLAND FOREST & SAVANNA
19. VENEZUELA & GUIANA HIGHLANDS
20. NORTH ANDES & GALAPAGOS
21. PUNA
22. JUAN FERNANDEZ
23. SOUTH ANDES
24. PATAGONIA
25. MONTE
26. CHACOS & PAMPAS
27. CAATINGA
28. PACIFIC DESERT
29. MACRONESIAN (AZORES, MADEIRA, CANARIES, CAPE VERDES)
30. WEST AFRICAN RAIN FOREST & SAVANNA
31. EQUATORIAL AFRICAN RAIN FOREST
32. COASTAL EAST AFRICAN FOREST & SCRUB
33. SOUTHEASTERN COASTAL AFRICAN FORESTS
34. AFRO-MONTANE
35. AFRO-ALPINE
36. SOUTH-CENTRAL AFRICA
37. KALAHARI & KARROO SCRUB
38. AFRICAN CAPE PROVINCE
39. MADAGASCAR
40. NORTH AFRICAN - INDIAN DESERT
41. INDIA & CEYLON
42. SOUTHEAST ASIA
43. MALAYA & BORNEO
44. PHILIPPINES
45. JAVA, CELEBES & MOLUCCAS
46. NEW GUINEA
47. SOLOMON & FIJI ISLANDS
48. NEW CALEDONIA
49. NORTHEAST AUSTRALIA
50. SOUTHEAST AUSTRALIA & TASMANIA
51. CENTRAL AUSTRALIA
52. WESTERN AUSTRALIA
53. MELANESIA & MICRONESIA
54. HAWAII
55. POLYNESIA
56. NEW ZEALAND
57. REGION OF ASCENSION & ST. HELENA
58. SOUTH TEMPERATE OCEANIC ISLANDS

Western Australia - August 24 - October 31, 1981

I selected photographs to illustrate various aspects of the procurement, vegetation, and flora of Western Australia. These were taken by R. Spjut and C. Edson. Two Nikon and one Nikromat were used with different photographic purposes in mind.

Two 4 x 4 vehicles were rented. Rates were very reasonable, and from my experience, these were the best vehicles suited for our type of field work. The American Consulate at Perth arranged the vehicle rental and handled the payments, using our fiscal data.

Southwest Australia has an exceedingly rich flora. Vegetation of the Northern Sand Plains consists of low shrubs, often with wiry stems not more than 40 centimeters high. Many species have small linear-terete leaves and inconspicuous flowers. This aspect of the vegetation, along with the immense variety, posed a new challenge. Never before have I had to concentrate on deciding which species were common enough for sampling. Considerable reconnaissance, with a hand lens, was sometimes necessary to distinguish species before gathering could begin. In other Mediterranean floras, such as in California, dominant species are conspicuous and diversity is seen mostly with change in topography and local climate; or, in tropical forests a single shrub or tree is usually large enough to yield sufficient quantities of dried material of several plant parts.

With the exception of Acacia and Eucalyptus, plants were sampled at random. One species of Acacia was intentionally collected since Australia species are quite different in contrast to a greater similarity among American, African and Asian species.

Six students (from Murdoch University and University of Western Australia) were interviewed, and three were later employed to gather samples. Another assistant, Chuck Edson, came from Eugene, Oregon. Chuck has worked with me in Mexico and the United States, and his experience was advantageous as it allowed me to concentrate on the botanical aspects, while he supervised and assisted in the gathering of samples. When Chuck departed in mid-September, WA assistants were well-trained and required less supervision.

Prior to this trip, my best collecting for general samples was 19 per day in Baja California. Our daily yield was never below 20 in Western Australia. Our best day was 50 samples, representing 23 species (near Norseman). The critical factor was my ability to sort, record, and press specimens.

Samples were dried in greenhouses located at the University of Western Australia, the Western Australian Herbarium, and in garages and sheds at three private residences. Samples dried slowly, due to cool temperatures and frequent rain. In one emergency situation, the University made available their plant driers and provided assistance.

In early October, I learned of NCI's decision to abolish their contracts on acquisition of crude natural products for anticancer screening. I had exceeded my goal by eight samples and projected 1200 could have been procured before leaving on November 1. Two of my assistants freely volunteered to continue working without pay to wind up drying and shipping of the samples.

I certainly appreciated the help of Graeme White and Robert Phillips in the wind-down, especially since it seemed apparent at the time that WA samples would not be utilized for any purpose. On my last business day scheduled in WA, I received fiscal data that was desperately needed to arrange for surface shipment of samples to Baltimore. Samples arrived here on April 1, and NCI has indicated they will now arrange to have WA samples screened at various laboratories for potential chemotherapeutic agents.

Identifications of WA specimens are nearly complete. Working at the WA Herbarium (PERTH) for several weeks was invaluable to gaining some insight on taxonomic problems. I continued with the identifications after my return and have sent lists of my determinations to Paul Wilson who reports that these are "largely confirmed." Additionally, he and his staff associates have identified collections from certain geographical areas, representative of certain families such as the Chenopodiaceae, and those which I neglected to bring with me. Finally, Terry McFarlane (at the WA Herbarium) is reviewing all determinations. I anticipate some corrections, especially since our local herbaria - Smithsonian Institution (US) and National Arboretum (NA) lack WA material for comparison which is necessary for reliable identifications. I am very grateful to the Western Australian Herbarium (PERTH) not only for their assistance with identifications, but also for the use of their dryers and fumigation of more than 500 specimens. Duplicates will be deposited at US, NA and PERTH.

Thus far, it appears that about one-third (250) of all samples (758) collected occur in genera that are new to the NCI screen. New genera total 60 and are identified in Table 2 which lists all genera with the number of species collected for each (in parenthesis).

Some Unique Aspects of the Flora of Western Australia

Aside from central Australia being occupied by desert, Australia might be compared with the United States turned upside down. For example, tropical humid forests in southern Florida parallel northeast Queensland. The arid endemic floras of the west contrast with the more humid forests of the eastern states. About one-third of 1,000 genera and 80% of 8,000 species that occur in Western Australia are endemic.

From WA plant collections, as listed in Table 2, the predominant families are Proteaceae (92 species in 13 genera), Myrtaceae (63 species in 20 genera) and Fabaceae (49 species in 18 genera). Also notable is the large representation of monocots, especially in the Liliales (Haemodoraceae, Liliaceae, Xanthorrhoeaceae and Iridaceae). The Liliales are known to be rich in alkaloids and perhaps, as pointed out by A.S. Barclay in a symposium on "Plants and Cancer", hold the most potential in future screening. Myrtaceae, rich in aromatic compounds, include 11 of 20 genera new to the program. All Fabaceae, except Acacia, belong to the Papilionoideae which in Australia are unique in being leafless, or with simple often opposite leaves, and fruits that are sphaerical to short-cylindric, or triangular, and often inflated.

Another interesting feature of the WA flora is that many families, particularly the Liliaceae, Restionaceae, Proteaceae and Rutaceae, have centers of distribution in mediterranean climates. Restionaceae and Proteaceae have most of their species in South Africa and Western Australia. Furthermore, the southwest of Western Australia is comparable to the cape region of South Africa. These rich floras with centers of diversity for many families and genera suggest a long association with the prevailing type of climate.

Although California has a mediterranean climate, its corresponding flora is probably an adaptation of a northern temperate element[1] and is relatively poor in generic diversity when compared to that of Western Australia. But, Californian deserts (including Baja California) are very rich and unique in comparison to desert floras in Australia where specialized forms never seem to really have developed. The difference in floristic richness, as associated with climate, may relate to age.

The Western Australian and South African floras may have their origins before Gondwanaland split apart[2] whereas mediterranean vegetation in California evolved much later (mid-Tertiary period). Similarly, desert floras of Madagascar, southern Africa and in North and South America may reflect lineages of a Gondwanaland desert flora. There is substantial evidence for a center of origin of flowering plants in Gondwanaland and also in an alternating wet and dry seasonal type of climate[3].

[1]P.H. Raven. "The Evolution of Mediterranean Floras in Mediterranean Type Ecosystem", 1973 (edited by F. Castri and H. Mooney). He also cites 10% of the genera and 40% of the species as endemic.

[2]Continental drift is now generally accepted but there is considerable disagreement as to how advanced Angiosperms had evolved when continents broke apart.

[3]P.H. Raven & D.I. Axelrod "Angiosperm Geography and Past Continental Movements". Ann. Missouri Bot. Gard. 61:539-673, 1974. The authors draw on their extensive bibliography in their analyses of geographical distribution patterns. Many families and most genera that occur on different continents are usually explained on the basis of long distance dispersal. For some taxa, such as the Celastraceae, their conclusions seem premature. Generic distribution of Celastraceae exemplify recognized phytogeographic patterns and probably reflect a relict group with a slow evolutionary rate. The union of Africa and South America (West Gondwanaland) probably formed an extensive arid interior.

Cost and Significance

Table 3 compares the actual with the projected costs. These are remarkably close; however actual costs would have been much less had NCI not terminated their contract with USDA. Subtracting three weeks of per diem, that could have been used to collect an additional 500 samples, the actual cost was near $18 per sample. Prices for general samples obtained through contracting range from $21 to $35 per sample.

Quality was not assessed in terms of species new to the program. Since 80% of the species are endemic to Western Australia, at least 320 are believed new to the program. By applying a point system, it can be shown that travel to Western Australia was at least 25% more effective in procuring samples than through contracts with suppliers.

The significance of the Western Australian trip is seen in the large number of new genera. About one-third of all samples (758) belong to genera new to the screen. Another one third are represented in the NCI program by less than six extracts tested.

How does WA novelty compare to other sources of supply? A single trip to Western Australia yielded more new genera than all the field trips combined for all other (5) laboratory botanists during the past 5 years. Comparative data are shown in Table 4. Data for contract suppliers are not completely available, but based on our largest supplier in the Amazon of Peru, only 9 new genera were recorded among 253 samples obtained between June 1980 and 1981*.

*This contract has been on-going for 10 years. Initially, numerous genera were probably new to the screen. Within a few years, the number of new genera decreased significantly. One major disadvantage to utilizing local resident suppliers is the short-term productivity aspect. In a long-term program, it is more advantageous to employ highly-trained, mobile botanists.

Tasmania: November 1 - 5

Recent screening of Tasmanian plants identified antitumor activity in a number of species, but only Notelaea ligustrina (Oleaceae) was of interest when I left Beltsville. Due to a paucity of information, re-collection prospects appeared rather slim. Interestingly, Dr. Brice Meeker, our Agricultural Counselor in Canberra, seemed to feel the same way when he expressed his view of this re-collection as a "formidable task" (letter of August 26, 1981). A specimen citation in Flora Australiansis (G. Bentham, 1869) reports Notelaea ligustrina as common for one Tasmanian location, and CSIRO mentioned Tasmania as the best place to attempt a re-collection; therefore, I decided to seek permission from the Tasmanian Forestry Commission and gamble on travel to Tasmania. In subsequent communications with the Tasmanian Forestry Commission, I became more optimistic and estimated five days would be sufficient.

A memorandum dated December 4, 1981, summarized the procurement of 398 pounds of root and 50 pounds of stembark. Based on the freight bill, I estimated we obtained 500 pounds of Notelaea root, but my memorandum was written before samples were completely dried. Costs were based on: additional air fare ($222), vehicle rentals ($92) per diem ($395), labor ($188) and miscellaneous ($16) for a total of $913 or approximately $2.00 per pound. This was very inexpensive, thanks to the assistance of the Tasmanian Forestry Commission that included free rental of two vehicles used to transport labor and plant samples.

In addition to Notelaea, Dr. Suffness, in March, reported unusually high activity in another Tasmanian plant - Anopterus glandulosus (Saxifragaceae). Since we are committed to a quota of 30 re-collections, Dr. Suffness will arrange payment for this out of his budget. I contacted the Tasmanian Forestry Commission and they agreed to collect Anopterus for the National Cancer Institute. This would not have been possible this fiscal year, had I not traveled to Tasmania.

TABLE 1. PROBABLE AND ACTUAL PERCENTAGES OF ACTIVE GENERA ACCORDING TO NUMBER OF SPECIES TESTED IN A GENUS

Class (Number of Species Tested)	Number of Genera	Percent of Active Species	Probable Percent of Active Genera	Actual Percent of Active Genera
1	1,672	6.8	6.8	6.8
2	602	9.5	18.1	17.4
3	289	9.1	24.9	24.9
4	185	10.9	37.0	28.1
5	146	7.4	31.5	25.3
6	85	10.2	47.6	38.3
7	88	11.2	56.5	44.3
8	56	6.9	43.6	39.3
9	54	7.8	51.8	38.9
10	30	9.0	61.1	46.7
11	39	7.9	59.6	56.4
12	23	7.2	59.2	47.8
13	29	7.7	64.7	51.7
14	17	4.2	46.0	41.2
15	16	5.8	59.2	43.8
16	22	7.7	72.3	63.6
17	10	7.1	71.4	70.0
18	17	6.9	72.4	61.1
19	15	6.3	71.0	63.2
20-22	29	8.4	84.2	75.9
23-25	20	9.1	89.2	70.0
26-29	28	5.8	80.2	67.9
30-39	22	9.7	96.5	86.4
40-59	20	6.3	95.6	95.0
60-99	14	7.2	99.3	100.0
100+	5	9.4	~100.0	100.0

Columns 1 & 2 illustrate the hollow curve distribution. For example, there were 1,672 genera with only a single species tested (= 1,672 species), but there were also 5 genera with at least 100 species tested (= 500 or more species). In essence, the bulk of the genera screened are rarely collected, but species most frequently collected belong to relatively few genera.

Column 3 - Activity includes any tumor system used in the NCI screen and not just limited to those of present use. Note that percentages of activity are consistently higher in genera with 2 to 7 species tested. This is probably due to more collecting in some geographical areas than others.

Column 4 - Probable percentages of active genera were determined from percentages of active species found in each class (column 3) using the binomial expansion of $(p + q)^n$ where n = number of species tested; p = frequency of activity in species; and q = frequency at which activity does not occur in species. The 6.8% activity for monotypic genera might approximate the real frequency of biological activity in natural products; however, the actual percent for each class was used to represent 'p' instead of applying 6.8% as a constant for all classes.

Table 1 Continued:

Column 5 - Actual percentages of active genera in many classes, especially in the middle range, is less than the probable indicating that activity is not entirely at random. As another example of this, the distribution of active species in genera that have 11 species tested (39 total) includes 14 genera with only 1 active species, 6 with 2 active species, 1 genus with 3 active species, none with 4 active species, but 1 had 5 active species. Except for a genus with 5 active species, the distribution of antitumor activity in genera was at random. Also, the probability of any genus with 11 species tested having activity in 5 of the species is extremely low. A comparison between probable and actual occurrences (number and percent) of active species in 39 genera with 11 species tested is shown below:

	Occurrence of Active Species				
	0	1	2	3	4
Probable -	17-18(45.0%)	14(35.4%)	6-7(17.0%)	1-2(4.2%)	Near 0
Actual -	17(43.6%)	14(35.8%)	6(15.4%)	1(2.6%)	0

TABLE 2: GENERA COLLECTED IN WESTERN AUSTRALIA

Red Algae

Unidentified (1)

Mosses

DICRANACEAE
Campylopus (1)

RHACOPILACEAE
*Rhacopilum (1)

THUIDIACEAE
Thuidium (1)

Ferns

DENNSTAEDTIACEAE
Pteridium (1)

Monocots

ARACEAE
Zantedeschia (1)

CYPERACEAE
Gahnia (2)
*Tetraria (1)

ECDEICOLEACEAE
*Ecdeiocolea (1)

HAEMODORACEAE
*Anigozanthos (3)
*Blancoa (1)
Conostylis (8)
Haemodorum (1)
Phlebocarya (1)

IRIDACEAE
*Chasmanthe (1)
Freesia (1)
Homeria (1)
*Homoglossum (1)
Sparaxis (1)
Patersonia (2)
Watsonia (1)

LILIACEAE
Acanthocarpus (1)
*Arthopodium (1)
Asphodelus (1)
*Corynotheca (1)
*Johnsonia (1)
*Sowerbaea (1)
Stypandra (1)
*Thysanotus (1)

POACEAE
Cortaderia (1)
Ehrharta(1)
*Neurachne (1)
*Plectrachne (1)
Stipa (1)

RESTIONACEAE
*Anarthria (3)
*Hypolaena (1)
*Lepidobolus (2)
*Leptocarpus (2)
*Loxocarya (4)
*Lyginia (2)

*Denotes a Genus New to the NCI program.

()Number in parenthesis indicates number of species collected in that genus.

Mosses were identified by Dr. Daniel Norris, Dept. of Biology, Humboldt State University, Arcata, California.

XANTHORRHOEACEAE
- Borya (2)
- *Dasypogon (2)
- *Kingia (1)
- Xanthorrhoea (4)

Dicots

AIZOACEAE
- Macarthuria (2)
- Tetragonia (1)

AMARANTHACEAE
- Ptilotus (3)

ASTERACEAE
- Arctotheca (1)
- *Cratystylis (1)
- Helichrysum (1)
- Helipterum (2)
- Olearia (3)
- *Podotheca (1)
- Senecio (1)
- Sonchus (1)
- Vittadenia (1)

BORAGINACEAE
- Halgania (3)

CELASTRACEAE
- Psammomoya (1)

CHENOPODIACEAE
- *Halosarcia (4)
- Maireana (1)
- Rhagodia (1)
- *Sclerolaena (1)
- *Sclerostegia (1)

CHLOANTHACEAE
- *Lachnostachys (2)
- Pityrodia (5)

CONVOLVULACEAE
- *Wilsonia (1)

DILLENIACEAE
- Hibbertia (8-12)

DROSERACEAE
- Drosera (1)

EPACRIDACEAE
- Acrotriche (1)
- *Andersonia (2)
- *Astroloma (2)
- Conostephium (3)
- Leucopogon (12)
- Lysinema (3)
- Styphelia (1)

EUPHORBIACEAE
- Monotaxis (1)
- Phyllanthus (2)
- Ricinocarpos (1)

FABACEAE
- Acacia (1)
- Bossiaea (4)
- Brachysema (1)
- *Chamaecytisus (1)
- *Chorizema (1)
- Daviesia (14)
- *Euchilopsis (1)
- Gastrolobium (16)
- Gompholobium (2)
- Hardenbergia (1)
- Hovea (2)
- Jacksonia (3)
- Kennedia (2)
- Mirbelia (2)
- Oxylobium (4)
- *Phyllota (1)
- Pultenaea (2)

FUMARIACEAE
- Fumaria (1)

Table 2 Continued:

GERANIACEAE
Pelargonium (1)

GOODENIACEAE
*Coopernookia (1)
Dampiera (5)
Goodenia (1)
*Lechenaultia (2)
Scaevola (5)
*Verreauxia (1)

GYROSTEMONACEAE
*Gyrostemon (1)
*Tersonia (1)

HALORAGACEAE
*Glischrocaryon (1)

LAMIACEAE
*Hemiandra (2)
Hemigenia (2)
Lavandula (1)
Prostanthera (1)
Westringia (1)

LAURACEAE
Cassythya (1)

LOGANIACEAE
Logania (1)

LORANTHACEAE
*Amyema (2)
*Nuytsia (1)

MYOPORACEAE
Eremophila (10)
Myoporum (1)

MYRTACEAE
Agonis (2)
*Astartea (2)
*Baeckea (4)
*Beaufortia (2)
Calothamnus (4)
Calytrix (4)
*Calythropsis (1)
*Chamelaucium (2)
*Conothamnus (1)
Darwinia (2)
Eremaea (4)

MYRTACEAE Continued
*Hypocalymma (4)
Kunzea (2)
Leptospermum (4)
Melaleuca (10)
*Micromyrtus (2)
*Phymatocarpus (1)
*Scholtzia (4)
*Thryptomene (2)
Verticordia (6)

POLYGALACEAE
Comesperma (1)

POLYGONACEAE
Muhlenbeckia (1)

PROTEACEAE
Adenanthos (3)
Banksia (7)
Conospermum (6)
*Dryandra (8)
Grevillea (27)
Hakea (12)
Isopogon (7)
Lambertia (3)
Persoonia (2)
*Petrophile (8)
Stirlingia (1)
*Synaphea (3)
Xylomelum (1)

RHAMNACEAE
Cryptandra (6)
Pomaderris (1)
Spyridium (1)
*Trymalium (1)

RUBIACEAE
Opercularia (2)

RUTACEAE
Boronia (1)
*Drummondtia (1)
Eriostemon (1)
Geijera (1)
Phebalium (3)

Table 2 Continued:

SANTACACEAE
- Choretrum (1)
- Exocarpos (2)
- Leptomeria (1)
- Santalum (1)

SAPINDACEAE
- *Diplopeltis (3)
- Dodonaea (2)

SOLANCEAE
- Anthocercis (1)
- Lycium (1)
- Solanum (2)

STACKHOUSIACEAE
- Stackhousia (2)

STERCULIACEAE
- *Guichenotia (1)
- *Keraudrenia (2)
- Lasiopetalum (2)
- Rulingia (1)
- Thomasia (2)

STYLIDIACEAE
- Stylidium (1)

THYMELAEACEAE
- Pimelaea (2)

VERBENACEAE
- Cyanostegia (1)

VIOLACEAE
- Hybanthus (2)

ZYGOPHYLLACEAE
- Zygophyllum (1)

Table 3. COSTS FOR WESTERN AUSTRALIAN SAMPLES

	Actual	Projected[1]
Air Fare	$ 1,465	$ 1,316
Per Diem & Miscellaneous	5,845 ($79 per day)[2]	3,144 ($71 per day)
Labor, Supplies, Gasoline	5,000	7,600
Vehicles (2)	4,177	4,800
TOTAL COST	$16,487	$16,860
Total # of samples	758	700
Cost Per Sample	$22[3]	$24 plus 15% for inflation or $28

[1]Costs below do not include 15% for inflation. This is added in the cost per sample figure. These are from a memorandum dated November 12, 1980.

[2]Plant collecting in Western Australia was terminated during the sixth week of the trip. However, it was cheaper to remain in WA because of an airline ticket already purchased on a 'super apex fare'. Instead of collecting more samples, about three weeks were devoted to plant identifications at the Western Australian Herbarium. About 1,200 samples could have been procured if NCI had not terminated their contract. Subtracting three weeks of per diem, the actual cost is much closer to the projected.

[3]Subtracting 21 days from per diem, the actual cost was about $18 instead of $22 per sample. As already indicated, procurement for general samples was discontinued in early October.

TABLE 4. SIGNIFICANCE OF TRAVEL TO WESTERN AUSTRALIA

Fiscal Year[2]	R. Spjut		All Other (Combined)[1]	
	General Samples	New Genera	General Samples	New Genera
78	106	0	0	0
79	413	46	285	11
80	173	15	129	11
81	286	82[3]	476	32
Western Australia	758	60		
TOTAL:	1,736	203	890	54

[1]All other includes six laboratory scientists, five of which conducted field work. Samples were obtained from Venezuela, Brazil, Puerto Rico, Kenya, Panama, Ecuador, China and the United States. Random collections of SLOP were not scored, although exceptions were allowed. SLOP affected one collector.

[2]Fiscal Year is from October 1 through September 30.

[3]Many genera here are of the Bryophyta. Except for about 250 lower plant samples (mosses, liverworts, hornworts & lichens) and the Australian samples, the remainder were of vascular plants from Mexico and the United States.