PN-ABA-405
XN-ABA-905-A

AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D.C. 20523

DATE: 9/20/88

MEMORANDUM

TO: AID/PPC/CDIE/DI, room 209 SA-18

FROM: AID/SCI, Victoria Ose

SUBJECT: Transmittal of AID/SCI Progress Report(s)

Attached for permanent retention/proper disposition is the following:

AID/SCI Progress Report No. 1. E-02
1st semi-ann. - ltr 24 June 82
1st qui month report - ltr 24 aug 82
6 mo - ltr 20 Sept 82 (mar 82 - Sept 82)
6 mo - ltr 4 April 83 (Sept 82 - mar 83)
ltr 24 mar 84
Attachment

(ltr 19 Jan 84 - (late 81 - late 84)
(FINAL (late 81 - 84)

mid-proj report - 2/3 ds into ul.

PD-ABA-905 J. Ventimiglia

1. E-0 V

Missouri Botanical Garden

19 December 1984

Dr. James Hester
AID Liaison Officer
US Agency for International Development
Washington, D. C. 20523

Dear Dr. Hester:

Enclosed please find the end of project report on AID grant No. DAN-5542-G-SS-1086-00, entitled "A botanical inventory of the eastern slope of the Andes of Central Peru". In addition to the regular six month reports, an overview of the work completed to date was submitted last summer. This report is largely based on the earlier documents.

Since the rejected end-of-project report constituted by my letter of 26 November, one additional significant paper has come out of the project. This is a paper entitled "An overview of neotropical phytogeographic patterns with an emphasis on Amazonia" and is the "state of the art" summary I presented at the first Humid Tropics Symposium at Belem in November. As I indicated in my letter of 26 November, the development-oriented people at that meeting seemed extremely excited by the oral version of this paper. Therefore I trust that your office will also find it of interest.

If I can be of further assistance, please let me know. As you know, we are extremely anxious to get re-funding for additional plant exploration in Peru.

Sincerely,

Al Gentry
Associate Curator

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This constitutes a summary report of AID grant No. DAN-5542-G-SS-1086-00. The grant period was for three years from late 1981 to late 1984.

We feel that we have been successful in our overall objective of increasing botanical knowledge of the Selva Central and adjacent regions. Altogether, ca. 30,000 collection numbers (totalling an estimated 120,000 specimens) have been collected. Because two duplicates of each collection are normally left in Peru, we estimate that probably 50,000 identified(!) specimens have been added to the herbaria of the Universidad de San Marcos and the Universidad Nacional de Amazonia Peruana.

Most of the first three-month period was spent in organizational work, which included hiring David Smith of Iowa State University as a full-time resident collector; Robin Foster, Missouri Botanical Garden Research Associate, as part-time collector; and Rodolfo Vásquez M. of Iquitos, Peru, as full-time resident collector in the Amazonian region. During this time, we acquired collecting supplies and worked out the necessary permits and political arrangements in Peru. A wide scope, long-term (6-year) Convenio between the Missouri Botanical Garden and the Ministerio de Agricultura was signed, which not only approves the plant collecting work of the project, but essentially designates the principal investigator of this project as coordinator of foreign plant collecting activities in Peru for the duration of the agreement. In February 1982, full-scale fieldwork was begun.

Since then we have collected throughout most of Amazonian Peru. Areas in which collecting was concentrated include the Oxapampa-San Ramon-Villa Rica area with major efforts focussed in the Cordillera Yanachaga proposed National Park area and in the montane palm forest and high altitude "pajoral" in the cordillera west of Oxapampa: the Palcazú Valley, especially around Iscozacin and Cabeza de Mono; the Pichis Valley, especially around and in the Cordillera de San Matías; the Río Pozuzo Valley, near Pozuzo and Codo Pozuzo; Bosque von Humboldt and the northern terminus of the section of the Carretera Marginal now under construction; and the Iquitos area, especially on white-sand soil near Mishana on the Río Nanay and on relatively rich soils at Yanamono near the mouth of the Napo. More sporadic collecting trips have also been made to many other parts of Peru, including the Huallaga Valley near Tingo María, the Tarapoto area, the Venceremos and Shillac regions on the Amazonas/San Martin border, the Huamachuco area and upland "ceja de la montana," the Gran Pajonal and Satipo regions, the environs of Cuzco and the upper Urubamba Valley, the Puerto Maldonado-Río Tambopata area, Manú Park, especially in the Cocha Cashu area, the Andoas region on the Río Pastaza near the border, Negro Urco and Quebrada Sucusari on the north and south banks of the Río Napo, respectively, Jenaro Herrera on the Río Ucayali, and the Río Samiria-Pacaya Reserve area between the Marañon and Ucayali.

Identification and New Taxa

We feel that the outstanding accomplishment of the project has been in greatly increasing the floristic data base for upper Amazonian Peru. Very many new and new-to-Peru species and even genera have been discovered during the course of this investigation. Many of these new species are ecologically important, even dominant, in their areas of occurrence.

Some examples of especially interesting species discovered during the course of this project include several families previously unreported for Peru, e.g., Magnoliaceae with no less than three different species of Talauma collected, at least one of them apparently undescribed; Drosera of the Droseraceae, a peculiar family of insectivorous plants previously known in the Andean region only in Colombia; Dialypetalanthaceae, a strange and very poorly known large tree previously known only from Central Amazonia. The dominant species of the forests above Oxapampa, so prevalent that every ridge line visible from the town is characterized by silhouettes of this species, turns out to be yet another genus new to Peru, the palm Dictyocaryum. Although this species, used to construct the floors of campesino houses throughout the area, is the most common and one of the best known plant species of the Oxapampa area, it had never been previously collected. That it proves to represent a genus previously unknown from Peru underscores the point that our knowledge of the Peruvian flora remains abysmally lacking. A second palm genus previously unknown from Peru was also encountered. This is Welfia, a genus of two species previously known from Costa Rica to Colombia, which is the most important roof-thatching palm in western Colombia and is also widely used there for making brooms. In addition, it has edible fruits which are relished by the Chocó Indians. To our knowledge, Welfia, which grows in mostly uninhabited areas in Peru, is not used locally but, extrapolating from its use in the Chocó, it could conceivably form the basis for developing a local cottage industry in Peru as settlers move into this region along the new highway. Again, we do not yet know whether the Peruvian Welfia is a new species or a 1500 km range extension of one of the two Colombian species. Several other palm species we collected during the first year of this project are clearly new, however. One is a species of Wettinia that is subdominant on top of the San Matías ridge. Especially noteworthy are new species of Chamaedorea and Geonoma, with possible horticultural importance. One has the most dramatically corrugate-coriaceous leaves of any palm species of which we are aware and will surely create something of a sensation in palm horticultural circles. Thus the palm family, often remarked as the most important economic plant family in the role it plays in the lives of forest peoples, provides an excellent example both of how poorly known floristically the study region (and much of the rest of the Neotropics) is and of how many as yet unknown Neotropical plant species may be of economic importance.

Of course, it is not just palms which are turning out to be new and new-to-Peru. One especially striking example comes from the one-hectare tree plot near Iquitos on the Río Nanay sampled by the PI in January. Generally a tree climber would climb a strategically located tree and then collect specimens of a number of nearby trees from a perch in its top, using a 15 m long extendable aluminum clipper pole. At one point, the material thus collected from a single climb included three genera new to Peru.

When the commonest liana species of the seasonally inundated forests around Iquitos turns out to be a new species, one of the commoner trees of the Samiria-Pacaya reserve is a genus new to Peru (Patinoa, a genus known to have an edible fruit in the Chocó!), and the commonest emergent tree in the Cocha Cashu area of Manu is an entire new genus of Lauraceae (though close to an Asian one), it is obvious that floristic knowledge of Amazonian Peru is inadequate! Altogether, many dozens of new plant species have been discovered in the course of this project.

In many ways, more interesting than new species are very large range disjunctions in known species. Some striking examples from Bignoniaceae are Spathicalyx duckei, found at Cabeza de Mono but previously known only from the Santarum area of Brazil, Clytostoma campanulatum, found at Cocha Cashu but previously known only from the environs of São Paulo in southern Brazil, and Tynnanthus puberulus, found at Tocache Nuevo, but known previously from French Guiana and Amapa. What such amazing disjunctions mean is unclear, but almost certainly many of them represent widespread species and are an artifact of our amazingly poor overall floristic knowledge of the Amazonian flora.

Not only is discovery of new species and new distributional records of importance in order to document the Peruvian flora. Perhaps even more important in many cases is re-collection of already described species which have been so rarely collected that the application of an old name has remained obscure. Because of taxonomic rules of priority, accounting for such old names is critically important in order to stabilize nomenclature and avoid the necessity of confusing name changes. The area of Peru in which we are working is especially important in this respect, due to the collections made there in the late 1700s by Ruiz and Pavón especially in the Pozuzo area. A number of species collected by Ruiz and Pavón are not known ever to have been collected again. However, in many of these cases the same plant species has undoubtedly been re-collected elsewhere and given a new name. This has happened in part due to sloppy taxonomy and in part because the Ruiz and Pavón collection at Madrid is not readily accessible to many botanists and also because some of the important early Peruvian type collections were destroyed in Germany during the second World War. Complete collections from the areas visited long ago by Ruiz and Pavón will help immeasurably in figuring out what plant species they were trying to describe and thus in the stabilization of taxonomic nomenclature not only for Peru, but for all of the Neotropics.

Plant identifications are important for many people besides botanists. For example, identification services were provided for several conservationally important studies of endangered mammals of the "ceja de la selva." Smith and Gentry spent several weeks in the field in the northern "ceja de la selva" collecting and providing preliminary identifications of plants in several of the last remaining habitat patches of the yellow-tailed woolly monkey, the second largest New World primate and long thought to be extinct until recently rediscovered in a few remote forest remnants. Significantly, our botanical fieldwork provided a floristic data base for a study of an exclusively Peruvian mammal being made by a Peruvian biologist, Mariella Leo. We also identified the large collection of plants made by Bernie Peyton, who has spent much time over the last several years studying spectacled bears in the most remote "ceja" regions of central and southern Peru, where this highly threatened species still survives. The study of spectacled bears included a strong habitat component, as well as food plant observations, that would not have been feasible without these botanical identifications. Identifications were also provided for various zoologists associated with John Terborgh in studies of the fauna of Cocha Cashu Biological Station in Manu Park and for another Peruvian primatologist, Marlene Ramirez, studying Saguinus mystax on the Río Blanco.

Some specific examples of significant identifications provided by this project include that of Calatola (Icacinaceae) for medical botanist Walter Lewis, who had previously thought the plant to belong to the quite unrelated family Nyctaginaceae. This plant is important in folk odontology among some of

the Indian tribes of Amazonian Peru and its anticaries properties are now being investigated by the Washington University School of Dentistry. There is no previous record of such a use for any member of Icacinaceae. Another identification of special interest is that of a formerly important timber tree of the Oxapampa region as Huertea glandulosa of the Staphyleaceae. There are apparently no previous records that this genus, or even its family, produces a useful hardwood. Proyecto Pichis-Palcazu personnel, who are interested in using this useful native tree in reforestation, had previously only been able to guess (erroneously) that it might be some kind of Meliaceae. Species identified for the Bosque von Humboldt foresters included Copaifera, a legume genus now being considered for commercial exploitation as a fuel source, which is very common locally although previously known from Peru from only a handful of collections. Identifications have also been provided to a German-sponsored reforestation project headquartered at San Ramón. We have collected many of the species of interest to their project and provided the desired identifications which include some of the species not re-collected since the 1700s. Another previously unidentified commercially important species is Cordia alliodora, a fast-growing tree of the Oxapampa area known as "nogal blanco." This tree is well known as a valuable timber tree in other parts of the Neotropics and is being considered for reforestation work by Dr. Brack of the Pichis Palcazu project staff. The tree had previously been misidentified as belonging to Annonaceae by the local specialists in dendrology and forestry consulted by Dr. Brack. As a result of discovery of the correct name and thus the potential timber potential of "nogal blanco," an active program of propagation of the plant for reforestation has now been initiated. Another unidentified species of commercial importance and locally known as "huamanchil co" has now been identified as Laplacea spathulata. This tree is of special importance as a leading timber tree, yet it has not previously been possible to identify it--a serious problem in view of the Peruvian government's requirement of identifications of all timber products in order to obtain export permits.

Theoretical Ecology

In addition to intensive general collecting and plant exploration throughout the upper central Amazonian region (and to some extent through much of the rest of Peruvian Amazonia), we initiated several more specific studies including setting up six permanent tree plots of one hectare each and several additional 1000 m^2 samples to quantify species composition and diversity in different regions. Data from these ecological samples formed the basis for a paper in the Peruvian Ministry of Agricultrure's new book on Manú National Park entitled "Some Preliminary Results of Botanical Studies in Manú Park," and for a paper presented as a state-of-the-art overview at the First Humid Tropics Symposium at Belém. A copy of the former manuscript (due out in January) was previously submitted. A copy of the latter is appended to this report.

The areas in which 1000 m^2 samples of all plants over 2.5 cm dbh were carried out include Cabeza de Mono in the Palcazu Valley, the Venceremos area (home of the rediscovered yellow-tailed woolly monkey), El Abra (a disjunct and unusual dry forest near Tarapoto), Bosque von Humboldt, and several sites near Iquitos. These samples, in addition to earlier ones made in Amazonian Peru and elsewhere, were obtained with the techniques described in Gentry 1982

(Evolutionary Biology 15:1-84) and make possible direct comparison of plant species diversity and floristic composition of these regions with many other Neotropical and paleotropical areas.

This new data base is leading to many new insights. For example, within the Neotropics, several very clear patterns in plant community diversity are becoming apparent. The most strikingly predictable trend is the strong correlation of precipitation with plant species diversity (Figure 1; Gentry, 1985). Lowland dry forests generally have about 50 species per 0.1 ha., moist forests ca. 100-150 species, wet forests ca. 200 species, and pluvial forests ca. 250 species in the continental Neotropics. This data set now includes 45 sites from 11 countries. Contrary to my original contention (1982b) the precipitation/diversity curve reaches an asymptote of about 250 species at 4000 mm of annual precipitation (Gentry, 1985). The replicability of these values for many different sites scattered through much of South and Central America and running the gamut from dry thornscrub forests to the wettest place in the world seems strong circumstantial evidence that the diversity of Neotropical plant communities is highly determinate and probably maintained at environmentally determined equilibria.

Not only does the diversity of mainland Neotropical plant communities appear to be highly predictable. The floristic composition of these communities similarly can be predicted from environmental parameters such as rainfall and soil. The only exception is that on very wet and/or rich soils, Moraceae are sometimes equally important; the increase in number of Moraceae species being predictable from the combination of rich soils and adequate rainfall. Like Moraceae, palm species are much better represented at wet sites; however, number of palm individuals seems more closely related to soil fertility with higher palm density on rich soil sites. At all extra-Amazonian wet forest sites, Palmae is the second, third, or fourth most important family in number of species. In all wet upper-Amazonian sites, essentially the same group of families is the most species rich (after legumes) in these samples--Lauraceae, Annonaceae, Rubiaceae, Moraceae, Myristicaceae, Sapotaceae, and Meliaceae. In progressively drier forests, on the other hand, wind-dispersed families become progressively (and predictably) better represented. Thus Bignoniaceae becomes the second most species rich family (after legumes) in all dry forest sites. Rubiaceae and Sapindaceae are also always among the half dozen most species rich families in dry forest samples.

Again, the predictability of these trends, despite the fact that very different sets of species are involved at the different sites, seems strong evidence that Neotropical forests are put together in an emphatically non-random way, a finding with much theoretical interest. Table 4 and Figure 1 in the enclosed manuscript summarize these new findings. Four one-hectare tree plots have also been sampled in Amazonian Peru. These were located at Yanamono and Mishana, near Iquitos, at Cabeza de Mono, near Isrozacin and at Cocha Cashu, Manú National Park. Two other tree plots were sampled at Tambopata, Madre de Dios, but specimens have not yet been processed. Our one-hectare tree plots are also theoretically exciting in demonstrating that Neotropical forests are the world's richest, contrary to the published literature which makes that claim for the Dipterocarp forests of Southeast Asia. Thus, all four one-hectare Amazonian Peruvian tree plots of which preliminary analyses have been completed have more tree species than the richest site reported for Southeast Asia by Whitmore (1975). Two are much richer than even the richest Asian samples at

Rèngam, Malaya (Cousens, 1951) and Gunung Mulu, Sarawak (Proctor et al., 1983). The most diverse Peruvian site has ca. 300 species out of 600 individuals ≥ 10 cm dbh!

Apparently the low-tree species numbers from earlier Neotropical studies were largely due to relying on identifications by "materos" or local tree-identifiers who always lump together under the same common name many species in the large taxonomically complex genera that contribute so much to local tree species diversity. In addition, many of the published Neotropical tree plot data sets have been from intrinsically low-diversity peripheral or poor soil areas such as Central America, the West Indies, or northern Guyana and Surinam. Some other insights from these plots are indicated below.

Another new ecological insight is the role that β-diversity plays in generating the overall species richness of Peruvian Amazonia. For example, for a series of 1000 m^2 samples on different substrates (upland white sand, upland lateritic, non-inundated flood plain, tahuampa or varzea seasonally inundated by black water, tahuampa inundated by white water) near Iquitos, each forest type sampled is very rich in species (163-249 spp. ≥ 2.5 cm dbh.) but there is very little overlap between the species of different substrates, even when the samples are located virtually adjacent to each other. Intriguingly, although each site has an almost completely different set of species, the familial composition of these different forests is remarkably similar. Not only do Leguminosae dominate in species numbers at each site but the other families that occur at each site are the same and in approximately the same sequence of species richness. At least seven of the 11 most species-rich families are the same at all the sites (see Table 4 of enclosed manuscript). These patterns would seem to suggest that each plant family may have a specific role in Neotropical forest communities, with a different set of species of each family specialized for different substrates in Amazonia. Such evidence suggests that the high species richness of Amazonia, and of particular Amazonian regions such as the area around Iquitos, is due not to greater α-diversity, but largely to the many floristically different plant communities that occur on the different substrates of the local habitat mosaic. If so, much of the high species richness of Amazonia, especially upper Amazonia where the habitat mosaic seems locally more complex, may be explained by β-diversity.

Land Use Planning

After three year's of botanical work and plant collecting in the central Peruvian part of Amazonia, we have accumulated enough knowledge of the region's flora to begin to seriously address another important objective of this project: to survey the floristic composition of the various vegetation types of the region from the viewpoint of selecting indicator species for various vegetation types, and, ultimately, using this survey capability and floristic data base in land use planning. Robin Foster concentrated especially on this phase of our analysis during his fieldwork. A general summary of some of our preliminary conclusions with respect to the main vegetation types of the region follows.

Although the Pichis and Palcazú Valleys are both covered with low hills, the vegetation of these two Valleys differs markedly. From all the plant

indicators, the hills of the broad Pichis Valley have richer soil and support greater plant productivity. Nevertheless, they are apparently much more subject to strong winds than the more protected Palcazú, since the forests of the Pichis Valley seem to be in a natural state of turmoil. Observations from the air suggest that this perennial disturbance is not limited to the few sites visited, but occurs throughout the basin down to Puerto Inca on the east side of the Pachitea. The alluvial fan floodplain of the Río Pozuzo from its exit from the mountains below Pozuzo to its junction with the lower Palcazú has a similar flora suggesting high relative productivity.

The Palcazu Valley (except the narrow flood plain) stands out among these lowland areas of the Selva Central in having unusually impoverished soil, but an exceptionally high forest. Perhaps the height of the forest is related to the protection provided by the adjacent mountains, or perhaps the greater tree stature is related to a relatively low level of disturbance associated with slower tree growth (and tree fall) in a less-productive environment. Five to ten km NE of Codo Pozuzo the alluvial plain of the Río Pozuzo suddenly ends in the steep 10-20 m tall wall of an ancient alluvial terrace. The flora and vegetation of this terrace are dramatically different from that of the adjacent flood plain and indicative of low nutrient status. This terrace shares with similar terraces along the Palcazu many rarely collected plant species, some of which are more typical of higher, wetter areas such as the San Matías ridge crest. Another feature of these terraces is that they have the highest densities of "tornillo" (Cedrelinga catenaeformis, the most important timber tree of the lowland Selva Central) that we have observed. An obvious conclusion from these observations is that cultivation of these apparently poor-soil terraces should be discouraged and controlled lumbering of tornillo could be the most appropriate ultimate land use for most of the Palcazu and adjacent regions of the Pozuzo.

Judging from its appearance from the air, there may be another quite different poor-soil area in the Selva Central region. At any rate, the forest on the low hills from near the base of the Serrania del Sira up to the Llullipichis looks distincitve and very likely reflects a much poorer soil. We have not yet collected in this region, which is of limited area but might be worthy of special conservational consideration if the flora does turn out to be distinctive.

The Serrania de San Matías is an abrupt anticlinal fold between the Pichis and Palcazu rivers, presumably the first stirring of the next major uplift of the eastward-growing Andean codillera. Due to its shape, a much greater diversity of rock layers (limestones, sandstones, red clays, etc.) is exposed on the west side than the east where we have conducted most of our fieldwork. The most distinctive change along the east side is a broad band of somewhat sandy soil about halfway up the ridge characterized by higher densities of rubber trees (Hevea), Rapatea (Rapateaceae), numerous small palms and the fern Schizaea elegans. This floristically distinct vegetation type is not discernable from the air. The two side ridges of the San Matías system which we have botanized to date had similar soil characteristics and exposures but many species different from each other and noticeably different relative abundances of most of the others. Our transit of the San Matías cordillera also revealed an outcrop of rich limestone and limestone-derived soil part way up the western slope of the cordillera. We were not the first to discover this richer-soil area: despite being far from the settlements along the river and

several hours' hike from them through little-disturbed forest, the part of the limestone region we saw is mostly second growth from old chacras. It is likely that this bank of soil, which should be easy to recognize by its distinctive flora, extends the whole length of the San Matías. This seems an excellent target area for intensive agriculture, rather than the sandy river terraces and lateritic hills where rich natural forests are currently being converted rapidly into substandard chacras and pastures.

Our hectare sample plot at Cabeza de Mono gives a clear indication of the timber potential of the sandy river terraces which predominate in much of the Palcazu Valley. The commonest large emergent tree in our plot is Cedrelinga catenaeformis, or "tornillo," a species of the legume family which produces a timber similar to that of Cedrela. Since mahogany and "cedro" have now been largely eliminated by overintensive exploitation through much of Amazonian Peru, "tornillo" is rapidly becoming the main timber wood of the Selva Central lowlands. That such a valuable timber wood is so common in the poor-soil Palcazu forests suggests that a well-planned program of commercial exploitation might provide a sustainable resource of much greater value than the poor quality crops or pastures which would be grown here were the forest cut. Moreover, Cedrelinga shows abundant regeneration in the undisturbed forest, ranging in diameter from giant emergents over 100 cm dbh. through intermediate size classes to small trees 10 cm dbh. and less. Altogether there are eight trees of Cedrelinga over 10 cm dbh. in our sample hectare, making this one of the commonest species in this very diverse forest which has 170 tree species plus 16 liana species ≥ 10 cm diameter.

This site contrasts strikingly in floristic composition with the remnants of richer soil vegetation along the actual river margins. Whereas rich-soil species like Ceiba pentandra occur along the river edge, they are conspicuously absent from the upland forest back from the rivers where such poor-soil specialists as Iriartella setigera and Aspidosperma are prominent instead. The moral of this floristic difference would appear to be that the long-term success at cattle raising by many of the German settlers in the Palcazu Valley should not be taken to indicate that the whole valley could be profitably converted from forest to productive cattle pasture: most of the fertile soils bordering the rivers which can sustain pasture have already been converted to that use. Farther upstream at Loma Linda where the Palcazu runs out of the more broken Andean foothill country, a recent attempt has been made by the indigenous Amuesha community to set up a cattle raising operation on the highly dissected lateritic hills away from the river flood plain. The soil is too poor for good pasture (as could have been predicted from its natural vegetation) and the cattle are barely able to eke out an existence on kudzu vine.

We may conclude that while limited rich-soil areas of Amazonia may be appropriate for agricultural development, most other areas just as surely are not. In view of the kinds of tightly integrated fine-tuned co-evolved interactions of tropical forest plants and their pollinators and dispersal agents indicated above, it is not surprising that destruction or degradation of the forest ecosystem generally has at least indirect negative effects on desirable species. Conversely, attempts to grow desirable species in plantations often have little success, due to missing elements of the intricately interwoven natural ecosystem. For example, Brazil nuts (Bertholettia excelsa) are harvested almost exclusively from wild trees. Attempts to grow Brazil nuts in commercial plantations have been largely

unsuccessful, with low fruit yield probably due to the failure of a pure stand of Brazil nuts to provide adequate sustenance for the needed specialist euglossine bee pollinators during the part of the year when Brazil nuts are not in flower. From an ecological perspective, it seems obvious that management so as to obtain valuable products like Brazil nuts from the structurally intact forest is critical to any sustained use of most tropical forests on poor soils.

For this to be possible, new markets must be found for new products, a daunting task. Yet, remember that most of the biotic diversity of the world occurs in tropical rain forests, especially in the Neotropics, while at present most of the world's useful plants are non-tropical. There can be no doubt that the many species waiting to be discovered in tropical rain forests include many of potential commercial value. The trick is to look for and learn to use this sustainable natural diversity rather than destroying it for unsustainable agriculture. Many examples of unrealized commerical potential in native Amazonian plants have been discovered in the course of this AID-sponsored fieldwork.

I hope that the examples noted below are adequate to indicate the indubitable but unrealized commerical potential of many Amazonian plants. Given this potential and the fact that cutting down the forest to grow crops or create cattle pastures had never been demonstrated to result in a long-term sustained yield on most Amazonian soil types without artificial fertilization, it seems clear that alternate approaches to clear-cutting should be investigated. Land use schemes must be developed that will result in sustainable profit without squandering the valuable biological capital constituted by the intact rain forest.

The one-hectare tree plot on extremely nutrient-poor sandy soil suggests hints for how such schemes can be made profitable. Hevea, the rubber tree, is the second commonest tree species on both of the one-hectare tree plots on extremely poor sandy soil analyzed. Natural rubber is currently the fourth-largest agricultural export from the Third World. By 1990, annual global demand for natural rubber is projected to boom from today's 3.5 million tons a year to 6 million tons a year, an increase that cannot possibly be supplied by Southeast Asia's rubber plantations. Nor can synthetic rubbers be substituted, since the new higher-quality tires now being produced require from 40% (car radials) to 95% (the Challenger space shuttle) natural rubber. In view of this picture, how insane it would be to cut down valuable forests rich in Hevea to replace them with unsustainable agriculture--yet many have talked of doing that in the Palcazú Valley. Instead, why not concentrate on developing a market infrastructure that will make it possible to harvest this valuable product from the structurally intact (and thus sustainable-yielding) forest?

These extremely poor-soil areas where Hevea is so prevalent provide an excellent case for forest use rather than destruction, since even the most blindly optimistic agronomist must concede their low agricultural potential. Taking the one-hectare tree plot at Mishana, near Iquitos, as an example, it is easy to document excellent economic possibilities for the intact forest. The commonest species is the palm Jessenia bataua (38 trees, not counting several cut down by wasteful local fruit gatherers) which provides the widely used oil-rich ungurahui fruit that is now being widely propagandized as an important new oil source. The second most common tree is Hevea (31 trees). Also common are two species of Mauritia (one the fifth commonest species), a palm with a

widely consumed fruit that makes the favorite ice cream flavor of Iquitos and whose export to Japan for that purpose was begun last year. Also prominent are 13 species of Myristicaceae (five of them among the 20 commonest species); Myristicaceae provide the major plywood lumber in Honduras (D. Hazlett, pers. comm.) and a new plywood source to replace the depleted stocks of Ceiba pentandra is desperately needed in the Iquitos area. Many latex or resin-producing species of families like Euphorbiaceae (17 spp.), Sapotaceae (16 spp.), Burseraceae (13-14 spp.), Apocynaceae (10-11 spp.), and Moraceae (18 spp.) are well represented. Several genera producing edible fruits and nuts are present, like Caryocar (almendro), Eschweilera (castana), Rheedia, Persea, Dialium, Hymenaea (azucar huayo), Inga, Pourouma, Eugenia, Euterpe, Scheelea, Prunus, and Parahancornia (naranjo podrido, the most esteemed fruit of the Iquitos region). Also well represented are alkaloid-rich lianas with medicinal potential like Strychnos, Menispermaceae, and Martinella. And this is in a single hectare! Of these, only a few of the fruit species are not locally exploited, but there is clearly economic potential here.

Economic Plants

Since most of the world's biotic diversity is contained in the small fraction of the earth's land surface covered by tropical forests, most of it's useful plants and plant-derived chemicals should be expected to be found there. Since this region is so rich and poorly explored, it is not surprising that many potentially useful new plants have been discovered during the course of our investigations. Papers reporting two such discoveries made in the course of the AID-sponsored fieldwork have already been written and copies previously submitted to AID. One is an eye medicine, the other an exceedingly promising oil seed. Other similar discoveries are currently under investigation in various laboratories (e.g., a much sought anti-cancer bark that had several US cancer research laboratories almost literally standing in line outside my office (see attached letter for the first lab results); a plant whose bark may constitute a new malaria cure; a plant that selectively and effectively kills crabs; a new genus of emergent Lauraceae with timber potential). Additional examples are given in the previously submitted reports.

Here we will only reiterate data on one of the most exciting potential economic plants and report on a second one that has not been previously emphasized.

The Cucurbitaceae liana genus Fevillea has been noted in the ethnobotanical literature as producing an emetic seed oil. Discovering that the Campa Indians of Amazonian Peru use the oil-rich seeds as candles, we investigated further and discovered that this plant has more oil per seed and per fruit than any other dicot. Moreover, there are several species of Fevillea with different seed oil compositions, and we calculate that, if the naturally occurring lianas of an otherwise intact forest were replaced by Fevillea vines producing fruit at their normal rate, the oil yield per hectare would be as great as that produced by any extant oil crop grown in monoculture.

Desmoncus, a spiny climbing Neotropical palm genus, is the New World equivalent of the rattans. In Southeast Asia rattans, mostly wild-harvested,

are an important crop. In fact, rattan products account for $4 billion per year and are the second most important export (after timber) from Southeast Asia. Some rattan work has long been done by local artisans at Iquitos using imported Asian rattan. However, it was recently discovered that one of the local Desmoncus rattans provides a fiber with better qualities than those from Asia, and at a fraction of the cost. In the last year or so, rattan wicker work based on this species had become a burgeoning cottage industry around Iquitos. Since the preferred species of Desmoncus is a common second growth species of white-water inundated tahuampa forests, there is a plentiful supply of it in an increasingly prevalent habitat. Perhaps a multimillion-dollar-a-year rattan industry similar to that of Southeast Asia is a real possibility.

Training Peruvian Botanists/Strengthening Peruvian Institutions

We have actively pursued a subsidiary objective of the AID-sponsored project--collaboration with the assistance to Peruvian researchers in expanding the capacities of their institutions. Such help has ranged from assisting in field ecology courses for advanced biology students at the Universities in Iquitos and Cuzco to providing logistical support for travel and fieldwork by faculty members of several Peruvian universities. Peruvian botanists who have participated in the project fieldwork include: Oscar Tovar, Blanca León, Joaquina Albion of the University of San Marcos; Angel Salazar and colleagues of the Bosque Nacional Alexander von Humboldt; Franklin Ayala Flores, Doris Alfaro, and colleagues of the University of Peruvian Amazonia; Washington Galiano and several of his students from the University of Cuzco; and Mariella Leo from the University of Florida (on leave from the Ministerio de Agricultura). Collaboration with Peruvian scientists also included fieldwork with Sanchez Vega of the Unversity of Cajamarca, Abundio Sagástegui of the University of Trujillo, and various personnel of the Proyecto Especial Fichis-Palcazu.

In addition to logistical support, the principal investigator has conducted informal mini-courses in tropical plant identification for these and other Peruvian botanists whose own independent studies should be directly benefited as a result. Identifications of plants collected by these botanists as well as by foresters, especially those associated with La Molina University in Lima, have also been carried out by the principal investigator. Identifications of plants eaten by primates in various anthropological and zoological investigations, especially those associated with the IVITA Proyecto Primatos program, based in Iquitos, have been an important contribution to Peruvian scientific research. The principal investigator was one of the featured speakers at the quadriennial Latin American Botanical Congress, held in Peru in 1982, was invited to conduct a short course for anthropologists, sponsored and funded by MAB and UNESCO, in Iquitos, and gave a state-of-the-art botanical overview for the First Humid Tropics Symposium in Belem. Such invitations suggest that the kinds of studies being carried out under the AID grant are appreciated and are making a real contribution to Peruvian science.

We contribute scientific literature, a very important resource, to the collaborating herbaria and researchers, and to the Ministerio de Agricultura. All project-related publications are sent, as well as the scientific journal of the Missouri Botanical Garden and other pertinent publications. It is very

difficult for researchers at many Peruvian institutions to obtain copies of recent research findings and we feel that contribution of this material is an important step in building up the resources and capabilities of Peruvian research and teaching institutions.

As noted above, duplicates of the plant collections have been deposited at two Peruvian herbaria, adding significantly to the resources available to the researchers working on the Peruvian flora. The compilations of photocopies of the herbarium specimens will be provided to the Proyecto Especial Pichis-Palcazu and to the Museum of Natural History at the University of San Marcos in Lima, to provide a portable guide to the plants of the Selva Central region when a herbarium is not available.

Conclusion

In closing, it is perhaps appropriate to summarize what we have accomplished and what more we hope to do. We feel that we have been quite successful in our overall objective of increasing botanical knowledge of the Selva Central region. Not only have we collected many new and new-to-Peru species, but we have begun to have, essentially for the first time, a reasonable idea of some of the specific kinds of environmental factors determining plant distributional patterns in Peruvian Amazonia. We have discovered a number of previously unknown potentially useful plants and, surprisingly in view of the little time elapsed since project initiation, some of these are already well along in the testing, which could lead ultimately to development of new medicines and crop plants. Development of the interdisciplinary ties which have made possible this rapid laboratory analysis is surely one of the general accomplishments of the project. Despite these positive results, it is clear that we have only scratched the surface in our attempts to catalog and understand the flora of Peruvian Amazonia and its potential uses. While we have made much progress toward these goals in the three years of the project, it is increasingly apparent that very much more remains undone. We hope that subsequently we will be able to obtain further funding so that exploration for new plants and new uses for those plants can be continued while the promising leads discovered so far can be followed up, and the new knowledge of plant distributions converted into more effective land use planning.

CANCER RESEARCH INSTITUTE
ARIZONA STATE UNIVERSITY TEMPE, ARIZONA 85287

G. R. PETTIT, DIRECTOR
AND PROFESSOR OF CHEMISTRY

October 1, 1984

Dr. Al Gentry
Director
Missouri Botanical Garden
P.O. Box 299
St. Louis, Missouri 63166

Dear Dr. Gentry:

We just completed the first biological evaluation of your Tabebuia impetiginosa in our P388 lymphocytic leukemia cell line laboratory. One of the initial separations gave a crude mixture with a P388 ED_{50} approximately 10 μg/ml which indicates marginal activity. So we are proceeding ahead with the in vivo studies and as I mentioned earlier, in some months we will have a better appraisal. However, I now feel that we should pursue this problem and wonder about the availability of some 200 lbs of bark and a similar quantity of the heartwood.

Again, my thanks for pursuing these matters and I look forward to hearing from you.

Cordially,

G. R. Pettit

GRP/mb

cc: Dr. James Duke

XN-ABA-905-A

1.E-02

Missouri Botanical Garden

24 March 1984

Dr. James Hester
Chief Environmental Officer
LAC/DR
Room 2252
U. S. Agency for International Development
Washington, DC. 20523

Dear Dr. Hester:

This letter is in lieu of a formal 6 months progress report for the period 1 October 1983 to 31 March 1984. Since a midproject report summarizing the results of all field work completed to date has just been completed (copy enclosed), it seems rather redundant to try to separate out that portion of the work completed during the last six months as a separate report. During this period Robin Foster spent two months in the field in Peru, Al Gentry spent 1 month in the field in Peru (plus an additional week teaching a tropical botany mini-course at the University of Cuzco), and David Smith and Rodolfo Vasquez continued with full time field work.

In view of the increasing AID emphasis on preservation of biological diversity, it should be noted that one activity undertaken during this six month period was a study of the habitat of the highly endangered yellow-tailed woolly monkey, the largest endemic Peruvian animal, a species that had been thought to be extinct for over 50 years until its recent re-discovery. This included field work by Smith in the Venceremos area, in conjunction with Peruvian zoologist Mariella Leo, and a 1000 m^2 vegetational sample by Gentry and Smith during February. The preliminary results of this analysis are most striking in that the plant species diversity of this 1900 m altitude site in the "ceja de la montaña" is much higher than anticipated at such a high altitude. The preliminary indication from this result is that some kind of causal connection may exist between the unusually rich vegetation and the unusual occurrence of this striking primate, which has the highest altitudinal range of any neotropical monkey.

The most exciting outcome of the AID-supported botanical investigation during the last six months has been additional analysis of the properties of Fevillea, our promising oil seed discovery. On a per-seed or per-fruit basis this would appear to be the richest oil source yet reported and our preliminary calculations suggest that it might be possible to grow Fevillea vines as a commercial oil crop inside the intact rain forest with an anticipated production equivalent to other oil crops which must be grown in cultivated fields. Contact has been initiated with St. Louis-based Ralston-

P. O. Box 299
St. Louis, Missouri 63166
314 577 5100

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Purina to further study the properties of Fevillea as an edible oil and potentially to develop field trials and agronomic testing in Peru in connection with that company's Peruvian subsidiary. A preliminary draft of a manuscript reporting the discovery of the oil seed potential of Fevillea is enclosed.

Rodolfo Vasquez is currently in St. Louis for six weeks of herbarium work and research funded by a grant from RARE (a World Wildlife Fund affiliate). This grant is specifically ear-marked for helping train a Peruvian biologist who is expected to contribute significantly to conservation on his return to his own country. During Vasquez's stay here, we have been collaborating on several reports focusing on the interface between economics and conservation in Amazonian Peru. A copy of the first of these, on the mismanagement of Ceiba as a natural resource, is also appended.

Sincerely,

Alwyn H. Gentry
Associate Curator

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Missouri Botanical Garden

1. E. 02

4 April 1983

Dr. James S. Hester
Chief Environmental Officer
Bureau for Latin America
and the Caribbean
Agency for International Development
AID
Washington, D. C. 20523

Dear Dr. Hester:

Enclosed please find the six month report for AID grant DAN-5542-G-SS-1086-00. I hope that you will find it satisfactory. Please note that specific data on David Smith's most recent activities are apparently delayed in the mail between Lima and St. Louis. Therefore some of what he has accomplished during the September 1982-March 1983 period may have to be reported with the next six month report. We have deemed it more important to be prompt with this progress report than to wait for the complete report of his activities from Peru.

Thank you for your support of this research.

Sincerely,

Alwyn H. Gentry
Associate Curator

P. O. Box 299
St. Louis, Missouri 63166
314 577 5100

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SIX-MONTH PROJECT REPORT -- September 1982-March 1983

USAID

This constitutes a six month progress report of AID grant No. DAN-5542-G-SS-1086-00. This report covers the period September 1982 to March 1983.

Project field work during this period has included full time plant collecting by resident collectors David Smith and Rodolfo Vasquez, a two month field trip by Research Associate Robin Foster and a month and a half of Peruvian field work plus supplementary herbarium study by principal investigator Alwyn Gentry. In addition to a continued focus on intensive general collecting and plant exploration throughout the upper central Amazonian region, we have initiated several more specific studies including setting up two permanent tree plots and several 1000 m^2 samples to quantify species composition and diversity in different regions.

Areas in which plant collections have been made during the current six month period include the Oxapampa-San Ramón-Villa Rica area with major collections from 2000 to 3000 m on Cerro Pajonal in the Cordillera Yanachaga (Smith, Foster), the cordillera west of Oxapampa in montane palm forest and up to 2800 m near the upper limits of "ceja de la selva" (Smith, Gentry, Vásquez), the Río Cacazu along the in-construction part of the Villa Rica-Puerto Bermúdez link of the Carretera Marginal (Smith, Foster), and the Chontabamba Valley near Oxapampa (1800 m; Smith, Gentry). We also worked in the lowland part of the Río Pozuzo valley (Smith and Gentry near Pozuzo; Foster 8 days around Codo Pozuzo) and the Pichis Valley (Smith several trips, Foster 16 days) including the low hills on the valley floor near Puerto Bermúdez, alluvial fans from the San Matías range at Santa Rosa de Chivis, and the Cordillera de San Matías, including the cloud forest along the 1000 m summit ridge. Further out into the Amazonian lowlands, collecting sites included the Río Pachitea Valley (Smith, 2 trips; Foster 1 week) with field work around Puerto Inca and Sungaro and the Bosque von Humboldt terminus of the Carretera Marginal 86 km W of Pucallpa (Vásquez, 1 week). Vásquez also collected in the Huallaga Valley (Yurimaguas area), around Iquitos (in part with Gentry), on the Río Napo (Quebrada Sucusari), at Genaro Herrera on the Río Ucayali, and at a number of sites in the Ecuador border region, especially around Andoas and on the Río Tigre. In addition to working in the Selva Central region, Gentry collected during this six month period on the Río Nanay near Mishana, the Río Napo near Negro Urco (a previously totally unbotanized region), and on the Amazon itself at Yanamono.

In addition, a number of short, mostly one day, field trips were made to such other sites as the Chilpes area above Vitoc (Gentry, Vásquez, Smith) to document the flora of a forest remnant from which Juglans ("nogal") is still being actively extracted (1400-1500 m), the interAndean valley of the Río Colorado (600 m; Gentry, Smith, Vasquez) which turned out to have many disjunct dry forest elements including some species previously unreported for Peru, and the Tulumayo Valley (Smith, Foster) where collections were made in lower montane forest above Esperanza and in an almost pure forest of Podocarpus at 1800 m at Rondayacu above Monobamba. A one week collecting trip was also made by

turned out to include no less than three genera previously unreported from Peru.

Not only is discovery of new species and new distributional records of importance in order to document the Peruvian flora. Perhaps even more important in many cases is re-collection of already-described species which have been so rarely collected that the application of an old name has remained obscure. Because of taxonomic rules of priority, accounting for such old names is critically important in order to stabilize nomenclature and avoid the necessity of confusing name changes. The area of Peru in which we are working is especially important in this respect, due to the collections made there in the late 1700's by Ruiz and Pavon, especially in the Pozuzo area. A number of species collected by Ruiz and Pavon are not known ever to have been collected again. However, in many of these cases the same plant species has undoubtedly been re-collected elsewhere and given a new name. This has happened in part due to sloppy taxonomy and in part because the Ruiz and Pavon collection at Madrid is not readily accessible to many botanists and also because some of the important early Peruvian type collections were destroyed in Germany during the second World War. Complete collections from the areas visited long ago by Ruiz and Pavon will help immeasurably in figuring out what plant species they were trying to describe and thus in the stabilization of taxonomic nomenclature not only for Peru but for all of the Neotropics.

An example of the far-reaching consequences of these somewhat esoteric points comes from a species described from a Ruiz and Pavon collection from "Peru" as Inga stipulacea. There is apparently no extant type collection and there are two closely related species to which the description could apply. Both of these species are known mostly from Ecuador, one from each side of the Andes. But to which species does the name Inga stipulacea apply? Our trip to Pozuzo in February resolved this problem, since the cis-Andean species of this complex was found to be so common at Pozuzo, a locality extensively collected by Ruiz and Pavon, that it seems unlikely that they would have overlooked it. Clearly the cis-Andean species is the real Inga stipulacea; accounting for this name makes it possible to describe the coastal Ecuadorian plant as Inga jaunechensis A. Gentry.

Several potential economically important plants discovered during the first year of botanical exploration have been noted in previous reports. Follow up work to evaluate the potential of these is being conducted in several laboratories in the US. Additional material of Fevillea, a cucurbitaceous liana with possibilities as an oil seed, was obtained during the current six month period and will be turned over to Dr. Eugene Schultz of the Technology and Human Affairs Department of the Washington University School of Engineering, making possible more complete testing of its potential.

We have also discovered another economically promising plant during the current six month period. Martinella obovata is a liana species of Bignoniaceae that occurs not only in Amazonian Peru but from Belize to Bolivia and Brazil. We have recently documented several instances of use of the roots of this plant, and of its congener Martinella iquitosensis, as an eye medicine by various indigenous groups in Peruvian Amazonia. Further investigation reveals the following incredible documentation of the efficacy of this never-before-noted use of a poorly known tropical forest species. We have located 15

Although the Pichis and Palcazu Valleys are both covered with low hills, the vegetation of these two valleys differs markedly. From all the plant indicators, the hills of the broad Pichis Valley have richer soil and support greater plant productivity. Nevertheless they are apparently much more subject to strong winds than the more protected Palcazu, since the forests of the Pichis valley seem to be in a natural state of turmoil. Observations from the air suggest that this perennial disturbance is not limited to the few sites visited but occurs throughout the basin down to Puerto Inca on the east side of the Pachitea. The alluvial fan floodplain of the Río Pozuzo from its exit from the mountains below Pozuzo to its junction with the lower Palcazu has a similar flora suggesting high relative productivity.

The Palcazu valley (except the narrow flood plain) stands out among these lowland areas of the Selva Central in having unusually impoverished soil, but an exceptionally high forest. Perhaps the height of the forest is related to the protection provided by the adjacent mountains, or perhaps the greater tree stature is related to a relatively low level of disturbance associated with slower tree growth (and tree fall) in a less productive environment. Five to ten km NE of Codo Pozuzo the alluvial plain of the Río Pozuzo suddenly ends in the steep 10-20 m tall wall of an ancient alluvial terrace. The flora and vegetation of this terrace is dramatically different from that of the adjacent flood plain and indicative of low nutrient status. This terrace shares with similar terraces along the Palcazu many rarely collected plant species, some of which are more typical of higher wetter areas such as the San Matías ridge crest. Another feature of these terraces is that they have the highest densities of "tornillo" (Cedrelinga catenaeformis, the most important timber tree of the lowland Selva Central), that we have observed. An obvious conclusion from these observations is that cultivation of these apparently poor soil terraces should be discouraged and that controlled lumbering of tornillo could be the most appropriate ultimate land use for most of the Palcazu and adjacent regions of the Pozuzo.

Judging from its appearance from the air there may be another quite different poor soil area in the Selva Central region. At any rate the forest on the low hills from near the base of the Serrania del Sira up to the Llullupichis looks distinctive and very likely reflects a much poorer soil. We have not yet collected in this region, which is of limited area but might be worthy of special conservational consideration if the flora does turn out to be distinctive.

The Serrania de San Matías is an abrupt anticlinal fold between the Pichis and Palcazu rivers, presumably the first stirring of the next major uplift of the eastward-growing Andean cordillera. Due to its shape, a much greater diversity of rock layers (limestones, sandstones, red clays, etc.) is exposed on the west side than the east where we have conducted most of our field work. The most distinctive change along the east side is a broad band of somewhat sandy soil about halfway up the ridge characterized by higher densities of rubber trees (Hevea), Rapatea (Rapateaceae), numerous small palms and the fern Schizaea elegans. This floristically distinct vegetation type is not discernable from the air. The two side ridges of the San Matías system which we have botanized to date had similar soil characteristics and exposures but many species different from each other and noticeably different relative abundances of most of the

permanent plots with all trees over 10 cm dbh. marked, measured, and identified (or collected for herbarium identification). In addition to the plot at Oxapampa (1800 m), we have completed a 1 ha. plot on the Río Nanay in the Amazonian lowlands and are beginning another one near Puerto Bermúdez.

The data from these plots, besides providing quantitative floristic data, will also make possible analysis of rates of turnover and recruitment. Some of these data (currently delayed in the mail somewhere between Lima and St. Louis) will be reported more fully in the next project report.

We have also made progress in the subsidiary project objectives of training Peruvian botanists and providing identification assistance to other researchers. During the current six month period two young botanists from the Universidad de San Marcos -- Blanca León and Joaquina Alban-- spent substantial amounts of time in the field with project personnel. As a result of this association, both have had the opportunity to learn many lowland plant genera as well as much tropical natural history and ecology. Rodolfo Vásquez has similarly provided instruction for many students from the Universidad Nacional de Amazonia Peruana in the Iquitos area. Plant identifications have been provided for the herbarium of the Universidad de San Marcos, the Universidad Nacional de Amazonia Peruana in Iquitos, the Proyecto Peruano-Aleman in San Ramón, La Molina University, Proyecto Especial Pichis-Palcazu, J. Gasché and his French Anthropological team, zoologists associated with the Iquitos-based Proyecto Primatos, and others.

Some specific examples of significant identifications provided during this period include that of Calatola (Icacinaceae) for medical botanist Walter Lewis, who had previously thought the plant to belong to the quite unrelated family Nyctaginaceae. This plant is important in folk odontology among some of the Indian tribes of Amazonian Peru and its anticaries properties are now being investigated by the Washington University school of dentistry. There is no previous record of such a use for any member of Icacinaceae. Another identification of special interest is that of a formerly important timber tree of the Oxapampa region as Huertea glandulosa of the Staphyleaceae. There are apparently no previous records that this genus, or even its family, produces a useful hardwood. Proyecto Pichis-Palcazu personnel, who are interested in using this useful native tree in reforestation, had previously only been able to guess that it might be some kind of Meliaceae.

1. E-02

A BOTANICAL INVENTORY OF THE EASTERN SLOPE OF THE ANDES OF CENTRAL PERU
MID-PROJECT REPORT

As we have now completed two-thirds of the tenure of the present AID grant (No. DAN-5542-G-SS-1086-00), it is appropriate to summarize what we have accomplished and what more we hope to do. We have been successful in our overall objective of increasing botanical knowledge of the Selva Central region. Not only have we collected many new species and range extensions, but we are beginning to have, essentially for the first time, a reasonable idea of some of the specific kinds of environmental factors determining plant distributional patterns in Peruvian Amazonia. We have discovered a number of potentially useful plants and, surprisingly, in view of the little time elapsed since project initiation, some of these are already undergoing the testing which could lead ultimately to development of new medicines and new crop plants. Development of the interdisciplinary ties which have made possible this rapid laboratory analysis is surely one of the general accomplishments of this project.

We have also initiated collaborative ties with agencies and institutions in Peru dealing with timber resources in an effort to clarify taxonomic identification, an important first step in utilizing tropical trees for timber. An additional objective of the project, training Peruvian botanists and providing identification assistance to other researchers, has been an active part of the project since the beginning. In addition, several publications have resulted from the AID-supported work and more will follow in the coming year.

ORGANIZATION OF THE COLLECTING PROGRAM

Most of the first three-month period was spent in organizational work, which included hiring David Smith of Iowa State University as a full-time resident collector, Robin Foster, Missouri Botanical Garden Research Associate, as part-time collector, and Rodolfo Vásquez M. of Iquitos, Peru, as full-time resident collector in the Amazonian region. During this time, we acquired collecting supplies and worked out the necessary permits and political arrangements in Peru. A wide scope, long-term (6 years) Convenio between the Missouri Botanical Garden and the Ministerio de Agricultura was signed, which not only approves the plant collecting work of the project, but essentially designates the principal investigator of this project as coordinator of foreign plant collecting acitivites in Peru for the duration of the agreement. In February 1982, full-scale fieldwork was begun with the principal investigator and resident collector, David Smith, making a joint field trip to Peru.

The initial year's collections from the Selva Central region have been mounted, had duplicates distributed to available taxonomic specialists, and many have had species determinations recorded on the original herbarium specimens. A notebook of photocopies of these initial Selva Central area specimens has been compiled. One copy of this reference book, which should provide a novel means for rapid plant identification, will be provided to the Proyecto Especial Pichis-Palcazu and another copy will be maintained by David Smith at the Museum of Natural History of the University of San Marcos in Lima. As additional collections are identified, these loose leaf notebooks will be updated, eventually providing a handy means for ready identification in Peru of the plants of the Selva Central region. Duplicates

Rondayacu above Monobamba in an almost pure forest of Podocarpus at 1800 m.

About 80,000 specimens (20,000 collection numbers) have been collected to date.

ECOLOGICAL STUDIES AND LAND USE PLANNING

In addition to a continued focus on intensive general collecting and plant exploration throughout the upper central Amazonian region, we have initiated several more specific studies. These include setting up four permanent tree plots of one hectare each and several additional 1000 square meter samples to quantify species composition and diversity in different regions. During his 1982 field work, Robin Foster concentrated especially on ecological analysis for land use planning. After two years of botanical work and plant collecting in the Central Peruvian part of Amazonia, we have accumulated enough knowledge of the region's flora to begin to address an important objective of this project: to survey the floristic composition of the various vegetation types of the region from the viewpoint of selecting indicator species for these vegetation types, and, ultimately, using this survey capability and floristic data base in land use planning. A general summary of some of our preliminary conclusions with respect to the main vegetation types of the region follows.

Although the Pichis and Palcazu Valleys are both covered with low hills, the vegetation of these two valleys differs markedly. From all the plant indicators, the hills of the broad Pichis Valley have richer soil and support greater plant productivity. Nevertheless, they are apparently much more subject to strong winds than the more protected Palcazu, since the forests of the Pichis Valley seem to be in a natural state of turmoil. Observations from the air suggest that this perennial disturbance is not limited to the few sites visited, but occurs throughout the basin down to Puerto Inca on the east side of the Pachitea. The alluvial fan floodplain of the Río Pozuzo from its exit from the mountains below Pozuzo to its junction with the lower Palcazu has a similar flora suggesting relatively higher productivity.

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Judging from its appearance from the air, there may be another quite different poor soil area in the Selva Central region. At any rate the forest on the low hills from near the base of the Serrania del Sira up to the Llullupichis looks distinctive and very likely reflects a much poorer soil. We have not yet collected in this region, which is of limited area but might be worthy of special conservational consideration if the flora proves to be distinctive.

One of our hectare sample plots is at Cabeza de Mono on the Río Iscozacin in the Palcazu Valley. This site, on poor sandy river terrace soil, is apparently typical of much of the still-forested land in the lower and middle Palcazu Valley. It constrasts strikingly in floristic composition with the remnants of richer soil vegetation along the actual river margins. Whereas rich soil species like Ceiba pentandra occur along the river edge, they are conspicuously absent from the upland forest back from the rivers where such poor soil specialists as Iriartella setigera and Aspidosperma are prominent instead. The implication of this floristic difference appears to be that the long term success at cattle raising by many of the German settlers in the Palcazu Valley should not be taken to indicate that the whole valley could be converted from forest to productive cattle pasture. Most of the fertile soils bordering the rivers which can sustain pasture have already been converted to that use. Farther upstream at Loma Linda where the Palcazu runs out of the more broken Andean foothill country, a recent attempt has been made by the indigenous Amuesha community to set up a cattle raising operation on the highly dissected lateritic hills away from the river floodplain. The soil is too poor for good pasture (as could have been predicted from its natural vegetation) and the cattle are barely able to eke out an existence on kudzu vine.

On the other hand, our transit of the San Matias cordillera revealed an outcrop of rich limestone and limestone-derived soil part way up the western slope of the Cordillera. We were not the first to discover this richer soil area: despite being far from the settlements along the river and several hours' hike from them through little disturbed forest, the part of the limestone region we saw is mostly second growth from old chacras. It is likely that this band of soil, which should be easy to recognize by its distinctive flora, extends the whole length of the San Matias. This seems an excellent target area for intensive agriculture, rather than the sandy river terraces and lateritic hills where rich natural forests are currently being converted rapidly into substandard chacras and pastures.

Our hectare sample plot at Cabeza de Mono gives a clear indication of the timber potential of the sandy river terraces which predominate in much of the Palcazu Valley. The commonest large emergent tree in our plot is Cedrelinga catenaeformis, or "tornillo", a species of the legume family which produces a timber similar to that of Cedrela. Since mahogany and "cedro" have now been largely eliminated by overintensive exploitation through much of Amazonian Peru, "tornillo" is rapidly becoming the main timber wood of the Selva Central lowlands. That such a valuable timber wood is so common in the poor soil Palcazu forests suggests that a well-planned program of commercial exploitation might provide a sustainable resource of much greater value than the poor quality crops or pastures which could be grown here were the forest cut. Moreover, Cedrelinga shows abundant regeneration in the undisturbed forest, ranging in diameter from giant emergents over 100 cm dbh. through intermediate size classes to small trees 10 cm dbh. and less. Altogether there are eight trees of Cedrelinga over 10 cm dbh. in our sample hectare, making this one of the commonest species in this very diverse forest which we anticipate will prove to have a total of about 185 tree species when herbarium indentifications of the voucher specimens of taxonomically problematic groups are completed.

Our discovery that Cedrelinga was in full fruit through much of the Selva Central region at the end of October, 1982, is another important observation which resulted from the field work. Since this is the region's major timber tree, several reforestation projects working in the region have been trying, unsuccessfully, to locate seed for use in reforestation. No information on the reproductive phenology

patterns caused by El Niño.) The now annual havoc caused by such extreme flooding along rivers like the Amazon and Ucayali provides an urgent warning that conservation and careful land use planning are essential if new areas of the Central Amazonian region are to be commercially developed.

ECOLOGICAL STUDIES AND BIOLOGICAL DIVERSITY

Another important benefit of the program of ecological sampling, now being made possible for the first time in Amazonian Peru as a result of the increasing floristic data base provided by the ongoing field work, is the ability to measure biological diversity. Based on a series of 1000 square meter samples of all plants over 2.5 cm dbh., we have suggested previously a linear relationship between plant community diversity and precipitation—the wetter the forest, the more species it has. However, the additional 1000 square meter samples now available from Amazonian Peru suggest that this relationship only holds for annual precipitations of less than 4000 mm a year. At about this value the species diversity/precipitation curve reaches an asymptote and all wetter lowland forests, right up to the wettest place in the world in Colombia, have similar species richness.

The hypothesis that the wettest lowland forests are the richest in species diversity focuses on Amazonian Peru as a repository for an exceptionally large fraction of the earth's total evolutionary heritage of plant species. Indeed our hectare plots show that the wettest Peruvian forests near Iquitos are by far the richest in the world, contrary to the extant scientific literature which makes that claim for the dipterocarp forests of Southeast Asia. While the results are highly tentative pending the results of herbarium analysis of the vouchers, the tentative figure of about 300 tree species out of 600 individual trees in the study site at Yanamono is impressive indeed. Even the estimated 185 species at Cabeza de Mono compares favorably with the richest Asian forests and is more diverse than any previously reported neotropical forest. Thus, from a conservational viewpoint, the incredibly species rich forests of Amazonian Peru, which we are only now beginning to document, merit worldwide emphasis. Moreover, such a diversity of plant species, many of them as yet unknown to science, adds strength to the argument that the forests of Peruvian Amazonia are likely to include many plant species with novel useful chemical compounds or other unsuspected economic significance.

COLLABORATION

Identification service to Peruvian forestry agencies

In addition to the basic plant collecting and survey work, the project provides a much needed plant identification service to many groups interested in the Central Amazonian and "ceja de la selva" regions of Peru. This collaboration resulted in identifying for the first time several previously unknown and commercially important or potentially important species. For example, a fast-growing tree of the Oxapampa area known as "nogal blanco" was identified as Cordia alliodora. This tree is well known as a valuable timber tree in other parts of the neotropics and is being considered for reforestation work by Dr. Antonio Brack of the Pichis Palcazu project staff. The tree had been misidentified as belonging to Annonaceae by the local specialists in dendrology and forest consulted by Dr. Brack. As a result of discovery of the correct name and thus the possible timber potential of

also provided for various zoologists associated with John Terborgh in studies of the fauna of Cocha Cashu Biological Station in Manu Park and for another Peruvian primatologist, Marlene Ramirez, studying Sanguinus mystax on the Rio Blanco.

Identification service for ethnobotanical studies

We provided a significant identification, that of Calatola (Icacinaceae), for medical botanist Walter Lewis, who had previously thought the plant to belong to the quite unrelated family Nyctaginaceae. This plant is important in folk odontology among some of the Indian tribes of Amazonian Peru and its anticaries properties are now being investigated by the Washington University School of Dentistry. There is no previous record of such a use for any member of Icacinaceae.

DISCOVERIES OF PLANTS WITH POTENTIAL ECONOMIC SIGNIFICANCE

Several potentially useful plants have been discovered during our first two years of botanical exploration. An especially exciting discovery of a vine, Fevillea cordifolia, with real economic potential was reported during the first six months of this project. It had been reported that the seeds of an unknown "tree" species of the Pichis-Palcazu region burn with a clear blue flame and are used by the Campas Indians in place of candles. We have identified the plant in question as Fevillea cordifolia, a member of the Cucurbitaceae (squash family). Moreover, consultation with Dr. Eugene Shultz at Washington University in St. Louis reveals that the property of burning with a clear flame is very rare in seeds and indicates unusual richness in natural oils. Seeds of such unusually high oil content are being actively investigated by the Center for Development Technology of the Technology and Human Affairs Department at Washington University in an attempt to find new alternative fuel sources. They are extremely interested in the Peruvian Fevillea as a potential fuel source. Not only are Fevillea seeds apparently extremely rich in oil, but they are also extremely large, probably the largest seeds of any Cucurbitaceae. Furthermore, the vine is fairly common in riverine habitats (where the unusually large seeds are probably associated with water dispersal), produces fruit prolifically, and is capable of growing in the second growth or forest edge habitats which are becoming increasingly prevalent throughout the tropics as the rain forest continues to be destroyed at a rapid rate. Investigations of the oil content of these seeds are now underway at Edwin Cooper Labs in St. Louis. The large size of the seeds, high ratio of seeds to fruit, high oil content of the seeds, and capability of growing the vine on second growth forests make Fevillea a likely plant to develop as a new crop.

We discovered another economically promising plant during the first half of the project. Martinella obovata is a species of Bignoniaceae (catalpa family) that occurs not only in Amazonian Peru but from southern Mexico to Bolivia and Brazil. Recently, we have noted several instances of the use by various indigenous groups in Peruvian Amazonia of the roots of this plant, and of its congener Martinella iquitosensis, as an eye medicine, a use never before documented. Further investigation revealed compelling confirmation of the efficacy of this poorly known tropical forest species. We have located twenty-three records of the medicinal use of Martinella by various tribes. These records, mostly gleaned from herbarium specimens (many of which were unidentified, some even to family), could be compiled only through the taxonomic expertise of the principal investigator. Together they record use of Martinella, always the roots and always as an eye medicine, by more than 13 different ethnolinguistic groups in eight different countries of northern South America. That widely divergent indigenous

process of being described from Peru, including one from the Selva Central region that represents a genus new to Peru as well (Geissospermum). The genus Aspidosperma provides an excellent example of how poorly known are the plants of this region. Only three species of the genus were known to occur in Peru in 1959 when the Flora of Peru treatment was written. We have collected eleven additional species, including at least one new one, almost quintupling the known Peruvian species. Yet many species of this genus are commerical timber trees and one section of it (series Nitida="remo caspi") is generally esteemed throughout Peruvian Amazonia as the raw material from which canoe paddles are made. "Remo caspi" trees have such deeply convoluted trunks that sections of the thin projecting trunk portions can simply be cut out in the outline of a paddle with the additional advantage of being very strong. One Selva Central species of Aspidosperma that we discovered may be of special physiological interest: It has both bright red and white latex in the same twigs, a situation possibly unique in the plant kingdom. One of the "remo caspi" type Aspidosperma species with deeply partitioned trunks is valued in Panama, where it is rare, for the table tops made from trunk sections. These are even exported to the U.S. Peru, with its wealth of Aspidospermas (e.g., six trees representing several species in the Cabeza de Mono hectare, 28 trees representing about six species at Mishana) might well be able to develop a market for this unique natural resource as well. Ing. Rios Trigosa at La Molina, for whom we are providing identifications, is particularly interested in the genus and its wood properties.

Another example of an economically useful Apocynaceae from Amazonian Peru is provided by the tribe Carisseae, many species of which produce delicious fruits. The most prized locally is that of Parahancornia peruviana, most inaccurately named "naranjo podrido" ("rotten orange"), which is endemic to Peruvian Amazonia, occurring mostly on poorer soil types such as those at Mishana and Cabeza de Mono. Although "naranjo podrido" trees are large, they are regularly felled in many areas in order to obtain the highly esteemed fruits. As a result, the species is rapidly becoming scarce near many settled areas. Yet "naranjo podrido" fruits are so delicious that they could easily be developed as an economically significant renewable resource harvested in a non-destructive manner or even grown in plantations. While this fruit is little known outside the campesino caserios of the lowland Peruvian forests, it is well known locally. In contrast, a close relative, locally even more common on white sand soils near Iquitos, proves to be an undescribed species, now being named as Ambelania occidentalis, the westernmost representative of its genus. The fruits of A. occidentalis are fairly similar to those of the "naranjo poidrido", though less tasty, and are easily accessible as the tree is a small one. Perhaps the two are close enough taxonomically to be hybridized, potentially combining the desirable qualities of small stature and high quality fruit. Even a breeding program using either species alone could produce similar results and a new commercial crop.

While an exceedingly obscure Apocynaceae vine, newly discovered to exist in Amazonian Peru, was noted above as a potential latex source, it is also worth emphasizing that the original Peruvian latex producer—the rubber tree, once the mainstay of the entire Amazonian economy--is one of the commonest tree species on our poor soil tree plots. There are fifteen Hevea trees per hectare in the Pelcazu Valley plot and twenty-one per hectare at Mishana, near Iquitos. There is no evidence that any of these are being tapped commercially, although rubber tree latex is still purchased in Peru and recently has been staging something of an economic renaissance in Amazonian Brazil. It might be that the failure to extract easily obtainable and readily marketable rubber from the rather dense

As noted above, duplicates of the plant collections have been deposited at two Peruvian herbaria, adding significantly to the resources available to researchers working on the Peruvian flora. The compilations of photocopies of the herbarium specimens will be provided to the Proyecto Especial Pichis-Palcazu and to the Museum of Natural History at the University of San Marcos in Lima, to provide a portable guide to the plants of the Selva Central region when a herbarium is not available.

PUBLICATIONS

A number of scientific publications, several of general interest, have already resulted either directly or indirectly from the AID-sponsored research. These include a general overview of Neotropical floristic diversity, a proposed correlation of vertebrate locomotor patterns with newly discovered intercontinental differences in forest structure, and a note reporting the discovery that the obscure and exclusively Peruvian genus Plagioceltis is in fact synonymous with Ampelocera, as well as descriptions of several new species.

Data from the ecological studies formed the basis for a paper to be included in the Peruvian Ministry of Agriculture's new book on Manu National Park, entitled "Some preliminary results of botanical studies in Manu Park". A copy of that manuscript (to be translated into Spanish prior to publication) is appended to this report since many of its observations of the flood plain vegetation of the Río Manu are relevant to rich soil areas of the Selva Central area. In fact, the Manu forest is probably more like the original forest communities of the central Huallaga Valley than are the degraded remnants present in the Huallaga Valley today.

A paper describing the discovery of the use of Martinella as an eye medicine as a result of the AID-sponsored Peruvian plant exploration has been submitted to the Journal of Ethnopharmacology. A copy of that manuscript is attached.

CONCLUSION

As a result of the plant collections which are accumulating from this project, floristic knowledge of the central Amazonian area of Peru has been increased significantly. Some examples of especially interesting species discovered during the course of the project include two families previously unreported for Peru—Magnoliaceae with no less than three different species of Talauma collected, at least one of them apparently undescribed, and Drosera of the Droseraceae, the peculiar family of insectivorous plants previously known in the Andean region only in Colombia. The dominant species of the forests above Oxapampa, so prevalent that every ridge line visible from the town is characterized by the silhouettes of this species, proves to be yet another genus new to Peru, the palm Dictyocaryum. Although this species, used to construct the floors of campesino houses throughout the area, is the most common and one of the best known plant species of the Oxapampa area, it had never been collected previously. That it is a genus previously unknown from Peru underscores the point that our knowledge of the Peruvian flora remains woefully lacking.

Missouri Botanical Garden

1. E. 02

30 September 1982

Dr. James Hester
Chief Environmental Officer
LAC/DR
Room 2252
U.S. Agency for International Development
Washington, DC. 20523

Dear Dr. Hester:

Enclosed please find the six-month report on Grant No. DAN-5542-G-SS-1086-00 for the period 30 March 1982 to 30 September 1982. Since the report for the first six month period was submitted late, there is a certain amount of overlap between this report and the previous one during the period April to June which ended up covered in both reports. We now have the time framework for reporting to AID firmly in mind and you should be able to expect future interim reports at the scheduled six month intervals.

If you have any questions, please let me know.

Sincerely,

Alwyn H. Gentry
Associate Curator

Kathleen Cook

P.O. Box 299
St. Louis, Missouri 63166
314 577 5100

30

SIX-MONTH PROJECT REPORT--March 1982-September 1982

USAID

This constitutes the second six month progress report of AID grant No. DAN-5542-G-SS-1086-00. Since the first progress report was submitted late, it included some of the work done during the March-September 1982 period and this report thus overlaps in part with the previous one.

The emphasis of the project continues to be on intensive collecting, especially of trees. Major collecting efforts during this six month period have been concentrated in both the middle and lower Huallaga Valley area and thePichis Palcazu region. David Smith, the project's full time resident collector, spent most of April in the Bosque von Humboldt, Puerto Inca, Río Pachitea region mostly working along the northern end of the currently under-construction segment of the Carretera Marginal. He collected 205 numbers and about a 1000 specimens during this period. In May and June he worked mostly in the Chanchamayo-Oxapampa-Villa Rica area with major collections from Río El Tunque (1620 m, near Pozuzo), Río Baqueria (1870 m, eastern side of the Cordillera Yanachaga) and west of Oxapampa (3500-4000 m, upper limits of the "ceja de la montaña"). A trip of 10 days was made to Iscosasin on the Río Palcazu where collections were made in lowland and mid-elevation forest, and several trips to the San Ramón area concentrated on obtaining collections of middle and upper elevation forest trees of that region. All of these collections have now been received in St. Louis and are currently being processed and identified. While it is too early to tell what portion of the collections represent new species or new distributional records, it is obvious that they will greatly increase knowledge of the floristically little known forests of these regions.

In June a short trip was made by the PI to the Pichinaki forest between La Merced and Satipo at 900-1000 m altitude. This trip was in conjunction with a field trip which he led preceding the Flora Neotropica Annual meeting and Latin American Botanical Congress. The resident collector also worked in this area for a number of days, largely collecting specimens of tree species of potential interest for inclusion in a joint German-Peruvian reforestation project now underway in this region. Indeed the process of deforestation on the steep slopes of this foothills area is so rapid that the entire cycle of timber harvesting, land clearing and short-term cultivation by campesinos, land abandonment, and (hopefully) reforestation is obvious along a few kilometers of a road being continually and inexhorably pushed further into the forest in search of "tornillo" and other valuable timbers. Although the soil fertility of much of this region has long since been lost, it is possible that immediate reforestation along the lower part of the new access road, using the native species from the forests just now being cut at the end of the road, will help cut down on the devastating loss to erosion which normally follows land-clearing in these areas. Obviously the potential for such a reforestation scheme depends to a large extent on knowing the tree species of the area, a service being provided by the AID-sponsored floristic project.

A major collecting trip was made by the PI and Resident Collector along most of the length of the Huallaga Valley to the Tarapoto area in July. Although much of the Huallaga Valley has been completely deforested, the part of the Tingo Maria-Tarapoto road between Balsapuerto and Campanilla passes through excellent stands of mature premontane forest, although these are being rapidly cleared. We collected in this area and in the isolated region of dry forest vegetation between Juanjui and Tarapoto. The latter area, although constituting a major and distinctive part of the Huallaga Valley ecosystem, has been very poorly collected and is very poorly known botanically. Among the most exciting discoveries in the remnant patches of natural forest we were able to locate on steep slopes overlooking the Huallaga River was Cuspidaria weberbaueri, an endemic species previously known only from two old collections from the now-deforested Chanchamayo area and feared to be extinct, but which turned out to be one of the commonest species of the Tarapoto area forest remnants. As an added bonus, the new collections were in fruit, making possible the description of the previously unknown fruit of this unusual plant.

Another species discovered to be common in these dry forest remnants, but which was previously unknown from the area, is Tabebuia impetiginosa. Collected only a couple of times previously in Peru (once from the Marañon valley, once from the Iparia), this wide-ranging but generally uncommon species has suddenly achieved prominence as the source of a bark now being widely propagandized as a cure for cancer. Many Brazilian populations of the species have been wiped out by bark hunters and the cost of the bark, which is just beginning to be widely introduced into the United States despite FDA qualms, is climbing rapidly. Since there are several solid scientific studies which show that the active principles of this bark do indeed cure some kinds of cancer in laboratory rats and mice, it is quite possible that a major new product is in the offing. Discovery of the Huallaga Valley populations could be significant inasmuch as they represent a very isolated population of a species whose intrapopulational chemical variation is completely unknown. Indeed one of the other Peruvian collections of this species was deemed so different that it was described as a new species. Moreover the development of a tree like this (the wood is also extremely hard and durable and much used in other countries, though not Peru) as a commercial crop could be a real boon to an ecologically devastated area like much of the Tarapoto region. Discovery of the plant was the first step; we are now initiating a collaboration with the pharmacognosy laboratory at the University of Illinois-Circle Campus to further study the chemical composition of the bark of this species, the new Peruvian population of it, and the anticancer activity of these compounds.

The Tarapoto trip also resulted in the first botanical collections ever made in the low mountain range between Tarapoto and Yurimaguas and a partial vegetational sample of 400 m^2 of one of the dry forest remnants overlooking the Huallaga. Altogether over 500 collection numbers and perhaps 2500 specimens were collected on this trip. The collections from the trip have arrived in St. Louis and are now being processed.

Additional field work during this period by the PI included a couple of weeks in lowland Amazonia. The high point of this field work was a week in the Río Samiria Reserve area between the mouths of the Ríos Ucayali and Huallaga, an area in which not a single plant collection has ever been made previously. This is an important wildlife habitat -- e.g. including apparently the last

known population of the giant Amazonian turtle and one of the few extant populations of Amazonian manatees. Thus some knowledge of its floristics is very important. The vegetation turned out to be similar to that formerly found along the Río Amazonas itself (white water-inundated tahuampa) but now virtually exterminated. Among the common species is a genus new to Peru--Patinoa (Bombacaceae)--as well as many very poorly known and rarely collected species formerly characteristic of this habitat. Rodolfo Vasquez has concentrated his collecting efforts in the lower part of Peruvian Amazonia, working out of the herbarium of the Universidad de Amazonia Peruana in Iquitos, with major collecting trips to Andoas on the Ecuadorian border and Genaro Herrera on the Río Ucayali. A couple of hundred collections a month from throughout the region are being received from Vasquez as are smaller collections for identification received from various foresters, anthropologists, and students. Currently a botanist from the Muséum d'Histoire Naturelle in Paris, France, is in St. Louis for several months, funded by a European anthropological project focused on Peruvian Amazonia in order to make use of the collections and expertise here to identify the collection vouchers obtained during their anthropological work. These identifications, of course, are in part dependent on the collections generated and identified by the AID-funded floristic work. The necessity for French anthropologists to bring their collections from Peruvian Amazonia to St. Louis for identification underscores the importance to the scientific world of the AID-sponsored floristic investigations.

Several areas for intensive study and especially concentrated collecting have been selected, including the Bosque von Humboldt area at 270 m on mostly lateritic soils, the San Matías range (between the Pichis and Palcazu rivers) from 340 to 1000 m and the Cordillera Yanachaga (1800 to 3000+ m). Complete species lists will be compiled for each of these regions to provide baseline data for correlating plant species distributions and environmental parameters. Vasquez is similarly concentrating on revisiting and sampling intensively several selected vegetation types and sites in Loreto Department. A complete sample has been made of all plants over 2.5 cm dbh in a 0.1 ha. area at Bosque von Humboldt and similar samples will be obtained for the other intensive study sites. These samples were obtained with the sample techniques described in Gentry, 1982 (Evolutionary Biology 15: 1-84) and will provide data making possible direct comparison of plant species diversity and floristic composition of these regions with many other neotropical and palaeotropical areas. Robin Foster, working 1/4 time for this project, arrived in Peru in August and is currently in the Chanchamayo area where he will be actively involved in sampling the natural forest vegetation as well as making general collections to document the flora of various vegetation types and regions.

The especially exciting discovery of a Cucurbitaceous vine, Fevillea cordifolia, with real economic potential was reported during the first six months of this project. It had been reported that the seeds of an unknown "tree" species of the Pichis-Palcazu region burn with a clear blue flame and are used by the Campas Indians in place of candles. We have identified the plant in question as Fevillea cordifolia, actually a liana of the family Cucurbitaceae. Dr. Eugene Schultz of the Technology and Human Affairs Department of the School of Engineering at Washington University, St. Louis, is currently undertaking testing of a limited stock of these seeds. We are now trying to obtain a much larger sample of the seeds from Peru for more extensive testing. They report that the fact that the seeds of this species,

which are among the largest in its family, burn with a clear blue flame when dried strongly suggests an unusually high oil content. Problems with oil seeds studied to date in the hopes of finding a charcoal substitute have been difficulty in burning whole seeds and in avoiding smoke formation. The preliminary results suggest that Fevillea might be a significant break through on both fronts. Another area in which Fevillea seeds could hold promise, according to Dr. Schultz, is in the expression of oil for illumination by village technology as a replacement for kerosene. Dr. Schultz reports that with the rise in prices of petroleum products, alternative and indigenous illuminants are badly needed and that Fevillea would seem an excellent candidate for producing such a product.

Another potentially economically and politically significant discovery made during the current phase of this project is that the predicted higher flood crests of the Amazon and its major tributaries suggested by the principal investigator (Science 210: 1354-1356, 1980; Science 215: 427, 1982), as a devastating and unexpected result of rampant deforestation of the headwater regions of the Amazon, are becoming increasingly critical. Deforestation continues unabated and the May 1982 flood was by far the highest ever recorded in the upper Amazonian region, at least as far downstream as Leticia, Colombia. The now annual havoc caused by such extreme flooding along rivers like the Amazon and Ucayali provides an urgent warning that careful land use planning is essential if new areas of the Central Amazonian region are to be commercially developed.

A final objective of the AID-sponsored project, collaboration with and providing assistance to the botanical inventory programs and capacities of Peruvian universities, has also been actively pursued during this six month period. Such help has ranged from assisting in a field ecology course for advanced biology students at the Universidad Nacional de Amazonia Peruana to providing logistical support for travel and fieldwork by faculty members of several Peruvian universities. Peruvian botanists who have participated in project fieldwork include Oscar Tovar and Blanca León of the Universidad de San Marcos, Angel Salazar and colleagues of the Bosque Nacional de von Humboldt, and Franklin Ayala, Doris Alfaro, and colleagues of the Universidad Nacional de Amazonia Peruana. In addition to logistic support, the Principal Investigator has conducted informal mini-courses in tropical plant identification for these and other Peruvian botanists whose own independent studies should be directly benefited as a result. Identifications of plants collected by these botanists as well as by foresters, especially those associated with the La Molina University in Lima, have also been carried out by the PI as have identifications of the plants eaten by primates in various anthropological and zoological investigations, especially those associated with the IVITA Proyecto Primatos program based in Iquitos. The PI was one of the featured speakers at the quadriennial Latin Botanical Congress, which was held in Peru this year, and has been invited to conduct a short course for anthropologists, sponsored and funded by MAB and UNESCO, in Iquitos in November. Such invitations suggest that the kinds of study being carried out under the AID grant are appreciated and making a real contribution to Peruvian science.

1. E- 02

Missouri
Botanical
Garden

4 August 1982

Dr. James Hester
Chief Environmental Officer
LAC/DR
Room 2252
U.S. Agency for International Development
Washington, DC 20523

Dear Dr. Hester:

Enclosed please find the report for the first six months' activity under grant No. DAN-5542-G-SS-1086-00, which I promised in my letter of 24 June. Dr. Gentry drafted this report while in the field in Peru.

Sincerely yours,

M.R. Crosby

Marshall R. Crosby
Director of Research

MRC:bc
Enclosure

P.O. Box 299
St. Louis, Missouri 63166
314 577 5100

AID Six-Month Report

During the first six months of the project the emphasis has been on intensive collecting, especially of trees, in the Pichis Palcazu project area. Approximately 3000 numbers have been collected to date, mostly in sets of five. Part of this material has already been sent from Peru to the Missouri Botanical Garden for processing and identification; the more recently collected material will be shipped to St. Louis in a few months. In addition, duplicates of Peruvian plants from the Central Amazonian region to be identified by project staff have been received from several Peruvian forestry groups including the Universidad Nacional Agraria de La Molina, the research staff at Bosque von Humboldt, and a reforestation project sponsored by West Germany and the Ministerio de Agricultura.

Most of the first three-month period (November to January) was spent in organizational work which included hiring as a full-time resident collector, David Smith, of Iowa State University, acquiring collecting supplies and shipping them to Peru, and working out the necessary permits and political arrangements in Peru. A wide scope, long-term (6 years) Convenio between the Missouri Botanical Garden and the Ministerio de Agricultura was signed, which not only approves the plant collecting work of the project but essentially designates the principal investigator of this project as coordinator of foreign plant collecting activities in Peru for the next six years. The new Convenio also resulted in obtaining a long-delayed exportation permit for previous Peruvian plant collections and the shipment to St. Louis in May of 16 large refrigerator boxes of plant collections which will be processed along with the collections of the AID-sponsored field-work.

In February 1982, full-scale fieldwork was begun with the principal investigator and resident collector making a joint field trip to Peru. About 1000 plant collection numbers (ca. 4000 duplicate specimens) were made and the resident collector trained in plant collection and field identification techniques used by the principal investigator. Fieldwork included two weeks in the Chanchamayo-Oxapampa-Villa Rica area with collecting efforts concentrated in the middle elevation cloud forests, especially in the Cordillera Yanachaga, and along the part of the Carretera Marginal now under construction from Villa Rica to Puerto Bermudez. Ten days were also spent at the other end of the Pichis-Palcazu project area, working in the Bosque Nacional Alexander von Humboldt and the adjacent area at the northern end of the segment of Carretera Marginal, which is under construction. Two weeks were also spent in the Iquitos area coordinating research efforts with Dr. Franklin Ayala and other faculty members of the Universidad Nacional de Amazonia Peruana, and doing fieldwork in the lowland Amazonian forests at Yanomono, Andoas, and Mishana.

The principal investigator returned to the U.S. in March while the resident collector continued to collect plants in the Central Amazonian and ceja de la montaña region. His collections now total

2000 numbers (ca. 8000 duplicates). His fieldwork has included three weeks in the lowland forests along the Río Pachitea and in Bosque von Humboldt region and a week at the current end of the Carretera Marginal, reached by a one-hour boat trip up the Río Pachitea from Puerto Inca, the latter reached by plane from Pucallpa. Taking advantage of tree cutting by the road-making activities it was possible to make an excellent sample of the trees of this region which was previously virtually unknown botanically. Smith also collected for four weeks in the Oxapampa region mostly in middle elevation cloud forests with major collections from Río El Tunque (1620 m, near Pozuzo), Río Baqueria (1870 m, on eastern side of the Cordillera Yanachaga), and west of Oxapampa (3500-4000 m, upper limits of "ceja de la montaña." A trip of ten days was made to Iscosasin on the Río Palcazu where collections were made in lowland and mid-elevation forests, and a five-day trip to the San Ramón area concentrated on obtaining collections of middle and upper elevation forest trees of that region. All these collections are now being processed and identified. While it is too early to tell what portion of the collections represent new species or new distributional records, it is obvious that they will greatly increase knowledge of the floristically little-known forests of these regions.

Several areas for intensive study and especially concentrated collecting have been selected, including the Bosque von Humboldt area at 270 m on mostly lateritic soils, the San Matías range (between the Pichis and Palcazu rivers) from 340 to 1000 m and the Cordillera Yanac haga (1800 to 3000+ m). Complete species lists will be compiled for each of these regions to provide baseline data for correlating plant species distributions and environmental parameters. A complete sample was made of all plants over 2.5 cm dbh in a 0.1 ha. area at Bosque von Humboldt and similar samples will be obtained for the other intensive study sites. These samples were obtained with the sample techniques described in Gentry, 1982 (Evolutionary Biology 15: 1-84) and will provide data making possible direct comparison of plant species diversity and floristic composition of these regions with many other neogropical and palaeotropical areas.

In addition to the basic plant collecting and survey work, the first six months of this project resulted in providing a much-needed plant identification service to many groups interested in the Central Amazonian and "ceja" regions of Peru. This collaboration resulted in identifying for the first time several previously unknown and commercially important or potentially commercially important species. For example, a fast-growing tree of the Oxapampa area known as "negal blanco" was identified as Corida alliodora. This tree is well known as a valuable timber tree in other parts of the neotropics and is being considered for reforestation work by Dr. Brack of the Pichis Palcazu project staff. The tree had previously been misidentified as belonging to Annonaceae by the local specialists in dendrology and forestry consulted by Dr. Brack. As a result of discovery of the correct name and thus the potential timber potential of "negal blanco,"

an active program of propagation of the plant for reforestation has now been initiated. Another unidentified species of commercial importance and locally known as "huamanchil co" has now been identified by the principal investigator as Laplacea spathulata. This tree is of special importance as a leading timber tree, yet it has not previously been possible to identify it--a serious problem in view of the Peruvian government's requirement of identifications of all timber products in order to obtain export permits.

Many identifications of trees for foresters from La Molina University and Bosque Nacional Alexander von Humboldt have also been provided during the course of this project. One of the more interesting of these is a member of the genus Auararibea (Bombacaceae), which is very rare in Peru and which is one of the most important canopy species along the dry part of the Río Perené. Species identified for the Bosque von Humboldt foresters included Copaifera, a legume genus now being considered for commercial exploitation as a fuel source, which is very common locally although previously known from Peru from only a handful of collections. Identifications have also been provided to a German-sponsored reforestation project headquartered at San Ramón. We have collected many of the species of interest to their project and will provide them with the desired identifications.

One especially exciting discovery of a potentially commercially important plant species has been made during the first six months of this project. The seeds of an unknown "tree" species of the Pichis-Palcazu region burn with a clear blue flame and are used by the Campas Indians in place of candles. We have identified the plant in question as Fevillea cordifolia, actually a liana of the family Cucurbitaceae. Moreover, consultation with Dr. Eugene Shultz of the Technology and Human Affairs Department at Washington University in St. Louis reveals that the property of burning with a clear flame is very rare in seeds and indicates unusual richness in natural oils. Seeds of such unusually high oil content are being actively investigated by the Center for Development Technology of the Technology and Human Affairs Department in an attempt to find new alternative fuel sources. They are extremely interested in the Peruvian Fevillea as a potential fuel source. Not only are Fevillea seeds apparently extremely rich in oil, but they are also extremely large, probably the largest seeds of any Cucurbitaceae. Moreover, the liana is fairly common in riverine habitats (where the unusually large seeds are probably associated with water dispersal), produces fruit prolifically, and is capable of growing in the second growth or forest edge habitats which are becoming increasingly prevalent throughout the tropics as the rain forest continues to be rapidly destroyed. Investigations of the oil content and fuel potential of these seeds are now underway at Washington University by one of Dr. Shultz's graduate students.

Another potentially economically and politically significant discovery made during the first six months of this project is that the predicted higher annual flood crests of the Amazon and its major tributaries suggested by the principal investigator (Science 210:

1354-1356, 1980; Science 215: 427, 1982), as a devastating and unexpected result of rampant deforestation of the headwater regions of the Amazon, are becoming increasingly critical. Deforestation continues unabated and the 1982 flood was by far the highest ever recorded in the upper Amazonian region. The now annual havoc caused by such extreme flooding along rivers like the Amazon and Ucayali provides an urgent warning that careful land use planning is essential if new areas of the Central Amazonian region are to be commercially developed.

A final objective of the AID-sponsored project, collaboration with and providing assistance to the botanical inventory programs and capacities of Peruvian universities, has also been actively pursued during the first six months of this project. Such help has ranged from assisting in a field ecology course for advanced biology students at the Universidad Nacional de Amazonia Peruana to providing logistical support for travel and fieldwork by faculty members of several Peruvian universities. Peruvian botanists who have participated in project fieldwork include Oscar Tovar and Blanca León of the Universidad de San Marcos, Angel Salazar and colleagues of the Bosque Nacional de von Humboldt, and Franklin Ayala and Doris Alfaro of Universidad Nacional de Amazonia Peruana. In addition to logistic support, the principal investigator has conducted informal mini-courses in tropical plant identification for these and other Peruvian botanists whose own independent studies should be directly benefited as a result.

Missouri Botanical Garden

I. E. 02

24 June 1982

Dr. James Hester
Chief Environmental Officer
LAC/DR
Room 2252
U.S. Agency for International Development
Washington, DC 20523

Dear Dr. Hester:

This letter constitutes the first semi-annual report due in your office for grant No. DAN-5542-G-SS-1086-00. Dr. Alwyn Gentry of our staff is the principal investigator, but he has been very heavily involved in fieldwork in various tropical areas for much of the year, and the due date of this report, 31 March, was inadvertently overlooked by both his and my office. We apologize for this delay in reporting on the first six months' activity, and future reports will reach your office in a more timely fashion.

The first six months of activity under the grant were concerned mainly with placing a field collector in Peru, and David N. Smith of Iowa State University was hired for this purpose. Given the logistical problems which have to be solved in order to fully implement the rigorous field program which is so important to this project, a good deal of time was spent acquiring and assembling the necessary equipment and making the necessary local arrangements both in Iquitos and in the work areas. Peruvian personnel are now also in place to help handle specimen collection, preparation, and shipment back to St. Louis. The receipt and identification of collections in St. Louis has been integrated with the other ongoing botanical exploration activities which are being carried out in other areas of Peru, and a full-time staff member in St. Louis is now in charge of overall coordination of handling plant specimens from the project. As specimens accumulate, they are sorted and either identified in St. Louis or sent to specialists

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in various taxonomic groups for identification, after labels have been prepared and intercalated with each specimen, as appropriate.

Dr. Gentry is now in South America, and will visit the study sites in Peru during his trip. Upon his return, I will ask him to write you a follow-up to this report, including more detailed information concerning activities in Peru.

Sincerely yours,

M. R. Crosby

Marshall R. Crosby
Director of Research

MRC:bc

cc: A. Gentry