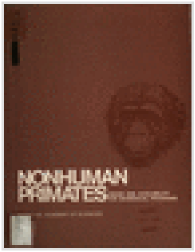

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NONHUMAN PRIMATES
USAGE AND AVAILABILITY FOR BIOMEDICAL PROGRAMS

Committee on Conservation of Nonhuman Primates
Institute of Laboratory Animal Resources
Assembly of Life Sciences
National Research Council

NATIONAL ACADEMY OF SCIENCES
Washington, D.C. 1975

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PREFACE

In response to the increasing scarcity of nonhuman primates for biomedical research and pharmaceutical production, the Animal Resources Branch of the National Institutes of Health requested information and advice from the National Academy of Sciences on the current use and availability of primates. The study was undertaken by the Committee on the Conservation of Nonhuman Primates of the Institute of Laboratory Animal Resources, which attempted to evaluate the numbers of primates used in biomedical programs, considered the problems of primate conservation, and developed recommendations for assuring a dependable longterm supply of primates for biomedical programs.

This report includes (1) a survey of the numbers and species of primates imported and maintained in the United States for biomedical purposes, (2) a consideration of the types of biomedical programs that use primates, (3) a description of factors that influence the status of wild populations, especially as they relate to the international primate trade and to habitat changes, and (4) recommendations as to methods for supplying primates needed for research, the testing of biologics, and the production of pharmaceuticals.

ACKNOWLEDGMENTS

The Committee was assisted by Dr. Nancy A. Muckenhirn, who served as its staff officer and who undertook first responsibility for compiling the basic data, summarizing it for review by the Committee, and preparing the initial drafts of the report. Special acknowledgment must also be given Dr. Clyde Jones and Ms. Jaclyn Wolfheim of the National Fish and Wildlife Laboratories, U. S. Department of the Interior, for their valuable discussions during the conduct of a parallel project concerning the status and trends of primate populations. The section on these topics in this report relies heavily on data developed by Ms. Wolfheim.

Dr. Richard Thorington, past chairman of the Committee for Conservation of Nonhuman Primates, facilitated the project by providing thoughtful guidance as well as office space. We gratefully acknowledge the assistance of Dr. L. Whitehair, and the cooperation extended by Drs. W. Goodwin and C. McPherson, Division of Research Resources and Drs. A. New and R. Whitney, Veterinary Resources Branch, all of the National Institutes of Health, and Drs. O. Clabaugh and D. Schwindaman, U.S. Department of Agriculture, who made information available from their files.

Finally, we wish to thank the staff of the Institute of Laboratory Animal Resources who contributed valuable advice, administrative and editorial assistance during this project, especially Dr. Robert Yager, Executive Secretary, Dr. Charles Frank, Ms. Lydia Koutze, and Ms. Andrea Lynn. Secretarial assistance by Ms. D. Clonce and Mrs. E. Jackson is gratefully acknowledged.

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INTRODUCTION

In many areas of the world, primate populations have been declining as a consequence of deforestation, expanding agriculture, urbanization, market hunting, and commercial exploitation. Several countries have established quotas that limit the number of monkeys that can be exported; others have entirely prohibited export. For example, in 1973 the government of India reduced the annual export of rhesus monkeys worldwide from 50,000 to 30,000 and indicated that further reductions might be imposed. Several years earlier, Thailand set a limit of 500 animals per year. Colombia and Peru have joined Brazil in prohibiting export of primates except under special permit. It can be anticipated as dealers respond by moving into new areas, that other countries will follow the example of those just cited.

The net effect of all these factors has been to create serious shortages of rhesus macaques, squirrel monkeys, marmosets, night monkeys, and several other species essential for biomedical programs.

It is not the purpose of this report to review or justify the role of non-human primates in biomedical programs. Their major contributions and unique functions in studies of physiology and immunology, infectious disease, cancer, metabolic disorders, cardiovascular and pulmonary disease, alcoholism and drug abuse, behavior, and a host of other biomedical problems, as well as their essential role in the testing of biologics and the production of vaccines, are thoroughly established.

Definitions

In order to examine the situation in detail, it is essential to recognize the precise way in which certain key terms are to be used.

Usage--in the general sense to indicate the numbers of animals involved in experimental, testing, or teaching procedures. It is not a synonym of the more limited terms acquisitions, inventories, or sacrificed.

Turnover--percent annual turnover as a consequence of imports, as estimated by the following equations.

1. Percent Annual Turnover of inventory =
   1/2 (imports + deaths of imports)/average daily inventory
2. Percent Annual Turnover of total volume =
   1/2 (imports + deaths of imports)/total acquisitions + inventory carryover from previous years

In both equations the multiplier 1/2 is used as a way of averaging annual imports and annual deaths.

Breeding Colony--a self-sustaining unit in which breeding stock is replaced through internal recruitment, as distinguished from production centers in which breeding stock is replaced by the importation of additional wild-caught animals.

Yield--gross yield, the total number of infants produced in a breeding colony or center, as distinguished from net yield, which is determined by subtracting from the gross yield the number of infant deaths and the number of surviving infants, if any, retained for replacement of breeding stock.

Primates--refers here only to nonhuman primates. In certain cases more than one common name, or more than one scientific name, are in current use for a given species. Some synonyms are indicated by footnotes in Appendix I. Additional examples include the following:

1. The long-tailed macaque, *Macaca fascicularis*, is frequently referred to as the cynomolgus or crab-eating macaque; *M. irus* is a synonym.
2. The stumptail macaque, *M. arctoides*, has also been called *M. speciosa*.
3. Two commonly used names for *Cercopithecus aethiops* are vervet and African green monkey.
4. Night monkeys, *Aotus trivirgatus*, are frequently called owl monkeys or douroucoulis.
5. Marmoset, as here used, includes the tamarins also.

RECOMMENDATIONS

Current and anticipated shortages of wild-caught primates for biomedical programs are such as to justify the development of a national plan that will incorporate the following features:

1. An adequate, assured supply of animals derived primarily from the establishment of self-sustaining domestic breeding colonies, but augmented by breeding colonies and production centers in countries of origin and also supported by the application of wildlife management techniques to natural populations.
2. Reduction of wastage in international primate trade by the adoption of sound managerial procedures--e.g., closer supervision of trapping, holding and shipping operations; and sponsorship of trapping expeditions in which all aspects of collection and transport are monitored.
3. Establishment of a computerized users' service that would encourage and facilitate multiple use of primates by rapidly matching available surplus animals to existing needs, and would permit accurate estimates of national needs based on usage data.

The overall administration of the proposed national plan should be undertaken by the National Institutes of Health (NIH), with the advice of a committee representative of the national biomedical community. Among the explicit responsibilities of NIH would be--

- Administration of contracts in support of domestic breeding colonies.
- Establishment and operation of a computerized users' service.
- Management of "Certificate of Need" programs.
- Development and distribution of guidelines for commercial trapping, holding, and shipping of primates, based on best available information.
- Coordination of methods and locations of trapping expeditions.
- Support of cooperative field studies on population dynamics of wild populations as they relate to the potential for sustained-yield harvesting.
- Development of contingency plans to deal promptly with shortages and to allocate resources when shortages develop.

It is essential that the plan look to meeting the needs of all major biomedical programs and be fully operative within a decade.

Stabilization of Supply

Achievement and maintenance of a dependable supply of primates for research and related needs will require a vigorous, balanced effort and support in four distinct areas outlined in the following sections.

Self-Sustaining Domestic Breeding Programs

Generally, the primate species now widely used in biomedical research, and doubtless others now relatively unknown, will rapidly become less available from naturally occurring populations. In no cases are wild populations adequate to provide the numbers and the quality of animals needed in the United States and other countries on a sustained basis. Hence, despite the possible application of artificial insemination, sperm banks, fertility drugs, or drugs that regulate reproductive cycles, there are no shortcuts or feasible alternatives to the development of large-scale breeding programs that depend on normal reproductive behavior. Indeed, even if fertility regulating techniques were to become feasible, it is likely that the costs would outweigh the potential benefits--costs of trained staff, nurseries for hand-rearing multiple and premature infants, and technical work.

Breeding colonies should be stocked with animals originating from known geographic localities. Blood samples should be taken from all members of the founding stock since their progeny will be used to stock future production colonies. Frozen samples of serum and cells should be retained. Various tests should be run on the serum and red cells to define the genetic constitution of the individuals and of the founding stock. All government supported Requests For Proposals (RFP's) for primate breeding should require the submission of a breeding plan with an identified portion of the progeny to be retained as replacement breeding stock.

If domestic breeding programs are to be successful they must be planned and funded on a long-term basis and must consist of colonies that are sufficiently large to assure adequate genetic diversity. Various political, economic and ecological forces are such that self-sufficiency for the United States within 15-20 years is essential. In moving toward this goal, certain priorities as to species that merit emphasis can be established:

Group 1--Species currently used in numbers that exceed long-term resources and for which, in fact, breeding programs should have been established several years ago. These include rhesus macaques (*Macaca mulatta*), squirrel monkeys (*Saimiri sciureus*), marmosets (e.g., *Saguinus mystax* and *S. fuscicollis*), and night monkeys (*Aotus trivirgatus*). Chimpanzees (*Pan troglodytes*) fall into this same group, but need be bred only on a substantially smaller scale. It is essential that support be provided for breeding programs in this group.

Group 2--Hardy species for which sufficient information is already in hand on which to develop breeding programs and for which efforts to increase their use in research are justified, especially as they might replace species in Group 1. In this category are baboons (*Papio* sp.), vervets (*Cercopithecus aethiops*), any other macaque species, particularly long-tailed macaques (*M. fascicularis*), Japanese macaques (*M. fuscata*), and pigtail macaques (*M. nemestrina*), and capuchins (*Cebus apella*). Substantial support for breeding programs in this group is highly recommended.

Group 3--Species that, if they could be obtained, are potentially useful, but about which more information is needed. These might best be bred in pilot colonies while their usefulness is evaluated. This group includes gibbons (*Hylobates* sp.), talapoins (*Cercopithecus talapoin*), and tree shrews (*Tupaia* sp.). Modest support for breeding programs in this group is highly recommended.

It cannot be overemphasized that the research potential of a large number of species is entirely unexplored and that information obtained on the proper husbandry of any species is likely to be applicable to breeding programs generally. Hence, species not explicitly cited in the three groups named above should by no means be ignored. Research data on primate reproduction, wherever obtained, will contribute to biomedical knowledge.

Breeding in Countries of Origin

Governmental actions in the countries from which primates of biomedical importance come indicate not only that animals for research and testing will become increasingly difficult to obtain in adequate numbers but that it may be difficult in certain species, to obtain sufficient breeding stock to establish large-scale domestic production units. Despite the uncertainties, it is essential to support the establishment and operation of breeding colonies and production centers in countries of origin. These enterprises would have the advantage of generally lower costs than in the United States and would to a degree relieve the pressure on wild populations. At the same time, they would act to stabilize the overall supply. It should be feasible, also, to augment the number of species involved and to achieve a greater genetic diversity.

Harvesting of Managed Wild Populations

Of approximately 201 species of nonhuman primates in 56 genera (Napier and Napier, 1967), a mere dozen species in 8 genera have been sufficiently studied to warrant their production in the United States. If the gene pools of the remaining 94 percent are to be assured for the future, it is necessary to provide encouragement and financial support for conservation and study of the habitats in which they are to be found, whether these habitats be unaltered or under some degree of management. As matters now stand, there are laws in some countries (e.g., Colombia) providing that private lands not being utilized will be confiscated for agricultural development. In other areas (e.g., Kenya) primates are regularly shot or poisoned as agricultural pests.

To improve the situation it is proposed that a sustained market for primates harvested from wild populations be developed and support be provided for the management of these populations on a sustained-yield basis. By so doing, it might be possible to make privately owned forest lands economically productive and thereby justify their preservation in essentially their natural state. A further move would be to explore, with appropriate governmental departments, mechanisms whereby trapped animals that would otherwise be destroyed as pests could be purchased for biomedical use. In this way, overall income to the landowner would be increased and the supply of primates somewhat augmented.

Improvement in the Primate Trade

Despite the fact that there have been improvements during the last 10 years, far too many animals are still lost through wasteful capture practices, careless handling prior to export, and destruction as forest and plantation pests. It seems clear that these losses can be appreciably reduced if scientifically sound practices are introduced and if all aspects of collection and transport are monitored by informed officials. Several specific measures are recommended here.

- When animals are needed for specific research projects or as breeding stock, collecting expeditions should be organized and supported that are manned by local trappers but supervised by zoologists and veterinarians. Thus managed, these expeditions should incur a minimal loss of animals and the quality of the animals should be enhanced, particularly as regards information on origin and genetic relationships.
- When feasible, collecting expeditions should be so timed and managed as to capitalize on situations where habitat destruction already dooms the natural populations or where they are being destroyed as pests.
- Losses in holding areas and in transport can be minimized by encouraging and supporting dealers who provide well-cared-for animals of known origin and by paying higher prices for healthy animals. Conversely, adverse publicity should be given to instances where the stock received is of poor quality. It would be well, also, to develop regulations that prohibit shipments on other than a prepaid basis.
- The physiological characteristics of relatively little-known species should be investigated, so that their potential usefulness in research can be assessed. When populations of these species face destruction as the result of habitat alteration, it would then be possible to harvest the animals for breeding and scientific research programs.

Maximum Utilization of Current Resources

Certain economies in the number of animals used can be realized by the establishment of a computerized users' service that would match availability to need and, overall, provide information for making sound estimates of annual needs. Such an information network would not only provide rapid information on available animals, or, conversely, the need for specific animals, but also facilitate the exchange of biological materials derived from primates. It would have the valuable ancillary advantage of making known to the medical community instances of the discovery of animals with spontaneous diseases or congenital defects, animals that would in the usual course of events be destroyed. Once identified, these animals could be transferred to the appropriate research laboratory for study. Obviously, an effective information and exchange system must provide for the costs of holding animals for a reasonable time while a suitable arrangement for transport is being worked out.

Still further economies could be obtained by critical attention to the validity of choosing primates as laboratory animal models in each instance. Through various media--periodic workshops, symposia, critical review articles--the biomedical use of primates and other taxa should be reviewed, and primates replaced, whenever possible, by faster-breeding, more readily obtainable species. Where legislative or regulatory actions are proposed that would hamper ready access to suitable and easily bred nonprimate species (e.g., dogs and cats), appropriate measures should be taken to discourage their enactment. In a similar sense, the fact that measures to prevent or inhibit ethical utilization of human fetuses or tissues will almost certainly augment the demand for primates as substitute experimental material must be faced.

The research community, and scientific editors, should be urged to reject any proposal or manuscript that does not include precise information as to the species, sex, size (or age), and source of any primate used in the experiment. Only by such strictures can it be assured that an informed decision has been made as to the choice of research material and that primates are essential in preference to any other species to achieve the results sought.

If reliable estimates of future needs are to be made, data must be collected more accurately and consistently than is now the case. A simplified permit system, similar to that proposed by the U.S. Department of the Interior (USDI) for dealing with injurious species, would do much to improve the situation and would provide more reliable data on numbers of animals imported and the reasons therefore. Data on reproductive rates and losses from deaths could well be required from all institutions holding primates, whether exhibitors or research establishments.

Administration by the National Institutes of Health

A national program of the kind recommended here would best be administered by NIH under the guidance of an advisory committee representative of the biomedical community. In so doing, it would be necessary for NIH to assume several discrete functions, each related directly to the key recommendations brought out in preceding sections of this report.

Support of Breeding Programs

In the overall process of initiating and enlarging self-sustaining breeding colonies, funding mechanisms should be devised that eventually shift the cost burden to the user, although this is not likely to be feasible in certain cases. There should be provision primarily for colonies of outbred animals and also for production of inbred lines selected for specific physiologic and immunologic characteristics, where it has been demonstrated that primate models are essential. A number of activities and responsibilities are called for:

- Review of proposals to breed primates.
- Administration of contracts for domestic breeding of primates for intramural and extramural programs.
- Preparation of guidelines for commercial primate breeders both within the United States and in countries of origin. These guidelines should specify methods for monitoring genetic heterozygosity as well as standards of nutrition, housing, and sanitation for individual species.
- Increase in breeding capacity of the Regional Primate Research Centers (RPRC) so that they become self-sufficient.
- Support of basic colonies of selected species, primarily as a resource from which to initiate production centers as the need arises. (This support might be provided through a competitive program open to any facility having colonies with F_2, or beyond, generations. Maintenance

of core breeding stocks is essential to ensure the integrity of established colonies with known genetic histories and social relationships and to make possible long-term reproductive studies. In this connection, the potential role of exhibitors, especially zoos, should be evaluated.)

- Encouragement of new designs for laboratory holding cages that will accommodate the changing patterns of primate research, particularly the increased length of time for which animals are held and the increased frequency with which both long-tailed and arboreal species are utilized. (For example, sliding doors between compartments would provide convenient means for isolating individual animals for examination, false floors of proper height above the substrate could prevent the tails of long-tailed species from becoming soiled with water or feces, and the addition of perches would allow for normal foot and tail postures.)

Maximal Utilization of Available Resources

In establishing a computerized users' service, several existing information programs should be evaluated with a view to adapting certain features to facilitate exchange of primate material. There is, for example, a computerized tissue typing registry of potential kidney transplant patients developed at the University of California, Los Angeles (Opelz and Terasaki, 1974). The 9th edition of Animals for Research (ILAR, In press) will provide information on commercial sources of many species. The Division of Computer Research and Technology, NIH, is developing programs to make this current information on suppliers of animals available more rapidly. Computerized bibliographic services that might be expanded to incorporate information on available experimental material include Medline (National Library of Medicine-NLM) and Current Primate References (Washington Primate Center).

The Animal Resources Branch, Division of Research Resources, NIH, has administered the India Rhesus Monkey Certification Program since 1955. This agreement with the Indian government stipulates that rhesus macaques exported from India will be used in a humane manner only for medical research and vaccine production. In order to administer this Certificate of Need program properly, match production capacity to research need, and implement an allocation system in time of shortages, it is essential to know the volume of imports, the output of captive-reared animals, and the level of use in biomedical programs. This information should be compiled either through the users' service noted above or in cooperation with other programs having similar responsibilities. The U.S. Department of Agriculture (USDA), for example, monitors primate usage annually; if these data were computerized and augmented through a more specific program of data gathering, the end product might be wholly adequate. Annual reports, such as those provided by the University of Michigan and Tulane University to USDA in 1972, stand as models for large institutions that have worked out a suitable methodology for record-keeping, by species. A proposed USDI permit system for all imported animals, if implemented, would provide valuable information. Finally, an International Species Inventory System is being developed (Makey *et al.*, 1974) to collect data on vital statistics and reproduction, as well as inventory, in zoological parks.

Improvement of Wild-Caught Primate Programs

A number of steps can be taken by NIH that should improve the situation as regards wild-caught primates used in U.S. biomedical programs. Among these are the following:

- Coordination of Certificate of Need programs with comparable agencies in other nations and extend the program to include species other than rhesus macaques. This would eliminate the conflicting and competing estimates that now confront the governments of several countries. Scientists in the United States would then be in a position to set forth their own priorities rather than relying on a competitive acquisition procedure that is filled on a first-come, first-served basis.
- Enlargement of the Certificate of Need program to provide an evaluation of the need for the species selected at the national level in addition to the review of the choice of animal model at the institutional level or during the funding process for the study.
- Fostering of international coordination of captive breeding programs and trapping operations through established international scientific channels. The International Council of Scientific Unions, the World Health Organization, the Pan American Health Organization, the International Union for the Conservation of Nature and Natural Resources, and the International Primatological Society should be encouraged to facilitate the translation and implementation of these recommendations by assisting foreign governments to take appropriate actions.
- Working to minimize duplicative expeditions for trapping primates and assure priority assignment of females to breeding colonies, rather than to direct biomedical use.
- Development of guidelines for trapping operations that take advantage of good wildlife management techniques, with a view to sustained yields from habitats that are to remain intact and animal salvage from habitats that are being destroyed.
- Withholding of funds from investigators shown to knowingly purchase primates that were trapped or exported in violation of the laws of the country of origin.
- Development of guidelines for improving compounds for holding animals trapped seasonally.
- Cooperation with air carriers and regulatory agencies, directly and through the National Council on Animal Transportation, to improve the methods, supervision, and scheduling of all shipments.
- Training workshops for local wildlife management personnel who can then assist trapping expeditions, or supply professional assistance through the mechanism of travel grants to U.S. specialists.
- Provision of funds for studies of population dynamics that will identify factors affecting the carrying capacity of different habitats and the geographical distribution of primate species, and monitoring of the impact of trapping in areas managed for sustained yield. It seems likely that costs for monitoring wild populations will have to be borne by the user community through various bilateral and multinational projects until effective methods are worked out. Data from studies of local populations will be essential as a basis for regulation of export and habitat conservation by the country of origin.

- Provision of support for immediate implementation of improved techniques for capturing primates, including use of anesthetizing drugs, that will replace the slaughter method whereby adult female chimpanzees, gibbons, and leaf monkeys are killed to obtain dependent young.

Allocation in Time of Shortage

Despite any precautions that may be taken, it is likely that there will be shortages of primates in the years just ahead. There must be, then, an allocation plan in readiness that will assign priorities for the distribution of imported and captive-bred animals from biomedically supported breeding centers to the most appropriate biomedical uses, thereby minimizing the undesirable impact of shortages on research programs and other important activities. It is likely, for example, that production and safety-testing of polio vaccines would be accorded priority over research needs.

It can be anticipated that export restrictions in countries of origin will be enforced with a measure of irregularity in the next few years, which will lead, in turn, to wide fluctuations in availability and price of wild-caught animals. It would be most unfortunate if these uncertainties were permitted to discourage the development of domestic captive-breeding ventures.

Improved Specifications for Research Animals

Much is to be gained by making the specifications for research animals as rational and precise as possible. When this is not the case, females that should be held for breeding will undoubtedly be used in research programs and thereby lost; a shift to specifications that call for more male animals is clearly indicated where otherwise acceptable. In other cases, specifications do not allow for acceptable alternative species or, conversely, unwittingly call for rare or endangered species where they are not in fact essential. For example, attention might well be directed to including acceptable alternate species such as *Macaca fascicularis* in the current federal requirement that presently permits the use of only rhesus macaques in neurovirulence testing for polio vaccines. Where possible, specifications should permit the adaptation of procedures to accommodate fluctuatuions in supply and take advantage of changing techniques; in addition, they should not lay excessive stress on the existence of accumulated baseline data, however convenient the latter may be.

For the protection of endangered species, the biomedical community should recognize the provisions of the U.S. Endangered Species Act (1970) and the Convention on International Trade and Endangered Species of Wild Fauna and Flora (1973) and fully support these instruments by sharply restricting, or prohibiting, any biomedical use that interferes with the normal reproduction and socialization of wild-trapped or F_1-laboratory born females of the species listed.

SUPPORTING DATA

Attitudes and Historical Trends in Primate Usage

Impressive contributions to public health have been made possible through the application of information derived from the use of laboratory animals in studies of basic biomedical problems and diseases. The most striking example of the benefit derived from the use of primates in research was the development of polio vaccine. The close phylogenetic relationship between monkeys and man has been cited repeatedly as a justification for using primates in research. Two recent statements by researchers crystallize the variance of scientific viewpoints that have developed on this topic. Typical of those investigators who specialize in the study of human medicine and look for an experimental substitute in the primate is E.I. Goldsmith, M.D., chairman of the utilization committee for the Laboratory for Experimental Medicine and Surgery in Primates, who stated:

> Our attitude is that when the fundamental research reaches a point where it needs to be translated toward human use, then it is logical to interpose the primate as an approximate of the human condition. (Zucker, 1974)

In general, scientists who have a medical orientation, a professional affiliation with a primate facility, or are in applied research with vaccine and drug testing will promote the use of primates. These scientists usually estimate that increasing demand will always exceed supply.

In contrast, scientists specializing in basic biological research have generally taken a more comparative stand, such as W. G. Hoag (1974):

> The ultimate test of any product for human usage must be made in man himself. The pretesting of such products in animal models is an important step leading to this final test. It is important that the animal model selected provides the test system which simulates the one in the human biological system. This similarity does not necessarily relate to the phylogenetic proximity of the animal species to the human species. It is important for investigators in planning animal experiments to look first for the model biological system.

Such researchers are generally affiliated with institutions having facilities for handling many species, including the larger domestic animals, and frequently recommend that the expected high costs of captive-bred primates will result in reduced demand for them as scientists are forced to shift to other species. They point out that the low cost and ready availability of primates in the past has resulted in a high rate of usage that has been opportunistic rather than scientifically based. The fact that the U.S.S.R. successfully launched and returned man from outer space based upon extrapolation from experiments using dogs instead of primates, as was practiced by the United States, is a case in point.

The problem of estimating future needs is compounded by a widely felt prestige factor associated with studying primates, which has followed the development of polio vaccine in one species of monkey. This has encouraged the widespread use of primates rather than the limited use of them in studies that are needed to expand the results derived from experiments on more rapidly bred species, including rodents, dogs and cats. As monkeys become more expensive, a greater selectivity in the choice of animal model and multiple use of primates on experiments will become necessary. Institutions that could not afford to hold animals between experiments, or to ship an animal at rates that exceeded the purchase price of a replacement will find that these actions may become economically feasible as relative costs change. Such developments should act to reduce the numbers of animals euthanized for obtaining single organs and consequently the total number of primates needed. Hence, some scientists predict decreasing needs for primates.

This range in predictions from greatly increasing needs to stable or decreasing needs creates a major dilemma for those charged with the responsibility of anticipating and planning supplies. The association of value judgments with professional background, affiliation, and research specialty should not be overstressed. However, because economics, prestige, and research specialties continue to color recommendations, it is necessary to identify and separate these factors from the question of needs based upon scientific criteria.

For the purposes of this report, it is recognized that primates have a significant role to play in certain areas of reproductive endocrinology, immunology, virology, and certain neurological studies. However, metabolic pathways may or may not be similar between primates and man. In certain areas of metabolism, physiology, and biochemistry, nonprimate species would appear to be as useful or more so as disease models. The advantages of dogs for many toxicological studies has been reasserted by the Committee on Toxicology (1974). Primates will always be of limited use in studies of genetics because of their slow reproduction.

Shifting needs for numbers and species have occurred. For example, exports of rhesus macaques to the United States alone at the rate of more than 200,000 individuals in the late 1950's (during the development of polio vaccine), were limited a decade later by the Indian government to around 50,000 for the entire world (Hartley, 1972). While the needs of monkeys for polio research have decreased, demand for other species--most noticeably, New World monkeys--has been created in the past few years due to developments in such research areas as viruses, hepatitis, and malaria.

Numerically, the most important species for medical research and drug testing has been the rhesus macaque, followed by other macaques, baboons, and vervet monkeys. The obvious reasons for the early popularity of these species was their greater survival rate under early captive conditions when little was known about nutritional needs. The extensive accumulation of baseline data, especially on the rhesus macaque, has increased its value for continued use. In one respect it is fortunate that these semiterrestrial species became popular in a commercial trade that depended upon wild caught animals. Their large geographical distributions and adaptability to many habitats protected them from decimation. They are favored in areas of mixed forests and open land and even increase in areas of subsistence agriculture as commensals of man. However, their continued survival demands that plans for their captive breeding and their management as a second crop on agricultural land be examined, as changing attitudes and more intensive, technological agriculture and forestry reduce cultural tolerance for agricultural pests.

Current Volume of the Primate Trade

Species Commonly Imported to the United States

Of the 82 species of primates imported into the United States over the past 3 years, 13 species comprise 96-98 percent of the total volume (Table 1). The two most important species are the squirrel monkey and the rhesus macaque, which together account for roughly 62-65 percent of all imports.

Import statistics for the United States are published in three forms. Overall volumes of wildlife imports have been published by the Fish and Wildlife Service of the U.S. Department of the Interior (USDI, 1968-1970a, 1971-1973). The mammals imported between 1968 and 1972 are also itemized by species in several reports by the same agency (Jones, 1970; Jones and Paradiso, 1970; Paradiso and Fisher, 1971; Clapp and Paradiso, 1973; and USDI, In preparation). It is unclear why the volumes of the latter reports are generally 10 percent lower than the former. Additional statistics are published by the U.S. Department of Commerce (USDC, 1965-1974). The statistics for rhesus macaques and for totals are compared in Table 2. The records maintained by the Indian government concerning monkeys exported to the United States are generally 10-percent higher than those for monkeys received by the United States.

Trends in the Export of Primates to the United States

The numbers of primates exported from the major supply countries are presented in Table 3. India, Peru, and Colombia are the only countries that have exported more than 20,000 primates during any year within the past decade. These three countries are responsible for 78 percent of the 1973 primate trade. Another 6 countries, Pakistan-Bangladesh, Thailand, Malaysia, the Philippines, Ethiopia, and the Somali Republic have exported over 2,500 primates during one or more years since 1964. These account for an additional 13 percent of the primate trade. The total numbers exported to the United States from all countries decreased by 32 percent from 1964 to 1973.

Most of the major source countries except Malaysia, which has fluctuating export numbers, have exported decreasing numbers of primates over the past decade. The steady 6-year decline in numbers from Peru and

TABLE 1 SPECIES COMMONLY IMPORTED INTO THE UNITED STATES*

Species	No. Imported 1970	1971	1972
Saimiri sciureus	26,124	29,877	25,295
Macaca mulatta	23,302	22,097	23,210
Cebus sp.	5,935	5,619	6,063
Saguinus sp.	4,189	5,333	5,545
Aotus trivirgatus	4,209	3,728	3,533
Cercopithecus aethiops and C. pygerythrus	3,106	2,817	3,272
Lagothrix lagotricha	2,244	2,226	2,125
Ateles geoffroyi	1,870	1,617	1,841
Macaca arctoides	1,070	1,207	1,676
Macaca fascicularis	1,609	1,727	1,397
Papio sp.	753	1,092	1,328
Macaca nemestrina	662	436	581
Pan troglodytes	185	205	234
TOTAL IMPORTS	78,375	79,691	77,636

SOURCE: Data from Paradiso and Fisher (1971); Clapp and Paradiso (1973).

*See Appendix I for a comparison of common and scientific names

TABLE 2 TOTAL PRIMATES IMPORTED INTO THE UNITED STATES COMPARED WITH EXPORTS FROM INDIA

Year	Total U.S. Imports, by Source* and Type					Exports from India**	
	A	B	C	Rhesus Macaques§	Imports from India¶	U.S.	Worldwide
1964	102,080				31,640	35,159	
1965	96,112				27,121	30,559	
1966	103,859				26,268	28,557	
1967	104,346	62,526			30,849	34,937	48,617
1968	126,857	124,440	113,714	30,933	30,315	34,791	48,162
1969	105,719	99,668	108,974	27,462	29,734	33,930	49,428
1970	90,743	85,151	78,375	23,302	26,056	28,791	41,959
1971	79,846	86,535	79,691	22,097	21,152	23,883	35,296
1972	75,784	90,559	77,632	23,210	21,330		
1973	69,548				25,413		

*All primates, source A=USDC (1965-1974); source B=USDI (1968-1970a, 1971-1973); source C=Jones (1970), Jones and Paradiso (1970), Paradiso and Fisher (1971), Clapp and Paradiso (1973), and USDI (In preparation).
§Rhesus data from same sources as C above.
¶U.S.-India import data from USDC (1965-1974).
**Exports from India data from Kawanishi (1972) cited from Monthly Statistics of the Foreign Trade of India.

TABLE 3 TRENDS IN THE EXPORT OF PRIMATES TO THE UNITED STATES FROM TROPICAL COUNTRIES

Country of Origin	Exports from Tropical Countries 1964	1966	1968	1970	1972	1973	Percent Change In Exports, 1964-1973
Asia							
India	31,640	26,268	30,315	26,056	21,330	25,413	-20
Thailand	3,785	2,026	2,855	1,738	2,425	2,201	-42
Pakistan (1973-Bangladesh)	2,974	2,455	1,270	707	-	515	-83
Philippines	1,874	5,095	705	130	300	925	-51
Malaysia	965	2,223	1,889	1,906	657	2,301	+138
Indonesia	26	-	-	110	240	280	+978
Singapore	-	-	75	55	80	145	+
Africa							
Kenya	5,199	4,015	1,398	1,324	754	1,200	-77
Ethiopia	3,440	4,481	5,628	2,556	929	1,972	-43
Somalia Republic	2,536	2,848	489	-	1,316	1,594	-37
Tanzania	595	1,568	634	954	1,157	697	+17
Sierra Leone	581	334	259	113	81	115	-80
Nigeria	396	6	78	150	173	320	-19
Latin America							
Peru	36,847	37,384	53,773	32,729	27,288	22,669	-38
Colombia	6,841	9,491	24,105	16,826	16,124	6,444	-6
Brazil	778	154	370	2,102	-	-	-
Paraguay	122	-	169	477	941	608	+398
Nicaragua	63	-	-	689	525	-	-
Other	3,418	5,511	2,845	2,121	1,464	2,149	-37
TOTAL	102,080	103,859	126,857	90,743	75,784	69,548	-32

SOURCE: Data from USDC (1965-1974).

Colombia, which currently export approximately half and a fourth, respectively, of their 1968 numbers, has been attributed to decreasing availability rather than demand and is in part responsible for the limitations imposed by these countries in 1973. The 10-year trend in exports of rhesus macaques from India has shown a steady overall decline of 24 percent. Kawanishi (1972) summarized the monthly statistics of the Foreign Trade of India, which showed a 27-percent decline in exports worldwide from 48,617 to 35,296 over the 5-year period between 1967 and 1971. This overall decline included a 33.5-percent decrease in exports to the United States and a 16.6-percent decrease to all other nations. There have been sizeable declines of 50-80 percent in exports originating in Sierra Leone, Kenya, and the Philippines. Only in such countries as Tanzania and Nigeria having export volumes less than 1,000 annually did the numbers change less than 20 percent. The striking increases of 80-90 percent in the newly developing export trade from Paraguay and Indonesia have not yet reached annual volumes exceeding 1,000.

Primates have not been exported to the United States from South Vietnam since 1965 or from Cambodia since 1966 due to the Indochinese war. Exportation was stopped from Pakistan during 1972 and re-established from Bangladesh in 1973. In 1974, however, Bangladesh instituted a 5-year moratorium against all primate export. Uganda has not exported primates to the United States since 1967, presumably for political reasons, and no trade with the Republic of China has been developed. Exportation of primates, opposed in Nepal for religious reasons, has never been allowed commercially from Burma (Southwick et al., 1970), and was stopped temporarily several years ago by the Indian government in response to religious criticism of the large losses in the commercial trade.

Sample Export and Import Volumes for Other Nations

The monthly statistics of the foreign trade of India as cited by Kawanishi (1972) illustrate that the worldwide trade in rhesus is only two-thirds of the 60,000 per year that has been the volume generally quoted within the United States. Of the 35,300 primates exported from India in 1971, the United States received 23,900 or 68 percent of the total. The United Kingdom and the U.S.S.R. each received approximately 10 percent or 3,400-3,500 animals. Another 4 percent was exported to Yugoslavia, which has rapidly increased its usage of Indian primates from 350 in 1967 to 1,360 in 1971. The remaining 8 percent of the Indian monkeys were shipped to several other countries: The Netherlands, Italy, West Germany, Thailand, Czechoslovakia, Japan, and Canada received 100-800 each.

Although the United Kingdom cut its total demand in half between 1967 and 1971 (Department of Education and Science, 1969a, b, c, 1972), several other countries are rapidly increasing their demands for primates. Japan doubled its volume of imports from 4,000 to 7,700 in the 7-year period 1962-1969. The demand nearly doubled again during the following 2 years, 1969-1971, to a current total volume of 14,300 (Kawanishi, 1972).

Although the overall volume imported into the United Kingdom and Japan is low relative to that imported into the United States, the species composition is very different. The volume of long-tailed macaques, the most important species in those 2 countries, is approximately 10-times the 1,500 imported into the United States (Table 4). Differences with other consuming nations also exist in the sources of primates used, because some countries that do not export primates to the United States are shipping to other countries. For example, North Vietnam ships several Asian species, including *Macaca nemestrina*, *M. arctoides*, *M. assamensis*, and *M. mulatta* to the Sukhumi Primate Center in the U.S.S.R. (Lapin *et al.*, 1965, cited by Wolfheim, In preparation).

Statistics of the volume of primates re-exported from various countries are scanty. The re-exportation volume from the United Kingdom typically exceeds a fourth of the total volume imported (Hartley, 1972). Neglect of the re-exportation volume in summing the import statistics for several countries could lead to a sizeable overestimate of the worldwide traffic in wild-caught primates.

Accuracy of Estimating Primates Needed for Research

In 1955, under an agreement between the governments of India and the United States, the Animal Resources Branch of the National Institutes of Health began to act as a central agency for forwarding certificates of need for rhesus macaques. During the past 3 years the number imported has ranged between 52 and 81 percent of the number requested (Table 5). By comparison, the numbers imported into the United Kindgom have been less variable, averaging between 71 and 79 percent of the numbers licensed. Whether the less variable estimates of needs in the United Kindgom result from the smaller total volume to be estimated or from the stricter procedure of licensing is not apparent.

The accuracy of estimating the future needs for primates in the United States must rely upon extrapolation from previous import data. It is, therefore, worthwhile to examine the proportion of the primate trade entering biomedical uses.

Estimates of Current Usage Volume

U.S. Department of Agriculture Estimates

Totals Since 1964, when the Animal Welfare Act, PL 89-544, was enacted, institutions that are involved with the research, exhibition or supply of animals have been inspected by the U.S. Department of Agriculture (USDA). Research facilities have been registered, and exhibitors and dealers have been licensed under this act. An amendment in 1970, PL 91-579, expanded the coverage of the inspection authority from facilities handling dogs and cats to those handling most species of mammals. An interesting account of the enactment of this law from a humane society's point of view has been published by the Animal Welfare Institute (Leavitt, 1968). The first annual report prepared by USDA gives the rates of usage of the major laboratory animals by state for 1972 (USDA, 1972). The total research use of 1,662,026 mammals published by USDA is somewhat greater than

TABLE 4 PRIMATES IMPORTED INTO THE UNITED KINGDOM AND JAPAN

Source	Species	United Kingdom 1967	United Kingdom 1971	Japan, 1971
Asia	All primates	-	-	11,033
	Long-tailed macaque	7,513	4,582	-
India and Pakistan	All primates	-	-	247
	Rhesus macaque	4,719	3,435	-
Africa	All primates	-	-	271
	Baboon	1,811	2,184	-
	Vervet monkey	3,139	184	-
	Patas monkey	2,533	737	-
Americas	All primates	-	-	2,623
	Squirrel monkey	2,282	610	-
Europe	All primates	-	-	95
TOTAL (all species)		24,895	12,150	14,269

SOURCE: Kawanishi (1972).

TABLE 5 ACCURACY OF ESTIMATING PRIMATE NEEDS

Country and Type of Primate	No. of Primates 1970	1971	1972
United States--rhesus			
Imports	23,302	22,097	23,210
Number requested	36,965	27,307	44,377
Percent of requests actually imported	63	81	52
United Kingdom--all primates			
Imports	11,695	12,962	13,087
Number licensed	15,765	16,344	18,426
Percent of licensed primates actually imported	74	79	71

SOURCE: Data from McPherson (pers. comm., 1974); Department of Education and Science (1972).

the arithmetic sum of 1,571,963 obtained by adding the totals by species. The 732 research facilities that were registered and that met the February 1972 filing date reported the following overall usage rates for mammals other than mice and rats:

Animal	No.	Percent
Rodents (guinea pigs and hamsters only)	851,295	54
Rabbits	379,375	24
Dogs	185,788	12
Cats	79,397	5
Primates	42,658	3
Other (animals from the wild and hoofed stock)	33,450	2
TOTAL	1,571,963	100

Although the number of registered research facilities increased to 871 in 1973, the reported animal usage remained static at 1,653,132 mammals (USDA, 1974).

Since data from individual reports for 1972 were released by the Congress of the United States for public use, it was possible to inspect the reports filed with the Animal and Plant Health Inspection Service of USDA for specific information relating to primate usage. Inspection of the individual reports revealed that 38 percent (276) of the registered research facilities outside of the federal government laboratories were using a total of 55,057 primates. It is difficult to account for the increase of 12,400 primates found during an examination of the same individual records that were the basis for the estimate of 42,658 submitted by USDA. Nearly 2,000 of the 12,400 increase results from research facilities that were known to use primates but were not located in the USDA file and presumably were not yet registered. Much of the discrepancy may be due to including in the 55,000 estimate individual reports that were filed after the February 1972 deadline. A small source of variation is the result of combining all prosimians and tree shrews with primates in the larger estimate of usage instead of following the example of USDA and summing them with other wild animals.

Size Classes of Research Facilities Using Primates The concentration of primates in a few institutions is emphasized in Table 6. Only 13 percent of the 276 research facilities use 40,000 or 72 percent of the total number of primates. Each of the 37 largest research facilities using 300 or more primates is identified in Table 7. Care should be taken in interpreting these tables since most facilities are combinations of several smaller units and, therefore, do not represent the holding capacity of any single laboratory or even geographically contiguous laboratories. A research facility (RF) as defined by USDA is that administrative unit that is legally responsible for the conduct and reporting of the various laboratories within its jurisdiction. This method of measuring size accentuates the size of research facilities for which the parent institution reports for all sites relative to those for which each site reports separately. Likewise, those states in which a university such as the University of California files one

TABLE 6 PRIMATES USED BY SIZE CLASS OF RESEARCH FACILITY (USDA, 1972)

No. Primates Used/Research Facility	Facilities Using Primates		Primates Used Per Year	
	Total No.	Percent	Total No.	Percent
1-99	189	69	6,776	13
100-299	50	18	8,381	15
≥300	37	13	39,900	72
TOTAL	276	100	55,057	100

TABLE 7 RESEARCH FACILITIES USING 300 OR MORE PRIMATES IN 1972 AS REPORTED TO USDA

A. Research Institutes, Hospitals, and Pharmaceutical Companies	
Merck & Co. (2 cities) Rahway, New Jersey	4,671
Litton Bionetics, Inc. Bethesda, Maryland	3,957
Hazleton Laboratories, Inc. Falls Church, Virginia	2,048
The Dow Chemical Company (2 cities) Midland, Michigan	2,037
Flow Laboratories, Inc. Rockville, Maryland	1,620
Southern Research Institute Birmingham, Alabama	1,220
Oregon Regional Primate Research Center Beaverton, Oregon	1,180
Peter Bent Brigham Hospital Boston, Massachusetts	1,000
Southwest Foundation for Research and Education San Antonio, Texas	898
American Cyanamid Company Pearl River, New York	881
Abbott Laboratories North Chicago, Illinois	501
Microbiological Associates, Inc. Bethesda, Maryland	448
International Research & Development Corp. Mattawan, Michigan	444
Sterling Drug, Inc. Rensselaer, New York	443
Retina Foundation Boston, Massachusetts	350
G. D. Searle and Company Chicago, Illinois	304
The Population Council New York, New York	310
Endocrine Laboratories of Madison, Inc. Madison, Wisconsin	300
B. Universities	
University of California (8 campuses and regional primate center) Berkeley, California	3,901
University of Texas System (includes 7 campuses and hospital) Austin, Texas	1,841
University of Washington (includes regional primate center) Seattle, Washington	1,694
University of Wisconsin (includes regional primate center) Madison, Wisconsin	1,302

Emory University (includes regional primate center) Atlanta, Georgia	1,202
Wake Forest University (Bowman Gray Medical School) Winston-Salem, North Carolina	1,016
Harvard University Medical Center (includes regional primate center) Boston, Massachusetts	719
Tulane University (includes medical school, hospital, and regional primate center) New Orleans, Louisiana	703
State University of New York (7 campuses) Albany, New York	574
Rush-Presbyterian-St. Luke's Medical Center Chicago, Illinois	565
University of Michigan Ann Arbor, Michigan	504
University Health Center of Pittsburgh (includes university and hospital) Pittsburgh, Pennsylvania	484
University of Chicago Chicago, Illinois	450
University of Hawaii and university hospital Honolulu, Hawaii	385
Baylor College of Medicine Houston, Texas	380
Johns Hopkins University and Hospital Baltimore, Maryland	371
Laboratory for Experimental Medicine and Surgery in Primates New York, New York	359*
Yale University New Haven, Connecticut	344

C. Government - State, Local

New York State Health Department (Roswell Park Memorial Institute--4 cities) Albany, New York	494

	Total No. Research Facilities	Total No. Primates
Research institutes	18	22,612
Universities	18	16,794
Government, local	1	494
TOTAL	37	39,900

*Figures from Dr. Moor-Jankowski, personal communication, 1974.

report for all campuses appear to have much larger facilities than do states in which each campus registers as an independent facility and reports separately to USDA. Many hospitals and research foundations that are affiliated with medical schools or universities and may share staff on joint appointments also register independently with USDA. A similar latitude in meaning exists for the term "site" as listed on the USDA questionnaires. A site within a RF may be a university department that holds animals in several buildings, a building that houses primates administered by several departments, an entire campus, or a complex of buildings at a geographical site such as a primate center or a research institution.

Estimates from Institute of Laboratory Animal Resources Surveys

Composition of ILAR Surveys The mailing list from previous surveys was augmented through the cooperation of the Washington Primate Center's announcement of the survey. Of 354 questionnaires sent to users, 255 (72 percent) responded for approximately 306 sites as active, 52 (15 percent) indicated they did not use or had discontinued using primates, and 47 (13 percent) did not respond to either a questionnaire or a telephone call. Six suppliers indicated they were out of business leaving 8, or a third of the remaining 24 suppliers on the active mailing list and half of the 15 known suppliers that reported their sales volumes.

The respondents to the ILAR 1973 survey are identified in Table 8 by type of institution and compared with those of earlier surveys. Pharmaceutical companies and the Regional Primate Centers are not specifically identified in Table 8 but maintain large inventories. The Pharmaceutical Manufacturers Association (PMA) surveyed its 35 member companies in 1973 and reported inventories of 6,300 primates and an import volume of 9,200 for that year. By contrast, PMA reported that its member institutions used 17,400 primates in 1967. At that time all commercial facilities reported using 20,000 primates (ILAR, 1970). Relatively few of the PMA member institutions participated individually in the ILAR 1971 survey (Thorington, 1971a), explaining the low number of institutions listed as research institutes for that year in Table 8. If the participating membership was approximately the same in both 1967 and 1973, the decrease in use by these companies was nearly 50 percent. If the 104,000 estimate of imports for 1967 is considered to be correct (Table 2), and the intermediate value between the 1972 and 1973 import numbers of 73,000 is accepted as representative of the survey period, then the decline in imports between 1967 and 1973 was roughly 30 percent.

Of the 264 sites in the private sector that reported inventories of 36,000 primates, 7 of these sites were Regional Primate Research Centers that reported a composite inventory of 8,165 and an import volume of 1,800. The NIH inventory of 6,100 in 1971 is greater than the 4,100 inventories recorded for NIH and the Caribbean Primate Research Center in 1973. The 1973 import volume for NIH was reported as 3,000 for the quarantine facility with a few hundred additional animals coming onto the campus from quarantine at other facilities. The average number of imported primates moving through the intramural quarantine during the past 15 years has been 3,800 with an annual volume ranging from 3,100 to 5,500.

TABLE 8 INSTITUTIONS SAMPLED IN ILAR SURVEYS COMPARED TO TOTAL RESEARCH FACILITIES REGISTERED WITH USDA

Type of Institution	No. Research Facilities	No. Sites	Total Primates
USDA Research Facilities (RF's)			
Universities*			
1972 USDA	122	266	22,678
Facilities omitted	7	19	1,385§
Composite USDA	129	285	24,063
Sample: 1971 ILAR*	79 (61)	116 (41)	15,250 (63)
1973 ILAR*	89 (69)	148 (52)	16,432 (68)
Research institutes, hospitals, pharmaceutical companies			
1972 USDA	133	165	29,791
Facilities omitted	6	7	269§
Composite USDA	139	172	30,060
Sample: 1971 ILAR	49 (35)	66 (38)	13,266 (44)
1973 ILAR	89 (64)	110 (64)	19,796 (66)
Local, state government			
1972 USDA	5	14	809
Facilities omitted	3	3	125§
Composite USDA	8	17	934
Sample: 1971 ILAR	5 (62)	6 (35)	159 (17)
1973 ILAR	6 (75)	8 (47)	413 (44)
SUBTOTAL (private sector users)			
1972 USDA	260	445	53,278
Facilities omitted	16	28	1,779§
Composite USDA	276	474	55,057
Sample: 1971 ILAR	132 (51)	188 (40)	28,675 (52)
1973 ILAR	184 (66)	266 (56)	36,641 (66)

Type of Institution	Year	No. Sites	Total Primates
Facilities Not Registering as RF's			
Federal Government			
NIH	1971	1	6,131
	1973	1	2,900
Caribbean Primate	1971	-	-
Center	1973	1	1,183
Center for Disease	1971	3	388
Control & Other	1973	6	433
Military-Dept. Defense	1971	14	2,482
& Veterans Admin.	1973	35	2,609
SUBTOTAL (federal	1971	18	9,001
government)	1973	43	7,125
Suppliers	1971	9	4,736
	1973	8	5,689
TOTAL SAMPLE	1971	215	42,412
	1973	317	49,455
Adjusted Total Inventory in United States			
1971 - Add 48% (26,382) to private sector subtotal to equal 100%			68,800
1973 - Add 34% (18,416) to private sector subtotal to equal 100%			67,900

NOTE: Numbers in parentheses indicate percentages of U.S. Department of Agriculture 1972 values for comparable types of institutions.
*USDA values for primates represent numbers "used" during 1972; ILAR survey values represent numbers on "inventory" on 1 Jan. 1971 (Thorington, 1971a) and 1 Oct. 1973 (this study).
§Primates for all composite estimates of USDA facilities include inventories reported to ILAR for omitted facilities. Inventories are not strictly comparable to use. See text.

The advent of required registration by the USDA for all users made it possible for the first time to estimate the proportion of users responding to ILAR surveys. As Table 8 illustrates, approximately 50 percent of the research facilities outside of the federal government that use primates did not participate in ILAR surveys during any specific year. Although the laboratories or units maintaining primate inventories reporting to ILAR and to USDA are not strictly comparable sites, a similar proportion of these smaller units was overlooked. Those sites that were not identified or did not return questionnaires were not limited to the small users. A comparison of the ILAR questionnaires returned in 1971 and 1973 prior to telephone inquiries indicated that a fourth of the institutions in the larger size class using 300 or more primates did not respond. None of the seven facilities omitted from the 1971 ILAR survey was a university. If use in 1972 is accepted as a measure of size, more than 5,000 monkeys were overlooked in these laboratories of the largest size class.

Inventories by Species The numbers of each species in the 1973 inventories of survey respondents are presented in Appendix I. Rhesus macaques outrank all other species with 20,400. More than 1,000 individuals of 9 other species are maintained. In descending order of abundance they are squirrel monkeys, marmosets (*Saguinus* sp.), baboons, long-tailed macaques, pigtail macaques, night monkeys, vervets, and stumptail macaques. Research facilities maintain between 500 and 1,000 capuchins and chimpanzees. Another 6 species with inventories between 100 and 500 include bonnet macaques, greater galagos, marmosets (*Callithrix*), Japanese macaques, and brown lemurs.

The inventories maintained in 1973 are compared to those of 1971 in Appendix I. Since the sample of laboratories differs slightly between the two surveys, the gross differences between 1971 and 1973 inventories are not strictly indicative of changes in species use. At first glance, it appears that 10 species have been deleted from inventories between 1971 and 1973 and another 10 species have been acquired. Many of the species that do not appear on inventories of both years were probably reported as "other" species, and were not itemized. The 11 *Cebus capuchinus* and 45 *Presbytis entellus* may represent actual deletions; the 5 species of callitrichids probably represent real additions. Increases in inventories of individual species include twofold increases in *Lemur fulvus* and *Cebus apella*. A fivefold increase in *Ateles* sp. may result from the increased use of this species in studies of malaria. It is not clear whether the 30-percent increase in inventories of *Papio* sp. or the 30-50-percent declines in *Erythrocebus patas*, *Macaca cyclopsis*, and *M. fascicularis* result from actual changes in usage rates or from a difference in the number and identities of laboratories sampled. Apparent decreases of 30-50 percent in the inventories of *Galago crassicaudatus* and *Cercopithecus aethiops* are probably real, with the latter decrease resulting from the Marburg virus scare.

The most striking change appears to be the 20-percent increase in inventories of callitrichids. The apparent shifts in inventories of *Saguinus fuscicollis* and *S. nigricollis* probably represent re-identifications rather than real changes. The reason for the tendency to hybridize tamarins, producing 114 hybrids, is probably due to lack of early identification.

Total acquisitions The numbers of imports and total acquisitions during 1973, including animals from other laboratories and from colony births, are presented by species in Appendix II. At least 61 percent of the 33,520 primates imported during 1973 were used in terminal studies within a year.

When the reported value for the number of deaths of 1973 imports resulting from terminal studies was lower than the difference between the number of imports and the inventory on October 1, 1973, then the latter value was accepted as an estimate of imports sacrificed within a year. Since the subtraction method could only be used for those laboratories having small inventories, the estimate of numbers of animals imported that are dead within a year must be viewed as a considerable underestimate. The discrepancy between reported and probable deaths was large only for tree shrews and night monkeys. The size of the range of values for these species may be attributed in part to under-reporting of the numbers "used up" within a year, but it was also a result of interpretation of the unfortunately ambiguous term terminal studies used on the questionnaire. Several respondents apparently did not consider use in drug production or safety testing as research use. Some investigators exempted from the category of terminal use certain procedures, such as experimental surgery, that may result in the loss of animals, since the sacrifice of animals is not required by the experimental design. Although the ambiguity of the question did not always allow needs for new imports to be distinguished from planned usage of primates already on inventory, the anticipated needs for 1974 exceed 1973 imports by 20 percent.

Proportion of the Trade Entering Biomedical Uses Approximately three-fourths of the primate trade entering the United States is consumed for biomedical uses annually. The other fourth of the trade supports exhibitors, a large pet industry, and includes the losses absorbed in dealers' compounds. Neither the sum for sales nor the sum of purchased imports in Table 9 can be considered complete. Although only half of the 15 dealers that supply primates for research responded to the 1973 survey, these suppliers reported selling more primates of 15 species to research institutions than users reported purchasing. On the other hand, users reported buying more of 6 species during the same interval than suppliers reported selling.

The proportion of each species that was used in research is only a rough guide to relative usage since the numbers of primates used and imported were not available by species for identical 12-month periods. The estimates exceeding 100 percent of purchases over imports for 7 species result from the attempt to compare purchases for 1973 with import volumes for 1972 rather than inaccuracies in reporting. The larger estimate of sales to research institutions, whether provided by the users or suppliers, was accepted as an indication of the percentage of imports used in biomedical programs for each species. The sum of the larger estimates of each species gives a minimum of 49,000 sales. Due to incomplete reporting, total sales probably reach 55,000 primates. As outlined previously (Table 2), the best estimate for total imports lies within the range of 70,000-80,000 primates for 1972 and 1973. The best minimal estimate for annual sales to researchers lies between 70 and 80 percent of total imports.

TABLE 9 COMPARISON OF ESTIMATES OF BIOMEDICAL USE AND THE TOTAL IMPORTS OF PRIMATES

Species	Supplier Reports			User Reports		
	Imports on Inventory 1 Oct. 1973	No. Suppliers	Import Sales to Users Oct. 1972-Oct. 1973	Imports Bought Oct. 1972-Oct. 1973	USDI Total Imports 1972	Percent Imports Used In Biomedical Fields
Tupaia sp.	60	2	200	53	0	100
Galago crassicaudatus	3	1	12	137	30	100
G. senegalensis	-	2	115	19	158	7
Nycticebus coucang	-	-	-	2	58	3
Cebuella pygmaea	-	1	4	0	111	4
Saguinus oedipus	42	2	436	368	2,419	18
S. nigricollis & S. fuscicollis	161	3	775	672	1,933	40
S. mystax	1	2	1,250	1,554	1,064	100
Marmosets	0	1	75	30	-	-
Aotus trivirgatus	61	3	1,871	2,062	3,533	58
Ateles sp.	23	1	31	63	2,070	3
Cebus sp.	168	5	766	455	6,063	13
Lagothrix sp.	0	2	67	11	2,125	1
Saimiri sp.	949	5	5,587	2,323	25,297	22
Cercocebus torquatus or C. atys	-	-	-	2	11	18
Cercopithecus aethiops & C. pygerythrus	200	2	3,200	2,787	3,272	98
Erythrocebus patas	45	2	155	86	221	70
Macaca arctoides	110	3	490	451	1,676	29
M. fascicularis	250	2	3,524	1,205	1,397	100
M. mulatta	2,641	6	24,139-28,139	17,224	23,210	100
M. nemestrina	89	3	230	335	581	58
M. nigra	-	1	10	52	11	100
M. radiata	2	1	-	6	0	100
Papio sp.	513	2	1,298	999	1,328	98

Species	Supplier Reports: Imports on Inventory 1 Oct. 1973	Supplier Reports: No. Suppliers	Supplier Reports: Import Sales to Users Oct. 1972-Oct. 1973	User Reports: Imports Bought Oct. 1972-Oct. 1973	USDI Total Imports 1972	Percent Imports Used In Biomedical Fields
Pan troglodytes	44	3	80	77	234	34
Pongo	-	-	-	5	2	100
Other species:	-	-	-	-	834	0
Alouatta 44	*Callithrix*	86	*Theropithecus*	3		
Callicebus 66	*Saguinus*	129	*Hylobates*	214		
Lemur 1	*Cercopithecus*	108	Unidentified	2		
Chiropotes 6	*Colobus*	9				
Pithecia 30	*Macaca*	58				
Callimico 4	*Presbytis*	74				
TOTAL	5,362	8	44,315-48,315	31,049*	77,638	63
Total of larger estimates of imports/species			49,031			

*Total includes 71 unidentified imports.

Research consumes nearly all of the individuals of several species imported in large numbers. These include rhesus monkeys, mystax marmosets, vervets, baboons, and probably both night monkeys and white-lipped marmosets. The continuing dependence of zoological parks and other exhibitors on wild-caught primates is illustrated by the annual importation of nearly 1,000 animals belonging to 14 genera, all of which represent exotic species that were not imported for biomedical research.

There is a minimal discrepancy of 41 percent between imports and research use for those New World species that are the most popular as pets. This discrepancy includes 19,700 squirrel monkeys, 3,100 marmosets, 5,200 capuchins, 2,000 woolly monkeys, and 2,000 spider monkeys. A total of 32,000 monkeys of these 5 or 6 species are unaccounted for and it has been assumed that most of them enter the pet trade. Plausible estimates of the maximum conservation of primates that could be realized by eliminating the pet trade range from 20,000 (75,000 imports less 55,000 research use) to the 32,000 identifiable South American monkeys. These estimates represent half to two-thirds of the savings anticipated from earlier estimates of 46,000 (Thorington, 1972) to 50,000. However, the magnitude of the earlier estimates is based upon incomplete surveys of research users. These figures suggest that the number of primates that would be saved by eliminating the pet trade has been overestimated.

Records for the intramural facility at NIH show that the average losses during quarantine have been 11-12 percent over the past 15 years. The majority of primates handled by the facility have been rhesus macaques which have been shipped directly from India. For certain South American species, especially the delicate night monkeys and marmosets, the NIH quarantine losses have reached 50 percent. Assuming that this loss rate is typical nationwide, then as many as 10,000 primates (13 percent of 75,000) may be lost annually by importers during conditioning and quarantining. Such estimates suggest that nearly half of the 20,000-40,000 imported primates that have been attributed to the pet trade may in fact be losses inherent in the present system of commercial collecting.

Trends in acquisitions Between 1959 and 1973, 65,537 primates were processed through the quarantine facility at NIH and may be considered representative of trends in acquisitions within the scientific community. During the last 15 years, the volume averaged 3,500 rhesus and 300 primates of other species yearly. Ninety-one percent of the primates acquired were rhesus macaques in a ratio of three 4-6-pound juveniles to one adult. Twenty-two species comprised the remaining 9 percent of the volume. Only chimpanzees, vervets, and squirrel monkeys were imported every year along with rhesus macaques. Long-tailed macaques and marmosets were imported in all but 3 of the 15 years. Since 1970, night monkeys, capuchins, baboons, and patas monkeys have been added to the list of species consistently imported.

An increasing demand for New World primates is also indicated by the Certificates of Need for 1974 that have been placed by researchers with a single supplier. These requests represent increases over the total 1973 sales to research identified for all of the participating suppliers as follows (Table 9): cotton-top marmosets, a fourfold increase; white-lipped marmosets, a threefold increase; mystax marmosets, night monkeys, capuchins, and woolly monkeys, each a twofold increase. These estimates of need, if filled, would increase the imports of mystax marmosets and night monkeys over the total volume for these species imported during 1972.

Composition and Turnover of Rhesus Macaque Inventories Users reported that 83 percent (14,287 of 17,224) of the rhesus macaques imported are sacrificed within a year (Appendix II). The 8,693 surviving monkeys from 1973 imports represent 38 percent of the total inventory of 22,980 reported by users. Another 22 percent (5,096) of inventories were identified as long-term holding of animals maintained for 3 or more years. The final 40 percent (9,191) of inventories is expected to be carry-over from acquisitions of 1-2 years. Due to the fact that the deaths from other acquisitions and from the carry-over held on inventory from previous years were not determined, the total percentage turnover for the inventory cannot be calculated. The percent annual turnover due to imports alone is 72 percent of inventory [1/2(17,224 imports + 14,287 deaths)/average inventory]. Likewise, the percent annual turnover of imports represents 50 percent of the total volume of rhesus macaques assigned to biomedical programs. The total volume of 33,182 includes total acquisitions and the carry-over from previous years held on inventory.

The percentage composition of total inventories provided in the sample of users may be used to extrapolate to the nationwide holdings of rhesus macaques It is generally accepted that nearly all of the 23,000 rhesus macaques imported are used for the purposes of research, and the production and safety testing of vaccines. The sales volume estimated by suppliers was slightly greater than the total import volume although only three-fourths of total imports were identified by the users sampled (Table 9). The inventories reported by users are probably two-thirds of the total (Table 8). Extrapolating from these values, it is estimated that the nationwide inventories may reach 34,800 rhesus macaques. The projected values suggest an inventory composition differing slightly from that of the above sample, with 11 percent (3,900) surviving imports of the previous year, 22 percent (7,700) rhesus on long-term holding, and 67 percent (23,200) as carry-over from 1-2 years.

Discussion of Usage Volume

Apparent Trends in Acquisitions

Since factors influence apparent trends in the primate trade, considerable care must be used in interpreting changes in export levels. Many of the declines, bans, or interruptions in primate exports have been politically motivated or have resulted from wartime conflicts or social reasons. Declines in the primate trade can also result from purely economic reasons, such as when an exporter retires or goes out of business. A decrease or shift in demand can account for reduced exports. The fact that the number of rhesus macaques exported from India during the past several years has declined steadily below the 50,000 annual quota established by the Indian government supports a real decreasing trend in the worldwide demand for this species. The final cause for reductions is a decline in supplies resulting from overexploitation and habitat destruction. Declines in overall exports from 127,000 to 70,000 between 1968 and 1973, despite a high trapping pressure in many countries, and the trend to expand into several additional countries for primates during the last half of the decade, support the reports that wild populations are declining and traditional trapping areas are being overexploited.

The difference in rank orders of species in use in various countries is of particular significance for the choice of alternative species that could be substituted if the species currently used in the United States become less available. Both long-tailed macaques and baboons have been suggested frequently as appropriate substitutes for the rhesus macaque. However, other countries already import these species in greater numbers than does the United States.

Comparability between ILAR and USDA Censuses

Because of the academic autonomy of biomedical researchers, surveying by questionnaire provides an incomplete census. The importance of the data collecting function of a government department, such as USDA, in identifying users and in assessing the volume of use of animals in research is highlighted by a comparison of their files with those of ILAR that are based upon voluntary cooperation.

One problem with interpreting the results of questionnaires has been to recognize duplication of inventories. This problem arose when research staff had joint appointments and experiments in progress at more than one laboratory, or when animals held in one facility but on contract with another laboratory were included in the inventories of both facilities. Omissions represent the reciprocal problem and occurred frequently when an investigator or administrator responded for only the colonies under his restricted jurisdiction but neglected to specify that he was not reporting for all departments of the medical school or all sites of the research institute or university. It is unlikely that any duplications exist for the 1971 and 1973 ILAR surveys.

There is no reason to believe that the comprehensiveness of the 1971 ILAR survey differed from that of earlier surveys. Since approximately 50 percent of the RF's and 50 percent of the primates used in the private sector were not reported to the ILAR surveys for a particular year, the previous estimate of primate inventories in biomedical research that were based upon these surveys should be increased by roughly 60 percent of the given value. Primate usage in surveys prior to 1971 refers to total acquisitions rather than inventories. Estimates of imports acquired by users were provided by suppliers, not users. Dealers' estimates of sales volumes in 1973 were illustrated in the section, "Proportion of the Trade Entering Biomedical Uses." These values underestimated sales volumes by 6 percent (46,000 vs. 49,000) to 20 percent (46,000 vs. 55,000). Previous ILAR surveys should be increased by at least this volume.

Interpretation of Usage

The difficulty in the interpretation of the term usage is exemplified by the following situation Pharmaceutical companies showed a decrease in importation rates that was greater than the national average. This suggests that there has been a proportional shift in usage patterns of monkeys from drug production and safety testing to research, a change in the composition of the PMA sample between the 2 years, or a shift in the use of primates from in-house to outside contractors by these companies. However, the potential difference in reporting between the words "use" in 1967 and "imports" in 1973 raises the question of whether reported use in 1967 included both imports and inventory. If so, the reduction between years would be 11 rather than 50 percent. Obviously, if half of the companies reported their use by each method, the overall decrease of approximately 30 percent is in line with the national average.

Most estimates of the volume of laboratory animals have been based upon reports of numbers "used" in research. This applies equally to early ILAR surveys and current USDA estimates. Unfortunately, the term "usage" has not been defined in these surveys and no consistent reporting from institutions can, therefore, be expected. Three hypothetical examples given below may illustrate the potential variance in the legitimate interpretations of the word "use." The number reported presumably will depend upon whether the institution wishes to minimize its apparent consumption of animals.

<u>Type A Laboratories with Stable Facilites</u> A few research laboratories are involved in long-term experiments that last from several years to the lifetime of the experimental animal. These laboratories generally have large inventories relative to their acquisitions. Examples of research areas include ethological studies, breeding colonies, learning or addiction studies, and basic physiological studies relating to metabolism, aging, debilitating diseases, and genetics.

- Example: A laboratory maintains approximately 100 animals on inventory and may import 10 per year to augment 10 births or acquisitions from other sources and to offset 20 deaths per year. Use may be reported as any of the following values:

As imports	= 10
As acquisitions	= 20
As mean inventory	=100
As total volume, i.e., all animals held over from the previous year plus acquisitions. The total volume covers all animals that were assigned to experimental studies during the year.	=120

<u>Type B Laboratories with Stable Facilities</u>. The majority of laboratories using primates in biomedical research appear to be involved in short-term procedures such as experimental surgery, characterization of pathogens, tissue culture work, or the development and safety testing of drugs and vaccines. These facilities generally have animal importation volumes considerably larger than their inventories.

● Example: A laboratory maintains an inventory varying between 50 and 100 animals. Fifty animals are imported and sacrificed during each quarter. Another 40 are obtained from other laboratories. Quarterly changes in this sample laboratory are summarized in Table 10. Use may be reported as any of the following values:

As inventory	
at start of year	= 60
at end of year	= 50
average for 4 quarters	= 64
As imports	=200
As total acquisitions	
(includes 40 from other labs)	=240
As deaths	
experimental	=225
all deaths	=250
As number "used up"	=190

While this example may be stretching the point slightly, if a laboratory wished to minimize the number of animals used up during a calendar year by deleting the number in quarantine and the number of carry-overs from the imports of the previous year, then the reported value for use may be considerably lower than actual use. In this example, the 50-60 animals deleted would represent a fourth of the number imported or a fifth of the total number of deaths.

Type C Laboratories with Fluctuating Inventories or with Changing Facilities
The hypothetical situations of laboratories with inventories that fluctuate on a time scale longer than 1 year or those with expanding facilities or decreasing usage rates create additional inconsistencies in interpreting previous estimates of the volume of animals used annually in research.

● Example: A laboratory adds 100 imports to an inventory of 100 animals. Ten animals die during the first year; another 90 die during the second year. Conceivably, such a laboratory may report use in any of the following ways:

Usage during year 1	
As imports	100
As inventory	
at start of year	100
at end of year	190
average	145
As deaths	10
Usage during year 2	
As imports	0
As inventory	
initial	190
final	100
average	145
As deaths	90

TABLE 10 QUARTERLY CHANGES IN A HYPOTHETICAL TYPE B LABORATORY

	No. Primates			
	Quarter 1	Quarter 2	Quarter 3	Quarter 4
Initial inventory	60	50	90	65
Imports	+ 50	+ 50	+ 50	+ 50
Other additions		+ 40		
Number sacrificed	- 60	- 50	- 50	- 65
Natural deaths			- 25	
Final on inventory	50	90	65	50

Note that in this example if the deaths were considered for a 2-year period, they would include all 100 animals and average 50 per year instead of the apparent 10, or 90 per year, derived from reporting on an annual basis.

Comparison of a Sample of Institutions Reporting Both USDA Usages and ILAR Inventories

As illustrated above, a major problem in interpreting usage volumes has been determining when the usage reported included both acquisitions and inventory and when usage implied acquisitions only. In the former case, there would be a considerable amount of redundancy in reporting the same inventory or holding capacity in successive surveys. The presence of both types of reporting was apparent from examination of a sample of 184 laboratories that reported to both ILAR and USDA. The laboratories were divided roughly into thirds, with each third of the laboratories reporting inventories that were greater than (36 percent), less than (25 percent), and equal to (39 percent) their usage rates. Clearly, a laboratory that reported an inventory differing by no more than 10 monkeys from its annual usage rate had a redundancy in reporting of 0 or 100 percent, or had under-reported its annual volume. Since the laboratories reporting similar volumes for usage and inventory were generally small sites ($\bar{x}$ = 54 monkeys), it is probable that many of them had negligible turnover and had nearly complete redundancy in reporting usage rates between years.

The group of institutions reporting usage rates lower than inventories cannot be easily explained except by under-reporting or by a very small replacement volume relative to inventory. Neither of the first two groups accounted for a significant proportion of the primates used. Nearly 71 percent of the primates used (25,500 of 35,000) were held in institutions that reported usage rates that were 41 percent greater than their inventories. Substitution of the terms "acquisitions" and "inventories" for "usage" in future questionnaires under the Animal Welfare Act would increase the accuracy of the surveys.

Research Areas Using Primates

Indications from the Survey

With the exception of studies in reproductive physiology, the designated research topics were grouped in Tables 11 and 12 into areas by diseases, when these were specified. Reproductive studies were grouped together whether disease related or not since few studies outside of these require animals of a specific sex. If behavioral studies are combined with reproductive studies, only 8 percent of the total research can justify a need for female monkeys. Most investigators did not designate the sex of animals in their orders for imports. The most frequently ordered animal was the 4-6-pound rhesus macaque.

The research interest in different species is illustrated in Table 11. The import volume or inventory was accepted as the number used in the research area for which the respondent listed a species and study but not the number of monkeys needed for that study. If the volume of animals is considered, there are 7 important species, each used at an annual rate over 1,000. Sixty percent of the use is focused on rhesus macaques. Rhesus together with marmosets, squirrel monkeys, night monkeys, vervets, long-tailed macaques, and baboons represent 96 percent of the use. Eight species are used in two-thirds of the 16 research areas (Table 11). The large-bodied pigtail and stumptail macaques need to be substituted for night monkeys to obtain a list of the most widely used species from the list of those used in the largest volume.

There is an apparent concentration of species used in particular areas. Pharmacology and toxicology account for the first 38 percent of all primates. The largest numbers of rhesus macaques and vervets are used in polio vaccine production and testing; these species are also used along with long-tailed macaques and squirrel monkeys in a variety of toxicological tests. Studies of various diseases, including experimental surgery, account for the second largest demand, or 36 percent of the total primates. Cancer studies consume marmosets over all other species, including rhesus. Both marmosets and night monkeys are used in proportionately high numbers along with rhesus in studies of infectious diseases. This probably reflects the use of marmosets for work in hepatitis and night monkeys in malaria. Nearly as many baboons as rhesus are used in experimental surgery, which is striking when one considers their relative total numbers in use. Neurophysiological studies account for 16 percent and represent the second largest use for each of 3 species: the traditionally available rhesus macaque, the relatively large-brained squirrel monkey, and the night monkey, which is favored for its large eyes and nocturnally adapted retinas. The final 10 percent of total primates are used in physiological and behavioral studies.

The research topics that were grouped together into research areas are identified in Table 12. The groupings of research areas are somewhat arbitrary due to overlap in both emphasis and techniques used. Obviously, physiological parameters are measured to describe the clinical signs of a disease, and developments in pharmacology and toxicology are specific to a particular disease syndrome. Psychobiology, which is mistakenly equated with behavior by biomedical researchers, is listed separately in Tables 11 and 12. Behavior is limited to those studies in which an animal could interact with conspecifics. In order to differentiate studies of social behavior and husbandry from studies of the reinforcement characteristics of an animal's button-pushing behavior, about 100 primates were shifted from studies in behavior to studies in psychobiology. The latter category includes studies in learning and addiction, which are typical of the studies undertaken at that facility. Since the facility was designed for single-caging except for mating purposes and infants are removed for hand-rearing, social behavior is severely restricted.

The numbers of animals mentioned were more dispersed over the research areas than were the numbers of animals used. This pattern underscores the concentration of use in a few research specialties and institutions. Sixty percent of the investigators studying infectious diseases (including hepatitis, malaria, and viruses) felt that another taxon could not be substituted for primates. By contrast, fewer than a third of respondents in other research areas indicated that it would not be acceptable

TABLE 11 PRIMATE SPECIES IN DEMAND BY RESEARCH AREA

Research area	Rhesus macaque	Marmoset	Squirrel monkey	Night monkey	African green monkey	Crab-eating macaque	Baboon	Capuchin	Pigtail macaque
Pharmacology, toxicology	7,370	36	838		1,147	810	81	165+	10
Safety testing and vaccine production	4,352	250	200		40	52			
Disease-infectious	1,844	614+	46	1,440	96+	+	37	50+	
Disease-neoplasm	505+	2,347	350	162	180			200	
Neurophysiology	2,084	10	526	7	12		154	45	15
Sensory	1,556		146	367		26		20	133
Other	1,230		37	15	304	112	100		226
Reproductive physiology	1,328		57		6	143	219		58
Behavior	952		328		63	228	3		53
Disease-organ systems	742		234	75	78	103	25	24+	27
Psychobiology	744	32	127		10		64		3
Experimental surgery	439	35	6	20		60	367+		10
Physiology	358+	20	179		24	10	152	74	18
Dental	341	120	50				124		
Environmental	441		180				+		
Disease-other	119	100				85			4
Disease-immunology	182	40	6						14
TOTAL	24,587+	3,604+	3,310	2,086	1,960+	1,629+	1,326+	578+	571
Percent	60	9	8	5	5	4	3	1	1

SOURCE: 1973 ILAR survey.

Stumptail macaque	Chimp, Ape	Tree shrew	Macaque, general	Galago	Bonnet macaque	Patas monkey	Spider monkey	Other	Total	Per-cent
3	4	20	+			15			10,499	25
	50								4,944	12
	70+	150		+		12	30+		4,389	10
									3,744	9
151	3	55		50			4	2	3,118	8
84			5				2		2,339	6
	2				13			2	2,041	5
45	2		2		9			+	1,869	4
5				17	2			5	1,682	4
106						30		20	1,464	4
29	105			5	17			6	1,142	3
78	15								1,030	2
			7				20	2	864	2
13									648	2
									621	2
5			150						463	1
12								+	254	1
531	251+	225	164+	72+	67	57	56+	37+	41,111	100
1	1	1				1				

TABLE 12 RESEARCH TOPICS INCLUDED IN RESEARCH AREAS AS IDENTIFIED BY SURVEY RESPONDENTS

Research Area and Topic	No. Mentions Topic Total	Area Total
Neurophysiology		93
Neurophysiology	59	
Central nervous system, neuropharmacology	14	
Neurosurgery	11	
Neuropsychology, implant studies	9	
Pharmacology-Toxicology		75
Toxicology	38	
Pharmacology	16	
Vaccine production, testing, tissue culture	12	
Blood studies	9	
Sensory		53
Ophthalmology	40	
Otolaryngology, vestibular, auditory	13	
Reproductive Physiology		52
Obstetrics-gynecology	22	
Reproductive endocrinology, birth control	10	
Fetal development, birth defects, teratology	11	
Perinatal studies	9	
Psychobiology		51
Addiction studies, psychopharmacology	26	
Learning	13	
Psychology	12	
Behavior		51
Unspecified	33	
Social	18	
Disease--Organ Systems		47
Cardiovascular, atherosclerosis	29	
Musculoskeletal-injury	5	
Respiratory-pulmonary, TB	5	
Endocrine-diabetes	3	
Nervous-epilepsy, multiple sclerosis	3	
Sensory-glaucoma, uveitis	2	
Infectious Disease		46
Virus	22	
Malaria, tropical diseases	12	
Parasitology	8	
Hepatitis	4	
Physiology		42
Metabolism, nutrition	16	
Physiology, anatomy	12	
Endocrinology	7	
Urology	7	
Other		31
Unspecified biology, microbiology		
Experimental Surgery		30
Dental		28

Research Area and Topic	No. Mentions	
	Topic Total	Area Total
Disease-Immunology		19
Environmental		20
Radiobiology, heavy metal toxicity, hyperbaric medicine		
Disease-Neoplasms, carcinogenesis		17
Other Diseases--pathology, pediatrics, dermatology		9
TOTAL MENTIONS		664

to substitute different taxa for primates. Pharmacologists and respondents generally mentioned that macaques were acceptable as alternate primates. Long-tailed macaques and capuchins were the most frequently mentioned specific alternatives.

Indications from Representative Literature

General The volume of scientific papers written in the field described as primatology is large enough to support three journals devoted specifically to primate studies: Primates (Japan Monkey Centre), Folia Primatologica, and Journal of Medical Primatology (S. Karger, Basel). In addition, a computerized weekly bibliographic service (Current Primate References) from the University of Washington Regional Primate Center covers approximately 200 papers per week, and these represent a small selected sample of the total. A quarterly newsletter, Laboratory Primate Newsletter (Brown University) disseminates current information to aid investigators in exchanging surplus breeders and research animals. The Primate Zoonoses Surveillance (Center for Disease Control, Public Health Service) is another quarterly bulletin that summarizes pathological findings in several large colonies.

The literature in primatology expands yearly with the publication of two monograph series: Contributions to Primatology, the successor to Bibliotheca Primatologica (S. Karger, Basel); and Primates in Medicine. The research areas in the latter series range from immunology (Kratochvil, 1968, 1972) to comparative studies and husbandry (Beveridge, 1969a, b) and conservation (Harrisson, 1971). Symposium volumes resulting from Conferences on Experimental Medicine and Surgery in Primates are published in a series entitled Medical Primatology (Goldsmith and Moor-Jankowski, 1969, 1971, 1972a, b, c) Papers from a variety of fields in primatology have been collected in volumes of the International Primatological Society since 1966.

Topics discussed at recent conferences include the utilization of primates in toxicology (Miller, 1966) and virology (Gerone et al., 1973). Disease hazards associated with laboratory primates have been considered (Perkins and Donoghue, 1969), as well as the health problems of concern in international shipments of wild primates (PAHO, 1972). Guidelines and handbooks on the care of monkeys, with speciesl emphasis on macaques, have been developed (Committee on Standards, 1973; Whitney et al., 1973; Valerio et al., 1969). Aspects of the utilization and supply have been examined for Asian primates (ICLA, 1973), South American primates (Thorington and Heltne, In press), and for a variety of species (Bermant and Lindburg, 1975). These discussions follow by two decades the conference on rhesus monkey supply that examined the need for large scale breeding in captivity (ILAR, 1955). Finally, special symposia have directed increasing attention to the maintenance and breeding of primates (Harris, 1970; Beveridge, 1972; and Diszfalusy and Standley, 1972).

The growth of a body of literature on specific species is shown by collections of contributed papers on chimpanzees (Bourne, 1971; Reynolds, 1969) and books of bibliographic citations (Rohles, 1962). Many gaps exist in species covered by published bibliographies over the range from chimpanzees to tree shrews (Elliot, 1971). The traditionally used baboon (Vagtborg, 1965) and rhesus macaques are subjects of several volumes, although works on the more recently used species like the squirrel monkey (Rosenblum and Cooper, 1968) are gradually being compiled.

Reviews Surprisingly few reviews of species selection for appropriate laboratory animal models for particular medical uses were located in the literature. In publications that do evaluate a species choice, primates are often dismissed because they are too costly and the supply too unpredictable (McKelvie et al., 1971) or they are considered necessary and a comparison with nonprimate species is then ignored. At present the reviews that do exist compare only a few of the total number of species that have been used in the study of a particular disease. The valuable compilations that are surveys of a wide variety of species, are typically not accompanied by a critical review of the advantages and limitations of the particular species listed (Cornelius, 1969; Jones, 1969). Two areas for which recent reviews are available are atherosclerosis and cholesterol metabolism (Strong, 1974; Taylor et al., 1973) and leukemia (Dutcher, 1973). The taxonomic spread of species that have been used in this research is very broad, suggesting that there are several primates and several nonprimates that can serve as appropriate models. Bibliographies have also been compiled on such diverse topics as spontaneous neoplasia in primates (Caminiti, 1974), deprivation and separation (Agar and Mitcher, 1973), and reproduction and breeding in primates (Morrow and Terry, 1974).

Characteristics of the Primate Trade

Costs

For the purpose of levying an import duty of 3.5 percent the U.S. Department of Commerce (USDC) places a value on each imported item that reflects its sales value in the country of origin. In 1973 the assessed value per monkey from most Asian countries was $15-17; from Colombia and Peru, $10-11; and from Sierra Leone, $223 (USDC, 1968-1973). The higher value from the latter nation reflects the numbers of chimpanzees that were imported with other species from that country. Prices quoted in early 1971 for an infant chimpanzee showed a mark up from a trapper's price of $20 to an exporter's price of $260 to an importer's price of $650 (Goldsmith and Moor-Jankowski, 1972d).

The issue cost of rhesus macaques to investigators at NIH varied from $53 in fiscal year (FY) 1969 to $70 in FY 1974. These low values were possible because little of the expense of quarantining primates was passed on to the individual investigator. During the first half of FY 1974 the price of an unconditioned import (established by contract for large quantities) varied between $28 and $38 depending upon the size class. During this period the issue rate for a primate was 50-55 percent of the cost of a kennel-raised dog, such as a foxhound. Per diem charges for primates were less than those for all types of hoofed stock.

During fiscal 1974 and 1975 the Veterinary Resources Branch revised the issue rates each 6 months and finally ended the indirect subsidizing of primates by incorporating both the quarantine costs and a mortality factor into the price schedules. The method is summarized in Table 13. This economically realistic step increased the issue costs over 100 percent within a year to $110 for the small rhesus macque of 4-6 lb, $160 for the large rhesus of 10-14 lb, and $250 for the extra large macaque of over 14 lb. Even at these prices, the smaller size class of monkeys is cheaper to use than dogs.

If the rate setting manual for an animal facility of a sample medical school is representative (Division of Research Resources, 1973), the cost of a conditioned rhesus macaque to an investigator at a university was approximately $162 in 1973. The procurement expense of a partially conditioned rhesus macaque is estimated at $80, with indirect university costs and a facility service fee raising the unit cost of a monkey to $108. The addition of a $54 cost for quarantine, based upon a per diem holding charge of $1.25 for 44 days, gave a total cost of $162.

Seasonality of the Primate Trade

Both the seasonal availability and a seasonal demand influence the peak months of primate shipments. Apparently, the trapping season in Indonesia and Malaysia lasts between March and August or September because both Japan and the United States import 80-84 percent of their total numbers from these countries during this half of the year (Kawanishi, 1972; USDC, 1968-1973). A comparable proportion of the numbers are imported into Japan during these same 6 months (Table 14). This overall peak period probably reflects both the fact that half of the total number of primates imported into Japan are from Indonesia and the fact that the fiscal and academic year in Japan begins in April after a holiday period. Total imports into the United States fall to three-fourths of the average monthly numbers during the vacation months of July and August. The United States imports the largest number of primates from Malaysia in September. Both October and December, which are peak months of primate importation for the United States, fall outside of the apparent peak of availability from the country of origin.

Tsalickis (1972) started a breeding colony of squirrel monkeys in Peru by releasing animals onto an island between 1967 and 1970. The months between July and December when he released 90 percent of the animals presumably reflect the period when his supplies exceeded the export demand and, therefore, also the main trapping season. The drop in imports from Peru during July and August to less than a third of the average monthly rate again reflects the decreased demand during the holiday months in the United States.

Losses in the Primate Trade

Heavy losses in collecting and shipping freshly trapped monkeys have been recognized for several years. Roth (1965) considered that losses of 35

TABLE 13 ISSUE COSTS OF RHESUS MACAQUES AT THE NATIONAL INSTITUTES OF HEALTH, FY 1974

Size Class	Purchase Price per Uncon-ditioned Monkey ($)	Quarantine			Adjustment for Mortality in Quarantine			Issue Cost ($)
		Required Duration (d)	Per Diem Cost ($)	Cost per Monkey ($)	Per-cent Loss	Purchase Price Loss ($)/ Issue	Added Holding Costs ($)/ Issue*	
Small 1.8-4.4 kg	50	75	.68	51.00	8	4	2	110
Large 4.5-6.3 kg	76	90	.68	61.20	16	14	6	160
Extra large 6.5 kg	135	120	.68	81.60	16	26	8	250

*Assume average loss at midpoint of quarantine

TABLE 14 SEASONALITY IN THE PRIMATE TRADE

	Imports into Japan 1971*		Imports into US 1970§		Estimated Trap Rate in Peru 1967-1970¶	Imports Into US, 1970¶
	From Indonesia	Total	From Malaysia	Total		
January	20	205	85	6,473	227	1,885
February	130	428	92	7,017	20	2,530
March	515	1,384	169	9,060	35	2,970
April	970	1,851	225	8,392	74	4,299
May	1,076	2,146	177	8,825	0	3,657
June	1,030	2,020	132	9,212	265	3,426
July	1,142	2,180	335	5,593	658	846
August	1,001	1,956	57	4,113	1,190	855
September	490	990	484	6,706	588	1,986
October	215	646	50	7,538	495	2,319
November	105	270	50	6,950	1,202	2,897
December	120	193	50	10,864	938	5,059
TOTAL	6,814	14,269	1,906	90,743	5,690	32,729
$\bar{x}$/mo.	568	1,189	159	7,562	474	2,727
6 Peak Mos. (Percent Total)	84	81	80	59	89	68

*Kawanishi, 1972
§USDC, 1970
¶Tsalickis, 1972

percent of the total number captured was a conservative estimate. Lewis (1973) described the importation of rhesus macaques and long-tailed macaques into Australia. By estimating from his graphs, only a half of the 47,216 primates imported between 1955 and 1961 survived a 12-week quarantine period. These losses were cut nearly in half when the consignments were shipped in small groups averaging 216 rather than in large groups averaging 1,089. The quarantine losses from shipping freshly trapped animals were reduced to less than 10 percent by transporting imports that were acclimatized for 12 weeks prior to shipment. Unfortunately the losses in the country of origin were not added to the losses in the receiving country to obtain a comparison of total losses from an acclimatizing program. This report is comparable to a 1973 estimate that 60 percent of the long-tailed macaques imported into Canada from Malaysia die within a month of arrival (M. Walcroft of Connaught Labs, personal communication to J. Vickers, 1974).

Considerable controversy exists over the causes for losses in primate populations. S. M Richards (personal communication, 1974) attributes many losses of vervets to the primate trade while Rowell (1968) implicates eradication programs for agricultural pests. Richards describes an unpublished report by P. Pegg submitted in 1967 to the Kenyan government. Pegg estimated that 62 percent of the vervets died within country from a variety of factors including dead animals at the collecting station, deaths in unattended traps, young released without their mothers, and the culling rate by dealers who accept only animals of a specific size. The culled animals are sold for dog food in Kenya and account for an estimated difference between 62-percent and 25-percent losses within country. The situation differs in Uganda where Rowell reports that approximately 6,000 vervets were killed as agricultural pests in 1964.

Specifically organized expeditions have proven to reduce losses. For example, baboons have been collected for the Southwest Foundation for Research and Education by special collecting trips to Kenya. The Wilsons have recently collected long-tailed macaques in Indonesia for the U.S. Primate Centers. Rhesus macaques have been shipped from Kashmir with minimal losses when monitored from trap to their U.S. destination at Charles River Breeding Laboratories, Inc. (Kaufmann, personal communication, 1974). The cost of 150 rhesus macaques acquired by this method was $152 per monkey, or about $50 higher than the 1974 purchase price from commercial dealers. The greater cost included higher shipment charges resulting from the use of crates with individual compartments, special handling during trapping, isolation from other shipments during truck transport and holding within India and during air shipment, and the travel expenses for two persons from the United States to the capture site. The special procedures included limiting contacts of the monkeys to handlers wearing protective face masks and gloves, provisioning with commerical pelleted feed and treated water, and screening for several diseases at the trapping site. The animals were tuberculin tested and vaccinated against measles. Serum and stool samples were obtained and later analyzed, especially for shigella, salmonella, and Herpesvirus simiae. These procedures reduced mortality from the typical 10-20 percent to less than 1 percent, and minimized the need for clinical treatments during quarantine. The reduction in quarantine losses decreased the difference between monkeys

TABLE 15 PROTECTED AND ENDANGERED PRIMATES, 1970-1973

International Treaty, 1973		U.S. Endangered Species Act	Where	IUCN Red	
Appendix I	Appendix II	Title 50, 1970*	Found	Data Book, 1972§	
Lemuridae, all members of genera		+	Madagascar and Comoro Islands		
Lemur	L. catta (some populations)			E - L. macaco - 4 subsp.	V - L. mongoz
Hapalemur					V - H. griseus R - H. simus
Lepilemur				E - L. mustelinus - 2 subsp.	R - 1 subsp.
Allocebus					R - A. trichotis
Cheirogaleus					V - C. medius
Microcebus					V - M. coquereli
Phaner					I - P. furcifer
Indriidae, all members of genera		+	Madagascar and Comoro Islands		
Indri				E - I. indri	
Avahi					V - A. laniger
Propithecus				E - P. verrauxi	R - P. diadenia
Daubentoniidae		+	Madagascar		
Daubentonia madagascariensis					
	Lorisidae	NL			
	Loris tardigradus		Sri Lanka and South India		
	Nycticebus coucang		Southeast Asia		
Callitrichidae					
Leontopithecus (Leontideus)		+	Brazil	E - L. rosalia E - L. chrysomelas	R - L. chrysopygas
Callimico goeldii		+	Brazil		I - C. g. (Brazil, Colombia, Peru)
Cebidae					
Chiropotes albinasus		+	Brazil		R
Cacajao		+	Peru, Colombia, Ecuador, Brazil, Venezuela	E - C. calvus (Brazil) E - C. rubicundus (Brazil, Peru) E - C. melanocephalus (Brazil)	
Alouatta palliata (villosa)		NL	Central and S. America		
	Cebus capucinus	NL	Central and S. America		
Saimiri oerstedii		+	Costa Rica		
Ateles geoffroyi frontatus		+	Guatemala		
		A. g. geoffroyi	Guatemala		
		A. g. ornatus	Costa Rica		
A. g. panamensis		+	Costa Rica		
Brachyteles arachroides		+	Brazil	E	

Nonhuman Primates: Usage and Availability for Biomedical Programs
http://www.nap.edu/catalog.php?record_id=18765

TABLE 15 (continued)

International Treaty, 1973		U. S. Endangered Species Act	Where	IUCN Red
Appendix I	Appendix II	Title 50, 1970*	Found	Data Book, 1972§
Cercopithecidae				
	Macaca sylvanus	NL	N. Africa	
M. silenus		+	India	E
Cercocebus galeritus galeritus		+	Kenya	E
Presbytis geei		NL	Assam-Bhutan	R
	P. johnii	NL	India	V
P. pileatus		NL	Southeast Asia	
P. entellus		NL	Indian subcontinent	
	Rhinopithecus roxellanae	NL	W. China	R
Pygathrix nemaeus		+	Indochina	E
Nasalis larvatus		NL	Borneo	
Simias concolor		+	Indonesia	E
	Colobus verus	NL	W. Africa	R
	C. badius gordonorum	NL	Tanzania	R
C. b. rufomitratus		+	Zanzibar, (Tanzania)	
C. b. kirkii		C. kirkii	Kenya	R - C. kirkii
Hylobatidae				
Hylobates		H. klossi	Indonesia	E
		H. pileatus	Malaysia	E
Symphalangus syndactylus		NL	Sumatra and Malaysia	
Pongidae				
Pongo pygmaeus pygmaeus		P. pygmaeus	Indonesia, Malaysia, Brunii	E
P. p. abelii				
	Pan paniscus	NL	Central and W. Africa	V - P. troglodytes
	P. troglodytes	NL	Tropical Africa	V - P. t. troglodytes V - P. t. veris
Gorilla gorilla		+	Central and W. Africa	E - G. g. beringei (Rwanda, Uganda, Zaire) V - G. gorilla

* NL=not listed
§ E=endangered; V=vulnerable; R=rare; I=indeterminate

TABLE 16 CURRENT BREEDING OF MOST COMMON SPECIES IN BIOMEDICAL RESEARCH LABORATORIES

Species	Total Inventory	Females in Breeding Colony	1973 Births	Rank by Births by Species
Macaca mulatta	22,980	2,732	991	1
Saimiri sciureus	4,358	499+	185	4
Saguinus sp.	3,129	414	316	3, 10, 13
Papio sp.	2,318	480	120	5
Macaca fascicularis	1,836	304	94	6
Macaca nemestrina	1,439	462	241	2
Cercopithecus aethiops	1,390	118	33	14
Aotus trivirgatus	1,316	23	2	-
Macaca arctoides	1,083	260	68	7
Pan troglodytes	673	145	46	11
Cebus apella	511	21	7	-
Macaca radiata	419	159	66	8
Galago crassicaudatus	295	94	64	9
Cebus albifrons	261	65	30	16
Callithrix jacchus	186	48	43	12

TABLE 17 PRIMATES THAT SHOULD BE BRED IN LARGE NUMBERS

Species	No. Citings
Rhesus macaque	148
Squirrel monkey	90
Baboon	46
Marmoset	36
Stumptail macaque	35
Pigtail macaque	23
Vervet monkey	23
Night monkey	16
Chimpanzee	15
Long-tailed macaque	14
Capuchin	12
Spider monkey	4
Others	15
TOTAL	477

SOURCE: ILAR 1973 questionnaire data from biomedical researchers.

acquired by expeditions and those imported commercially to $28 per monkey ($214 vs $186 issue cost from a $0.68 per diem-90 day quarantine). The anticipated benefits from decreased death losses in the breeding colony resulting from reduced incidence of pathogens will further offset and justify the greater initial expenditures (Kaufmann, personal communication, 1974).

Regulations

The Convention in International Trade and Endangered Species of Wild Fauna and Flora that was signed by several nations in 1973 could become law in 1975 if a total of 10 countries ratifies the Convention. If so, the animals listed in Appendixes A and B will become regulated internationally. Table 15 compares the species protected by the International Convention, those protected by the import restrictions of the U.S. Endangered Species Act of 1969, and those species listed in the International Union for the Conservation of Nature and Natural Resources (IUCN) Red Data Book (IUCN, 1972).

Captive Breeding of Primates

Species Currently Bred in Research Laboratories

Survey Totals No major changes in the numbers of births, the numbers of breeding females, or the species bred during the last 4 years are apparent from a comparison of the ILAR surveys for 1970 (Thorington, 1971a) and 1973 (Appendix III). Efforts to breed certain species are evident from the increase in births of *Galago crassicaudatus* from 34 to 64 and of *Cebus* species from 10 to 37.

The most commonly bred species in research facilities are ranked by order of numbers held on inventory in Table 16. Generally, the species used most frequently are not those currently being bred in the largest numbers. *Aotus trivirgatus* and *Cebus apella* both rank among the top 15 species used but are not among the top 15 species bred. The lack of emphasis on breeding is further illustrated by the small number of females assigned to breeding colonies and by the low number of live births occurring in 1973.

Biomedical researchers were requested to list the species they thought should be bred in large numbers for research. Predictably, most listed the species they were studying. The order of the preferred species listed in Table 17 reflects the relative usage rates of these species more closely than does the rank order of the species currently being bred (Table 16).

A second generation of a variety of species has been bred in captivity (Appendix III). These primates represent a valuable breeding resource and current inventories of laboratory reared stock are increased from 700 F_1 and F_2 females to nearly 1,000 when primates of several generations at the Caribbean Primate Center are included.

Rhesus Macaques A sample of the usage of the reproductive output of breeding colonies exemplifies the priorities of current programs (Table 18). At first sight the apparent productivity of 41 percent of the adult females seems particularly small. This proportion underestimates considerably the reproductive success because the value for births applies to 1972 and the number of adult females assigned to breeding colonies applies to October, 1973. Since it could be expected that several females have been added to colonies during this interval, some females would not have been in residence in the colony long enough to complete a gestation period.

Of particular interest is the fact that 29 percent of the total productivity is used as experimental fetuses. Of those pregnancies that complete term, 57 percent are reared to 6 months of age. A fairly large proportion of these infants are also used experimentally.

A breeding colony as defined in this report is one that is self perpetuating. Under such a definition, only one research institution could realistically be classified as a breeding colony for rhesus. The California Regional Primate Research Center holds the majority of the 100 captive-raised breeding females that could be traced through the 1973 survey. These F_1 females have produced only 50 second generation offspring.

Estimates of gross yield for breeding macaques frequently assume an 80 percent reproductive rate and 10 reproductive years for each female. These rates have been considered to be overly optimistic by many researchers and rates of 50 percent for 5 years may be more realistic, especially for species other than rhesus. Net yield per 100 breeding females could reach 57 yearlings if the sex ratio of breeders were 10 females : 1 male; the reproductive rate was 80 percent per female; 10 percent of the breeders were replaced annually; and infant losses were 15 percent. Fifty-seven yearlings could be produced for $640 each for a colony with these characteristics if the holding costs were $0.50/day for each of the 212 breeders and maturing young necessary to perpetuate a colony of 100 females.

Marmosets Since marmosets can produce twins annually, and occasionally twice per year, they can theoretically maintain a level of 200 percent productivity annually. The few research facilities that have bred marmosets have demonstrated that this level of reproduction can be achieved (Table 19). However, most of these laboratories remove the infants at birth for the expensive procedures of hand rearing. Such reproduction would not come under the definition of a breeding colony in the strict sense since the colonies depend upon a continuous supply of wild-caught adults. *Saguinus* sp. are most frequently bred in the United States while *Callithrix* sp., especially *C. jacchus*, are typically bred in the United Kingdom. Production of marmosets in the United States was 350 in 1972 by breeding colonies that maintained 450 females. Hobbs (personal communication, 1974) has reported 532 marmoset births in the United Kingdom for 1972. Taking the lead in the United Kingdom was the Imperial Chemical Industries with 350 births and Fisons Pharmaceuticals, Ltd., with 112 births.

An examination of reproduction in zoos shows that only 46-68 percent of the infants survive when they are raised by their mothers (Table 20). This range spans the survivorship of 61 percent achieved under intensive laboratory management of individually caged pairs. Based upon observed losses in the marmoset colony at Rush-Presbyterian-St. Luke's Medical Center, the 39-percent infant loss includes 21 percent stillbirths, 16-20

TABLE 18 RHESUS MACAQUE BREEDING COLONIES IN 1972

	No. Primates	Percent Use of Neonates
Adult females (on inventory, October, 1973)	2,532	
Experimental fetuses	286	
Live births - 1972	817	
Use of Neonates - Sample N = 632		
Experimental deaths	217	34
Nonexperimental deaths	57	9
Reared to 6 months	358	57

TABLE 19 REPRODUCTIVE RATE OF CALLITRICHIDAE BRED IN UNITED STATES RESEARCH INSTITUTIONS DURING 1970

Species	Live Births/Female (Percent)	No. Births	U.S. Research Colonies
Saguinus fuscicollis	155	96	1
Saguinus nigricollis	199	291	3
Saguinus oedipus	159	62	5
TOTAL		449	9

SOURCE: Thorington (1972).

TABLE 20 SURVIVAL RATE OF CALLITRICHIDAE BORN IN WORLD ZOOS DURING 1970 AND 1971

Species	Infant Survival (Percent)	No. Births	No. Zoos with Births	Maximum No. Births Surviving at 1 Zoo in 1 Year
Leontopithecus rosalia	46	151	20	5 San Diego, U.S.A.
Callithrix jacchus	58	76	17	6 Rio de Janeiro, Brazil
Saguinus oedipus	68	106	20	4 London, ZSL G.B.
15 species of Callitrichidae	60	441	55	6 Inuyama, Japan (*Cebuella pygmaea*)

SOURCE: Data from Lucas and Duplaix-Hall (1972); Duplaix-Hall (1973).

percent loss during the first 30 days for hand-reared or mother-reared infants, and an annual holding loss of 8 percent (L. G. Wolfe, personal communication, 1974).

The differences between observed and expected production are compared in Table 21. The net yield from the idealized production centers of wild-caught breeders have overestimated the obtainable yield by 46 percent (160 vs. 86) based upon present management methods. Under the same sets of assumptions the food costs per yearling produced are somewhat higher for rhesus macaques ($640) than for marmosets ($560, Table 21). Additional savings in breeding marmosets should be realized from lower costs for equipment and space.

The calculations for Table 21 are based upon 200 established breeders. The Rush-Presbyterian facility has experienced a 20-percent loss during 3 months of quarantine. If there were no harvesting, it would take 4 years at observed survival rates to produce 16 F_2 progeny and to double the inventory of 148 imports surviving quarantine. It would take at least 5 years to double the colony size above the original 200 imported animals.

Planned and Proposed Production Centers

A number of primate breeding colonies have been established in recent years, but most have been funded to provide animals for the internal needs of the funding organization, specifically intramural NIH and the primate centers. Table 22 summarizes the large production centers that are currently funded. Current inventories of adult breeders are projected to increase over the next 5 years from 5,800 to 9,500. The nuclear breeding stock at primate centers and several other institutions have been described by Goodwin (1972) and Neurauter and Goodwin (1972). The need for continued expansion of breeding efforts has been stressed by Goodwin (1974). One commercial free-ranging colony has been started for breeding rhesus macaques on an island in the Florida Keys by Charles River Breeding Labs, Inc. Commercial production centers for compound breeding are being planned by Earth Science Products, Inc. in Hawaii and South American Primates in Brazil and Peru, in addition to the commercial centers already funded in the United States (Table 22). The development of a primate center in Israel has also been proposed, although the original projections were based upon the assumption that the center could serve as a conditioning facility for continuously available wild primates, rather than as a production center (Goldsmith and Moor-Jankowski, 1972d).

Cost estimates made in 1971 (excluding profits) for production centers have been summarized by Hobbs (1974) for colonies in the United Kingdom. He suggests that a yearling macaque could be bred for $225-$260, a young marmoset for $85-$90, and a squirrel monkey for $170. Estimates derived from 1971 costs at the National Primate Centre at Tigoni, Kenya, suggest a 6-month old vervet would not exceed $68. Elliott (1972) estimated that a macaque could be raised in outdoor compounds in Singapore for $66 each in 1971. However, the difficulties in controlling insect and avian-borne

TABLE 21 OBSERVED PRODUCTION OF MARMOSETS IN BREEDING COLONIES

Observed rates include: 90% birth rate (assumed for 10 yr/female)
1.92 infants/birth
39% infant loss until one year of age
equal birth and death rates for each sex

Category	Colony Composition Female	Colony Composition Male	Observed Inventory
No breeders	100	100	200
Gross annual production	86.5	86.5	-
Infants surviving to 1 yr	53	53	-
Replacement holding for 2 yrs	10	10	40
Net yield (held for sale at 1 yr)	43	43	86
TOTAL			326

Annual Net Yield	No. Produced	Cost ($)/ Yearling*
Observed annual net yield/100 females (inventory 326)	86	692
Expected annual net yield/100 females in idealized production colony of wild-caught breeders assuming 80% reproductive rate, 100% twinning, negligible infant losses (inventory 360)	160	411
Expected annual net yield/100 females in self-sustaining colony with 80% reproduction, 10% breeder replacement, and 15% infant loss (inventory 356)	116	560

SOURCE: Data based on colony at Rush-Presbyterian-St. Luke's Medical Center, Chicago, Illinois; L. G. Wolfe, personal communication, 1974.

*Based on $.50/day/animal x 365 days x inventory/yearlings produced.

TABLE 22 PUBLIC HEALTH SERVICE SUPPORTED DOMESTIC PRODUCTION OF PRIMATES

Contractor and Location	Funding Agency	Current Status Adult Inventory, Mid-1974	Proposed No. Breeders by 1979	
Rhesus Macaques				
Timed Pregnancy				350
VRB, Bethesda, MD	NIH-DRS	160	160	
VRB-NINDS, Bethesda, MD	NIH-DRS	40	40	
Gulf South Research Inst., New Iberia, LA	NIH-DRS	100	100	
NICHD, Bethesda, MD	NIH-NICHD	50	50	
Production Colonies				6,860
VRB Center, Perrine, FL	NIH-DRS	350	700	
U. Puerto Rico (CPRC), La Parguera, PR	NIH-NINDS	160	160	
U. Puerto Rico (CPRC), La Parguera, PR	FDA-BOB	600	1,000	
Regional Primate Centers (RPRC's)	NIH-DRR	1,150	1,150	
California RPRC, Davis, CA	NIH-NICHD	250	300	
Delta RPRC, Covington, LA	FDA-BOB	100	1,000	
CDC, Atlanta, GA	CDC	150	300	
Gulf South Research Inst., New Iberia, LA	NIH-DRS	100	350	
Hazelton Corp., Herndon, VA	NIH-DRS	225	350	
Hazelton Corp., Edinburgh, TN	NIH-DRR	140	500	
Bionetics Corp., Yamassee, SC	NIH-DRR	110	400	
Charles River Corp., Key Lois, FL	NIH-DRR	600	600	
Research Funding Proposal	NIH-NIDR	0	50	
RHESUS SUBTOTALS: NIH institute contracts		2,285	3,760	
Other agencies (BOB, CDC)		850	2,300	
Regional Primate Centers		1,150	1,150	
		4,285	7,210	
Other Macaques				1,131
Washington RPRC, Seattle, WA	NIH-DRR	650 pigtail	650	
RPRC's	NIH-DRR	120 long-tailed	120	
RPRC's	NIH-DRR	160 stumptail	160	
California RPRC, Davis, CA	NIH-DRR	115 bonnet	115	
Wisconsin RPRC, Laredo, TX site	NIH-DRR	86 Japanese	86	
Baboons				88
RPRC's	NIH-DRR	15	38	
Washington RPRC, Seattle, WA	NIH-VRB (for NICHD)	9	9	
Southwest Fdn. Research and Education, San Antonio, TX	NIH-VRB (for NICHD)	20	31	
LEMSIP, Sterling Forest, NY	NIH-VRB (for NICHD)	10	10	

TABLE 22 (continued)

Contractor and Location	Funding Agency	Current Status Adult Inventory, Mid-1974	Proposed No. Breeders by 1979	
Patas Monkeys				120
Meloy Labs, Springfield, VA	NIH-NCI, NINDS	0	120	
Chimpanzees				177
Yerkes & Delta RPRC's	NIH-NHLI	10	27	
LEMSIP, Sterling Forest, NY	NIH-NHLI	0	100	
Albany Medical Center, Hollomon AFB facility, Alamogardo, NM	NIH-NIAID, FDA-BOB, CDC	40	50	
New World Monkeys				565
VRB Center, Perrine, FL	NIH-VRB	50 squirrel	100	
NIMH, Bethesda, MD	HEW-NIMH	100 squirrel	10	
Delta RPRC, Covington, LA	NIH-DRR	60 squirrel	155	
Delta RPRC, Covington, LA	NIH-NIAID, FDA-BOB, CDC	30 (*Saguinus mystax*	300	
Prosimians				132
Oregon RPRC, Beaverton, OR	NIH-DRR	74 (*Galago crassicaudatus*)	74	
Oregon RPRC, Beaverton, OR	NIH-DRR	38 *Lemur fulvus*	38	
Oregon RPRC, Beaverton, OR	NIH-DRR	20 *L. catta*	20	
OTHER SPECIES SUBTOTALS	NIH institute contracts	30	411	
	Other agencies (BOB, CDC, HEW)	100	10	
	Regional Primate Centers	1,387	1,792	
		1,517	2,213	
TOTAL		5,844	9,465	

CDC - Center for Disease Control
CPRC - Caribbean Primate Research Center
FDA-BOB - Food and Drug Administration, Bureau of Biologics
LEMSIP - Laboratory of Experimental Medicine and Surgery in Primates
NIH - National Institutes of Health
- DRR - Division of Research Resources
- DRS - Division of Research Services
- NCI - National Cancer Institute
- NHLI - National Heart and Lung Institute
- NIAID - National Institute of Allergy and Infectious Diseases
- NICHD - National Institute for Child Health and Human Development
- NIDR - National Institute of Dental Research
- NINDS - National Institute for Neurological Diseases and Stroke
- VRB - Veterinary Resources Branch

NIMH - National Institute of Mental Health, Department of Health, Education, and Welfare
RPRC - Regional Primate Research Center

diseases is cited as one disadvantage of outdoor compounds (Hobbs, 1974). These 1971 estimates are considerably lower than the current estimates between $250 and $500 for primates raised at the proposed Hawaiian facility of Earth Sciences Products, Inc., and more than $500 in most U.S. facilities. Most facilities in the United States assume a holding charge of at least one dollar per day for each animal.

Porter (personal communication, 1974) of South American Primates has estimated a production volume of 4,000-5,000 platyrrhines per year in facilities to be built in Peru and Manaus, Brazil, with costs for captive-bred animals to be in the range of $100-$150 as are current for wild-trapped animals. During the initial phases of development of these facilities and selecting breeding stock, he expects to condition and provide about 400 per month for research. After 5 years Peru has indicated that all exported primates will have to be captive bred. Plans for Manaus include breeding monkeys in cages rather than on islands. The monkeys are expected to cost twice as much but also be free of tropical diseases.

Considerable skepticism has been voiced concerning the sincerity of breeding efforts since there are examples of discontinued or poorly managed colonies. Carpenter (1972) has documented the sporadic history of the free-ranging rhesus macaque colony released on Cayo Santiago Island in Puerto Rico. This colony has been managed since its establishment in 1939 for several different purposes ranging from studies on social behavior to production of experimental animals. The colony was not continuously provisioned for nearly 10 years after the second World War, and the population declined from around 600 to 150 in 1956, although half of the initial number were probably trapped and sold.

A second example is a free-ranging colony of squirrel monkeys established on Isla de Santa Sofia II, in Leticia, Colombia, and has been described by Tsalickis (1972). Tsalickis released 5,690 monkeys onto the 400-hectare island between 1967 and 1970 and estimated that the population should reach 20,698 by 1971 if there were an 80-percent birth rate and no mortality. After censusing the island in 1972, Bailey et al. (1974) estimated that the population was under 1,000 animals.

Despite historical problems with the transplanted macaques on Puerto Rico, the populations have provided information useful for management. The net annual increase at Cayo Santiago Island has been 16 percent; that at La Parguera, 13 percent (Drickamer, 1974). Because the data from these colonies have been accumulated on known animals for over 10 years, they are more accurate than estimates of the potential harvest of vervets on St. Kitts (McGuire, 1974). A harvest of 10-40 percent may be derived from McGuire's estimate of 2,000 animals killed for bounties from a population estimated to be between 5,000 and 20,000. The life tables obtained for provisioned populations differ from those obtained from natural populations. In the toque macaque, higher death rates offset birth rates and lead to stable populations (Dittus, 1974).

Discussion of Primate Trade and Breeding

Research Use of Primates

One way of differentiating research demand for species is presented in Table 11. Both marmosets and night monkeys may be considered as "special use" species at the present time because more than 80 percent of the animals of these species are used in a single research category--that related to specific diseases. This pattern contrasts to the "general use" species such as the rhesus macaque and the squirrel monkey , which are utilized in each of the research categories. The relevance of this separation for the selection of species to be bred in captivity is the trend in use that the pattern reflects. Demand for a species that is found to be useful in basic research into a particular disease increases from several disciplines as baseline data on the species accumulate over several years. As drugs or vaccines are developed for a disease, the proportional demand for that species shifts to the area of pharmacology and toxicology. If the level of demand for marmosets and night monkeys to test the safety of cancer drugs and malarial vaccines parallels the demand for rhesus macaques and vervet monkeys in the earlier work with polio, then the demand for these New World species will increase substantially. Other species are so poorly known and so unavailable that no demand currently exists for them; however, the number of citings for capuchins, tree shrews, and patas monkeys that were noted for work in infectious diseases and neoplasms is indicative of potential demand. Even though each of these species comprises less than 1 percent of the listed demand, it may be assumed that their usage would rise with availability. The belief that supply creates demand has been shared by many investigators, the important factor being the reliability of a captive-bred supply that is sufficiently large to respond to research demands (Hobbs, 1974).

Recent editions of Bowker's Medical Books in Print confirm the recent explosion of work in neurophysiology and the diversification in species examined. Prior to 1968 the rhesus macaque, squirrel monkey, and chimpanzee were subjects of brain-mapping studies. By 1970, stereotaxic atlases had been published on seven more species of primates--the baboon, capuchin, long-tailed macaque, pigtail macaque, Japanese macaque, common marmoset (*Callithrix jacchus*), and tree shrew. With a description of 10 primate species and 10 other laboratory animals (dog, cat, rat, *Citellus* sp., mouse, guinea pig, hamster, rabbit, pigeon, and mallard) to choose from, this research area exemplifies the need for evaluation and review before species lists are magnified without direction.

The expanding volume of publications that describe studies using monkeys has frequently been considered an indication of the increasing need for primates in research. However, there are serious shortcomings in much of the medical literature that result from a lack of attention to defining experimental variables. Several studies lack a statement on the number of animals used, sex, or weight class (as an estimate of age), and do not describe diet and housing conditions. This lack of sophistication in describing the animal model contrasts greatly with the awareness and control of environmental variables in work with other species (Magalhaes, 1974). St. Clair *et al*. (1967) conducted one of the few studies that correlated a physiological variable in monkeys, blood cholesterol levels, with the type of caging and the time since capture. Many original papers still refer to "the monkey" or "the marmoset" without giving an accurate identification of the species used (Hershkovitz, 1965a, 1965b). Thorington (1971b) has also stressed the need for proper identification and voucher specimens of primates used in viral research. Medical journals are far behind journals of primatology in using scientific nomenclature for experimental primates as can be seen by a perusal of the titles cited in the Washington Primate Center's "Current Primate References." The addition of specific identifications in titles would reduce costs and time in bibliographic indexing and could be implemented easily by revised editorial policies and conscientious peer reviews.

A second noticeable shortcoming is the magnification in the literature citations of single-occurrence or rare observations. This practice is particularly unfortunate when the observation is made in an endangered species with a limited normal gene pool. Examples include observations of mongolism (McClure, 1972) and kuru in chimpanzees (Gajdusek and Alpers, 1970, cited in Moor-Jankowski and Goldsmith, 1972). These citations have been added to the compilation of animal models of human diseases prepared by the Armed Forces Institute of Pathology. The importance of the first demonstration of a slow neurotropic virus of human origin (kuru) in primates is widely recognized. However, through the process of repetition and extraction of citations covering a single species choice, certain animal models become overemphasized to the neglect of potentially more appropriate ones. Marsh (1972) is one of the few authors selected in such compilations who compares a class of related diseases and susceptible animal models. If kuru resembles transmissible mink encephalopathy, scrapie, and Creutzfeldt-Jakob disease, the range of potential animal models for at least one of these diseases that could be substituted for chimpanzees and gibbons in studies of slow viruses includes squirrel monkeys, stumptail and rhesus macaques, hamsters, mice, mink, raccoons, striped skunks, and goats.

The Primate Trade

The amount of primate use has been influenced by the relative costs of other experimental animals, maintenance, and acquisition costs. The lower charges noted at NIH for primates relative to laboratory-bred dogs have undoubtedly encouraged the research use of primates over the past several years for economic reasons alone. Because quarantine nearly doubles the initial price of primates, some investigators have questioned the need for a long quarantine period.

Pressures from professional organizations and government regulations have converged in attempting to correct abuses of the past commercial trade in primates. The Joint Primate Specialist Group of the International Union for the Conservation of Nature and Natural Resources and the International Primatological Society stated in a 1973 resolution that primates have been undervalued as a national resource by most countries. The organization recommends that governments in the source countries should not only restrict exports of wild primates but should also tax exports if necessary to conserve natural populations of laboratory primates and to encourage the development of self-sustaining breeding colonies.

One of the services of commercial suppliers appears to have been that of absorbing the holding costs of several months between the period of dry season trapping and peak demand. For example, only 2 of the 6 high import months for primates from Peru correspond to the high months of availability in that country. It seems probable that the large primate trade volume in the past several years, contributed to, in part, by the pet trade, has buffered researchers from the seasonal effects of availability of wild-caught animals. As the volume of exports is restricted by any particular country, researchers will have to absorb these holding costs or experience several months of unavailability annually for these species.

Whenever animals are captured through special trapping expeditions, there is the added advantage that they are obtained from known localities. Special collections permit comparative studies into the variability within species and the extrapolation of results that previously has been impossible. A smaller sample size needed for statistical significance of results can also be expected from the use of more homogeneous groups of experimental animals. Conservation objectives have been gained through the reduction in losses during capture and shipping of semi-terrestrial species. It is important that a similar effort be directed toward the capture of arboreal species. Additional innovations are necessary to curtail losses presently occuring in marginal and underfinanced holding facilities which compound the problems of infectious diseases, nutritional deficiency, and crowding stresses.

Losses resulting from unsystematic collecting methods have been estimated by some to be as high as 50 percent of the numbers captured. If the purchase prices of primates must cover a loss rate of 50 percent, the economic advantages resulting from reducing losses and the numbers of treatments during quarantine should offset the increased costs of specific expeditions. Biomedical researchers have been generally so specialized that they have not informed themselves about the degree of poaching and illicit trade they have supported inadvertently through providing a demand for research animals. Government officials in the exporting countries could be expected to be cooperative towards an expedition method of trapping since the legitimacy of the research user, the acceptability of the trapping sites, and adherence to the trapping and export regulations could be monitored more readily. Permit quotas and certificates of need channeled through commercial exporters represent an indirect approximation of the expedition method financed directly by the users.

Captive Breeding

It is clear from the data presented that breeding was funded in the past primarily for research on facets of reproduction and most of the reproduction served experimental purposes rather than replacement. These priorities for restrictions on breeding were justified economically in the past while imports were available and inexpensive, but they have maintained the dependency of researchers upon wild-caught monkeys up to the present time. The feasibility of multigenerational breeding for many species has been shown by the determination of several investigators who have bred primates in spite of negligible funding for this purpose. However, the results of captive breeding (illustrated by marmosets) suggest that basic studies of husbandry are needed before self-perpetuating breeding colonies can become productive on a large scale.

Cadigan and Lim (1975) have recommended managing multiple species under natural conditions since sympatric forms maintain spatial stratification and different activity patterns. Free-ranging colonies may offer sizable savings in labor and maintenance costs while providing a net annual growth varying between 13 and 16 percent. However, since animals in free-ranging colonies require continuous provisioning and monitoring, the planning and financing of additional colonies will have to be large enough in scope to carry them from their inception to self-supporting levels of production. Without long-term financing for future colonies, the question of whether production colonies could become a screen for exporting primates will continue to be raised.

Ecological Considerations of Primate Populations

Relatively little information is available on the status of wild primate populations because biomedical funds have been primarily directed to research on health problems of national concern, and have not been so readily available for studies related to population dynamics of wild-caught research animals. Thus, the acquisition of large numbers of primates for biomedical programs has not coincided with a program of monitoring the impact of the commercial trade on trapped populations. The recent curtailment of primate exports by countries having a commercial trade and a developing interest in a sustained harvest of primate populations raises several questions: (1) What is the population size of different primate species in the wild, (2) what are the trends within these populations, (3) what does the area of national reserves indicate about the size and diversity of primate populations that will receive long-term protection, and (4) what are the prospects for wild populations?

Population Densities

Estimates of populations were located for only 16 named forms. The majority of these estimates can be found in the Red Data Book of threatened and endangered forms (IUCN, 1972) (see Table 23). Except for threatened species with very restricted distributions, only two regional or national population estimates are available that have been extrapolated from study populations by authors familiar with local habitats. These studies illustrate the value of applying demographic methods in estimating populations over 100,000. Southwick *et al*. (1970) estimated that rhesus macaques number a half million in Uttar Pradesh; Chivers *et al*. (In press) estimated that there may be a quarter million gibbons on the Malayan peninsula.

Wolfheim (In preparation) has itemized field studies and identified trends for many primates based upon a recent survey of the literature and field investigations. Most current estimates must be regarded as ecological density estimates (estimates based upon usable habitat) but a few are more properly considered as crude density estimates (overall or geographical estimates). Density estimates are of limited value when authors do not report the total area and number of animals from which the estimates were derived. This prevents the reader from identifying the type of density estimate when comparing species and study sites.

Selected population densities for several species are given in Table 24 and 25 for New World and Old World species, respectively. These estimates provide examples of population densities which might be considered common in representative habitats under normal ecological circumstances. Average population densities are almost impossible to calculate since they vary considerably in different habitats and regions. Maximum densities have the advantage of indicating potential populations in areas of most favorable habitat. However, maximum densities are often exceptional cases since estimates of several authors cluster at much lower values. The higher density estimates noted for provisioned macaques in city parks (Southwick, 1961a; Neville, 1968; Southwick and Cadigan, 1972) and temple areas and for howlers in remnant forests in expanding agricultural areas (Baldwin and Baldwin, 1972) have not been included although it is recognized that managed primates can be maintained at much higher densities than occur naturally. Differences in authors' census techniques, actual carrying capacities, and protection from exploitation that have contributed to the high density estimate for squirrel monkeys have not been evaluated. Those primates with the lowest maximum densities include the large-bodied apes and savanna species, such as patas monkeys.

Trends

Declining trends in rhesus macaques and vervets are well documented. These include a 75-percent decline in unprotected populations of rhesus macaques in the Aligarh district of India over the last 15 years and an estimated 90-percent decline over the last 20 years (Southwick and Siddiqi, In press). A 33-percent decline in vervet populations within six years between 1964 and 1969 occurred in Masai-Amboseli Game Reserve (Struhsaker, 1973). The decline in vervet numbers may have resulted from changes in the water table or the loss of food trees destroyed by competing elephants or livestock. Recent surveys have shown that market hunting for meat is a serious drain on primate populations in Colombia and Peru. This exploitation has reduced primates by 90 percent in some areas and the problem of hunting for local consumption has been exaggerated by the practice of supplying petroleum survey teams with wild meat (Neville and Castro, In preparation).

Less quantitative estimates are available for describing trends in other species. General population trends for 10 types of primates used in large numbers in biomedical work are summarized below.

Marmoset, *Saguinus* species *Saguinus mystax* occurs in parts of Peru and Brazil, while *S. nigricollis* occurs in adjacent areas of Colombia and Peru from the Ecuadorian border to the Brazilian border. The more widespread *S. fuscicollis* with 13 named races extends through parts of Colombia, Ecuador, Bolivia, Peru, and Brazil. *S. fuscicollis* occurs up to nearly 1,400 meters in Peru, a higher elevation than has been noted for several other species (Grimwood, 1968). Hernandez and Cooper (In press) noted that these white-lipped marmosets occupy secondary forests and some primary rainforests in lowland areas of Colombia and survive around areas of moderate human activity. Marmosets generally appear to do well in forests with thick tangles of vines and understory vegetation that increases in luxuriousness around forest edges, treefalls, and streams.

TABLE 23 POPULATION ESTIMATES FOR PRIMATE SPECIES

Species	Population Estimates	Country	Reference
Latin America			
Leontopithecus rosalia	700 - 1,600	Brazil	IUCN, 1972;
L. r. rosalia	400 - 600		Coimbra-Filho
L. r. chysomelas	200 - 500		and Mittermeier,
L. r. chrysopygus	100 - 500		1973
Brachyteles arachnoides	3,000	Brazil	IUCN, 1972
Asia			
Presbytis geei	550	Assam-Bhutan border, 1964	IUCN, 1972
Macaca silenus	1,000	India	Sugiyama, 1968a
Pongo pygmaeus	4,450 - 12,200		Basjarudin, 1971;
	1,000 - 4,500	Indonesia-Sumatra	Mackinnon, 1971;
	1,000 - 4,000	-Kalimantan (Borneo)	Reynolds, 1967;
	2,000 - 3,000	Malaysia-Sabah	Rijskin, 1974;
	450 - 700	-Sarawak	Schaller, 1961
Hylobates syndactylus	30,000 ± 5,000	Malayan peninsula	Chivers, In press
Macaca fuscata	22,000 - 34,000	Japan	Takeshita, 1964 cited by Itani, 1975
Hylobates lar	205,000-255,500	Malayan peninsula	Chivers, In press
Macaca mulatta	500,000	India-Uttar Pradesh (earlier estimate 1 million)	Southwick et al., 1970; Southwick et al., 1961b
	Present, no population estimates	Bhutan, Afghanistan, Burma, Bangladesh, China, Cent. India, Laos, Pakistan, Nepal, Thailand, Sikkim, Vietnam	
Africa			
Colobus badius kirkii	144 - 200	Tanzania-Zanzibar	IUCN, 1972
Propithecus diadema perrieri	500	Madagascar	IUCN. 1972
Gorilla gorilla beringei	1,000	Rwanda, Uganda, Zaire	IUCN, 1972
Cercocebus galeritus galeritus	1,500 - 2,700	Kenya	IUCN, 1972
Colobus badius rufomitratus	1,900	Kenya	IUCN, 1972

TABLE 23 (continued)

Species	Population Estimates	Country	Reference
Pan troglodytes	14,550 - 15,750	Total estimates of studied or surveyed populations in 5 of 18 countries	
	Present, no estimates; generally reported as declining	CAR, Cameroon, Congo, Guinea, Gabon, Ivory Coast, Mali, Liberia, Togo, Rwanda, Sudan, Sierra Leone, Tanzania	
	50	Senegal-Niokolo Koba NP	Dupuy, 1970
	12,500	Guinea (90,000 km)	Bournonville, 1967
	1,000	Ghana, total	Booth, 1956
	200	Studied in Zaire -70-80 Beni -97 eastern Zaire	Kortlandt, 1962, cited by Bournonville, 1967; Rahm, 1967
	1,000 - 2,000	Uganda-Budongo Forest	Reynolds and Reynolds, 1965
	Continued presence questionable	Burundi, Nigeria, Dahomey, Upper Volta	
Gorilla gorilla	5,000 - 15,000	Rwanda, Uganda, Zaire	Schaller, 1963
	400 - 500	Virunga volcanoes	
	200	Kayonza Forest	
	Present, reported declining	CAR, Cameroon, Gabon, Congo-Br.	
	Few hundred	Eq. Guinea	Jones and Sabater Pi, 1971
	Continued presence questionable	Nigeria	

SOURCE: Table adapted from information summarized in IUCN, 1972 for some population estimates and in Wolfheim (In preparation) for species presence in several countries.

TABLE 24 SELECTED POPULATION DENSITIES REPORTED FOR NEW WORLD PRIMATES

Species	No. individuals/km^2	Country	Reference
CALLITRICHIDS			
Saguinus fuscicollis	8-16	Peru	Freese, In prep.
	12	Peru	Neville and Castro, In prep.
S. imperator	5	Peru	Freese, In prep.
S. oedipus geoffroyi	60	Panama	Dawson, Pers. comm., 1975
CEBIDS			
Ateles paniscus	12-15	Colombia	Klein and Klein, In press
Callicebus moloch	2-14	Peru	Freese, In prep.
Cebus albifrons	2-24	Peru	Freese, In prep.
C. apella	6-10	Colombia	Klein and Klein, In press
	2-36	Peru	Freese, In prep.
	15-46	Peru	Neville and Castro, In prep.
Lagothrix lagotricha	7	Peru	Freese, In prep.
	12-46	Peru	Neville and Castro, In prep.
Saimiri sciureus	19-31	Colombia	Klein and Klein, In press
	16-84	Peru	Freese, In prep.
	151-528	Peru	Neville and Castro, In prep.
Alouatta palliata	50	Canal Zone	Carpenter, 1934*
	72-102	Canal Zone	Chivers, 1969*
A. seniculus	12-29	Colombia	Klein and Klein, In press
	15	Peru	Neville and Castro, In prep.
	61-108	Venezuela	Neville, 1972

NOTE: Density estimates are not based on standardized field methodology. There is no intention to imply that these densities prevail throughout the range of the species.
*Estimates as calculated by Baldwin and Baldwin, 1972.

TABLE 25 SELECTED POPULATION DENSITIES REPORTED FOR OLD WORLD PRIMATES

Species	No. individuals/km²	Country	Reference
PROSIMIANS			
Galago alleni	14-25	Gabon	Charles-Dominique, 1971
Perodicticus potto	5-28	Gabon	Charles-Dominique, 1971
Galago demidovii	32-117	Gabon	Charles-Dominique, 1971
CERCOPITHECINES			
Cercopithecus aethiops	89	Uganda	Gartlan and Brain, 1968
	17-153	Kenya	Struhsaker, 1967b
Erythrocebus patas	0.6-1.2	Uganda	Hall, 1965a, b
Macaca fascicularis	11	Malaya	Medway and Wells, 1971
	33-143	Sumatra	Wilson and Wilson, In prep.
M. mulatta (forest)	39	India	Southwick et al., 1961b
	20-57	India	Neville, 1968
M. nemestrina	1.5	Malaya	Medway and Wells, 1971
	4-28	Sumatra	Wilson and Wilson, In prep.
M. sinica	100	Sri Lanka	Dittus, 1974
Papio cynocephalus	4-10	Kenya	DeVore and Hall, 1965
	11	Uganda	Rowell, 1966
P. hamadryas	2	Ethiopia	Kummer, 1968
COLOBINES			
Presbytis cristatus	22-120	Sumatra	Wilson and Wilson, In prep.
P. entellus	3-6	India	Yoshiba, 1968
	85-135	India	Sugiyama, 1964; Sugiyama et al., 1965
	97-104	India	Vogel, 1971
P. melalophos	9-51	Sumatra	Wilson and Wilson, In prep.
	20	Malaya	Medway and Wells, 1971
ANTHROPOIDS			
Gorilla gorilla	0.5-2.6	Zaire, Uganda	Schaller, 1963
Hylobates agilis	6-18	Sumatra	Wilson and Wilson, In prep.
H. lar	0.9-1.1	Malaya	Southwick and Cadigan, 1972
H. syndactylus	3	Malaya	Chivers, 1971
Pan troglodytes	0.05-0.5	Guinea	Bournonville, 1967
	0.3-1.5	Equatorial Guinea	Jones and Sabater Pi, 1971
Pongo pygmaeus	0.2	Sarawak	Schaller, 1961
	1	Sumatra	MacKinnon, 1974
	3	Kalimantan	Rodman, 1973

NOTE: Density estimates are not based on standardized field methodology. There is no intention to imply that these densities prevail throughout the range of the species. Most estimates are based on small samples, e.g., the density of 0.6 patas/km² was determined from the home range of a single troop (Hall, 1965a). Hall noted the crude density for his study area based upon 5 troops with 110 patas was 0.04 individuals/km².

Marmosets are found in family groups frequently reported as varying between 3 and 10 members. Recent estimates of less than one individual per 2 hectares are lower than previously assumed based on the animal's size (Table 24). Both Dawson's recent study of the Panamanian marmoset and Neyman-Warner's data on the Colombian form of Saguinus oedipus indicate that the membership of groups is not stable. This variability increases the difficulties of determining accurate population densities. Cotton-top marmosets have the most restricted distribution of marmosets of biomedical importance and have declined seriously due to the habitat loss within their limited range and the heavy trapping pressure for export (Hernandez and Cooper, In press; Struhsaker et al., In preparation; Green, In press). Except for the cotton-top marmoset of northern Colombia, estimates of population trends for the marmosets most in demand for research are not available.

Night monkey, Aotus trivirgatus Night monkeys occur from Panama south to central Brazil, Paraguay, and Argentina. Brumback (1973) demonstrated karyotype differences in night monkeys from opposite sides of the Andes. Despite this large distribution, the biomedical usage of night monkeys has been concentrated on animals of Colombian origin as the preferred model for malarial research. Most of the 4,000 night monkeys imported into the United States annually have been from Colombia prior to the export limitations imposed by that nation in an effort to protect the species until the effects of trapping can be determined (Hernandez and Cooper, In press). These nocturnal monkeys generally live in family groups consisting of a pair with their young. Night monkeys have a wide habitat and altitudinal tolerance in Colombia, extending up to 3,200 meters. No density estimates for this species are available in the literature.

Squirrel monkey, Saimiri sciureus Although the squirrel monkey is reported to be common in parts of Peru (Grimwood, 1968), its status in most countries from its northern limit in Costa Rica to its southern limit in Paraguay is not well documented. Deforestation is responsible for declining squirrel monkey populations in Panama (Baldwin and Baldwin, In press) and is largely responsible for the inclusion of the Central American subspecies on the U.S. endangered species list. This widespread and adaptable species tends to be relatively more abundant than other neotropical forms (Grimwood, 1968). This contention has been supported by recent field data from those habitats that support several primate species (Freese, In preparation; Neville and Castro, In preparation; Klein and Klein, In press) but is not true in all cases (Baldwin and Baldwin, In press). Thorington (1968) cautioned against acceptance of the frequently repeated large group sizes for squirrel monkeys. He noted that estimates reported to him for his study area were 2-5 times greater than the number he determined from age and sex class identifications. Field studies that have included home range or density estimates have not verified the concentrations of 200-300 animals that have been noted away from human habitation in Amazonia (Baldwin and Baldwin, 1971). Instead, group counts from accessible study areas generally range from 10-50 animals (Baldwin and Baldwin, 1971; Neville and Castro, In preparation; Freese, In preparation) with estimates frequently being in the twenties and thirties (Baldwin and Baldwin, In press; Klein and Klein, In press). More than a tenfold difference exists between available density estimates of 20-30 animals/km^2 (Klein and Klein, In press) and 150-500/km^2 (Neville and Castro, In preparation). This reflects differences in sampling methods in addition to population differences between two forests in southern Colombia and Peru. This variance in estimates of troop size and densities illustrates the lack of our current understanding of the population status and dynamics of a species that has been imported into the United States at the rate of 25,000 annually.

Vervet monkey, *Cercopithecus aethiops* The vervet monkey is generally abundant in relation to other monkeys within its distribution, which encompasses most of subsaharan Africa. This species is one of the few for which estimates of both crude and ecological densities are available. Struhsaker (1967b) found 4 troops in Masai-Amboseli Game Reserve living at crude densities of 17-153 monkeys/km^2. The ecological densities for these troops were 126-319/km^2. The vervet populations supported within these home ranges declined by 33.3 percent within 7 years (Struhsaker, 1973). Initially troops averaged 24 individuals in the reserve (Struhsaker, 1967b). Vervets have been studied in a number of countries and do well in a variety of habitats as long as some moisture, sleeping trees, and an adequate density of food species are available. Vervets are controlled in some areas of Sierra Leone, Uganda, Ethiopia, northern Rhodesia, and Cameroon, where they are considered as agricultural pests. They are shot for bounties in agricultural areas of St. Kitts, a Caribbean island to which they were transplanted.

Long-tailed macaque, *Macaca fascicularis* This widespread species occurs throughout Southeast Asia from Burma to the Philippine and Indonesian islands. No recent information was located with respect to its status in China, Burma, or most of Indochina. It is reported to be decreasing in Thailand, South Vietnam, the Philippines and parts of Indonesia. Recent field studies have shown this species to be more common in some areas of Indonesia and Malaysia than previously known. The species has been reported as common on the Malaya Peninsula, (Medway, 1969), Sumatra, and the island of Borneo (Wilson and Wilson, In preparation).

The long-tailed macaque is an adaptable "edge" species showing greater abundance in riverine, disturbed and secondary forests than in primary rain-forest. Types of disturbed forests include those seasonally flooded, coastal mangroves, lumbered areas, urban parks, and those around Buddhist temples and plantations (Wilson and Wilson, In preparation). Long-tailed macaques are dependent on man for much of their food in many cultivated areas of Malaysia, Sumatra, Java, and Thailand, and are killed as agricultural pests. They are hunted for food in both Thailand and Malaya. The export trade from the Philippines has practically ceased due to the depletion of these macaques (Rabor, 1968). Nearly 70,000 *Macaca fascicularis* were exported annually from West Malaysia in the early 1960's (Southwick and Cadigan, 1972) but this number had dropped to a seventh of this volume by the end of the decade. The 2,000 imported into the United States was about 20 percent of these exports. Greatly reduced populations have been reported for Thailand (Lekagul, 1968), the third country that has exported large numbers. The export trade from Indonesia has been increasing with a Japanese company exporting large numbers from Java. Wilson and Wilson (In preparation) have considered long-tailed macaque populations to be large enough in Sumatra to support a managed export trade for several years. This is a primate resource which could be utilized more fully if cropped animals were supported by more reliable feeding, handling, and transportation.

Rhesus macaque, Macaca mulatta This species is abundant in some parts of northern and central India with scattered populations stretching from eastern Afghanistan to the Kowloon peninsula of Hong Kong. It has been eliminated from much of its former range in Thailand, and probably parts of Indochina. Its status in Pakistan, Nepal, Sikkim, Bhutan, Bangladesh, and China is not known. Data on population trends are available only from Uttar Pradesh where more than half of all rhesus macaques are found in villages and towns (Southwick et al., 1961a, b, 1965; Southwick and Siddiqi, 1966, 1968, 1970, In press; Southwick et al., 1970). These surveys established an estimate of a half million rhesus macaques for this North Indian province--a major decrease from previous reports of 10-20 million. By recensusing the same populations, the Aligarh district studies have demonstrated the effect of commercial trapping on the age structure of troops. During the years of intensive trapping in the 1950's and early 1960's, the percent of immatures dropped to 30 percent from 50 percent, which was found in stable populations. Juveniles were particularly reduced from a normal population representation of 25-30 percent to a low of 5.9 percent. After a decade of reduced trapping pressure, the effect of the modified age structure was still evident because most troops had only 44.6 percent immatures.

Southwick et al. (1970) calculated a potential renewable harvest from Uttar Pradesh of 60,000 rhesus monkeys annually based upon the assumption that a population of 500,000 produced 176,000 infants annually and 35 percent of these could be cropped. The feasibility of sustained-yield harvesting from agricultural areas has been noted by Bermant and Chandrasekhar (1971) and Southwick (1971). The need for such management is evident in the light of increasingly urban and concentrated populations, a shift that results from a combination of three factors. Both commercial trapping of woodland macaques and human efforts to exterminate agricultural pests are contributing factors. The most important factor may be the shifting land use patterns with the proportion of the province under cultivation, in fallow, or uncultivatable increasing above 86 percent, while the area of natural forest is decreasing from 14 percent at the rate of 2 percent annually in some places. A recent report by Mukherjee and Mukherjee (1972) indicates densities of a different order of magnitude from those of other investigators. An estimates of .008-.05/km^2 for rhesus along roadsides around Delhi contrasts strikingly to estimates of 5-57/km^2 from longer studies in other areas. Since no other indications of such population decimation are available, an evaluation of census techniques and studies of larger scope would be appropriate before export restrictions are modified in the light of this report.

Pigtail macaque, Macaca nemestrina Pigtail macaques occur in a variety of lowland and hill forests in Thailand, Malaya and Sumatra (Wilson and Wilson, In preparation). Pigtails appear to have lower natural densities and wider ranging habits than other species of macaques. The status of pigtail macaques is unknown through its range from Assam eastward to Indochina, Malaysia and Indonesia, except for Thailand, Sumatra, and West Malaysia where it is seriously declining. Considerable hunting pressures are exerted on this species due to its destructiveness to crops in Thailand (Lekagul, 1968), Malaysia (Bernstein, 1967) and Sumatra (Wilson and Wilson, In preparation), its value for use as a trained coconut picker (Bertrand, 1967), for meat, and for the biomedical export trade.

Stumptail macaque, Macaca arctoides No field studies of the stumptail macaque have been conducted that would provide estimates of population density or home range size although Bertrand (1969) was unable to find groups outside of protected forests in southern Thailand that had not been trapped or shot. This species, which has been imported into the United States from Thailand and Assam at the rate of 200-300/year, is becoming scarce in these countries and in Malaya. Its present status in Burma, China, and Indochina is not known. Factors responsible for decreasing numbers include deforestation or military activity throughout most of its range. Trapping for export to the United States with the killing of animals too old to export and hunting for meat have been detrimental factors in Thailand and Assam.

Baboon, Papio cynocephalus Altmann and Altmann (1970) have considered baboons to be the most abundant and widespread African primates. Baboons utilize a wide range of forested savanna and altered habitats. They are more dependent upon a water source than patas monkeys (Hall, 1965a, b) but tolerate droughts better than some ungulates due to a varied diet that includes tubers (DeVore, 1965). Yellow and olive baboons generally occur at low densities of 4-10 individuals per km^2 in two Kenyan reserves (DeVore, 1965; Devore and Hall, 1965) and 11/km^2 in Uganda (Rowell, 1966). Troop size averages from the twenties to eighties with groups infrequently topping 100 individuals (Altmann and Altmann, 1970; DeVore and Hall, 1965; Rowell, 1966). Divergent views exist regarding the effects on baboon numbers of pest control programs, localized trapping for export (which totals less than 1,000 annually to the United States), and various agricultural practices. For example, Kingdon (1971) felt pest control programs in Uganda had not greatly reduced baboon populations, but Hall (1965a) noted that baboons were rare in some farming areas. The existence of pest control programs in some subsaharan countries from Uganda (Rowell, 1968; Kingdon, 1971) to South Africa (Keith and Stoltz, 1971) attests to the abundance of baboons but also to the erosion of their habitat and numbers with the spread of agriculture.

Chimpanzee, Pan troglodytes Density estimates ranging from .05-6.7/km^2 are available from studies conducted in Guinea (Bournonville, 1967), Equatorial Guinea (Jones and Sabater Pi, 1971), Tanzania (Lawick-Goodall, 1968), and Uganda (Sugiyama, 1968b). The species is reported as declining in those countries for which information regarding their status is available. Habitat destruction, and hunting chimpanzees for meat and to reduce their damage to crops are factors contributing to declining populations, but the effect of shooting females to obtain young for export is considered to be a sufficient factor by itself to account for the decimation of populations of these slowly reproducing apes. For example, if 4-6 mothers are killed in Africa for each young chimpanzee that survives international shipment, then 3,000-4,000 chimpanzee mothers would have been lost from Guinean populations in order to sustain 1 supplier's average export rate of 16 young chimpanzees annually between 1917 and 1960. Kortlandt (1966) estimates further that this loss would be equivalent to all mothers in a population of approximately 15,000 chimpanzees. By extrapolation, Sierra Leone and Liberia cannot be expected to maintain their current rates of export without exterminating their populations within a few years.

Forested and Reserved Areas

For many species, the rapid development of natural areas means that only those populations afforded long-term governmental protection will continue to survive. For planners whose primary interest is the number of primates available for consumption, it is necessary to know the minimum size of future populations. A first approximation of this figure may be obtained by combining estimates of population densities with figures for areas set aside as national parks and reserves in tropical countries. The areas of wildlife reserves currently set aside within the estimated distributions of primate species are compared in Table 26-28 with the total areas and forested areas in Latin America, Asia, and Africa. Only those reserves such as the Galapagos Islands and waterfowl marshes that provide no primate habitat were eliminated from the list. An additional refinement of this list would exclude certain arid areas in Botswana and areas outside primate distributions in Argentina and other countries.

Even though area estimates were not obtained for all countries and the areas vary greatly in habitat quality for primates, the available statistics provide a perspective for comparing countries. The importance of the tourist trade and the conservational organization in each country is indicated by the proportion of the total land mass set aside in reserves that meets the criteria of the United Nations (UN) list (ICNP, IUCN, 1971; Harroy, 1972). There are four countries each in Latin America and Asia with at least 1 percent of their total geographical areas in reserves. Those in South America are Surinam, Venezuela, Colombia, and Peru; those in Asia include Japan, Sri Lanka, Cambodia, and Malaysia. By comparison, 29 of the 42 African countries listed have 1 percent or more of their total areas in reserves. Currently, the rank of a country by total size does not correspond to its rank in listed national reserves. For example, Brazil is the largest Latin American country but ranks third after Argentina and Peru in the size of reserved areas. India ranks second to China in size but follows Japan and Indonesia in the area of sanctuaries. Sudan is the largest African country with endemic primates but is ninth in listed reserves.

The criteria for inclusion of reserves in the UN list of national parks and equivalent reserves require legal protection under a central government, a minimum size of 5-20 km^2; a supervisory commitment of one person per 40-100 km^2, and an expenditure in U.S. dollars of from \$5 to \$10,000 per km^2. The large ranges of minimum values depend upon the human population density of the area surrounding the reserve. The pattern of development of reserves is illustrated by the maps accompanying the UN list (ICNP, IUCN, 1971). Reserves are generally established as development intensifies around urban centers. Few reserves have been demarcated specifically through land use planning to protect large gene pools of endemic species within their natural distributions. The large number of additions and exclusions from sequential editions of the UN list demonstrates that the protection afforded the wildlife populations is continually changing.

Primate Diversity

The distributions of primates have become important to planners whether they are interested in ranching primates, in assessing populations that cannot withstand the added stress of trapping, in epidemiologic and

TABLE 26 ASIAN FORESTLANDS AND NATIONAL PARKS

Country	Geographical Area* (1,000 km^2)	Forested Area* [1,000 km^2 (%)]	Listed National Parks and Reserves§ [1,000 km^2 (%)]	Minimum Reserves Not Listed§ (1,000 km^2)
Sri Lanka (Ceylon)	65	44 (68)	2.1 (3.2)	1.3
India	3,270	605 (19)	5.2 (0.1)	NI-72 parks
Afghanistan	658	NI	-	-
W. Pakistan	801	26 (3)	0.04	0.3
Nepal	141	45 (32)	1.0 (0.7)	0.8
Bhutan	47	NI	-	0.4
Bangladesh	143	22 (15)	-	1.1
Burma	678	91 (13) "Reserved forests"	1.2 (0.2)	4.2
Laos	236	NI	NL	1.5
Vietnam (N)	159	NI	NI	NI
Vietnam (S)	172	NI	-	9.3
Cambodia	181	82 (45)	2.1 (1.2)	78.0
Thailand	514	308 (60)	3.8 (0.7)	8.7
Malaysia			5.1 (1.5)	1.4
W. Malaysia	132	55 (42)¶	4.4	0.5
Sabah	80	NI	0.7	
Sarawak	121	NI	0.02	0.9
Indonesia	1,900	903 (48)	11.3 (0.6)	13.0
Java			1.8	-
Sumatra			8.5	4.7
Kalimantan (Borneo)			0.07	5.1
Sulawesi (Celebes)			0.06	-
West Bali			0.2	-
Sunda Archipelago			0.6	-
West Irian			-	3.2
Philippines	300	159 (53)**	1.9 (0.6)	2.6
Taiwan	36	23 (64)	NL	-
China	9,597	120 (1)	NI	84.0
Korea (N)	122	ca. 98 (80) "Non-cultivatible"	NI	NI
Korea (S)	98	NI	0.4 (0.4)	1.9
Japan	370	250 (68) (Includes grassland)	20.0 (5.4)	-

NOTE: NI = no information; NL = none listed.
*Paxton (1973).
§ICNP, IUCN (1971); Harroy (1972).
¶Reserved forests 33 (25); productive forests 22 (17).
**Commercial forests 87 (29); non-commercial forests 72 (24).

TABLE 27 LATIN AMERICAN FORESTLANDS AND NATIONAL PARKS

Country	Geographical Area* (1,000 km^2)	Forested Area* [1,000 km^2(%)]	Listed National Parks and Reserves§ [1,000 km^2(%)]	Minimum Reserves Not Listed§ (1,000 km^2)
Mexico	1,967	385 (20)	1.6 (0.1)	5.6
Guatemala	109	72 (66)	0.9 (0.8)	-
British Honduras	23	8 (35)	-	5
Honduras	112	50 (45)	-	-
Salvador	21	8 (38) (non-agricultural)	-	-
Nicaragua	139	40 (29)	-	-
Costa Rica	51	40 (78)	0.3 (0.6)	-
Panama	76	58 (76) (undeveloped)	0.03	9
French Guyana	91	80 (88)	-	-
Surinam	163	NI	4.8 (3.0)	1
Guyana	210	183 (87)	0.1 (0.1)	-
Brazil	8,512	NI	13.4 (0.2)	25.6
Venezuela	912	NI	14.6 (1.6)	22
Colombia	1,139	599 (52)	11.0 (1.0)	2
Ecuador	456	233 (51)	-	-
Peru	1,285	NI	19.0 (1.5)	42
Bolivia	1,098	926 (84)	2.2 (0.4)	20
Paraguay	407	NI	-	-
Argentina	2,778	889 (32)	26.5 (0.9)	-
Trinidad	5	2 (30)	-	1.7

NOTE: NI = no information.
*Paxton (1973).
§ICNP, IUCN (1971); Harroy (1972).

TABLE 28 AFRICAN FORESTLANDS AND NATIONAL PARKS

Country	Geographical Area* (1,000 km²)	Forested Area* (1,000 km²)	Listed National Parks and Reserves§ [1,000 km² (%)]	Minimum Reserves Not Listed§ (1,000 km²)
Mauritania	1,031		-	3.1
Senegal	198		8.3 (4)	-
Gambia	0.08		-	-
Mali	1,204		3.5 (0.5)	5.4
Niger	1,187		3.0 (0.5)	45.3
Chad	1,284		4.1 (0.5)	26.6
Sudan	2,500	347; 691 savanna	24.5 (1)	14.3
Ethiopia	1,000		.2	4.4
French Somaliland	23		-	1.0
Somalia	700		6.2 (1)	-
Portuguese Guinea	36		-	-
Guinea	246		13.0 (5)	-
Sierra Leone	73		-	-
Liberia	113		-	-
Ivory Coast	322		15.7 (5)	1.9
Upper Volta	274		5.4 (2)	5.4
Ghana	238	82; 156 savanna¶	8.0 (3)	-
Togo	56		.6 (1)	-
Dahomey	113		7.8 (7)	23.9
Nigeria	924		5.3 (1)	-
Cameroun	474		9.1 (2)	10.7
Cent. African Repub.	625		14.2 (2)	38.6
Equatorial Guinea	28		.3 (1)	1.0
Gabon	267		4.2 (2)	1.5
Congo-Brazzaville	342		1.1 (0.5)	11.3
Zaire	2,345		52.6 (2)	-
Uganda	236		8.4 (4)	40.9
Kenya	569	16.8 reserves	25.7 (4)	4.8
Rwanda	26		2.7 (10)	-
Burundi	28		-	-
Tanzania	886	10.4 tropical forest** 349.6 savanna forest	36.9 (4)	56.9
Angola	1,247		21.2 (2)	41.3
Zambia	752		59.0 (8)	-
Malawi	94		3.1 (3)	2.0
Mozambique	785		5.7 (4)	19.3
Rhodesia	391		28.5 (7)	-
Southwest Africa	823		65.0 (8)	26.9
Botswana	575		100.1 (18)	-
South Africa	1,221	12.5§§	31.8 (3)	6.1
Swaziland	17		.03 (0.5)	-
Lesotho	30		.06 (4)	-
Madagascar	594		10.5 (2)	-

*Paxton (1973).
§ICNP, IUCN (1971); Harroy (1972).
¶Of totals, 15,000 km² of forest and 6,000 km² of savanna are reserved.
**Forest reserves covered 117,700 km², 1961.
§§Exotic trees cover 10,000 km²; indigenous trees 2,500 km².

zoogeographic studies, or in selecting experimental species that might be imported from harvested wild populations for several years. For planning to be effective the number of alternative countries that could export a particular species must be known, as well as the number and size of countries that could provide alternative species. The identification of those countries that, geographically or politically, represent sole suppliers for a particular species is equally relevant. The questions of alternative experimental species and the relative protection provided and needed by various species require that the examination of primate populations not be limited to the species traditionally used.

If management is limited to a single species, then any country in which the species does not represent an exotic introduction is a potential candidate for establishing protection or ranching. However, if efforts are to be cost effective for the greatest number of species, then a knowledge of species diversity would allow better decisions to be made in land management--decisions that would perpetuate the ecological complexity of habitats within those countries with the greatest species diversities. Six Latin American, 3 Asian, and 12 African countries have 14 or more primate species. Brazil and Colombia, Indonesia and Malaysia, and Zaire and Cameroon rank highest in diversity for each of the 3 continents, respectively (Tables 29-31).

The widespread distributions of primate families and selected genera suggest considerable flexibility in obtaining related primates from alternative countries. This flexibility would lessen the effectiveness of export restrictions imposed for political considerations. However, the geographic and genetic variability within these taxa indicated by the number of named forms (subspecies) would preclude their interchangeability for many biomedical uses. For example, although a representative macaque occurs in many Asian countries, the genus Macaca includes 12 species and 49 distinct races (Napier and Napier, 1967). Each primate form can be expected to differ in its disease susceptibilities and immunities as the examples of macaques and night monkeys have demonstrated.

Areas Protecting Primates

Any assessment as to how well a given species or species group is protected by the establishment of reserves within its geographic range depends at least in part on one's opinion as to taxonomic relationships. If species are broadly defined, protection seems to be more complete than if fine taxonomic distinctions are made. In the latter case, some populations are likely to be found outside of any protected areas. The protected areas within the estimated distributions of primate species are given in Tables 32-34. The pattern of simultaneous increase in the total protected area, the number of named forms within a listed taxon, and the number of countries protecting a species, is evident for all three continents.

While no Asian species occurs in more than 30,000 km^2 of protected area, a few Latin American species receive protection in reserves totaling up to 80,000 km^2. The development of reserves in Africa is of a different order of magnitude with the protection afforded widespread taxa reaching 450,000 km^2. The greater governmental protection offered many African forms is shown by the fact that nearly 40 percent of the African forms (as grouped in Table 34) have more protection than any Latin American species (Table 33) and nearly 60 percent have more protection than any

TABLE 29 DIVERSITY OF PRIMATE TAXA IN ASIAN COUNTRIES

	Lorisids	Tarsiids	Cercopithecids: Macaca	Cercopithecids: Presbytis	Cercopithecids: Other Colobines	Hylobatids	Pongids	Total
Total genera (species) named forms	2(30) 6	1(3)12	1(11)48	1(12)86	4(5)9	1(6)20	1(1)2	11(41)193
No. countries	12	3	19	16	7	11	2	19
Country*								
Sri Lanka	(1)	-	(1)	(2)	-	-	-	3 (4)
India	(2)	-	(60)	(3)	-	(1)	-	5 (12)
Afghanistan	-	-	(1)	(1)	-	-	-	2 (2)
W. Pakistan	-	-	(1)	(1)	-	-	-	2 (2)
Nepal	-	-	(2)	(1)	-	-	-	2 (3)
Bhutan	-	-	(2)	(2)	-	-	-	2 (4)
Bangladesh	-	-	(2)	(1)	-	(1)	-	3 (4)
Burma	(1)	-	(3)	(4)	-	(2)	-	4 (10)
Laos	(2)	-	(4)	(2)	(1)	(3)	-	5 (12)
Vietnam-N	(1)	-	(5)	(30	(2)	(1)	-	6 (12)
Vietnam-S	(1)	-	(4)	(2)	(1)	(1)	-	5 (9)
Cambodia	(1)	-	(3)	(1)	(1)	(2)	-	5 (8)
Thailand	(1)	-	(4)	(4)	-	(4)	-	4 (13)
Malaysia	(1)	(1)	(3)	(5)	(1)	(2)	(1)	7 (14)
Indonesia	(1)	(2)	(3)	(5)	(2)	(3)	(1)	8 (17)
Philippines	(1)	(1)	(1)	-	-	-	-	3 (3)
Taiwan	-	-	(1)	-	-	-	-	1 (1)
China	(1)	-	(5)	(3)	(2)	(3)	-	6 (14)
Japan	-	-	(1)	-	-	-	-	1 (1)

*Numbers in columns indicate No. genera (No. species). Genera are given only in total column. Number of named forms follows Napier and Napier (1967); species are grouped according to Wolfheim (In preparation).

TABLE 30 DIVERSITY OF PRIMATE TAXA IN LATIN AMERICAN COUNTRIES

	Cebids					Callitrichids		
	Alouatta	Ateles	Cebus	Aotus, Saimiri	Others§	Saguinus, Callithrix	Others¶	Total
Total genera (species) named forms	1(7)22	1(1)16	1(4)33	2(2)17	5(12)30	2(13)37	3(3)6	15(42)161
No. countries within distribution	20	16	13	13	10	8	5	20
Country*								
Mexico	(2)	(1)	-	-	-	-	-	2(3)
Guatemala	(2)	(1)	-	-	-	-	-	2(3)
Br. Honduras	(1)	(1)	-	-	-	-	-	2(2)
Honduras	(1)	-	-	-	-	-	-	1(1)
Salvador	(1)	(1)	-	-	-	-	-	2(2)
Nicaragua	(1)	(1)	-	-	-	-	-	2(2)
Costa Rica	(1)	(1)	-	(1)	-	-	-	3(3)
Panama	(1)	(1)	(1)	(2)	-	(1)	-	6(6)
Fr. Guyana	(1)	(1)	(2)	(1-2)	(3)	(1)	-	7-8(9-10)
Surinam	(1)	(1)	(2)	(1-2)	(3)	(1)	-	7-8(9-10)
Guyana	(1)	(1)	(2)	(1-2)	(3)	(1)	-	7-8(9-10)
Brazil	(4)	(1)	(3)	(2)	(11)	(11)	(2)	14(34)
Venezuela	(2)	(1)	(3)	(2)	(6)	-	-	10(14)
Colombia	(2)	(1)	(3)	(2)	(7)	(5)	(2)	13(22)
Ecuador	(2)	(1)	(3)	(2)	(4)	(10	(1)	10(14)
Peru	(2)	(1)	(2)	(2)	(6)	(4)	(2)	12(19)
Bolivia	(3)	(1)	(2)	(2)	(3)	(3)	(1)	11(15)
Paraguay	(1)	-	(2)	(2)	(1)	-	-	5(6)
Argentina	(2)	-	(1)	(1)	-	-	-	3(4)
Trinidad	(1)	-	(1)	-	-	-	-	2(2)

* Numbers in columns indicate No. genera (No. species). Genera are given only in total column. Number of named forms follows Napier and Napier (1967); species are grouped according to Wolfheim (In preparation). Distributions were estimated from above sources and Hernandez and Cooper (In press), Thorington (1974).
§ Others include genus (No. species) No. named forms: Brachyteles (1), Cacajao (2)4, Callicebus (3)14, Chiropotes (2)3, Lagothrix (3)5, Pithecia (2)3.
¶ Others include: Callimico (1)1, Cebuella (1)2, Leontopithecus (1)3.

TABLE 31 DIVERSITY OF PRIMATE TAXA IN AFRICAN COUNTRIES

	Lorisids	Galagids	Cercopithecids: Cercocebus	Cercopithecids: Cercopithecus	Cercopithecids: Papio	Cercopithecids: Colobus	Pongids	Total
Genera (species) named forms	2(2)7	3(6)31	1(4)11	2§(23)78	1(7)25	1(10)31	2(3)8	13(56)193¶
No. countries	20	35	14	38	38	23	22	38
Country*								
Mauritania	-	-	-	(1)	(2)	-	-	2(3)
Senegal	(1)	(2)	-	(2)	(1)	(2)	(1)	8(9)
Gambia	-	(1)	-	(2)	(1)	(2)	-	4(6)
Mali	-	(1)	-	(1)2	(2)	-	(1)	4(5)6
Niger	-	(1)	-	(1)2	(1)	-	-	3(3)4
Chad	-	(1)	-	(1)	(1)	-	-	3(3)
Sudan	-	(1)	-	(3)	(2)4	(2)	(1)	6(9)11
Ethiopia	-	(1)3	-	(5)8	(2)	(1)2	-	6(10)17¶
Somalia	-	(2)	-	(3)5	(3)	-	-	4(8)10
Port. Guinea	(1)	(2)	-	(1)	(1)	-	(1)	6(6)
Guinea	(1)	(2)	(1)	(6)	(2)	(3)4	(1)	9(16)17
Sierre Leone	(1)	(2)	(1)	(6)	(2)	(2)	(1)	9(15)
Liberia	(1)	(2)	(1)	(5)	(1)	(2)	(1)	8(13)
Ivory Coast	(1)	(2)	(1)	(5)8	(1)	(3)5	-	9(14)19
Upper Volta	-	(2)	-	(2)	(1)	-	-	5(5)
Ghana	(1)	(2)	-	(5)	(1)	(2)	(1)	9(12)
Togo	(1)	(2)	-	(5)	(1)	(1)	(1)	8(11)
Dahomey	(1)	(2)	-	(5)	(1)	(1)	(1)	8(11)
Nigeria	(2)	(4)	-	(8)9	(3)	(1)	(2)	10(20)21
Cameroon	(2)3	(4)	(1)	(9)11	(3)5	(3)	(2)3	11(24)30
CAR	(2)	(2)	(1)	(3)	(1)	(1)	(2)	11(12)
Eq. Guinea	(2)	(3)	(1)	(5)6	(2)	(2)	(2)	11(17)18
Gabon	(2)	(3)	(2)	(5)6	(2)	(1)	(2)	11(17)
Congo-Br.	(2)	(2)	(2)	(6)	(2)	(2)	(2)3	10(18)19
Zaire	(2)3	(4)5	(2)4	(10)21	(2)	(4)8	(3)4	11(27)47
Uganda	(1)	(4)	(1)	(7)8	(1)2	(3)	(2)	11(19)21
Kenya	(1)	(3)8	(2)	(6)9	(2)4	(3)5	-	8(17)29
Rwanda	(1)	-	-	(4)	(1)	-	(2)	5(8)
Burundi	(1)	-	-	(3)	(1)	(1)	(1)	5(7)
Tanzania	-	(3)10	(1)	(3)11	(2)	(4)5	(1)	8(14)30
Angola	-	(3)	(1)	(5)7	(2)	(1)	-	6(12)14
Zambia	-	(2)	-	(4)	(2)3	-	-	4(8)9
Malawi	-	(3)	-	(2)4	(2)	-	-	4(7)9
Mozambique	-	(2)3	-	(2)6	(2)3	-	-	3(6)12
Rhodesia	-	(2)3	-	(2)	(2)	-	-	3(6)7
SWA	-	(2)	-	(1)	(1)2	-	-	3(4)5
Botswana	-	(2)	-	(1)	(2)	-	-	3(5)
S. Africa	-	(2)3	-	(2)4	(1)4	-	-	3(5)11

*Numbers in columns indicate No. genera (No. species) No. named forms. Number of genera are given only in total column. Nomenclature is adapted from Hill and Meester (1971), Dandelot (1971), and Napier and Napier (1967). Distributions were estimated from above sources and Wolfheim (In preparation). A few countries were excluded from the table: Fr. Somaliland, Swaziland, and Lesotho were not specified regularly in described distributions; Tunisia, Libya, and Egypt lack primates; Morocco and Algeria include the range of *Macaca sylvanus* only; Madagascar includes Lemurids only.

§*Erythrocebus* is totaled as a separate genus, although it is included as a subgenus of *Cercopithecus* by Dandelot (1971).

¶*Theropithecus gelada* occurs in Ethiopia and Saudi Arabia; the two subspecies were included only in the totals.

Asian form (Table 32). This pattern of protection is inversely related to the current biomedical demand for species by continent.

The rank order of safe areas provided the more studied African species appears to agree with their relative abundance. For example, the drill, Papio leucophaeus, has been considered to be among the most threatened of African primates while vervets and baboons are regarded as being among the most abundant species on the continent (Struhsaker, 1967a, b; Altmann and Altmann, 1970). Gartlan (1974 personal communication to Wolfheim, In preparation) has found that the drill is restricted to 78,000 km^2, or half its total previous range in Cameroon. If the drill remains only in the Korup Reserve in Cameroon and not in the reserves of neighboring countries, then the estimate of the protected area must be reduced from 15,000 km^2 to 1,250 km^2. Upward adjustments may be needed for other species as additional reserves become more closely administered. For example, the woolly spider monkey, Brachyteles arachnoides, is protected within eight state and private reserves set aside for its safety (Aguirre, 1971, cited in IUCN, 1972). These reserves double the protected area for this species from the 593 km^2 for the 5 listed national parks to 1,165 km^2.

It should be emphasized that while the rank order of primates may be representative, many reserves do not provide adequate habitat for many species and the protected areas listed are therefore considerable over-estimates. Distributional limitations imposed by altitude, amounts of forested habitat, and rainfall need to be considered to increase the accuracy of the tables. In addition, certain species occur in different regions of the same country but not sympatrically. Because these cases were not always possible to discriminate, and due to the larger relative sizes of African reserves, the largest overestimates may be expected for Africa. The listing needs to be refined based upon actual faunal lists of reserves to avoid assigning a primate to a sanctuary in which it does not occur.

There are several species in Latin America and Asia that do not appear to reside in any areas qualifying for the UN list. Additional species occur in a single country or are protected in only one of the countries in which they are found. Except for the callitrichids, the 10 species traditionally used in biomedical studies are protected in a least 1 reserve in 4 or more countries (Tables 32-34). With more than 100,000 km^2 of listed reserves, the protection afforded the 5 African species of medical importance contrasts sharply with that offered Asian species. In the New World, the 3 frequently exported cebids are protected within at least 40,000 km^2 but the protection marmosets receive is limited. Saguinus oedipus is variously considered as one or two species. The Colombian form, which has been employed in medical work, currently receives no protection. The protected status of populations of Saguinus nigricollis, which is restricted to Colombia and Peru, is only slightly less critical. The further biomedical use of species that are not protected in countries of origin, such as Saguinus oedipus, will be wholly dependent upon captive-bred individuals.

If one assumes that the density of many forest species lies between the 10 macaques per km^2 that Medway and Wells (1971) found for Macaca fascicularis in Malaysia and the 100 macaques per km^2 that Dittus (1974) found for Macaca sinica in Sri Lanka, then there are fewer than 50,000-500,000 animals of at least 23 Latin American species, 29 Asian species, and 3 African species that are protected. At these density estimates of 10-100 rhesus macaques per km^2, there may be only 60,000-600,000 rhesus macaques in its 6,000 km^2 of protected range.

TABLE 32 PROTECTED AREAS WITHIN THE ESTIMATED DISTRIBUTIONS OF ASIAN PRIMATE SPECIES

Protected Area*, 1,000 km^2	Species (No. named forms)§	No. Countries Within Distribution or Protecting Species
No known protection	Hylobates klossi (1)	Metawi Isl., Indonesia
	Macaca cyclopis (1)	Taiwan
	Nycticebus pygmaeus (1)	Laos, Vietnam
	Presbytis francoisi (4)	China, Laos, Vietnam
	P. potenziani (2)	Metawi Isl., Indonesia
	Simias concolor (2)	Metawi Isl., Indonesia
	Rhinopithecus avunculus (1)	N. Vietnam
	R. roxellanae (3)	China
<1		
0-0.7	Presbytis geei-P. pileatus (6)	1 Assam
0-0.7	P. rubicunda (5)	2
0-2.0	Pygathrix nemaeus (2)	1 Cambodia
0.06	Macaca nigra (4)	1 Sulawesi, Indonesia
0.06	Tarsius spectrum (5)	1 Sulawesi, Indonesia
0.08	Presbytis frontata (2)	2
0.1	Nasalis larvatus (1)	2
0.2-0.5	Presbytis phayrei (4)	2
0.3	Hylobates concolor (6)	1 Thailand
0.8	Presbytis johni (1)	1 India
0.8	Tarsius syrichta (3)	1 Philippines
1-9		
1.1	Macaca silenus (1)	1 India
1.1	M. radiata (2)	1 India
1.2-7.7	¶M. arctoides (4)	3-4
1.4	Presbytis senex (5)	1 Sri Lanka
1.8	Hylobates hoolock (1)	2
2.1	Macaca sinica (3)	1 Sri Lanka
2.8	Tarsius bancanus (4)	2
3.7	Loris tardigradus (6)	2
4.1	Hylobates pileatus (1)	2
4.5	Presbytis obscura (7)	2
6.2	¶Macaca mulatta (4)	4
7 0	Pongo pygmaeus (2)	2
7.1	Macaca assamensis (2)	4
8.3	Presbytis entellus (15)	4
10-19		
12.9	Hylobates syndactylus (2)	2
13.3-15.3	Presbytis cristata (8)	1-2
18.0	Hylobates lar (9)	3
20-29		
20.0	Macaca fuscata (2)	1 Japan
20.4	Presbytis aygula-melalophos (27)	4
21.0	¶Macaca nemestrina (4)	5
23.6	Nycticebus coucang (9)	7
25.2	¶Macaca fascicularis (21)	6

* Protected areas listed in ICNP, IUCN (1971); Harroy (1972).
§ Named forms follow Napier and Napier (1967); species are grouped according to Wolfheim (In preparation); occurrence in reserve was estimated from above sources.
¶ Traditional species of biomedical importance.

TABLE 33 PROTECTED AREAS WITHIN THE ESTIMATED DISTRIBUTIONS OF LATIN AMERICAN PRIMATE SPECIES

Protected Area*, 1,000 km2	Species (No. Named Forms)§	No. Countries Within Distribution or Protecting Species
No known protection	Alouatta pigra (1)	Mexico, Guatemala, Br. Honduras
	Cacajao calvus (3)	Colombia, Peru, Brazil
	C. melanocephalus (1)	Venezuela, Colombia, Brazil
	Callimico goeldi (1)	Colombia, Peru, Bolivia
	Callithrix humeralifer (2)	Brazil
	Cebuella pygmaea (2)	Colombia, Brazil
	Lagothrix flavicauda (1)	Peru
	Saguinus bicolor (2)	Brazil
	S. inustus (1)	Colombia, Brazil
	S. labiatus (2)	Colombia?, Brazil
	S. leucopus (1)	Colombia
<1		
0-0.7	Callithrix argentata (4)	2
0-0.7	Chiropotes albinasa (1)	1 Brazil
0.03	¶Saguinus oedipus (2)	1 Panama
0.03	Leontopithecus rosalia (3)	1 Brazil
0.6	Brachyteles arachnoides (1)	1 Brazil
1-9		
0-4.0	Saguinus mystax (3)	1 Peru
0-4.7	Callicebus torquatus (3)	1 Peru
0-10.0	Alouatta belzebul (5)	1 Venezuela
2.6	Callicebus personatus (4)	1 Brazil
2.7	Alouatta fusca (3)	1 Brazil
4.0	¶Saguinus nigricollis (2)	1 Peru
4.5	Cebus capucinus (5)	3
5.0	Saguinus midas (2)	2
11.0	Callithrix jacchus (7)	1 Brazil
10-19		
14.0	Alouatta caraya (1)	2
14.0	Saguinus imperator (2)	1 Peru
14.0-20.0	¶S. fuscicollis (7)	2
15.0	Pithecia pithecia (1)	3
15.0	Chiropotes satanus (2)	3
20-39		
20.0	Cebus nigrivittatus (5)	3
31.0	C. albifrons (12)	3
31.7	Lagothrix lagotricha (4)	4
31.7	Callicebus moloch (7)	4
32.5	Alouatta palliata (7)	6
40-59		
40.4	Pithecia monachus (2)	5
44.0-58.6	¶Saimiri sciureus (8)	6-7
51.4	Alouatta seniculus (5)	6
51.1-56.1	¶Aotus trivirgatus (9)	9
60-79		
67.4	¶Cebus apella (11)	8
67.4	Ateles paniscus (16)	11

* Protected areas listed in ICNP, IUCN (1971); Harroy (1972).
§ Named forms follow Napier and Napier (1967); species are grouped according to Wolfheim (In preparation); occurrence in reserves was estimated from above sources, Hernandez and Cooper (In press), and Thorington (1974).
¶ Traditional species of biomedical importance.

TABLE 34 PROTECTED AREAS WITHIN THE ESTIMATED DISTRIBUTIONS OF AFRICAN PRIMATE SPECIES

Protected Area*, 1,000 km^2	Species (No. named forms)§	No. Countries Protecting Species
<1		
0.06	Theropithecus gelada (2)	1 Ethiopia
0.3	Papio hamadryas (1)	2
1-19		
15	Papio leucophaeus (2-3)	4
15	P. sphinx (1-3)	5
20-59		
22	Pan paniscus (1)	1 Zaire
24	Colobus verus (1)	3
28	Euoticus spp. - E. elegantulus and E. inustus (3)	6
34	C. talapoin (4-1)	3
60-79		
63	C. lhoesti (2)	4
70	Cercocebus torquatus and C. galeritus - supersp. torquatus (6)	5
72	Galago alleni (1)	5
79	Gorilla gorilla (3)	8
80-99		
85	Arctocebus calabarensis (2)	7
96	Subgenus Piliocolobus-including 5 spp.: C. badius, C. kirki, C. pennantii, C. rufomitratus, C. tholloni (20-14)	10
100-199		
110	¶Erythrocebus patas (4)	17
118	Perodicticus potto (5)	13
119	¶Pan troglodytes (3-4)	14
152	Cercopithecus ascanius (5)	8
165	Cercocebus albigena and C. aterrimus - supersp. albigena (4-5)	8
186	Subgenus Colobus-including 4 spp.: C. angolensis, C. guereza, C. polykomos, C. satanas (22-16)	17
200-299		
214	Galagoides demidovii (7)	18
243	Cercopithecus mitis and C. albogularis (20-19)	12
273	¶Galago crassicaudatus (10-11)	10
300-399		
396	G. senegalensis (9)	27
400-499		
446	¶Cercopithecus aethiops group including 4 spp.: C. aethiops, C. pygerythrus, C. sabaeus, C. tantalus (21)	28
450	¶Papio cynocephalus group including 4 spp.: P. anubis, P. cynocephalus, P. papio, P. ursinus (12-18)	31

* Protected areas listed in ICNP, IUCN (1971); Harroy (1972).
§ Nomenclature is adapted from Hill and Meester (1971), Dandelot (1971), and Napier and Napier (1967). Named forms follow Napier and Napier (1967); second values indicate differences in Hill and Meester (1971), and Dandelot (1971). Occurrence in reserve was estimated from above sources, Williams (1968), Smithers (1971), ICNP, IUCN (1971), Curry-Lindahl and Harroy (1972), and Wolfheim (In preparation). Thirteen forest Cercopithecus sp. that were each protected in less than 60 km^2 of area were not itemized in the table due to their lack of use in biomedical work and lack of field data on them.
¶ Traditional species of biomedical importance.

Prospects for Wild Primates

Several factors complicate the evaluation of the lists of protected areas and general population trends for different species. These include 1) the habitat quality within the reserves, 2) the purpose for which the reserves and forestlands are managed, 3) whether the habitat is fragmented or reaches a minimum area required to sustain a heterogeneous gene pool, 4) the rate of deforestation, and 5) the relative size of species populations inside and outside of the reserves.

Habitat Quality in Reserves The number of primates supported by an area of a particular size varies with the quality of that habitat. Most field studies have been conducted at study sites selected for high quality and correspondingly high primate densities because this maximizes the productivity of visual observations. This factor indicates why current estimates of many primate densities may be higher than those in many reserves. Reserves are frequently established in areas that are minimally productive agriculturally. These areas also represent marginal habitat for many wildlife species. The size of such areas may give an inflated impression of the actual protection offered native wildlife. For example, in Sri Lanka, nearly 85 percent of the area of listed reserves lies in the arid and dry zones of the country. The carrying capacity of the habitat in one of the dry zone reserves was much less for all primates than the carrying capacity estimated at a wetter study site outside of the reserve, but still within the dry zone. The reserve supported less than 1 kg/km^2 of macaque (*Macaca sinica*) or purplefaced langur (*Presbytis senex*) while the wetter site supported 190 kg/km^2 and 1,000 kg/km^2, respectively (Eisenberg *et al.*, 1972). The reserve also supported 38 times less biomass of gray langurs (*Presbytis entellus*). Therefore, it is not possible to use the size of reserves, independent of habitat evaluation, as a measure of the size of protected populations.

Management Purposes After the absolute size and the habitat quality of reserves, the third factor that influences the size of primate populations is the purpose for which the area is managed. Some reserves may receive government protection only as long as specific endangered species survive in them; others may be managed to the detriment of primate populations. A reading of the UN list illustrates the focus, with primates and species smaller than ungulates and carnivores rarely itemized. This emphasis raises doubts concerning whether many reserves will be continued if the conspicuous species, such as the Asiatic lion in the Gir forest, are eliminated. The dry Gir forest is currently the largest Indian sanctuary within the distribution of rhesus macaques.

In other instances, primate populations may be cropped for competing with species of primary concern. An example of this situation occurred at Lake Manyara National Park, Tanzania, where 700 baboons were killed in 1962 for their alleged destruction of bird populations (Altmann and Altmann, 1970). Struhsaker (1967a, b) found elephants to be the major competitors of vervets in East African savanna, where elephants knock down the refuge and food trees of primates. Areas managed to protect elephants may show corresponding reductions in primate populations. The opposite policy also has negative long-term effects as elephants and other species play important roles in the dispersal of seed plants which in turn form part of the diet of primates. When forestry departments reduce elephants as destructive to growing timber, or spray herbicides, they may be upsetting poorly understood equilibria. Such influences may reduce the quality and diversity of the forest for many wildlife species by producing long-term changes in its botanical composition (Struhsaker, 1972).

Critical Population Size The assumptions and methods for managing wild populations must be re-evaluated to allow for the biological differences in recruitment rates between species identified as "r-strategists" and "K-strategists." The minimum population size necessary to maintain a diverse gene pool in wild populations will differ considerably for these two groups of species. Life tables for wild, unprovisioned primates are needed to supplement the data collected on other species before adequate estimates of minimum population size can be made.

The organisms most frequently found as domestic stock, as pets, or as research animals share several biological characteristics not shared with primates. These characteristics that allow intensive utilization and management include annual or more frequent reproduction, multiple births, and rapid maturation. These species have been labeled as "r-strategists" by population ecologists due to their high rates of natural increase. These species can recover rapidly from low population densities and colonize new environments that are only temporarily suitable for their survival. Historically, the administrative familiarity with only this type of species in agriculture and wildlife management has resulted in management practices for wildlife that have been based on the implicit assumption that harvesting will remove surplus animal production rather than decimate the breeding population.

Only recently have data been collected on life tables for species that have the opposite reproductive strategy. These species have been referred to as "K-selected" species after a term for the saturation density for the species in the logistics equation that describes the growth of populations. K-strategists are species that tend to have longer life spans, slower maturation rates, and fewer offspring. However, since each offspring receives more parental investment, it has a higher probability of survival. Because K-selected species have lower rates of increase and mortality and have a closer adjustment to the long range carrying capacity of the environment, they tend to be found in habitats that have traditionally been very stable. Lumbering, slash and burn agriculture, and irrigation have tended to supplant stable ecosystems with transient ones. Gradual habitat changes and selective pressures for hunting and trapping have resulted in a proportionately high representation of K-selected species on the lists of species that are either threatened or in danger of extinction.

The large-bodied primates with a 3-4 year maturation time and a single offspring born at 1-2 year intervals are prime examples of K-selected species. Unfortunately, life tables for primates under natural conditions are not available. However, a recent publication based upon another species with similar population characteristics has demonstrated how extremely slow recovery is for these species. Miller and Botkin (1974) calculated the population dynamics of sandhill cranes, a species with a 25-year life span and a 4-year age at puberty. They showed that a population that has been reduced to approximately 200, 000 birds would be forced to extinction within 25-30 years if only 5 percent of the population were harvested annually. A computer simulation of the long-range effect of an annual harvest of 6,000 individuals indicated that 30 years of harvesting at this rate would reduce the population to 50 percent of its former level. Even if a moratorium were introduced at the end of 30 years, it would take another 70 years for the population to return to its former equilibrium level. Although the values of the constants, the annual recruitment rate, and the age-specific survivorship would differ somewhat for each species of primate, the general magnitude of the slow recovery rate can be extrapolated directly.

For a species of bird with known wintering grounds and migratory routes, one would expect that census data would be rather accurate relative to data on tropical forest species, and that it could be used to monitor population fluctuations. To the contrary, the authors state that the data cannot be used in this way since sampling errors were probably the cause of a 35-percent discrepancy between censuses taken 2 years apart. Since harvests of only 2,000 individuals annually would reduce the equilibrium value for the population, the authors concluded that the discrepancies "emphasize that current census methods are too crude to detect significant population decreases in fluctuations. To the contracy, the authors state that the data cannot be used in this way since sampling errors were probably the cause of a 35-percent discrepancy between censuses taken 2 years apart. Since harvests of only 2,000 individuals annually would reduce the equilibrium value for the population, the authors concluded that the discrepancies "emphasize that current census methods are too crude to detect significant population decreases in time to take the necessary remedial action." Further, their model demonstrated that population events cannot be predicted accurately with a simple annual census of total numbers. The authors' conclusion that too little is known to manage this species properly also describes the situation for all primates.

The above theoretical example illustrated one method for making long-term projections about populations; it also illustrated how short a time wild populations have been censused. The earlier discussion of the protected area provided by reserves ignored the amount of fragmentation of populations and the minimum size of reserves necessary to protect heterogeneous populations. Medway and Wells (1971) have accepted a population of 5,000 individuals as a minimum number that should be provided continuous protection. This is a good heuristic figure for which we need more data. If this is a good estimate, then the 2 langur species would require areas of 250 km^2 (98 mi^2) and 500 km^2, respectively, for populations of 5,000 individuals in Malaysian forests. A long-tailed macaque population would require 500 km^2, while the gibbons and siamang would need areas of nearly 2,000 km^2. The wider ranging pigtail macaque (<u>Macaca nemestrina</u>) would require over 3,300 km^2 of continuous habitat to provide safety for a heterogeneous gene pool of this size.

A minimum population is necessary to maintain diversity in wild populations but few estimates are available. Studies of the heterozygosity of 22 vertebrate species have shown the proportion of polymorphic loci to vary between 10 and 20 percent. Recently, Bonnell and Selander (1974) have been unable to identify any polymorphisms in the blood proteins of surviving wild populations of elephant seals. This species was reduced to fewer than 100 individuals and 1 or 2 harem-breeding males at the turn of the century.

These authors suggested that the lack of variability with which to adapt to changing conditions increases the vulnerability of this species to environmental modifications. A similar situation, but without the breeding bias, is greatly reducing polymorphisms and increasing the vulnerability of several species of primates.

Primates (are typically forest species that) represent a small portion of the mammalian fauna in tropical forests even before they are exposed to hunting and trapping pressures. The only available estimates for balanced ecosystems are those of Eisenberg and Thorington (1973) who calculated that primates represent from 6 percent to 10 percent of the total mammalian biomass in Surinam and on Barro Colorado Island, respectively. The primate portion of the fauna is further characterized by slow recruitment--typically, one young per year or every other year--and slow maturation--typically, 3-5 years. The combination of factors, including habitat destruction by deforestation, slow population recruitment, and selective hunting and trapping of species that initially represent a small proportion of the mammalian biomass, creates a bleak picture for the future of unprotected primate populations in the wild. The increasing number of reports of population declines throughout the tropics arise from this combination of circumstances.

Rate of Deforestation Forest habitats of many primate species are being depleted as a result of logging and clearing for other purposes. The changing pattern of land use in South America is indicative of trends throughout the tropical forests. Estimates of the actual area of tropical forest that has been cleared in South America range from 50,000-100,000 km^2 annually, although the proportion of this area that may be second growth is not indicated (Nelson, 1973). Estimates of new cropland are 10,000 km^2 annually. In Brazil, 84 percent of the increased crop output between 1948 and 1962 has been attributed to the incorporation of additional area. In the 17 years between 1950 and 1967, an area of 90,000 km^2 in the humid tropical regions of South America was converted to agriculture (Nelson, 1973). This area is one third greater than the protected area for any single primate species throughout Latin America (Table 33). Deforestation in tropical countries has concerned several authors. For example, the loss of habitat resulting from deforestation in Equatorial Guinea (Sabater Pi and Jones, 1967), in Thailand (Lekagul, 1968), in northern Colombia (Struhsaker et al., In preparation), and in Malaysia (Southwick and Cadigan, 1972) is reducing the ranges of some primate species. Lumbering has progressed at a rate of 223 km^2 annually in Malaysia. Finally, Richards (1973) has predicted that all major blocks of tropical forest will be gone by the year 2000.

Relative Numbers of Primates Inside and Outside Reserves Primates have been trapped from undeveloped areas in past years--ones neither managed intensively nor set aside as reserves. While the size of reserves provides an estimate of minimum future populations and indirectly of government attitudes towards the development of natural areas, the reserves will not supply the primate trade. Indeed, most are managed to prevent exploitation of animals. The following discussion compares the chimapnzee, a species that probably will occcur only inside reserves within a few years, and other species that adapt to moderate agricultural development and should continue to occur in larger numbers outside of reserves.

The diversity and widespread nature of the pressures exerted on primate habitats is illustrated by chimpanzees because the species has a wide geographical distribution and large home ranges (Wolfheim, In preparation). The most severe land exploitation within the distribution of chimpanzees has occurred in such areas as western Guinea where 40 percent of the land is under intensive nomadism and agriculture (Bournonville, 1967). The range of chimpanzees is being reduced in Equatorial Guinea through the degeneration of soil conditions after forests are cleared (Sabater Pi and Jones, 1967). Less diverse vegetation frequently replaces rain forests where timber concessions are granted, where plantations replace natural forests, or where natural forests are being managed for single objectives with little ecological consideration. Struhsaker (1972) stated that timber concessions threaten the Tai Reserve, which is the last forested area where chimps occur in the Ivory Coast. A program using arboricides to weed out noncommerical species of trees after logging is a method of forestry management presently practiced in Uganda that alters the habitat for chimps (Reynolds and Reynolds, 1965). Suzuki (1971) reported that a fourth of the Budongo Forest had been treated with herbicides and future plans included spraying the entire area. The program kills primate food sources, such as fig trees, and it promotes growth of secondary brush. The ability of chimpanzees to survive in agricultural areas has been documented by Dunnett et al. (1970), but the hunting and trapping pressures summarized by Wolfheim (In preparation) have had a devastating effect on populations outside of reserves.

The prospects for the continuation of much larger populations outside than inside reserves are more favorable for the species numerically more important in biomedical work than they are for the rarer and larger species. Semi-terrestrial species such as rhesus macaques, baboons, and vervet monkeys and arboreal species such as squirrel monkeys have in common the ability to utilize a variety of habitats (Eisenberg et al., 1972; Southwick et al., 1965; Altmann and Altmann, 1970; Gartlan and Brain, 1968; Rosenblum and Cooper, 1968). The baboons can exploit the drier savannas as well as the mixed, regenerating, and riverine forests utilized by the other species. These species are not specialists but consume a wide variety of natural foods including fruits, flowers, buds, insects, and small vertebrates. They are well adapted to live at the ecotone, or the interface between habitats, where food supply increases with botanical diversity. Because the medically important species, rhesus macaques, baboons, and vervet monkeys, are both opportunistic feeders and semi-terrestrial, they have frequently shown population increases in areas where the mature forest is degraded to mixed and successional growth and also where patches of forest are interspersed with cultivated crops. Such increases have been observed during the early stages of agricultural expansion where there is a slash and burn subsistence pattern of planting and fallow. Such increases continue until the human settlements become more densely populated and the forest patches that serve as retreats for monkeys are removed.

As agriculture shifts to a cash crop basis and becomes increasingly technological, monkeys become labelled as crop raiders and may be exterminated through systematic hunting, trapping, or poisoning. Baboons are considered to be sufficiently damaging as agricultural pests in South Africa to warrant governmental publication of a brochure for farmers that explains how to capture and dispose of troops systematically (Keith and Stoltz, 1971). McGuire (1974) estimated that 2,000 vervets were killed annually for bounties on the Caribbean island of St. Kitts. Small numbers of vervets were introduced onto the island decades ago and current population estimates range between 5,000 and 20,000. Rowell (1968) estimated that 6,000 vervets were killed as agricultural pests in Uganda in 1964. Such animals represent untapped sources of primates that could potentially be harvested on a sustained-yield basis through purchases from farmers who allow the depredations of these animals on their crops during the year. If the eradication programs succeed, the population increases of these opportunistic primate species may turn out to be only temporary increases lasting for a few years in actively developing agricultural regions.

Although certain monkeys may continue to exist in large numbers outside of reserves, urban monkeys that co-exist with humans become less useful for medical research because they may carry antibodies to the disease under study and may have various pathologies that confuse the clinical and histological picture of the disease syndrome. They also require increasingly expensive quarantine procedures to cure them prior to use. Southwick and his colleagues have documented a general increase in scavenging urban populations and a corresponding decline in the numbers of rural and woodland monkeys because these are trapped more intensively for biomedical use and are also trapped or shot as agricultural pests. Although problems of continually changing disease status can be minimized by obtaining experimental animals consistently from known localities, this trend in the relative abundance of urban and agricultural monkeys is reducing the potential biomedical usefulness of many monkey populations found outside of reserves.

Few populations of primates have been sampled repeatedly in a fashion that has provided data for understanding population trends. Only a fifth of the 146 field studies conducted during the last few years have been supported to any extent by the National Institutes of Health (Chivers and Chivers, 1974). An awareness of the trends in wild populations that influence the quality of animals has become increasingly important for users because there will be a continuing need to procure breeding stock and to obtain animals for comparative studies.

Programs that develop captive colonies cannot afford to ignore the need for protecting wild populations that can serve as insurance against colony loss. Risks inherent in captive colonies include the loss of genetic diversity, selection for detrimental genes, and nutritional problems, as well as the risk of colony loss from an epidemic. Unless breeding colonies are established on a large scale, it will be necessary to supplement breeding stock from the wild. If breeding colonies are too small, genetic drift or decreasing fertility may occur. Fertility has been found to decline with inbreeding by the sixth to eighth generation in several species of nonprimates. At 5 years per generation of macaques, such a reduction could be expected in as little as 30-40 years of captive breeding in closed colonies where turnover is maximized in order to study the influence of inheritance on disease susceptibility and resistance. There are examples of unanticipated selection in the literature, e.g., progressive deafness appearing in strains of mice susceptible to audiogenic seizures (Ralls, 1967). Captive breeding generally promotes rapid growth and maturation. Few reproductive studies based upon small captive gene pools are available. Recent observations on exotic birds indicate that growth rate is as finely tuned as any physiological parameter and that increasing the growth rate for tropical species may result in physical deformities when bone, muscle, and tendon growth do not keep pace with each other (Kear, 1973).

Both the intrinsic population ecology of primates and current environmental changes in the tropics have increased concern for the future of wild primates. More accurate data on the status and trends of closely monitored wild populations must be accumulated in order to manage harvestable populations both in the wild and in captivity.

SUMMARY

Usage and acquisition patterns for primates in the United States can be described by four parameters: 1) the holding capacities of facilities using primates, 2) the volume of imported primates, 3) the biomedical uses of primates, and 4) current breeding programs.

Size of Facilities Using Primates

The results of a 1973 ILAR survey are summarized in Table 35. Inventories of nearly 50,000 primates were identified by respondents to the questionnaires. The facilities in the private sector included research institutions, pharmaceutical companies, and hospitals; universities and primate centers; and state and local health departments. Federal government facilities reported holding 7,150 primates with 3,000 of these primates held intramurally at NIH, 2,600 at military laboratories and Veterans Administration hospitals, and 400 at other facilities including the Center for Disease Control. The final 1,150 primates held at the Caribbean Primate Research Center were included with federal facilities.

Because the term "use" led to ambiguities in estimating the total number of primates used for biomedical programs, it was found to be less appropriate for annual reports than records of inventories and new acquisitions. Under the Animal Welfare Act of 1970, USDA registered facilities in the private sector and reported usages of 55,000 primates by 276 research facilities in 1972 and a similar number in 1973. Although inventories and usages were not strictly comparable, if a third of the omitted facilities in the private sector were assumed to hold a third of the primates, then the total inventory of biomedical facilities nationwide should be adjusted to 68,000.

The Volume of Imported Primates

The estimated volume of primates most frequently imported in 1972 are contrasted in Table 36 with those volumes reported by users and suppliers to be imported for biomedical programs in 1973. The majority of the 34,600 Old World primates imported were used in biomedical programs. Of the total imports, 2,400 were species generally imported only for exhibition. Three of the four most frequently used primate species were imported from South America, although only 1/4-1/2 of the New World imports were identified as used in biomedical programs. The most frequently imported species were rhesus macaques, squirrel monkeys, marmosets, and capuchins. These species along with vervets, long-tailed macaques, baboons, and night monkeys were the most widely used scientifically.

TABLE 35 NUMBERS OF PRIMATES MAINTAINED FOR BIOMEDICAL PROGRAMS IN UNITED STATES INSTITUTIONS

Facilities	No. Primates USDA, 1972 Use	ILAR, 1973 Inventory
Research institutes, drug companies	29,100	18,800
Universities, primate centers	25,000	17,450
Local government	900	400
TOTAL (private sector)	55,000	36,650
Federal government		7,150
Suppliers		5,700
SURVEY TOTAL		49,500
Adjustment, 34% private sector not surveyed		18,400
ADJUSTED TOTAL		67,900

TABLE 36 CURRENT VOLUMES OF PRIMATES IMPORTED AND USED IN BIOMEDICAL PROGRAMS IN THE UNITED STATES

Species	Minimum No. Biomedical Imports 1973	Total Imports USDI 1972	Imports for Biomedical Use (%)
Old World			
Rhesus macaque	25,000	23,000	100
Vervet monkey	3,200	3,300	97
Long-tailed macaque	3,500	1,400	100
Baboon	1,300	1,300	100
Other	1,600	4,000	40
TOTAL (Old World species)	34,600	33,000	100
New World			
Squirrel monkey	5,600	25,000	22
Saguinus sp.	2,800	5,400	52
Night monkey	2,100	3,500	60
Capuchin	800	6,100	13
Other	100	4,600	2
TOTAL (New World species)	11,400	44,600	26
Old World	34,600	33,000	100
New World	11,400	44,600	26
TOTAL	46,000	77,600	59
Range of estimates	46,000-55,000	70,000-91,000	50-71
Current "best estimate"	55,000	75,000	73

Current estimates of total imports range from a low value of 70,000 published by the U.S. Department of Commerce for 1973 to 91,000 for the higher of 2 estimates published by the U.S. Department of the Interior for 1972. A higher percentage of imported primates was used in biomedical programs than has been reported previously and the best current estimate is 55,000 of 75,000, or at least 73 percent. The remainder were imported for exhibition and the pet trade and also included dealers' losses.

Records for the intramural facility at NIH showed that the losses during quarantine averaged 11-12 percent over the past 15 years. The majority of primates handled by the facility were rhesus macaques shipped directly from India. Quarantine losses for night monkeys and marmosets reached 50 percent. Assuming that this loss rate is typical nationwide, then as many as 10,000 primates (13 percent of 75,000) may be lost annually by importers during conditioning and quarantining.

Dealers have buffered the scientific community from an awareness of the volume of these losses by the practice of selling partially conditioned animals to many institutions. Estimates of losses have indicated that nearly half of the 20,000-40,000 imported primates attributed to the pet trade may in fact be losses inherent in the present system of commercial collecting. Past estimates for the pet trade were derived by subtracting scientific use from total imports. The lack of regulations by importing countries to eliminate the unsystematic pet trade in South American primates has been considered to be one of the major reasons for increasing restrictions on exports by host countries. New regulations proposed by the U.S. Department of the Interior and the Public Health Service, covering the importation of animals, would effectively eliminate the pet trade. Termination of the pet trade will also eliminate the scapegoat for many of the losses accruing from the wasteful methods of trapping, shipping, and holding imported primates. The responsibility that users assume in reducing the wastage in transit and use may be expected to affect the number of imported primates available to cover a portion of the needs of medical research. A few institutions have already demonstrated success in reducing losses in collecting rhesus macaques, baboons, and long-tailed macaques by sponsoring expeditions to capture and ship these animals. The importance of similar efforts for capturing arboreal species is stressed.

Pressures from professional organizations and government regulations have converged in attempting to correct the abuses of the past commercial trade in primates. In 1973, the primate specialist group of the IUCN recommended that governments in the source countries should not only restrict exports of wild primates but should also tax exports if necessary to conserve natural populations of laboratory primates and to encourage the development of self-sustaining breeding colonies.

Biomedical Uses of Primates

Respondents to the 1973 ILAR survey indicated their 1974 needs for primates from imports and current inventories. In a sample of 41,000 primates, summarized in Table 37, pharmacology and toxicology, together with vaccine production and safety testing, accounted for the first 37 percent of the primates used. The largest annual requirement of rhesus macaques was for the production and safety testing of polio vaccines, which required 3,000 and 2,000, respectively. Studies of specific diseases and experimental surgery accounted for the second largest demand, or 36 percent of the total primates. Another 16 percent of the demand came from studies of neurophysiology, while the final 11 percent were used in studies of physiology, reproduction, and social behavior.

Few investigators indicated a preference for the sex of experimental animals. The substitution of males for females in many experiments was considered important in protecting the reproductive capacity of captive and wild populations. Increased emphasis on husbandry and social behavior was considered necessary for managing multigenerational breeding colonies.

Biomedical demand for general use species such as rhesus macaques and squirrel monkeys has been distinguished from demand for special use species, such as marmosets and night monkeys. As summarized in Table 25, more than 80 percent of the animals in the latter group are currently used in a single research category. Demand for special use species is expected to increase and broaden as baseline data accumulate on them.

The substitution of other taxa for primates was not considered to be feasible by 60 percent of the investigators studying infectious diseases, and a third of respondents working in other fields. Table 38 summarizes the alternative primate species that are presently used in various research areas.

Current Breeding Programs

Total 1973 births represented less than 5 percent of the total annual demand. Breeding of night monkeys and capuchins was noticeably lacking relative to their usage rates. Breeding colonies have been supported until now primarily to obtain fetuses and infants for research rather than for production. The production of fetuses was not indicated in tabulations on birth rates but represented a fourth of all reproduction for rhesus macaques.

The inventories of F_1 and F_2 females have nearly reached 1,000 animals but no long-term funding has been established for these colonies. Placing a higher priority on research over captive breeding has resulted in using current breeders (that are already adjusted to confinement) for experimental purposes rather than for production.

Captive breeding has been discussed frequently in terms of production centers for wild-caught breeders, and these overestimate potential net yields from captive colonies. A distinction between production centers and self-sustaining breeding colonies was stressed because it has become unrealistic to assume that there will be a continuing supply of wild-caught breeders available to stock colonies. The estimates of net yield summarized in Table 39 were based upon a reproductive rate of 80 percent for 10 years per female with 15-percent losses of infants. Many researchers have considered these rates to be overly optimistic. Rates of 50 percent for 5 years may be more realistic, especially for species other than rhesus macaques. Such estimates would greatly increase the numbers of maturing animals that must be held for replacement of breeding stock and would

TABLE 37 PERCENT DEMAND FOR SPECIES BY BIOMEDICAL RESEARCH AREA

Research Area	Percent Demand for Species by Research Area					Sample	
	Rhesus	Marmoset	Squirrel	Night	Other	Total	Percent
Pharmacology-toxicology	30	1	25	0	30	10,499	25
Vaccine production, safety testing	18	7	6	0	2	4,944	12
Disease, experimental surgery	24	90	27	82	39	14,654	36
Neurophysiology	17	1	25	18	13	6,599	16
Physiology, reproduction, social behavior	11	1	17	0	16	4,415	11
TOTAL	24,587	3,604	3,310	2,086	7,524	41,111	
Percent	60	9	8	5	18		100

TABLE 38 MOST FREQUENT ALTERNATIVE SPECIES USED IN BIOMEDICAL PROGRAMS

Research Area	Rank of Species by Area		
	1	2	3
Pharmacology-toxicology	Rhesus	Vervet	Squirrel
Vaccine production, safety testing	Rhesus	Marmoset	Squirrel
Diseases			
Infectious	Rhesus	Night	Marmoset
Neoplasm	Marmoset	Rhesus	Squirrel
Organ system	Rhesus	Squirrel	(Long-tailed)*
Experimental surgery	Rhesus	Baboon	(Stumptail)
Neurophysiology	Rhesus	Squirrel	(Baboon)
Sensory	Rhesus	Night	(Squirrel)
Reproductive physiology	Rhesus	Baboon	(Long-tailed)
Social behavior	Rhesus	Squirrel	Long-tailed

*Parenthesis indicate <200 animals of species reported.

TABLE 39 COMPOSITION AND PRODUCTION OF A SELF-SUSTAINING BREEDING COLONY PER 100 BREEDING FEMALES

	Colony Composition*		
	Female	Male	Inventory
No. breeders	100	10	110
Gross annual production	40	40	-
Infant loss in 1st yr-15%	34	34	-
Replacement holding for 3 yr	10	1	33
Net yield (held for sale at 1 yr)	24	33	57
TOTAL INVENTORY			212
Annual colony maintenance costs ($0.50/day/animal x 365 days x inventory)	$36,500/57 yearlings $640/yearling $6.4 million/10,000 yearlings		

*Assume 80% birth rate for 10 yr/female.

greatly reduce net yield. Current estimates of per diem costs are $1.00 per day for most biomedical institutions rather than $0.50 per day. Maintenance costs of captive-reared young will be considerably higher than the $640 indicated in this table, unless economies can be realized from large scale production of breeding in free-ranging conditions and in compounds outside of present research facilities. Total costs would rapidly increase if there were a reduction in the reproductive rate, increases in daily maintenance costs, or demand for primates older than 1 year.

Population Trends

Few estimates of total wild populations are available except for rare and endangered species. The area of established national reserves in tropical countries that meet the UN criteria for listed national parks represents a first approximation of the size of primate populations that will be afforded long-term protection. More government protection is afforded African primates than species on other continents due to the larger size of African reserves. Nearly 60 percent of the African forms have more protection than any Asian species and nearly 40 percent have more protection than any Latin American form. This pattern of protection is inversely related to the current biomedical demand for species by continent. The decreasing supply of wild primates resulting from deforestation and habitat loss has emphasized the need for an immediate long range investment in self-sustaining breeding colonies if primates are to continue to be available on a predictable, though modest, scale as experimental animals.

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APPENDIX I COMPARISON OF PRIMATES BEING MAINTAINED ON 1 JANUARY 1971 AND 1 OCTOBER 1973

Species*	Inventory		No. Maintained	No. Labs	
	1 Jan. 1971	1 Oct. 1973	>3 Yr as of 1973	1 Jan. 1971	1 Oct. 1973
Tupaiidae					
Tupaia sp., tree shrews	46	65	-	4	9
Lemuridae					
Cheirogaleus medius	-	7	3	-	1
Hapalemur griseus, grey lemur	-	3	3	-	1
Lemur catta, ring-tailed lemur	45	78	7	3	3
L. fulvus, brown lemur§	91	161	84	3	3
L. macaco, black lemur§	23	27	6	3	2
L. mongoz, mongoose lemur	24	14	-	3	1
L. variegatus	-	8	4	-	1
Microcebus murinus, mouse lemur	9	9	6	2	1
Indriidae					
Propithecus verrauxi coquereli, sifaka	-	5	4	-	1
Lorisidae					
Galago crassicaudatus, thick-tailed galago	451	295	157	8	12
G. senegalensis, Senegal galago	60	40	1	9	7
Nycticebus coucang, slow loris	47	30	7	7	4
Perodicticus potto, potto	10	2¶	-	1	1
Cebidae					
Aotus trivirgatus, night monkey**	1,061	1,316	67	28	29
Ateles geoffroyi, black-handed spider monkey	3	30	-	1	2
A. paniscus, black spider monkey	9	4	-	4	1
Ateles sp., spider monkey	11	64	3	5	11
Callicebus moloch, dusky titi	34	39	14	1	2
C. torquatus, royal titi	4	-	-	1	-
Cebus albifrons, white-fronted capuchin	255	261	102	26	15
C. apella, tufted capuchin**	177	511	37	9	31
C. capucinus, white-throated capuchin	11	5	-	2	1
Cebus sp.	14	50	-	2	1
Lagothrix lagotricha, woolly monkey	22	29+	-	6	8
Saimiri sciureus, squirrel monkey**	3,941	4,358	670	86	100
Callitrichidae					
Callimico goeldii, Goeldi's marmoset	13	13	5	2	2
Callithrix argentata, silver marmoset	-	3	2	-	1
C. jacchus, cotton ear marmoset	-	186	16	-	2
C. jacchus x C. penicillata, hybrid	-	4	-	-	1
C. penicillata, black ear marmoset	-	4	-	-	1

APPENDIX I (continued)

Species*	Inventory 1 Jan. 1971	Inventory 1 Oct. 1973	No. Maintained ≥3 Yr as of 1973	No. Labs 1 Jan. 1971	No. Labs 1 Oct. 1973
Cebuella pygmaea, pygmy marmoset	44	2	4	3	2
Saguinus fuscicollis, brown-headed tamarin	317	1,199	395	1	3
S. fuscicollis x S. nigricollis, tamarin hybrid	-	108	38	-	1
S. geoffroyi, Geoffroy's tamarin	-	2	1	-	1
S. illigeri, tamarin	-	5	-	-	1
S. illigeri x S. nigricollis, tamarin hybrid	-	2	-	-	1
S. mystax, moustached tamarin**	462	717	4	5	5
S. nigricollis, black and red tamarin**	1,359	441	94	8	6
S. oedipus, cotton-top marmoset	390	614	123	14	13
Marmoset	-	41	6	-	2
Cercopithecidae					
Cercocebus aterrimus, black mangabey	2	-	-	1	-
C. lunulatus	-	2	2	-	1
C. torquatus, sooty and white-collared mangabeys§§	158	60	26	4	9
Cercopithecus aethiops, vervet monkey**	2,057	1,390	107	31	37
C. mitis, blue and sykes monkeys¶¶	8	-	-	4	-
C. talapoin, talapoin monkey	34	42	18	1	3
Erythrocebus patas, patas monkey	168	157	30	8	9
Macaca arctoides, stump-tailed macaque**	809	1,083	287	53	60
M. cyclopsis, Formosan macaque	103	40	12	2	2
M. fascicularis, long-tailed macaque**	2,689	1,836	555	45	40
M. fuscata, Japanese macaque	120	178	116	4	6
M. mulatta, rhesus macaque**	23,300	22,980	5,096	148	161
M. nemestrina, pig-tailed macaque**	1,327	1,439	576	36	36
M, nigra, Celebese macaqueΦ	77	83+	52	4	6
M. radiata, bonnet macaque**	441	419	203	10	11
M. sylvanus, Barbary ape	15	-	-	1	-
Macaca sp.	6	-	-	3	-
Papio cynocephalus, savannah baboonΦΦ	1,535	2,299	426	47	57
P. hamadryas, sacred baboon	9	19	-	2	1
P. leucophaeus, drill	5	-	-	1	-
P. sphinx, mandrill	4	-	-	1	-
Presbytis entellus, hanuman langur	45	-	-	1	-
Theropithecus gelada, gelada baboon	32	8	2	2	2
Hylobatidae					
Hylobates concolor, black gibbon	2	+	-	1	1
H. lar, white-handed gibbon	14	32	6	3	3

APPENDIX I (continued)

Species	Inventory 1 Jan. 1971	Inventory 1 Oct. 1973	No. Maintained ≥3 Yr as of 1973	No. Labs 1 Jan. 1971	No. Labs 1 Oct. 1973
Hylobates sp., gibbon	23	5	5	3	1
Symphalangus syndactylus, siamang	2	-	-	1	-
Pongidae					
Gorilla gorilla, gorilla	17	17	13	2	2
Pan troglodytes, chimpanzee	443	673	150+	24	27
Pongo pygmaeus, orangutan	27	39	28	1	2
New World "unidentified"	-	7	6	-	3
Old World "unidentified" or single individual per species	7	206	49	1+	-
New World					
Cebidae	5,542	6,667	893		
Callitrichidae	2,585	3,341	686		
Unidentified	-	7	6		
New World Total	8,127	10,015	1,585		
Old World					
Prosimians	806	744	282		
Cercopithecidae	32,944	32,035	7,308		
Anthropoids	528	766	202		
Unidentified	7	206	49		
Old World Total	34,285	33,751	7,841		
TOTAL PRIMATES	42,412	43,766+	9,426+		

NOTE: Totals for 1973 do not include the 5,689 primates held in suppliers' compounds (see Table 8); the 4,736 primates held in suppliers' compounds in 1971 were included in totals for that year (Thorington, 1971a).

*No names or combinations thereof are proposed as new names. The nomenclature generally follows Napier and Napier (1967), except where noted.

§Lemur macaco has been described as conspecific with L. fulvus in Napier and Napier (1967).

¶Probably included with Old World "unidentified" in 1973 figures.

**Pharmaceutical Manufacturers Association (PMA) figures are included with inventory. However, it is not known how many of the 34 reporting companies maintain the particular species. Thus, there is no numerical inclusion of PMA in the number of labs for 1973.

§§Animals identified as Cercocebus atys and C. fulliginosus are listed under C. torquatus.

¶¶Listed under Cercopithecus mitis are also animals reported as C. albogularis.

ϕListed under Macaca nigra are also animals reported as M. maurus, M. hecki, and M. tonkeanus.

ϕϕListed under Papio cynocephalus are also animals reported as Papio anubis, P. doguera, P. papio, and Papio sp.

APPENDIX II IMPORTS AND ACQUISITIONS, ILAR SURVEY, 1973

Species	Imports 1973	Total Acquisitions 1973	Deaths of 1973 Imports	Needs 1974
Tupaiidae				
Tupaia sp., tree shrews	53	137	83	225
Lemuridae				
Lemur catta, ring-tailed lemur	-	10	-	-
L. fulvus, brown lemur	-	42	-	-
L. macaco, black lemur	-	8	-	-
L. mongoz, mongoose lemur	-	1	-	-
L. variegatus	-	8	-	-
Hapalemur griseus, grey lemur	-	2	-	-
Cheirogaleus medius	-	4	-	-
Lorisidae				
Galago crassicaudatus, thick-tailed galago	137	242	-	20
G. senegalensis, Senegal galago	19	19	10	52
Nycticebus coucang, slow loris	2	7	-	12
Cebidae				
Aotus trivirgatus, night monkey	2,062	2,157	1,034	2,066
Ateles geoffroyi, black-handed spider monkey	-	8	-	-
A. paniscus, black spider monkey	4	4	-	3
Ateles sp., spider monkey	59	63	2+	22+
Callicebus moloch, dusky titi	-	6	-	-
Cebus albifrons, white-fronted capuchin	33+	79+	28	65+
C. apella, tufted capuchin	372	386	99	480+
Cebus sp.	50	50	-	32
Lagothrix lagotricha, woolly monkey	11	23	10+	1+
Saimiri sciureus, squirrel monkey	2,323	2,598	1,350	3,091
Callitrichidae				
Callimico goeldii, Goeldi's marmoset	-	5	-	-
C. jacchus, cotton ear marmoset	-	85	-	60
Saguinus fuscicollis, brown-headed tamarin	508	697	15	410
S. fuscicollis x S. nigricollis, tamarin hybrid	-	35	-	-
S. mystax, moustached tamarin	1,554	1,555	1,528	-
S. nigricollis, black and red tamarin	164	274	19	595
S. oedipus, cotton-top marmoset	368	398	41	609+
Marmoset	30	30	-	1,660

APPENDIX II (continued)

Species	Imports 1973	Total Acquisitions 1973	Deaths of 1973 Imports	Needs 1974
Cercopithecidae				
C. torquatus, sooty and white-collared mangabeys	2	8	6	+
Cercopithecus aethiops, vervet monkey	2,787	2,850	2,564	1,459+
C. talapoin, talapoin monkey	-	2	-	-
Erythrocebus patas, patas monkey	86	83	62	57
Macaca arctoides, stump-tailed macaque	451	558	329	438+
M. cyclopsis, Formosan macaque	-	9	-	-
M. fascicularis, long-tailed macaque	1,205	1,344	490	1,128+
M. fuscata, Japanese macaque	-	32	-	+
M. mulatta, rhesus macaque	17,224	18,895	14,287	22,756
M. nemestrina, pig-tailed macaque	335	679	229	454+
M. nigra, Celebese macaque	52	54	-	-
M. radiata, bonnet macaque	6	82	10	17+
Papio cynocephalus, savannah baboon	999	1,083	714	964+
P. hamadryas, sacred baboon	-	1	-	+
Theropithecus gelada, gelada baboon	-	-	-	+
Hylobatidae				
H. lar, white-handed gibbon	-	18	-	24+
Pongidae				
Pan troglodytes, chimpanzee	77	109+	27	174
Pongo pygmaeus, orangutan	5	5	-	-
New World unidentified	3	3	-	100
Old World unidentified	68	68	2	150
New World				
Cebidae	4,914	5,374	2,523	5,760
Callitrichidae	2,624	3,079	1,603	3,334
Unidentified	3	3	-	100
New World Total	7,541	8,456	4,126	9,194
Old World				
Prosimians	211	480	93	309
Cercopithecidae	23,147	25,680	18,691	27,273
Anthropoids	82	132	27	198+
Unidentified	68	68	2	150
Old World Total	23,508	26,360	18,813	27,930
TOTAL PRIMATES	31,049+	34,816+	22,939+	37,124+

APPENDIX III BREEDING COLONIES IN RESEARCH FACILITIES

Species	No. Births* 1972	No. Births* 1973	No. Adult Females 1973§	No. Labs with Births in 1973§
Lemuridae				
Cheirogaleus medius	-	4	3	1
Hapalemur griseus	-	1	2	1
Lemur catta	17	6	34	2
L. fulvus	29	28	53	2
L. macaco	6	6	11	2
L. mongoz	2	1	7	1
L. variegatus	-	5	4	1
Microcebus murinus	-	-	(4)	(1)
Indriidae				
Propithecus	2	-	3	1
Lorisidae				
Galago crassicaudatus	72	64	94	6
Nycticebus coucang	2	2	11	2
Cebidae				
Aotus trivirgatus	-	2	23	1
Callicebus moloch	6	6	7	1
Cebus albifrons	-	30	65	1
C. apella	-	7	21	3
Saimiri sciureus	121	185	499+(5)	8+(2)
Callitrichidae				
Callimico goeldii	2	-	4	2
Callithrix jacchus	45	43	48	2
Saguinas fuscicollis	256	189	240	2
S. mystax	2	1	1+(4)	1+(1)
S. nigricollis	48	61	85	4
S. oedipus	42	30	78+(6)	5+(1)
S. nigricollis x S. fuscicollis	49	35	10	1
Marmoset	-	-	(20)	(2)
Cercopithecidae				
Cercopithecus aethiops	43	33	118	3
C. talapoin	7	2	23	2
Macaca arctoides	89	68	260+(19)	14+(1)
M. cyclopsis	17	9	33	2
M. fascicularis	127	94	304	9
M. fuscata	23	31	60	3
M. mulatta	752	991	2,732+(18)	31+(1)
M. nemestrina	272	241	461+(1)	6+(1)
M. nigra	7	2	17	1
M. radiata	46	66	159	3

APPENDIX III (continued)

Species	No. Births* 1972	No. Births* 1973	No. Adult Females 1973§	No. Labs with Births in 1973 §
Papio cynocephalus	146	119	468+(12)	7+(1)
P. hamadryas	1	1	12	1
Theropithecus gelada	-	-	(4)	(1)
Hylobatidae				
Hylobates lar	1	2	17	2
Hylobates sp.	-	-	(8)	(1)
Pongidae				
Pan	31+	46	145	5
Pongo	4	4	11	1
New World				
Cebidae	127	230	615	
Callitrichidae	444	359	466	
Unidentified	-	-	-	
New World Total	571	589	1,081	
Old World				
Prosimian	130	117	222	
Cercopithecidae	1,530	1,657	4,647	
Anthropoids	36+	52	173	
Old World Total	1,696+	1,826	5,042	
TOTAL PRIMATES	2,267+	2,415	6,123	

*Births for 1972 reported for 12 months; births for 1973 reported as of 1 October, and thus may underestimate the total for the calendar year.
§Numbers in parentheses are new colonies in which no females have produced offspring.

APPENDIX IV F_1 BREEDING BY SPECIES

	Breeding F_1 Pairs				Breeding F_1 x F_0 or Nonbreeding			
	No. Institutions	No. Adult Males	No. Adult Females	No. F_2	No. Institutions	No. Adult Males	No. Adult Females	No. $F_{1.5}$
Prosimians								
Lemur catta	2	27	21	12				
L. fulvus	2	36	36	17				
L. macaco	1	2	1	1	1	-	3	1
L. mongoz					1	-	1	-
Microcebus murinus					1	3	-	-
Propithecus verrauxi					1	-	1	-
Galago crassicaudatus	2	42	36	38	4	13	11	-
Nycticebus coucang	1	1	1	2	1	1	-	-
Subtotal		108	95	70		17	16	1
Cebids								
Saimiri sciureus					3	1	13	3
Subtotal					3	1	13	3
Marmosets								
Callimico goeldii	1	4	2	1				
Callithrix jacchus	1	19	16	46				
Saguinus fuscicollis	1	42	37	39	1	2	-	-
S. nigricollis					1	2	-	-
S. oedipus	2	13	7	5	1	2	2	-
Marmoset hybrids	1	4	8	9				
Subtotal		82	70	100		6	2	-
Macaques								
Macaca arctoides	2	3	13	7				
M. fascicularis	3	14	45	18	1	-	4	1
M. fuscata	2	11	26	12	1	1	2	-
M. mulatta	4	21	94	47	7	21	44	5
M. nemestrina	2	38	32	28	1	5	5	-
M. nigra					1	-	9	1
M. radiata	1	16	7	5*				
Subtotal		103	217	117		27	80	11
Other Old World								
Cercopithecus aethiops					1	2	6	-
Papio cynocephalus	1	4	17	6	1	4	6	-
P. hamadryas					1	2	2	-
Pan troglodytes	1	4	14	4				
Subtotal		8	31	10		10	14	-
TOTAL PRIMATES		301	413	297		61	125	15

NOTE: Totals do not include primates at the Caribbean Primate Center.

*One of breeding age.