The Emigrant Pests

By

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THE EMIGRANT PESTS

A Report to:

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May 1973

A report on exotic pests and diseases of plants and animals, including --

- --an analysis of the threat they pose to the environment and the agriculture of the United States,

- --an evaluation of the inspection and quarantine programs of the U.S. Department of Agriculture,

- --a proposal for increasing the supply of protection on a global basis.

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OVERVIEW AND CHAPTER SUMMARIES

The Phenomena

I There is a continuous stream of new organisms being carried into the U. S. from overseas and establishing themselves in the North American biota.

A. During the past 480 years, 1,115 new insects have become established increasing U.S. insect fauna by 1%.

B. The rate of establishment of new insect species has been relatively stable since about 1920, at 9 new insects a year.

C. These 9 annual insect immigrants include 5 agricultural pests, 2 beneficial insects, and 2 insects of no importance.

II There is a substantial reservoir of organisms awaiting transportation, including many that are expected to become pests upon arrival.

A. There are 1,333 pests believed to be a significant threat 22 animal diseases, 551 plant diseases and 760 insects. These are individually identified and described in the report.

B. At present rates of establishment there is a known 300-year supply of insects alone, that are expected to be important U. S. pests.

C. There are 29 species that would attack the U.S. soybean crop, 7 of which are individually capable of causing yield lossess of 10% or more.

III When they are established these emigrant pests are expected to produce a wide range of economic impacts on U. S. agriculture.

A. Two percent of them (25 species) may produce impacts from $401 million to $4 billion; whereas 75% of them (1,001 species) may produce impacts of less than $4 million, a thousand-fold range between classes.

IV There is no objective evidence that U. S. quarantine actions are having any significant impact on this flow. That doesn't mean the program is without effect, but rather that the haphazard use of sampling during inspection and the lack of certain biological information precludes a quantified evaluation.

Proposed Actions

I Until such time as objective evidence of program efficacy can be provided, the continuation of some kind of quarantine effort appears prudent.

II The regulation of passenger baggage by APHIS is judged unlike to contribute to significant risk reduction and should be abandoned or substantially modified.

III The regulation of agricultural cargoes has received general acceptance by the nations of the world, but existing practices should be strengthened by the implementation of the principles inherent in ASIST (Agricultural Source Inspection and Surveillance Technique.)

SUMMARY

CHAPTER 1 - Introduction

Doubts about the efficacy of our efforts to prevent the entry of exotic agricultural pests and diseases coupled with rising volumes of international trade and travel during a period of budget restrictions prompted Department officials to look for more efficient alternatives to the present array of quarantine program activities.

A Task Force, comprised of individuals not then employed by the then Agricultural Quarantine Inspection Division of ARS and chaired by an outside consultant, was appointed to do this. The Task Force was told that its objective was not primarily to evaluate and critique the current program, but rather to define and quantify, if possible, the risks from the entry of those exotic agricultural pests and diseases that are major threats to our environment and our food supplies, and to develop and analyze strategies for protection against these pests and diseases.

The approach to the problem as spelled out by Drs. Ned Bayley, then Director of Science and Education, and Francis J. Mulhern, Administrator of APHIS, and the procedures followed by the Task Force are described in the closing paragraphs of Chapter 1.

CHAPTER 2 - The Arrival of Immigrant Species

The continental U. S. has been and is particularly prone to pest introduction. It was settled and developed agriculturally in less than 500 years. In many instances pests came along with the introduced crops and livestock species comprising the bulk of our farm output.

Conservative estimates place the number of insect species in the world within a range of 2.5-5 million. Among this vast horde exist species adapted to fill any conceivable ecological niche. It is doubtful that any terrestrial animal or plant is immune from some form of insect attack. The same is true of pathogenic organisms. The fact that plants and animals are able to exist in communities pervaded by such entities is a consequence of evolutionary processes that interpose checks and balances on the disproportionate increase of any member of the ecological community.

Since ecosystems evolved long before man became an important force in evolution, their stability was determined by factors of climate, geography and isolation. During the past 480 years, the geographic barriers provided by the Atlantic and Pacific Oceans have been breeched and the ecology of the Western Hemisphere changed by man's agricultural, social and industrial activities.

The consequence of this has been the colonization of a succession of immigrant agricultural pests and diseases. Initially, the successful species were those associated with man, his stored products and his livestock which could survive a long sea voyage. Later, nursery stock for planting orchards was brought in accompanied by a variety of disease pathogens and insects. The new species often found previous "pest-free" crops and an environment where natural enemies were absent. Changing patterns of immigration have resulted in an influx of agricultural pests from all over the world.

Since 1940, aircraft have assumed increasing importance as a pathway of entry, as they have permitted short-lived, winged hitchhikers to survive transit and escape into new geographic areas. Deliberate introduction of pests occur occasionally as a result of carelessness in scientific research. This pathway could become more important as research on genetic control increases.

Following the arrival of an agricultural pest, a succession of events must transpire before the pest becomes established. These events take the form of obstacles which must be overcome--each with its own probability of occurrence. They are considered in some detail in Chapter 2, and taken together, they add up to a formidable natural barrier to successful colonizations.

Despite these natural forces, a substantial number of agricultural pests and diseases have become established. For example, over 1,100 foreign species of insects and mites now call North America home. These immigrants amount to only 1 percent of the total insect and mite fauna of the Continental U. S., but the pests among them account for over two-fifths of total crop losses. The record of discovery of new insects reveals a rapid increase up to about 15 species per year in the 1910-19 decade. Since then, discoveries of new species have leveled off to a rate of around 9 species per year. The number of potentially significant varibales affecting this time series makes interpretation difficult.

The experience of Hawaii in attempting to keep foreign pest invaders at bay may be significant in appraising the effectiveness of quarantines. These climatically favored islands have never been connected to any continental land mass and were geographically isolated from world biota prior to the arrival of Europeans in the 18th Century. Over the past 250 years, the native fauna has been, in good part, displaced as a result of the actions of nonindigenous man. Over 1,000 species of insects and mites have been recorded as immigrant to Hawaii, and in the 1942-72 period, the rate of colonization per 1,000 square miles was 40 species, 500 times the rate for the continental U. S. This, despite a quarantine effort more intensive than that for the contiguous U. S. Conclusion: It is not the deterrent effect of quarantine inspection but rather some ecological difference that accounts for the disproportionately low immigrant fauna present in the contiguous States.

A breakdown of the 1,115 immigrant insect species shows that 221 were not economically important; 404 became minor pests; 212 were important pests (but we wouldn't have expected 139 of them to be so on the basis of their performance in their native land); and 278 turned out to be beneficial (of which 126 were deliberate introductions).

Manifestly, there is a high degree of unpredictability about the likelihood of exotic insects becoming pests.

CHAPTER 3 - Defining the Threat

There are perhaps 2,500,000 insect species not present in the U. S. About 800,000 of these have been identified and 6,000 of them are known to be damaging in foreign areas having ecological equivalents of the U. S. It may be that the low predictability for pest behavior among insects precludes compilation of a list of injurious exotic species which would provide reasonable basis for program decisions. However, since we cannot protect ourselves against everything, it is useful to have some ordering of the potential invaders that provides an opportunity to make choices, however uncertain, in the use of program resources.

The Task Force identified 600 species of insects and mites that may be regarded as high risk. There are perhaps 10 times that number that may be suspect. Exclusion of all 6,000 might be desirable, but the cost would be prohibitive, if it could be done at all. While the probability of establishment differs among species of emigrants, taken as a whole the probability of any given species becoming established in a given year is very low. Experience suggests it may be on the order of 0.04 to 0.22 percent. The situation with respect to plant pathogens is quite similar, with 551 species believed to pose significant risks to our agriculture from a list of 2,000 potentially bad actors.

With increasing concern about environmental quality, the relationship between environmental and aesthetic values and exotic pests and diseases is one that deserves more attention than it has received.

The impacts which exotic pests may have on the environment are difficult to quantify, but that they can be serious from the standpoint of the affected public is evident from the reaction to such imports as the gypsy moth and the fire ant. New pest arrivals can also upset established methods of pest control and result in greater reliance on pesticides.

Through the use of a mathematical model, the Task Force sought to identify the most serious emigrant pests (based on information provided by knowledgeable scientists) and to rank them according to the risk they posed to U. S. agriculture. The usefulness of the model is limited by the quality of the scientific judgments that constitute the greater part of the inputs, by the decision not to include social and environmental values, and by its static nature. In fact, the results of the model are best thought of as a summary of the opinions of the expert biologists on the Task Force. It would be misleading to consider those results as scientifically (i.e. experimentally) derived.

Simply stated, a ranking of exotic pests emerged from a three-step procedure:

1. Estimate the probability of specific exotic pests becoming established in the U. S.

2. Evaluate the economic impact if those pests became established.

3. Multiply the results of step 1 by those of step 2 to obtain the expected economic importance of each pest.

This brief outline of the concept severely understates the complexity of the formulae used to complete steps 1 and 2. These are elaborated in detail in Chapter 3.

Through the use of computers the manifold computations were completed, and the desired information printed out. One of the more important outputs was a bar chart where the length of the bars represent a 75 percent confidence interval for the "Expected Economic Impact" of the pest, and with the pests listed in descending order of the upper end of the confidence interval.

CHAPTER 4 - The Exotic Pests and Diseases

Task Force biologists provided essential information on 1,333 exotic pests and diseases which, in their view, constituted a significant threat to the U. S. In this group were 22 animal diseases, 551 plant diseases and nematodes and 760 insects and mites.

The 100 top ranking exotic pests identified by the methods described in Chapter 3 are shown on a table in Chapter 4 and the complete list of plant pests and diseases ranked in order of their Expected Economic Impact is a part of the computer printout included in the Appendix. The list of the top 100 illustrates how rapidly the EEI declines as one proceeds down the ranking: From a top of almost $4 billion, to $40 million. Given the weakness in the available information, the dollar figures should be used more as a scoring device than as a representation of true value.

Twenty-five species, or 2 percent of the 1,333 agricultural pests and diseases regarded as potentially serious had EEI's exceeding $400 million. At the other end of the highly skewed array were 1,001 species - 75 percent of the total - with EEI's of less than $4 million.

Twenty-one of the top 100 species have a high probability of establishment--a mean time until first infestation of up to 3 years. This first group included 6 animal diseases, 7 plant diseases and 8 insects. Forty-three species fall in the 4 through 6 year category, while the average time of first establishment of the remaining species is more than 99 years.

Here again, these findings should not be taken too literally. In assembling information on the exotic pests, Task Force biologists often found that biological knowledge of key attributes was quite limited or missing altogether. This creates a great deal of uncertainty about international movement, colonization, damage, etc., and is responsible for the wide range of EEI's observable in the printout. We should gather much more information about exotic pests, expecially those at the top of the list.

While the top 100 represent a "clear and present danger", it would be foolhardy to ignore classes of pests which present similar danger even though individual members do not appear important in themselves.

A comparison of the Task Force list with other lists of dangerous exotic pests disclosed a large number of differences which are not easy to reconcile. Details are presented in Chapter 4.

--Major International Pest and Disease Threats
--The Consequences of Introducing Exotic Pests
--International Pathways of Pest and Disease Movement
--The Effectiveness of Quarantine Programs
--Protection as a Concept
--Increasing the Future Supply of Protection
--New Programs

These topics served as a working outline for the final report. They also provided the framework to identify the individual tasks that needed to be done.

Second, 36 separate tasks were described, assignments of personnel were made, and deadlines established.[1] Each description included the title, objectives, assignment, performer, time, deadline, product, and approach.

Third, a critical path flowchart was laid out illustrating the span of working time for each task and its relationship to other tasks.[2] This chart, termed a "Game Plan," also arranged the tasks according to the kinds of talents required; i.e., entomology and pathology; psychol and sociology; history, law, policy analysis; economics; engineering and transportation; statistical analysis; organization and management; synthesis and interpretation. In addition, the Game Plan called for 12 output and recommendation papers to be produced during the year-long study As expected, there were many alterations made along the way, and the deadlines required constant readjustment.

Fourth, six Task Force members, knowledgeable in some aspect of the problem, were selected to assist in getting the task completed. At the first meetings the objectives, the outline of issues, the task outlines, and the Game Plan prepared by the chairman were reviewed and revised. At subsequent meetings progress was reviewed, status reports were prepared, and plans were updated and revised.

Finally, the chairman prepared a draft from the papers submitted for each of the tasks. Each member of the Task Force reviewed and critiqued the draft, resulting in this final report.

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1. A complete list of titles of the tasks is in Appendix 1-A.
2. A copy of the Game Plan is Appendix 1-B.

TABLE 4-1 (Cont.)

Rank	Species	Type	Probability of Establishment	EEI Mid-Point	EEI Range (Plus or Minus) Confidence Interval 50%	90%	Direct Estimate
41	Lepidosaphes tubulorum	I	L	183	89	219	
42	Heartwater (R. ruminantium)	A	H	178			50
43	Acenthostigma parasiticum	P	M	174	8	20	
44	Sclerospora philippinensis	P	M	161	12	30	
45	Sclerospora spontanea	P	M	152	7	18	
46	Scolytus scolytus	I	L	151	423	1,045	
47	Cerambyx cerod	I	L	151	104	258	
48	Tomicus piniperda	I	L	137	95	235	
49	Teschen disease	A	L	133			44
50	Maize streak virus	P	M	132	8	18	
51	African horse sickness	A	H	120			30
52	Mycosphaerella sojae	P	M	116	8	18	
53	Cerambyx scopolii	I	L	116	324	801	
54	Rice dwarf virus	P	L	115	8	20	
55	Septoria maydis	P	H	112	10	25	
56	Rift valley fever	A	M	112			33
57	Synchytrium dolichi	P	H	112	10	25	
58	Xanthomonas vaculorum	P	M	107	6	12	
59	Synchytrium umbilicatum	P	H	104	10	23	
60	Datura 437 virus	P	M	97	6	14	
61	Corynebacterium tritici	P	H	92	8	20	
62	Macrophoma mame	P	M	91	6	14	
63	Lepidosaphes newsteadi	I	L	91	45	111	
64	Dasychira pudibunda	I	L	87	162	399	
65	Ceratitis capitata	I	H	84	11	29	
66	Zabrus tenebrioides	I	L	83	44	109	
67	Agrilus viridus	I	L	82	231	570	
68	Colletotrichum zeae	P	M	80	8	22	
69	Zadiprion vallicola	I	H	78	2	11	
70	Operophtera brumata	I	L	71	35	85	
71	Maize stripe virus	P	M	71	4	10	
72	Heliothis armigera	I	L	67	27	67	
73	Trogoderma granarium	I	H	66	4	10	
74	Soybeans yellows mosaic	P	M	65	4	8	
75	Targionia vitis	I	L	63	25	63	
76	Pythium volutum	P	H	61	6	14	
77	Pseudomonas radiciperda	P	M	61	3	7	
78	Liothrips setinodis	I	L	60	30	74	
79	Diplodia zeicola	P	L	58	4	10	
80	Cucurbitaria piceae	P	L	56	4	10	
81	Eutetranychus orientalis	I	L	55	29	73	
82	Agriotes obscurus	I	L	54	22	54	
83	Sclerophtora raysiae	P	M	53	2	6	

TABLE 4-1 (Cont.)

Rank	Species	Type	Probability of Establishment	EEI Mid-Point	EEI Range (Plus or Minus) Confidence Interval 50%	90%	Direct Estimate
84	Amblyoma hebraeum	I	L	53	36	90	
85	Chrysomyxa deformans	P	M	52	2	6	
86	Chrysomyxa himalensis	P	M	52	2	6	
87	Agriotes sputator	I	L	50	20	50	
88	Nairobi sheep disease	A	L	48			16
89	Adelges japonicus	I	L	47	23	57	
90	Adelges tardus	I	L	47	23	57	
91	Spodoptera exempta	I	M	45	8	20	
92	Thecopsora areolata	P	M	44	2	6	
93	Ips typographus	I	L	43	57	136	
94	Physopella zeae	P	L	43	7	17	
95	Melanagromyza phaseoli	I	H	42	9	22	
96	Monolepta discrepens	I	L	42	53	131	
97	Macrosteles laevis	I	H	42	8	21	
98	Panolis flammea	I	L	40	17	41	
99	Heterodera rostochiensis	P	M	40	2	4	
100	Pucciniastrum padi	P	M	39	2	5	

1. Rank is based on the midpoint of Expected Economic Impact (EEI)
2. Type and number of species

A = Animal diseases	16
P = Plant diseases and nematodes	49
I = Insects and mites	35
Total species	100

3. Probability of establishment is rated as High (25-99%), Medium (16-24%), and Low (1-15%).
4. Range is the distance from the mid-point to the maximum or minimum value.
5. The EEI range for the animal diseases was estimated directly rather than by use of the model.

The data bank assembled by the Task Force can be used to assemble lists of pests that would attack specific animals or crops, and that could be carried by particular vectors. Examples of this are shown in the Report.

Chapter 4 closes with a table showing how the 100 most dangerous species are distributed over the world.

CHAPTER 5 - Programs for Foreign Protection

The Task Force reviewed the approaches foreign governments have taken to protect their agriculture from exotic pests and diseases. While about 80 percent of them regulate one or more categories of arriving agricultural cargo, most of them do not try to intercept agricultural products brought in by arriving travelers. Only 20 percent regulate both incoming cargo and passengers. All of the regulatory techniques we employ are also in use somewhere else in the world. We didn't find any countries using promising techniques that were not used by us, with one possible exception. At least one country requires its returning animal husbandmen to have their shoes and clothes cleaned before returning to their farms.

Although several hypotheses were advanced to explain the widespread policy of ignoring travelers as vectors of pest introduction, none stood up very well under examination leading to the conclusion that there was tacit recognition in most countries that the ratio of risk reduction to cost for this particular pathway is small.

Several of our attaches were asked to inquire about the existence of any assessments or evaluations of the agricultural quarantine programs that were being carried out in their assigned countries. None were found. The value and effectiveness of such programs is simply accepted on the basis of the presumptive evidence at hand.

CHAPTER 6 - Programs for U. S. Protection

The Task Force asked Vivian Wiser of ERS to prepare a history of agricultural import inspection work. The results of her research provide useful perspectives for the review of policies and programs. Chapter 6 begins with a condensation of that history which appears in full in the Appendix to the report. Following that there is a review of the program as it stands today, starting with a listing of the agencies involved in the inspection of personnel and cargo entering the U. S.

The acknowledged objectives and strategy of the present program are considered and found to be too narrow in their definition, and an alternative is offered, to wit:

> The objective of plant and animal quarantine programs is to provide adequate protection to the plant and animal resources of the nation, while avoiding unnecessary restrictions on international trade and commerce. This will be done by encouraging shipments of clean cargo, fostering inspection at source, and by excluding or restricting goods, materials, or carriers as necessary to prevent the entry of those exotic plant and animal pests and diseases expected to cause great damage.

The Task Force found that while the legal basis for the program provides sufficient authority to prevent the introduction of <u>any</u> exotic agricultural pest or disease, the quarantines and the quarantine manuals issued under the authority given us leave a lot to be desired. We recommend - and suggest a format for doing it - that the Quarantine Manual be completely rewritten so that it can easily be used by our employees in the field as an operating guidebook. Ideally, the Manual should contain a step-by-step outline of what inspectors should do from the time the carrier arrives until inspection of carrier and cargo has been completed in a manner which will result in reducing "pest risk" to a level acceptable to program managers.

We also believe that the initiation, modification and termination of quarantines needs more systematic attention in view of the rapid change in trade and transportation technology.

The issues of new transportation technology and new detection devices are considered at great length. Containerization will require a new configuration for the deployment of our personnel and different approaches to inspection. Bioluminescent sniffers are tools of great potential value in raising the effectiveness of our inspection efforts.

Finally, the Task Force took a look at sampling and its application to quarantine inspections. The need to employ some kind of sampling arises from our manifest inability to look at everything. The argument is over the particular approach to take. The adoption of probability sampling will yield reliable information about the population of imported items we inspect. The institution of such a system will require considerable soul searching on the part of program managers, for they will have to decide what level of infestation they are willing to live with. Right now we are obviously tolerating some level of infestation. But because of our traditionally unsystematic approach to sampling, we don't know what that level is or how it may have been changing over time. In fact, our haphazard use of this powerful tool precludes an objective evaluation of our import inspection efforts.

CHAPTER 7 - Assessment of U. S. Quarantine Efforts

Recognizing that ignorance must account for much of the contraband plant and animal material brought to the U. S. by international travelers, the Task Force inquired of the APHIS Information Division as to their experiences with attempts to educate the traveling public.

Although man-years expended in this effort have been small, the effort has resulted in:

Inclusion of pertinent information in the passport and, after a long delay, on the Customs Declaration, and in the popular travel guides.

Development of a working relationship with DOD on enforcement of AQI regulations with respect to returning personnel and retrograde cargo.

Production and distribution of exhibits, publications, foreign language flyers, motion pictures and consumer interest features for newspapers, radio and T. V.; testing effectiveness of using direct messages with airline passengers; and use of direct message at Mexican border checkpoints.

Information people have concluded that direct messages seem to be the best and most economical way reaching travelers. They have also learned that airlines are positively not interested in helping AQI out with the direct message approach, and that cooperation between agencies in developing multiagency handouts for use by carriers, terminal operators, etc., is all but impossible to achieve.

"Pestina," the AQI identifying symbol, is miscast. Her sexy features are inconsistent with the "don't pick her up" message.

The proportion of travelers receiving the APHIS messages is unknown, but for those who do and who wish to deliberately violate the regulations, there are two important incentives: It's o.k. if Customs doesn't find it and even if they do, the Customs or Agriculture inspector often allows it to pass; and the sanctions on discovery of contraband are trivial, if any. Not all products are, in fact, prohibited. The decision (made by a college graduate inspector) appears to be a service for travelers paid by the general public. Manifestly, maximum protection to that public would result from automatic confiscation by Customs, followed by immediate destruction.

The major handicap in attempts to evaluate the agricultural quarantine program is the paucity of data that would throw some light on the effectiveness of AQI activities. The inadequacies of the cargo sampling procedures have already been noted. On another level, we are unable to associate new pest finds with something that happened at a port of entry. The data situation with respect to inspection of baggage for contraband is much better, even though they point to a conclusion which does not support baggage inspection as it is carried out today.

Clearly, a major issue involved in enforcing agricultural quarantines is that of deterrence. Since a huge increase in manpower would be required to detect the low levels of infestation in cargo, and to intercept all the contraband, and since such increases are not in the cards, it follows that a major problem facing program managers is determining the number of policemen (inspectors) required to limit the number of attempts to bring in contraband or infested cargo to some tolerable level. Unfortunately, the learned journals and our law enforcement agencies have nothing to offer by way of theories of deterrence.

The Task Force did, however, acquire a conception of the conditions necessary for deterrence to work. These, together with a discussion of penalties for violating AQI regulations, appear at the end of the section on deterrence in Chapter 7.

Several examples of quarantines used as trade barriers are offered as evidence that quarantine programs are not without subterfuge.

The Task Force Chairman interviewed a number of key airline personnel at Kennedy International Airport to assess program impacts on airline activities. In general, the airlines will actively oppose any rules or requests for cooperation which will raise their costs by so much as one iota. They do not wish to impair their competitive position in the field of transportation, and they are severely limited by government regulation as to the extent to which they can pass increased costs onto their customers.

Major complaints were directed against AQI activities that increased dwell time for cargo, turn around time for aircraft, and food waste.

The Task Force invited <u>all</u> agricultural import inspectors to provide Dr. McGregor with their comments, complaints, and insights concerning the program. A disappointing number of responses was received (15), but their quality was high. Subjects drawing the greatest attention were: the sealing of ship's stores in galleys on freighters; lack of scientific information about pest establishment; need for a global approach to the problem; requirements for inspectors; preclearance and compliance agreements.

Chapter 7 closes with a lengthy discussion of the problems involved in assessing ~~the~~ value of our quarantine efforts and a theoretical approach to maximizing the amount of protection with the available funds. Neither the data routinely collected as a part of program operations nor the program procedures as variously pursued at the many ports of entry fit into frameworks appropirate to cost-effectiveness analysis. The available evidence does not support any particular conclusion as to the value of the program. Thus, the effectiveness of our import inspection efforts remains a matter of speculation.

CHAPTER 8 - Conclusions and Recommendations

Major changes are needed in order to achieve the maximum reduction of risk that is possible with whatever resources are available. A transformed program should be based on these eight principles:

Worldwide movement of pests should receive primary attention.

APHIS should adopt a more balanced, realistic program goal.

Effort should be concentrated on the highest risks.

Biological uncertainties with respect to pest distribution, survival in transit, colonization characteristics, etc., should be reduced through the acquisition of new knowledge.

Compliance, not enforcement, should be the operating philosophy.

Private efforts to reduce risk should be encouraged.

Explicit standards with respect to tolerable levels of infestation must be established.

Both the framework and the data for evaluating the effectiveness of import inspection should be built into the program.

In line with these principles, the Task Force recommends the development of a source inspection system which will provide incentives for exporters in foreign countries to ship us pest-free commodities, and sanctions if they do not. It involves shifting the cost of treatment and intensive inspection from general taxpayers to the exporters. The proposed Agricultural Source Inspection and Surveillance Technique (ASIST) involves mainly: Establishment of standards, source inspection of material, monitoring the performance of the exporters in the U. S.

Recognizing that the development of ASIST will take a lot of time, the Task Force recommends several changes in the current program in line with the previously stated principles:

1. Revise strategies so as to concentrate on high risk species, with emphasis on exclusion as the appropriate policy.
2. Turn over passenger baggage inspection and the interception of contraband to Customs, eliminate the practice of allowing exceptions to be made as to the admissability of certain agricultural products, and monitor the performance of Customs in seizing contraband.
3. Eliminate border inspection of passenger vehicles.
4. Regulate germ plasm traffic more carefully.
5. Develop a Pan-American Quarantine.

Whether or not ASIST is adopted, the following changes should be made in program operations:

1. Review and streamline regulations.
2. Establish uniform inspection procedures.
3. Employ statistical sampling.
4. Use new detection and control devices.
5. Test pathway survival.

1 INTRODUCTION

11 STATEMENT OF THE PROBLEM

Responsible officials in the U. S. Department of Agriculture have long had an uneasy feeling about the efficacy of efforts to prevent the entry of exotic pests and diseases of plants and animals. The rapid increase in traffic at this time of budget restrictions limiting program effectiveness dictated the need for a close examination of current status, with the hope that some new procedures for dealing with risk from exotic pests might be found which would be more effective and less expensive.

The problem is viewed as a matter that requires a complete examination of the U. S. policy of pest and disease exclusion and not as a matter of evaluating the efficiency of current programs. Alternatives for change in the present policy and programs will be severely circumscribed by constraints of budget, bureaucratic and organizational limitations, and attitudes in the political and industrial environments.

There are many facets to the problem. Among the questions and considerations that led to this study are the following:

11.1 Disagreement on Objectives. There are different concepts of the purpose of the regulatory program. The program managers and indeed the inspectors themselves seem to believe that the objective is to protect U. S. agriculture by the complete exclusion of exotic pests and diseases. This is to be accomplished by permitting the entry of only those agricultural materials that have been inspected and found to be pest-free, or are so certified by other authorities, or by treating the materials to eliminate the pest or disease present. In addition, any imported material must be inspected to preclude the possibility that it is harboring agricultural pests. As a result, program accomplishment is reported in terms of the number of damaging pests that have been intercepted; i.e., excluded, from the U. S.

On the other hand, a number of key policymakers, noting the rapid expansion in international trade and passenger traffic and the difficulty of obtaining resources for a program of exclusion, are more realistically considering development of a program based on risk reduction. The objective of such a program ought to be to limit the risk of importation to a level that can be tolerated by U. S. agriculture without a massive increase in personnel and funds.

Thus, stress has developed between the policy officials and the program managers. The program people are frustrated and disheartened by the lack of resources which in their view are needed to carry out the program. Policy officials are frustrated because they can't get a real handle on program efficacy and are unable to visualize exactly the program configuration to be usefully employed. Furthermore, they find program people generally unwilling to experiment, committed as they are to a policy of exclusion. A policy analysis and an improved program design is needed.

11.2 Program Effectiveness. It is unfortunate that the numerical data on the regulatory program has to be treated empirically, because the figures cannot be analyzed statistically or scientifically. The number of inspections and the amount of contraband intercepted may be a measure of individual or unit work performance. However, the quantity of interceptions has no meaning as a measure of program effectiveness because its relationship to the total size of the import assault is unknown. Furthermore, there is no way of measuring the number of pests which have entered and failed to become established, or the number of challenges which are required to establish a pest. As a result, the Secretary's office and the Congress have no basis for determining the amount of resources that may be usefully employed. Managers have little guide to the deployment of their resources against flows of incoming materials. Nor is there any basis for responding to criticisms of program effectiveness. A significant number of pests and diseases have entered the country since 1884, when the program was instituted; e.g., Foot-and-Mouth Disease (3 times); Medfly (5 times); and Chestnut Blight.

The recent findings at Kennedy Airport of a 50% probability of discovering agricultural contraband when present in passenger baggage certainly indicates that present procedures are not very effective in blocking that particular route of introduction. In addition, the findings raise fundamental questions: What should be the rate of contraband interception in order to achieve a significant reduction in risk? How much risk is associated with agricultural contraband in travelers' baggage? What proportion of the total risk of introduction is in airline passenger baggage vis-a-vis other pathways of entry?

11.3 Changes in International Traffic. The increased volume of passenger traffic entering the U.S. by air and by the land routes from Mexico and Canada places severe stress on the existing inspection force. The attempt to streamline inspection at Kennedy and other airports a few years ago was in reaction to the problem of rapidly increasing workload. Currently, the rising emphasis on stopping drug importations now takes first priority among the various reasons for inspecting passenger belongings.

The rapid rise of containerization raises all sorts of questions about cargo inspection procedure and about the validity of any procedure.

Since cargoes are often assembled in containers well within the boundaries of the exporting country, and since U.S. destinations are not only inland but widely diffused, traditional inspection sites at ports, whether of embarkation or entry, seem to be obsolete. Can containers be opened at a point of entry without undue interference with rapidly moving commerce and without reduction in the economic benefits inherent in containerization? If opened en route is inspection a practical matter, given the problems of access to the cargo? Consideration of the container itself as an environment in which the pest must travel requires detailed study.

A substantial change is taking place in the relative importance of U.S. ports as an increasingly larger percentage of cargo enters the U.S. in containers. Inspection personnel ought to be deployed to meet this change.

The expanding and shifting patterns of agricultural trade as developing nations begin to enter world markets and as the U.S. attempts to increase its own agricultural exports to benefit our balance of payments raise challenges to our present quarantine operation.

All of these changes in international traffic will have effects on the risk of pest importation. Better understanding of these impacts and suggestions for adapting the program are needed.

11.4 Expanding Budgets. In the annual budget cycle it is necessary to consider the financial needs of the existing inspection and quarantine program. With the rising traffic volume there is a temptation to relate dollars directly to "workload," and to lose sight of the fact that what is being purchased is some amount of risk reduction rather than a number of inspections. What is the risk? How much risk reduction is being purchased by the present program operations? Doesn't more luggage and more cargo simply require more inspectors? If not in direct proportion, isn't there at least some relationship between traffic volume and resources required?

No one appears to have satisfactory answers to these questions, and the annual decisions on budget are at the least uncomfortable, and at worst purely arbitrary.

11.5 Agency Relationships. Agency relationships, particularly with the Bureau of Customs, appear to be unsatisfactory. In passenger baggage, Customs receives funds from Agriculture to enable them to increase the volume of baggage that they would normally inspect. What volume does Customs consider "normal" to meet its responsibilities? How much additional inspection takes place? Does this increment meet Agriculture's needs? Are Agriculture's needs (standards) 100% inspection? Is the additional increment of Customs inspection purchased by Agriculture allocated to appropriate ports for high risk passengers in conformity with Agriculture's assessment of risk?

How do inspectors decide whether imported foods are to be inspected by the Food and Drug Administration or by Agriculture? Is it improper to have these products inspected by both agencies? Does the Fish and Wildlife Service inspection for endangered species consider the likelihood of domestic animal diseases?

How is it that the Customs job can be done with high school graduates, whereas Agriculture requires a college degree? Since Customs has the responsibility for enforcement of the Acts, is there a legitimate role for an agricultural inspector, where a Customs man is on duty?

11.6 Baggage Inspection Standards. Agricultural policy seems to emphasize 100% inspection of passenger baggage in order to secure adequate protection. Indeed, this is sometimes given as the rationale for the transfer of funds to Customs. Yet, the present rate of baggage inspection by Customs is estimated to be about 20% overall at our largest port of entry. Is the 100% standard possible? What standard is desirable? Is some standard less than 100% acceptable?

11.7 Improved Detection Capability. There has been remarkable technical achievement in sensors in recent years and many new devices are available or under development. What are the possibilities for such devices in baggage or cargo inspection? Should investments be made to adapt such technologies to the inspection process?

These wide-ranging questions and considerations led to this study. It was hoped that answers might be found, or at least, that some new kinds of useful information could be provided.

12 OBJECTIVES

The study has two objectives, agreed upon at the outset, as follows:

- --To define and quantify the risks from the entry of those exotic plant and animal diseases that are major threats to our environment and our food and fiber supplies during the next twenty years.
- --To develop and analyze strategies for protection against exotic diseases and pests.

13 APPROACH

The approach puts together scientific, technical and administrative judgments from the best sources available. The study is partly descriptive, partly analytical, and partly judgmental. It includes background on the biology of major exotic pests and diseases, descriptions of trade patterns, developments in detection technology, economic assessment of probable losses, and comments on current performance. It is a compendium of many kinds of expertise and judgments.

Domestic quarantines are excluded, as are domestic control and eradication efforts. Also excluded are the inspection and quarantine actions of the States, such as California and Florida. The relationships between Agricultural Quarantine Inspection and the major border inspection activities of the Department of the Treasury (Customs), Justice (Immigration and Naturalization), and HEW (Public Health) have not been explored. The study focuses on agricultural quarantine of exotic pests and diseases.

Dr. Ned D. Bayley, Director of Science and Education, when the study was initiated, posed the objectives, sought to formulate the major questions, and encouraged the Task Force. The study was undertaken at the request of Dr. Francis J. Mulhern who provided for the participation of the Task Force members, and periodically reviewed progress. The original design for the study was formulated by Mr. Richard D. Butler, Director of the Planning and Evaluation Staff, APHIS. In addition, Mr. Butler monitored the day-to-day operations of the study, working closely with the Task Force Chairman.

The study was conducted under the leadership of Dr. Russell C. McGregor of the University of California, who was employed by the Animal and Plant Health Inspection Service (APHIS) as a part-time consultant. Dr. McGregor was responsible for conceptualizing the problem, selecting the Task Force members, establishing the study procedures, assigning tasks, and writing the final report. While the members of the Task Force are in overall agreement on the content of the report, they do not necessarily support each of the final conclusions and recommendations. These are the responsibility of Dr. McGregor.

It was agreed that the study might propose new laws, policies and the most effective programs to reduce risk, including trials of new procedures and methods, or more effective configuration and deployment of existing quarantine efforts to increase the probability of exclusion. The proposals were to be operationally feasible and reviewed and critiqued by APHIS program managers prior to submission of the report; they did not need to be limited to actions that could be taken within existing funds, nor need they be limited by existing laws or policies. Detailed organizational plans were not required, since they could be developed by APHIS officials subsequent to completion of the study.

14 PROCEDURE

Having agreed upon the objectives and the general approach to the problem, the procedure for carrying out the study consisted of five operations.

First, an outline was prepared of the principal analytical issues and critical questions to be considered by the study. This outline included a discussion of seven topics. Their titles were as follows:

--Major International Pest and Disease Threats
--The Consequences of Introducing Exotic Pests
--International Pathways of Pest and Disease Movement
--The Effectiveness of Quarantine Programs
--Protection as a Concept
--Increasing the Future Supply of Protection
--New Programs

These topics served as a working outline for the final report. They also provided the framework to identify the individual tasks that needed to be done.

Second, 36 separate tasks were described, assignments of personnel were made, and deadlines established.[1] Each description included the title, objectives, assignment, performer, time, deadline, product, and approach.

Third, a critical path flowchart was laid out illustrating the span of working time for each task and its relationship to other tasks.[2] This chart, termed a "Game Plan," also arranged the tasks according to the kinds of talents required; i.e., entomology and pathology; psychology and sociology; history, law, policy analysis; economics; engineering and transportation; statistical analysis; organization and management; synthesis and interpretation. In addition, the Game Plan called for 12 output and recommendation papers to be produced during the year-long stud As expected, there were many alterations made along the way, and the deadlines required constant readjustment.

Fourth, six Task Force members, knowledgeable in some aspect of the problem, were selected to assist in getting the task completed. At the first meetings the objectives, the outline of issues, the task outlines, and the Game Plan prepared by the chairman were reviewed and revised. At subsequent meetings progress was reviewed, status reports were prepared, and plans were updated and revised.

Finally, the chairman prepared a draft from the papers submitted for each of the tasks. Each member of the Task Force reviewed and critiqued the draft, resulting in this final report.

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1. A complete list of titles of the tasks is in Appendix 1-A.
2. A copy of the Game Plan is Appendix 1-B.

2 THE ARRIVAL OF IMMIGRANT SPECIES 1/

21 THE POTENTIAL FOR INTRODUCTION

The continental United States has been and is particularly prone to pest introduction. It is a large land mass settled and developed agriculturally in 500 years. Our crops are introductions for the most part. Pests were in many cases introduced with these crops. The "melting pot" of ethnic groups, it is likewise the melting pot of crops and pests.

In 1919, J. A. Stevenson of the Bureau of Entomology and Plant Quarantine listed 120 foreign plant diseases known to have been introduced into this country, and commented that the list was far from complete both because all present are not recorded and because those introduced in earliest colonial times were not so recorded. Some rusts and smuts of cereals are in this category.

The appearance of additional foreign pests has continued since that accounting and there is no doubt that introduction and establishment continues. For example, the Dutch Elm Disease was first noted in Ohio in 1931, the golden nematode of potato in Long Island in 1941, witchweed of corn in 1950 - these are only a few. A recent listing by A. J. Watson, 1971, lists 1,492 bacterial and fungal diseases foreign to the United States, and the listing excludes viruses, nematodes and all diseases of forest trees.

No one can say with certainty how many different kinds of insects are included in the total world fauna. We know that somewhat more than 900,000 have been named. Conservative estimates of the actual number of species range from 2.5 to 5 million. Of those named, detailed knowledge of the behavior, biology, and ecological requirements of all life stages is available for no more than 10,000. Among the vast array of insects and related anthropods there exist species adapted to fill almost any conceivable ecological niche. It is doubtful that any terrestrial or fresh water plant or any land animal is immune from some form of insect attack.

While many insect-host associations are mutually beneficial and others benign to the host, many insects and mites are able to completely destroy their primary host. This may be due to direct utilization of the host as food or indirectly as the vector of disease. The fact that plants and animals are able to coexist in communities and ecosystems is a consequence of evolutionary processes that interpose checks on the disproportionate increase of any member of the ecological community - be it plant, animal, insect or pathogen. These checks take the form of host resistance and natural enemies adapted to utilize other organisms as food. The mortality caused by an attacking insect commonly elicits some form of defensive response that tends to protect the host. At the same time natural enemies respond to increased numbers of a host by causing progressively greater mortality, and thus become regulative.

1/ This Chapter is based on material contributed by the Task Force Scientists: Reece Sailer, Charles Kingsolver, and Don Johnson.

Since ecosystems evolved long before man became an important force in evolution, their stability was determined by factors of climate, geography and isolation. During the past 5,000 years man has modified the environment at an accelerating rate. Through his agriculture and other impacts on environment he has created new, usually much less complex, ecosystems that became increasingly vulnerable to disruption through pest attack as the area and intensity of agriculture grew. Initially these effects were small and confined to areas where crop plants and livestock were first domesticated. However, the age of discovery that began when Columbus discovered America in 1492, set in motion changes that affected the world biota on every continent and most islands. No continental area has been more affected than that of the United States.

During the past 480 years the geographic barriers provided by the Atlantic and Pacific Oceans have been breeched by man's commerce, and the ecology of the continent changed by his agriculture and other activities. In developing the agro-ecosystems that now occupy most of the United States, European immigrants adopted and greatly expanded the culture of such native crop plants as corn, cotton, potatoes, and tobacco. They brought with them wheat and other small grains, forage crops, livestock, vegetables, and fruit trees. Inadvertently they also brought weeds, insect pests, and pathogens. Many thrived because they were unaccompanied by natural enemies that were present in the agro-ecosystems of Europe. Others failed to overcome the natural ecological barriers to colonization. As commerce to other parts of the world increased new pests and diseases continued to arrive.

22 THE PATHWAYS

22.1 Historical Pathways. Insects and pathogens foreign to North America have been gaining entry and colonizing favorable habitats within the boundaries of the United States for at least 350 years. The successful immigrants for the most part have been those best adapted to survive in the pathways of entry and fortunate enough to find a favorable environment in which to live and reproduce once they arrived. Initially the successful species were those associated with man (bedbugs, body lice), his stored products (granary weevil, angoumois grain moth, cheese mites, etc.), and his livestock (house fly, cattle grub, and horse bots). These were species that could survive a long sea voyage because they remained associated with their food supply. During this early period of colonization the entry of animal pathogens with importations of livestock was probably constrained by the long sea voyage. Animals weakened by disease could not survive and were disposed of at sea. During this early period and continuing until comparatively recent times, ship ballast provided means for the entry of many soil-inhabiting pests. Those that arrived early by this route were mostly innocuous or even beneficial forms such as ground beetles, but later arrivals included such notorious pests as the imported fire ant, and white fringed beetle.

As settlement progressed and permanent agricultural communities became established, nursery stock for planting of orchards was imported, accompanied by a variety of such pests as fungal, bacterial and viral pathogens, scale insects, aphids, and codling moth. With arrival of additional human immigrants from different countries new kinds of crop plants and additional kinds of insects and plant pathogens were added to American agro-ecosystems. The new species often found previously pest-free crops and an environment where natural enemies were largely absent. The resulting population explosions of pest species were an all too common phenomenon and in good part explains why the United States very early gained world leadership in the field of plant pathology and economic entomology.

Until comparatively recent times, as might be expected, most of the invading species came from Europe. However, from the last quarter of the 19th century through about 1915, as the source of imports shifted, there was a large influx of immigrant species from many other parts of the world. Many of these were insects belonging to groups that feed by sucking the sap of their host plants. They were the scale insects, aphids, thrips, and mites. More than 200 such species arrived with serious and often catastrophic effect to citrus and deciduous fruit production, as well as to a great variety of ornamental plants. Unquestionably living plants, the soil in which they were rooted and their seeds or fruits, have been a pathway of entry for a majority of the foreign fungal and insect species and the nematodes and viruses now in the United States.

It was not until the middle of the 19th century, that farmers and agriculturalists became acutely aware of the economic significance of the losses to our agriculture caused by pests and pathogens being introduced with imports from foreign countries. The epizootics of contagious bovine pleuropneumonia (1843) and Foot-and-Mouth Disease (1870) led to the appointment of specialists to study the diseases. Reports of these studies included evidence identifying countries of origin, importers, pathways of entry and the economic impact of the disease. Unquestionably, there were prior incursions of pests and pathogens of crops and livestock of equal or greater economic significance; however, the disease was either less dramatic in appearance at the time of entry, or the origin and economic impact was obscure. These studies increased our awareness of the vulnerability of our developing agricultural industry to foreign pests and diseases and gave impetus to the enactment of legislation authorizing the quarantine of imports to reduce the threat.

For 1972, the Bureau of Customs reports that the pathways of entry consist of an estimated 70 million carriers of persons and merchandise arriving in the U.S. from foreign countries. More than one-half of these were vehicles entering from across the Mexican border. This volume of traffic is steadily increasing.

22.2 Aircraft. Since 1940, aircraft have assumed increasing importance as a pathway of entry. The rapidity with which planes move from one part of the world to another allows short-lived, winged adult insects and infective propogates of plant pathogens to survive transit and escape into new geographic areas. The number of planes involved, and the number of distant locations that may be visited on a single flight, increases the magnitude of this threat.

Many of the new exotic additions to our North American insect fauna will arrive by aircraft. Among these insects are those which serve as vectors of plant virus diseases. It is possible that viruliferous insects could survive this pathway to introduce new virus diseases. Short-lived spores of plant pathogens will also enter by this route.

22.3 Scientists as Pathways. The airplane has accentuated another problem that has long existed. For a variety of reasons biologists frequently wish to use exotic pests and plants as objects of experimentation. Often this is because a foreign scientist has used these species in his research and has developed background knowledge of a kind essential as a starting point for the American scientists' research. In other instances a traveling scientist is tempted to bring breeding stock to his home laboratory because it has characteristics that pique his curiosity. Once such an organism has become the subject of some unusual research contribution, other scientists will often wish to obtain cultures. Unquestionably, certain exotic species of cockroaches have become naturalized as a result of this kind of dispersal.

We may expect that this avenue of entry will become more important as a result of increased interest in research on genetic control of a variety of pests and diseases. In this case, the danger is often that of increasing the gene pool of an already established pest, but there is also the danger of introducing closely related species having different potential as pests. This could be the result of deliberate introduction for use as sterile hybrids in control experiments or inadvertent introduction of species thought to be the same as an established pest.

Where such research is conducted by competent, responsible scientists under adequate quarantine, no significant hazard will be involved. However, competency, responsibility, and adequacy are all relative terms and any such research should be kept under strict surveillance by competent regulatory personnel.

A more serious danger is the scientist who wishes to bring in an organism but is either unaware of regulations or deliberately chooses to ignore such regulations. He may correctly regard his plant or insect to be entirely harmless, but what he may not recognize or have the competence to detect are associated pathogens and potentially injurious parasites. When such efforts to introduce organisms in violation of regulations are detected they should be investigated. Undetected violations are sometimes discovered later, as the scientist is likely to publish results of research involving the illegally imported organisms. If the violation has resulted in any adverse economic effect, or could have done so, the violator should be held responsible and the matter fully publicized.

23 COLONIZATION AND ESTABLISHMENT

23.1 Food Resources and Environmental Resistance. One of the principal characteristics of all living organisms is their innate tendency to exploit food resources to limits imposed by their environment. Where the entire resource is within bounds of limiting environmental factors both the organism and the resource are in jeopardy of extinction. In long established ecosystems evolutionary processes establish mechanisms that allow the organism and a self-replenishable resource to coexist. In the case of insects and the plants on which they feed, the accomodating mechanisms take a variety of forms. One of the more common is some form of host resistance whereby the plant imposes limitations on the fecundity or survival of the developmental stages of the insect. A second mechanism is one that pervades all ecosystems; this relates to the role of natural enemies whereby a plant-feeding insect is in turn the food resource of one or more other organisms. Like host resistance, the action of the natural enemies imposes limits on the ability of the plant-feeding insect fully to exploit its host.

These fundamental characteristics of host-exploiter relationships and ecosystem evolution are critical to an understanding of the objectives and operation of agricultural quarantine and pest control programs. One of the explanations for the successful invasion of new organisms lies in the post-Pleistocene history of the North American flora and fauna.

Following the withdrawal of the last continental ice sheet about 10,000 years ago, the North American biota reoccupied the glaciated areas and species assorted themselves into life zones and biomes according to their environmental requirements and to limitations imposed by internal ecological or geographic barriers. Except as they made use of fire, the aboriginal inhabitants had little influence over the history of the ecosystems that evolved in North America prior to the arrival of Europeans. However, within a few years after Columbus made landfall at the island of San Salvador in 1492, events were set in motion that were to affect the North American biota more profoundly than did the glaciers of the earlier epoch.

With the arrival of the Spaniards, Frenchmen, and Englishmen, came the livestock, field crops, horticultural crops and ornamental plants of Europe, accompanied by camp-following insects, weeds, and diseases. As the population of the U.S. increased, the number and size of the farms increased to meet the demand for food. The increased acreage of crops and herds of livestock enhanced the probability that a susceptible host would be exposed to, and infected by a foreign pest or pathogen that might enter. The concentration of the industry increased the potential for diseases to spread and become established. As agriculture spread across North America, commerce reached out to all parts of the world, and additional alien species gained entry and became part of the North American biota.

23.2 "The Sweepstakes." It is evident that there is an unknown, but very large number of foreign insects, bacteria, fungi, viruses, and nematodes that are potentially dangerous to the agriculture and environment of the United States. These may number 6,000 insects alone. On the basis of past experience we can predict that a certain number of these species may gain entry in a given period of time, but we cannot predict their identity. We can predict with greater reliability that certain notorious pests such as the Mediterranean fruit fly and the Khapra beetle will be excluded during the same period, but even here the confidence limits are not reassuring.

These potentially dangerous species are ticketholders in a sweepstakes lottery. A relatively small number of the species hold a disproprotionate number of the tickets and thus increase their chance of entry. Many of the tickets are lost in the pathways of entry. Since the sweepstakes are illegal in the U.S., any tickets found by quarantine inspectors are confiscated and destroyed. Before the final drawing inside the United States the ticketholders are subjected to a series of chance hazards and a final fitness test.

With few exceptions, each of the 6,000 or so pests on our list will almost surely not become established in the U.S. in the next few years. Yet, it is almost surely true that some of them will become established here. This paradox points to the futility of gearing countermeasures to a pest-by-pest approach. We cannot have a thousand programs to counter a thousand unlikely pests. Some will get through.

Once past the quarantine barrier, the pests, represented in the case of insects by perhaps no more than a single fertilized female, must find a food source. If such a female is adapted to the subtropical climate of Florida, and finds herself on the ground at Kennedy airport, she is a loser. On the other hand, if the same female manages to make it over the fence of the Miami, Florida, airport, chances of finding a favorable habitat for her progeny are vastly improved. However, a chance encounter with a hungry ant, bird, or other predator, may eliminate a potential winner. But assuming that the gravid female survives all hazards and produces her allotted number of progeny, these must survive and reproduce. Numerous hazards continue to confront the incipient population. Weather, the availability of food, and predators threaten extinction. But, perhaps of greater importance, behavioral and genetic characteristics now may determine the success or failure of permanent establishment. If the species is parthenogenetic, then it has a great advantage. In a bisexual species, the individuals of different sex may mature at different times, and may exhibit a dispersal phase between adulthood and sexual maturity, that is genetically determined. This can easily result in the failure of the females to find mates when they are sexually receptive, and a consequent failure to colonize.

As in the insect case cited, plant pathogens face a somewhat similar sequence of probabilities. The infective propagule must be transported except for those with airborne spores - to a susceptible host crop and arrival must coincide with environmental conditions required for infection. Probability of success is extremely low, but propagule populations are high and resistance of some fungal spores and of nematodes to adverse environmental conditions is astounding.

23.3 Genetic Barriers. Assuming that the first generation of females have found mates and food resources are abundant, there remains a genetic barrier to successful establishment. This is the genetic load of recessive, deleterious and often lethal alleles that are present, to some degree, in all organisms. This genetic load differs between species, and within a species may vary between populations. To avoid the deleterious effects of the genetic load, most bisexual organisms have evolved mechanisms to prevent inbreeding. In the case of man, laws against incest serve this purpose. Where close inbreeding occurs, as it does in a new immigrant population, any recessive deleterious alleles have a high probability of becoming homozygous, and the recessive characteristics they determine will be expressed. This commonly results in reduced fecundity, high mortality during development, and the shortened longevity of adults. It is the frequent cause of loss of laboratory cultures of insect species maintained through several generations. If, despite this reduction in reproductive potential, an incipient immigrant population can survive through several generations, it may eventually reduce its genetic load sufficiently to restore genetic vigor. This would result from selective elimination of deleterious alleles from the gene pool. There is also the chance that new arrivals would permit restoration of genetic vigor through outbreeding. Obviously, this final obstacle to establishment of an immigrant population will be affected by the number of colonizing individuals as well as the level of genetic load of the population and mating behavior characteristics of the species.

In view of the hazards encountered in the pathways of entry and obstacles to be overcome during early stages of colonization, the number of "sweepstake winners" is remarkably high. This again points to the overriding importance of an adequate food resource and the absence of appreciable environmental resistance as dominant factors in the success of invading species. Quarantine measures may change the odds, but they cannot change the basic rules of the game.

24 THE RECORD OF ESTABLISHMENTS

Under the leadership of Dr. Reece I. Sailer of the Task Force, a survey of adventive insects known to be established in the continential United States was undertaken, with the help of the taxonomists in the ARS Systematic Entomology Laboratory and the Smithsonian Department of Entomology. While not complete, the resulting list now includes 1,115 species. The insects and mites that comprise this list gained entrance during the past 480 years and have become part of the North American fauna. None were deliberately introduced by man, yet few, if any, would have reached the United States through natural pathways of dispersal. Fewer still could have founded colonies without the substantial changes in food resources and the reductions in environmental resistance caused by the development of agro-ecosystems.

While 1,115 species may appear to be an impressive number, it is in fact only about one percent of the total insect and mite fauna of the continental United States. Yet this one percent includes pest species that account for a great part of the losses caused by pests.

In assembling the list of adventive immigrant species, a date of earliest known occurrence in the U.S. was established for as many of the 1,115 species as possible. Such dates were fixed for 955. Admittedly, such dates for many of the species are the accident of collection or of study by a taxonomist, and the rate at which they are discovered may reflect the amount of effort expended in searching, as much as any other factor. In most cases, a species would have been in the United States many years before it was collected and identified, and it would be hopeless to attempt to pinpoint the year of arrival. This is particularly true in the earliest years, when there was a scarcity of talent for identification. Nonetheless, it is of interest to examine the historical record of new alien species as recorded by their earliest known occurrence in the United States.

Table 2-1 is a listing of immigrant insect and mite species, not purposely introduced, according to their estimated time of arrival in the United States. The record includes only the 48 contiguous States. Introductions in the 17th and 18th centuries are mostly those inferred by the known habits of the species, although reasonably accurate dates can be fixed for a few. For example, it is known with some certainty that the Hessian fly became established in 1778, and the boll weevil in 1892. These insects caused so much damage that the time of their introduction was widely noted. In view of the nature of the records, however, it seems appropriate to lump the early data into 100-year periods. Following 1800 the records are treated as totals for 20-year periods, and after 1900 the quantity and quality of data is such that 10-year periods are used. Note that dates of arrival have not been established for 160 species.

Table 2-1 also lists the average number of new species established per year, in each of the periods of record. This reveals a rapid increase up to about 15 species per year in the 1910-1919 decade. Since about 1920, the rate of establishment of new species has stabilized at between 8-1/2 and 9 species per year. This information is presented graphically in Figure 2-1.

TABLE 2-1

NUMBER OF IMMIGRANT SPECIES OF INSECTS AND MITES,*
BY PERIOD OF FIRST KNOWN ESTABLISHMENT IN U.S.**

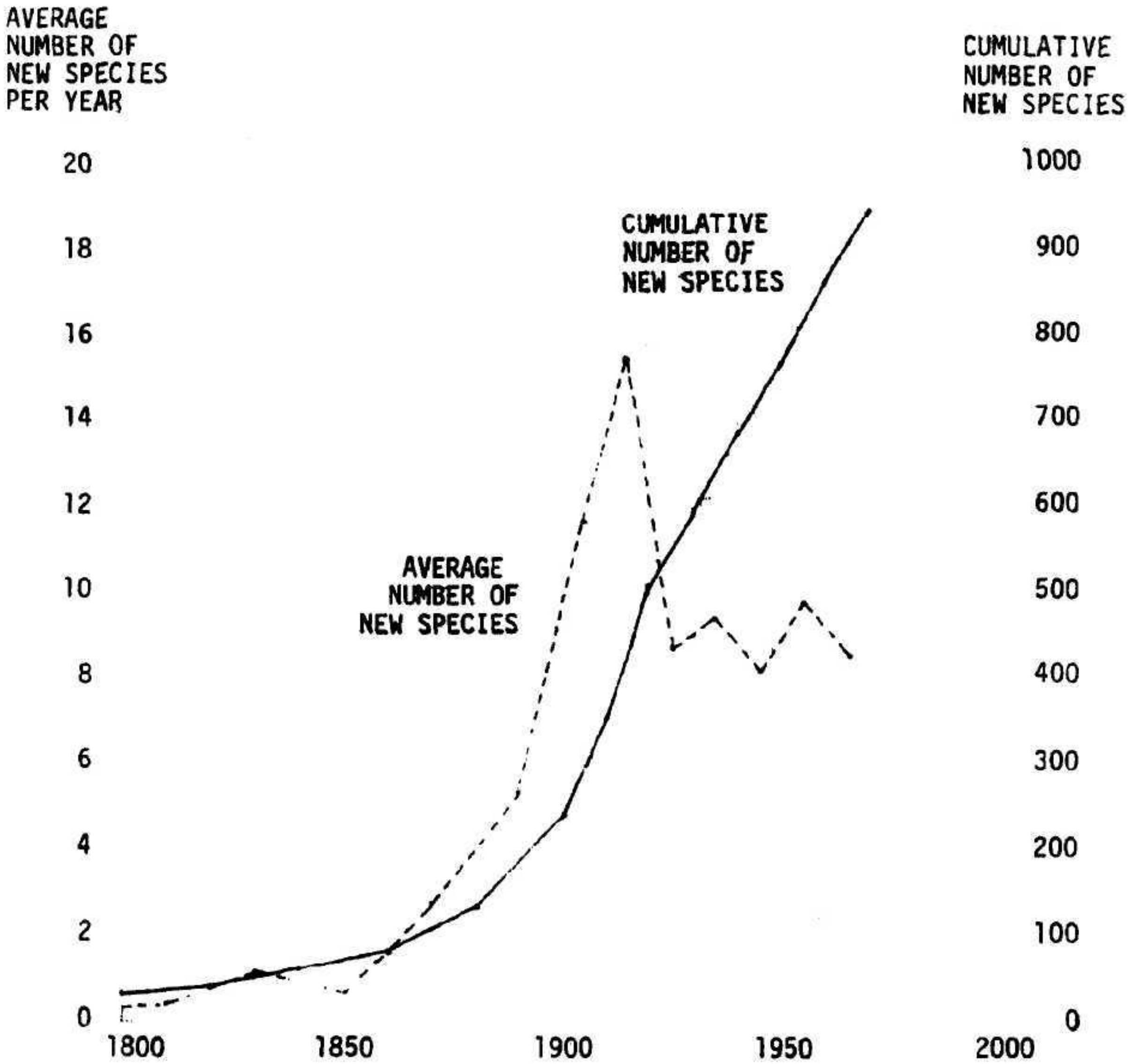
Period of Establishment	Number of New Species Established	Average Number of New Species Established Per Year	Cumulative Number of New Species Established
100-Year Periods:			
1600 - 1699	13	0.1	13
1700 - 1799	17	0.2	30
20-Year Periods:			
1800 - 1819	9	0.4	39
1820 - 1839	22	1.1	61
1840 - 1859	13	0.6	74
1860 - 1879	53	2.6	127
1880 - 1899	105	5.2	232
10-Year Periods:			
1900 - 1909	115	11.5	347
1910 - 1919	153	15.3	500
1920 - 1929	86	8.6	586
1930 - 1939	92	9.2	678
1940 - 1949	80	8.0	758
1950 - 1959	96	9.6	854
1960 - 1969	83	8.3	937
Recent Period:			
1970 - 1972	18	6.0	955
Unknown Period:	160	-	-
TOTAL	1,115		

* Excludes those species that were purposely introduced.
** Includes only the 48 contiguous States.

FIGURE 2-1

NUMBER OF IMMIGRANT SPECIES OF

INSECTS AND MITES ESTABLISHED IN THE U. S.



The fourth column of Table 2-1 lists the cumulative number of new species established, excluding the 160 for which dates have not been established. This data is also displayed graphically in Figure 2-1. It will be noted that the number of alien species increased very slowly prior to 1860. Following this date, the curve of the line rises steeply, until 1920, when there is a modest deflection of the slope, which then continues as a nearly straight line to the present date. The deflection of the nearly exponential curve to a straight line following 1920 is a puzzling phenomenon.

In addition to the increasing volume of trade following 1920, the later time period includes the advent of air travel. There was a burgeoning increase in ship and aircraft arrivals and a remarkable decrease in transit time between foreign and U.S. seaports and airports. These factors should have increased the rate of introduction of foreign species and the establishment of colonies. At the same time, there was an increasing number of entomologists engaged in research, regulatory and control activities. This factor would presumably decrease the time lag between establishment and discovery. Quarantine exclusion measures may also play a role.[1] However, to whatever extent quarantine measures are able to focus of pest organisms, rather than on all immigrant species, their influence on the rate of introductions will be selective, rather than providing a general restraint. Increasing environmental resistance due to the rapid filling of ecological niches in the prior period may also be a part of the explanation. Unfortunately, the data do not appear to provide a basis for deciding on the relative importance of these influences, and the decreased rate of establishment since 1920 remains unexplained.

25 THE HAWAIIAN EXPERIENCE

The Hawaiian Islands are remarkably well suited to the study of factors relating to invasion of foreign organisms. The climatically favored islands have never been connected to any continental land mass and have been geographically isolated from the world biota since their origin several million years ago. Prior to the arrival of Europeans in the 18th century, the islands were populated by a fauna and flora derived from waif species that have been estimated by Zimmerman to have arrived at a rate of one per 50,000 years. During the past 250 years, the native fauna and flora have been in good part displaced, and many species reduced to extinction as a result of invasion by nonindigenous man, his crop plants, domestic animals, and camp following weeds and other organisms. It was early recognized that the crops which thrived when first introduced were highly vulnerable to insect pests that either accompanied the imported plants or gained accidental entry at a later date. This problem was so serious that Hawaii early recognized the importance of importing parasites and predators and was remarkably successful in obtaining biological control of most of the pests.

1. The effectiveness of quarantine exclusion measures is discussed in Section 73.

At the same time, Hawaii became aware of the importance of excluding foreign pests and for many years has maintained a quarantine inspection program more rigorous than that of the continental U.S. This effort was facilitated by the fact that most imports came through a single port, Honolulu. Although an active center of commerce, as a way station across the Pacific, the total volume of commerce has been only a fraction of that of continental U.S. With these factors in mind, a list of insects immigrant to the Hawaiian Islands has been compiled. In developing the list, information provided by the Hawaiian Department of Agriculture was most helpful, but again, much information was obtained from the taxonomists of the ARS Systematic Entomology Laboratory and those of the Smithsonian Department of Entomology.

Interestingly enough, this list includes almost the same number of species as are included in the list of species immigrant into continental U.S. While again not complete, 1,041 species of insects and mites have been recorded as immigrant to Hawaii, compared to 1,115 for continental U.S., as shown in Table 2-2.

TABLE 2-2

COMPARISON BETWEEN THE UNITED STATES AND HAWAII
IN THE NUMBERS OF IMMIGRANT SPECIES OF INSECTS AND MITES

	Continental U.S. (48 Contiguous States)	Hawaii
Number of Ports of Entry	30+	1
Number of Immigrants (species)	1,115	1,041
Number of Dated Immigrants (species)	955	955
Number of Immigrants, 1942-72 (species)	250	244
Percent of Dated Immigrants, Arriving in 1942-72	26	26
Area (thousands of square miles)	2,977	6
Rate of Colonization, 1942-72 (species per thousand square miles)	.08	40

It is a remarkable coincidence that of the 955 immigrant species in Hawaii for which earliest dates of known occurrence are available, 244 are recorded for the period 1942-72. This is 26% of the dated species and precisely the same percentage figure as that for the 1942-72 period for the 48 contiguous States.

In attempting to place these figures in perspective and interpret their significance, several aspects of the problem must be examined. The land area of the Hawaiian Islands is only 0.2% that of continental United States. Where Hawaii has one port of entry the mainland States have more than 30, and in addition, the latter has several inland international airports that provide potential pathways into the heartland of the country. Hawaii, in proportion to its land area, has a very much larger number of entomologists, and in terms of volume of commerce, a larger quarantine inspection force. Although there is a much greater diversity of crops and habitats within the continental States, these are dispersed over a vastly larger land area. In Hawaii, where the overall diversity is less, the various habitats are more readily accessible from the principal port of entry. The more moderate and stable climate is also more favorable for an invading species than is the climate over much of the continental States. A well established principle of zoogeography states that when two species from different geographic areas come together and compete for the same ecological niche, the species from the larger land mass will displace the species native to the smaller land mass. This results in a remarkably high rate of colonization in Hawaii. As shown in Table 2-2, in the period 1942-72 the rate of colonization per thousand square miles was 40 species, 500 times the rate of the continental U.S.

With these facts in mind, what conclusions can be drawn from a comparison of the immigrant insect faunas of Hawaii and the 48 contiguous States? First of all, it would appear that it is very much easier for an insect to gain entry and establish a population in Hawaii than in continental U.S. Or, put another way, the obstacles to invasion of the continental States are much greater than are those in Hawaii. Are these obstacles those imposed by quarantine inspection activities? This seems unlikely, for Hawaii has a more strict and rigorously enforced quarantine program than do the 48 continental States. Geographic isolation cannot be the important barrier since the 48 States are contiguous with Mexico and Canada. The volume of commerce is certainly not involved since that to Hawaii is only a fraction of that entering the ports of the contiguous States. We are left with the only possible conclusion - there is a very much higher probability that an insect will establish a colony once on the ground in Hawaii. This, in turn, implies that it is not the deterrent effect of quarantine inspection but rather some ecological difference between Hawaii and the contiguous States that accounts for the disproportionately low immigrant fauna present in the latter area.

Pronounced ecological differences are readily apparent in the biotic characteristics of insular and continental faunas. One of the most marked differences in degree of diversity resulting in insular ecosystems being less complex and accordingly less stable than the more complex ecosystems characteristic of continental areas. We may, therefore, conclude that North American ecosystems are more resistant to invasion than those of Hawaii. While true of both agro- and natural ecosystems, it is evident from the list of immigrant species that most of those now resident in North America are associated with man-modified environments. Where, as in natural forests, the native biota have remained little affected by man, there are few immigrant species. In Hawaii, on the other hand, the native fauna and flora seem unable to resist invasion and displacement by foreign species.

26 IMMIGRANT SPECIES AS PESTS

With the settlement of North America by Europeans, vast food resources became available that were vulnerable to exploitation by Old World insects. When these insects gain entry to North America they are normally not accompanied by the natural enemies that tend to regulate their abundance. Native natural enemies being poorly adapted to exploit the new arrivals, and the crop plants having developed in areas where natural enemies were the dominant limiting factor, the newly arrived insects increase with little or no restraint. The result may be catastrophic destruction of the host plants. These often catastrophic outbreaks of a recently arrived pest present a problem all too familiar to farmers, orchardists, and foresters. These people, as well as many entomologists employed to find methods for control of such pests, are often at a loss to explain why such alien species should be serious pests in the United States when they often have little or no importance in their home country.

For the most part, these immigrant species are associated with man-modified environments which encompass all agro-ecosystems. Within these ecosystems the immigrants tend to be much more disruptive than they are in the homeland systems from which they came. The reasons for this difference must be sought in the evolutionary history of agro-ecosystems. In the Old World these systems evolved over a period of several thousand years, during which man domesticated and improved indigenous crop plants. Associated with these crop plants were numerous indigenous pests that accompanied the plants into the new agro-ecosystems. The pests were in turn accompanied by natural enemies specialized to exploit individual pest species as a food resource. These enemies functioned as agents that regulated the abundance of the pest species and tended to prevent explosive outbreaks of the kind so often experienced when the same pests invaded North America.

Several factors are responsible for the failure of natural enemies to accompany their hosts to the United States. First of all, an enemy species is normally less numerous than its host, and thus is less likely to enter an entry pathway. Once in the pathway it is more likely to be eliminated, again because of the effect of smaller numbers. But, of even greater significance is their status as secondary consumers. As part of an ecosystem, crop pests are primary consumers and so compete directly with man for the same food resources. A pest of a crop plant arriving in the United States finds an abundant food supply, but the natural enemy, as a secondary consumer adapted to utilize the pest as a food resource, is in double jeopardy. It must not only survive transit but also find a population of its host. Clearly, the entry pathway and process of colonization acts as a selective filter through which pests can pass more readily than parasites, predators, and pathogens. Plant quarantine measures tend to make the filter more impervious to entry of both pests and their natural enemies, while beneficial insect introduction programs are designed to facilitate entry of the secondary consumers needed to stabilize agro-ecosystems.

Thus, American agro-ecosystems are not only already subjected to the adverse effects of a past imbalance between immigrant pests and their natural enemies, but they remain highly vulnerable to a vast assemblage of alien pests than have as yet failed to gain entry.

Yet not all of the 1,115 immigrant species of insects and mites become pests. Some species even prove beneficial. Figure 2-2 is a classification of species that have immigrated to the 48 contiguous States. In Table 2-3, 50 percent of the immigrants are shown to be pests, and only 212 of these, or about 19 percent of the immigrants, are considered important pests.[1] These include, however, many of the more serious pests of American agriculture and account for about 50% of the total pest losses in plant agriculture and horticulture. This estimate excludes forests, which have not suffered so severely from foreign insect invaders.

Of the 616 immigrant pest species, 6 have been eradicated since their introduction, and 10 are believed to be naturally extinct. Two of the minor pest introductions were deliberate, rather than accidental.

One-fourth of the immigrants have proven beneficial. That is, they are known to be enemies of pest species or belong to insect groups known to be mostly or entirely predacious. As such, these 278 species are plus factors in maintaining the stability of the ecosystems in which they live.

Somewhat more than 600 attempts have been made to introduce beneficial species, but only about 420 of these efforts reached the field level. As a result, 126 beneficial species have been deliberately introduced.

Two hundred twenty-one species, about one-fifth of all the immigrants, have proven to be of no particular importance.

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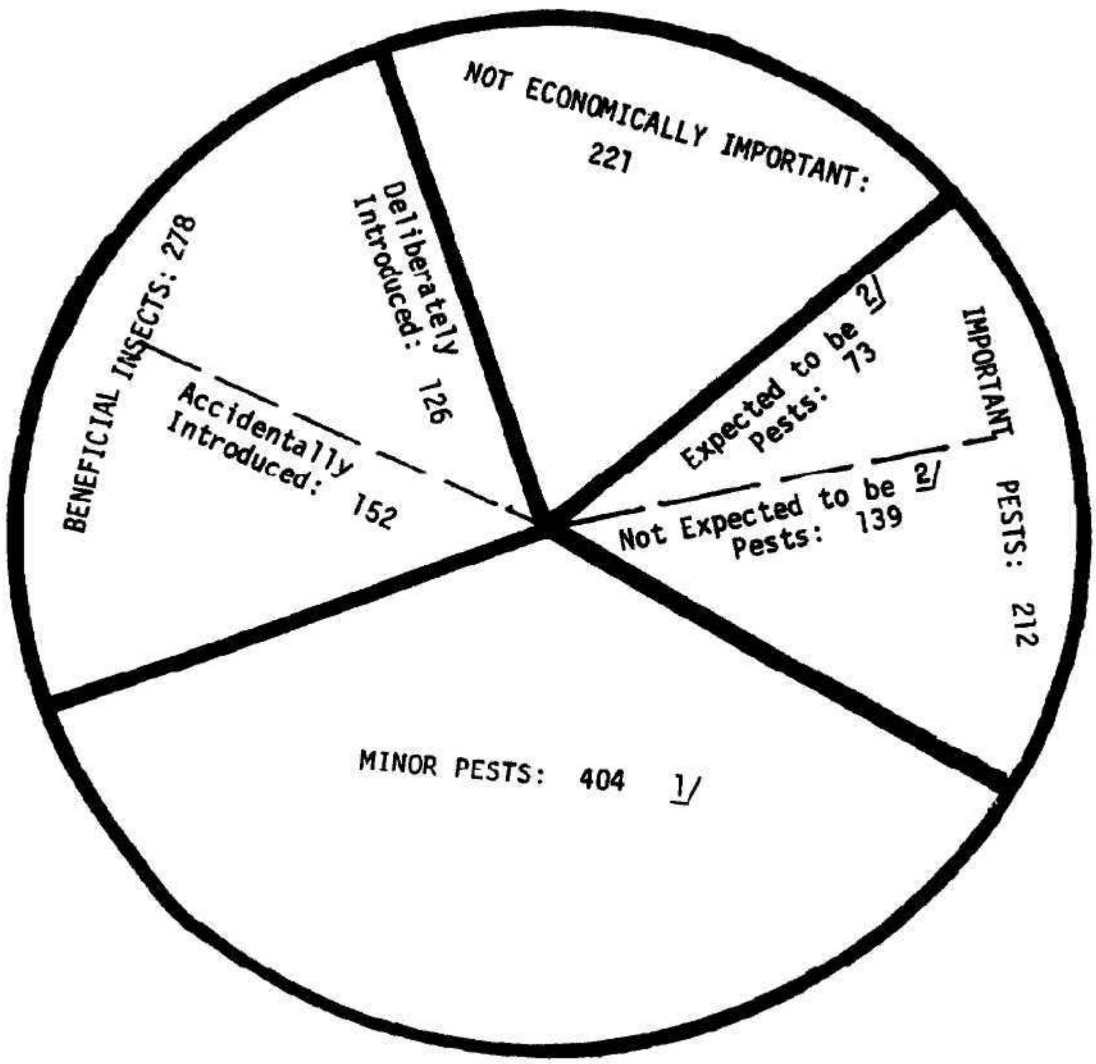
1. For comparison, in Hawaii 75 out of the 400 immigrant insect species, or 19 percent of those arriving in the 25-year period 1937-61, were found to be of "some economic or medical importance." See Beardsley, John W. 1962, On Accidental Immigration and Establishment of Terrestrial Arthropods in Hawaii During Recent Years. Proceedings of the Hawaiian Entomological Society for 1962 XVIII (1) 102 Aug. 1962.

FIGURE 2-2

TOTAL NUMBER OF IMMIGRANT INSECT SPECIES
TO THE 48 STATES: 1,115



1/ Includes 2 introduced deliberately. 35 of the 404 minor pests are important in their countries of origin.

2/ Prior to introduction.

TABLE 2-3

ECONOMIC IMPORTANCE OF IMMIGRANT SPECIES
OF INSECTS AND MITES ESTABLISHED IN THE U.S.*

Relative Economic Importance	Accidentally Introduced	Deliberately Introduced	Total Immigrant Species	Percent of Immigrant Species
Important Pests	212	--	212**	19%
Minor Pests	402	2	404**	36%
Beneficial Insects	152	126	278	25%
No Importance	221	--	221	20%
TOTAL IMMIGRANT SPECIES	987	128	1,115	100%

* Includes only the 48 contiguous States.
** Six of the pest species have been eradicated and 10 are believed to be naturally extinct.

26.1 Predictability. A comparison of the behavior of these immigrant species in their original overseas habitats with their impacts in the U.S. reveals significant differences. As shown in Table 2-4, of the 212 immigrant species which became important pests in the U.S. only 73 were expected to be important, based on present knowledge of their economic significance in the country of origin. Thus, the behavior of two-thirds of the important pest immigrants came as a surprise to entomologists. So did most of the minor pest species; only 35 species were expected to be of minor pest importance and there were 367 "surprises" that proved to be such. Overall, only 18 percent of the immigrant species that proved to be either important or minor pests in the U.S. would have been expected to behave as they did.

TABLE 2-4

EXPECTATIONS CONCERNING THE BEHAVIOR OF IMMIGRANT PEST SPECIES

Relative Economic Importance	Pest Behavior		Total Pest Species
	Expected	Not Expected	
Important Pests	73	139	212
Minor Pests	35	367	402*
TOTAL PEST SPECIES	108	506	614
PERCENT	18%	82%	100%

* Excludes 2 minor pests that were deliberately introduced.

There has been, therefore, a high degree of unpredictability about the likelihood of exotic insects becoming pests. Presumably, this uncertainty is susceptible to reduction by an expansion of scientific knowledge about species resident overseas, and an investigation, or simulation, of the possible availability of U.S. ecological niches prior to the arrival of the species.

26.2 Relative Importance. Within the geographic boundaries of the 48 contiguous States there are about 10,000 kinds of insects, mites, and ticks having some degree of importance as pests. Of the approximately 700 that fall in the category of important pests, only 212, or 30 percent of the total, are of foreign origin. These include many of our most serious pests, as exemplified by the European corn borer, gypsy moth, boll weevil, Oriental fruit moth, European pine shoot moth, and the alfalfa weevil.

In spite of the great importance of immigrant species as pests, however, recent estimates show that the annual damage by native species of insects is still greater. Table 2-5 shows the relative importance of native and immigrant insect pests, ranking them according to the amount of annual crop loss. The pests listed in the Table account for 75 percent of the total crop loss by insects. Native insects are responsible for a larger amount of the total losses than are the immigrant species: $956 million compared to $716 million. In addition, native insects occupy more of the higher ranks as pests than do the immigrant species.

TABLE 2-5

RELATIVE IMPORTANCE OF NATIVE AND IMMIGRANT INSECT PESTS BY SIZE OF ANNUAL CROP LOSS

Insect	Annual Crop Losses ($ Millions)	
	Native Pests	Immigrant Pests
Corn earworm	206	
Boll weevil		201
European cornborer		158
Lygus bugs, cotton fleahoppers and other sucking insects (cotton and potatoes)	136	
Grasshoppers	132	
Bollworms	100	
Tobacco budworms (native), hornworms (native), and green peach aphis (introduced)	100	
Corn rootworm	92	
Spotted alfalfa aphid		79
Green bug		62
Potato leaf hopper	50	
Cutworms	45	
Alfalfa weevil		41
Pea aphid		41
Hessian fly		28
Wheat stem sawfly		24
Fall armyworm	22	
Corn leaf aphid	17	
Apple mites		16
Cabbage looper (native) and cabbage worm (introduced)		16
Armyworms	14	
Strawberry mites	13	
Meadow spittle bugs	13	
Brown wheat mite		12
Orange mites		9
Orange scale insects		8
Chinch bug	8	
Mexican bean beetle		8
Southwestern corn borer	8	
Onion thrips		7
Alfalfa seed chalcid		6
TOTAL LOSSES	956	716

SOURCE: USDA, ARS, 1965 Losses in Agriculture, Agriculture Handbook 291.

3 DEFINING THE THREAT

Given the record of establishment of immigrant species and the subsequent importance of many of them as pests, there is good reason to inquire about the additional foreign species that may be able to invade the United States. We need to establish the magnitude of the threat from invasion by additional foreign pests. On the other hand, given the large number of species and the low predictability for pest behavior among insects, as pointed out in the last chapter, is it meaningful to try to determine the precise nature of the threat?

31 THE THREAT OF INVASION

There are perhaps 2,500,000 insect species, identified and unidentified, that are not present in the U.S. About 800,000 of these have been identified, and 6,000 of them are known to be damaging in foreign areas having ecological equivalents in the U.S. These relative magnitudes are illustrated in Figure 3-1. There are about 600 plant diseases and 20 animal diseases that may be considered significant.

Some entomologists contend that the large potential for invasion, with its uncertainties, makes any attempt at ordering those foreign insect pests which are potentially most damaging to U.S. agriculture, totally misleading. The viewpoint of these entomologists is that there are hundreds of thousands of insect species abroad, and only a comparative handful of them are of economic significance. While most of the latter turn up on the lists of unwanted insects, they do not always live up to their reputations following arrival to their new environment. On the other hand, a number of the more serious introduced pests have come from that vast group of foreign pests whose potential for damage is unknown or not suspected. In other words, our ability to predict the consequences of the introduction of any given foreign insect is so poor that any list of allegedly injurious species would provide an inadequate basis for program decisions.

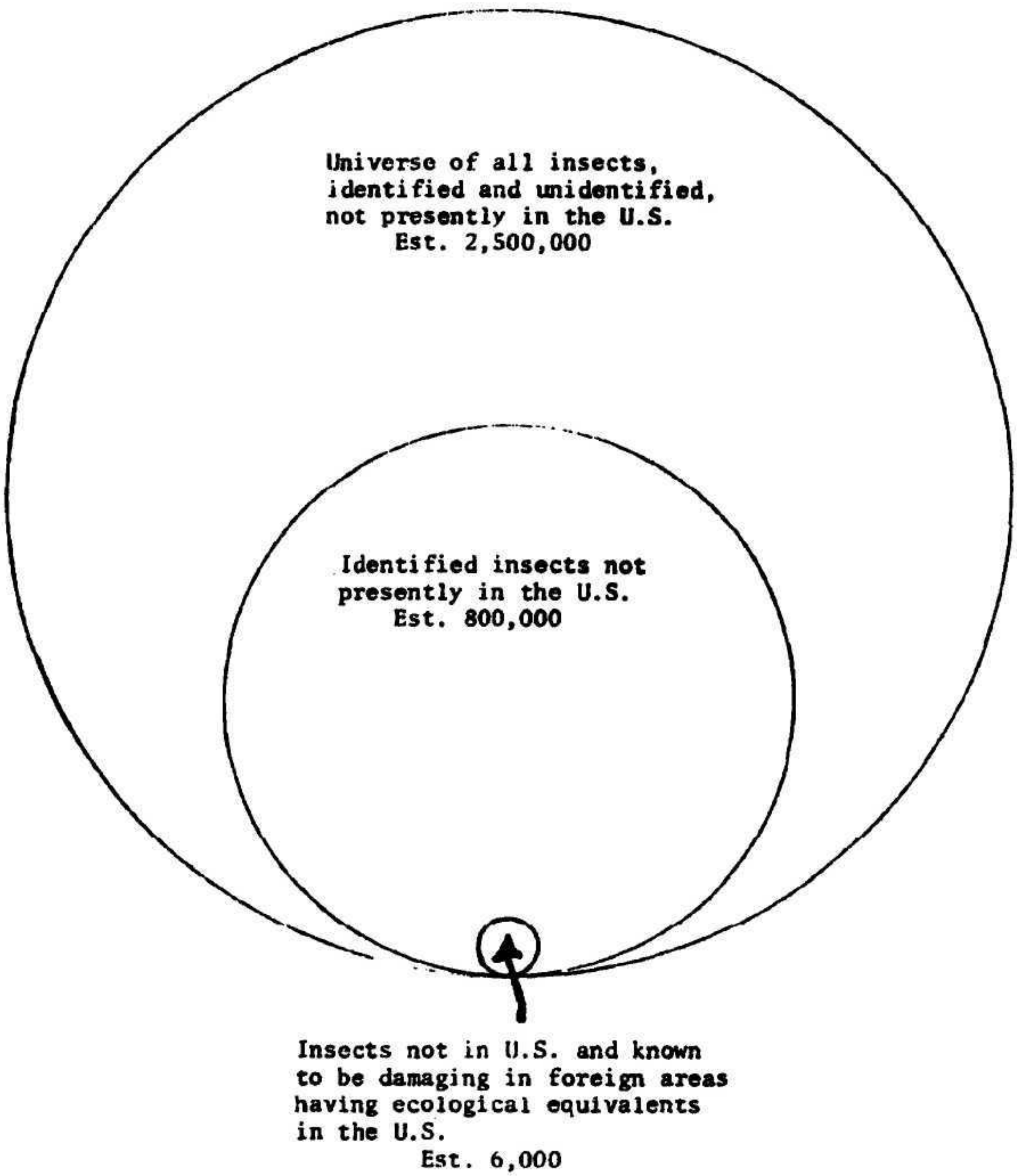
The question boils down to this: how accurate do our predictions concerning the economic significance of particular foreign species introducible into the U.S. have to be before it makes sense to identify particular species to look for at ports of entry?

A rational program for protection needs some notion of what species it is trying to keep out. Since it is faced with limited resources and cannot protect the nation against everything, it is useful to have some ordering of the potential invaders that provides an opportunity to make choices, however uncertain, in the use of program resources.

A survey of the insect and other alien arthropod pests of potential danger to American agriculture has identified about 600 species that

FIGURE 3-1

Foreign Insect Species in Perspective



may be regarded as high risks. These are species known to attack, or to serve as vectors of diseases that attack, crop plants and livestock on which American agriculture and forestry depends. In addition to these species, there is a very much larger number, perhaps ten times as many species, that must be regarded as suspect. These are species having little economic importance because of the regulative action of specific natural enemies or because of agricultural practices that minimize their ability to develop injurious populations. All such species constitute a potential danger should they become established in the U.S. Past experience shows that many of our more serious insect pests are of this latter type. The Japanese beetle, spotted alfalfa aphid, and the cereal leaf beetle are examples of alien species that would not have been included in a list of pests known to have significant economic importance in their countries of origin. Many others could be added.

Assuming then, that there are as many as 6,000 foreign insects and mites that are potentially dangerous to the United States and that only 600 of these can be listed by name, what are the prospects for the future? Obviously, total exclusion of all 6,000 is desirable, but experience suggests that this would be possible only at prohibitive cost, if possible at all. As long as commerce exists between the United States and other parts of the world there is a probability of establishment for each potentially dangerous species. The level of probability will be different for each species and may be affected by regulatory activities designed to exclude their entry.

With the number of exotic insects and mites discovered over the past 480 years averaging a little over two per year, and the recent average of discoveries eight per year, as shown in Table 2-1, it is obvious that the probability of an exotic pest becoming established is very low. For example, assuming that an overall probability for each species might be as low as one percent (1%) and that establishments by the various species are independent, one should with high probability (99%) expect at least 43 new species to be reported as established in the United States each year. Actually, the rate at which exotic pests have recently been discovered (8 per year) would suggest an average probability between 0.04% and 0.22% at the 95% confidence interval.

Although we are dealing with relatively small probabilities, we should not be misled into thinking that this implies a lack of importance.

This is a situation where a 1% probability may be very high. To illustrate this point, Table 3-1 relates the probability of establishment to the time required before we would expect the pest to appear.

TABLE 3-1

RELATIONSHIPS AMONG PROBABILITIES OF ESTABLISHING AN AGRICULTURAL PEST, AVERAGE PEST INFESTATIONS, AND AVERAGE YEARS UNTIL FIRST PEST INFESTATION*

Probability of Establishment of an Agricultural Pest (Percent)	Average Pest Infestations Per Year** (Number)	Average Years Until First Pest Infestation*** (Number)
1	0.01	99.5
2	0.02	49.5
3	0.03	32.8
10	0.11	9.5
20	0.22	4.5
30	0.36	2.8
40	0.51	2.0
50	0.69	1.4
75	1.39	0.7
99	4.60	0.2

* An example of the interpretation of these numbers is as follows: If a pest has a probability of establishment of 20 percent, one would expect 0.22 infestations per year, and on the average one might expect the first infestation in 4.5 years.

** Assumes the arrival of infestations are described by a Poisson distribution.

*** Reciprocal of the average infestations.

The situation for plant pathogens is somewhat similar, recorded establishments averaging 3 per year over a 25-year period. From the listings of approximately 2,000 foreign plant pathogens 551 were chosen by the Task Force representative[1] as posing significant risk to our agriculture. The selection of this 551 is influenced to a major extent by economic value of its host or hosts. We thus introduce an additional factor in the quarantine concept in that not only is the probability of entrance because of the nature of the pathogen considered but the possible economic impact; i.e., a pathogen of corn is of greater economic concern than one of geraniums. No consideration of the universe of fungi, bacteria, nematodes and viruses was attempted in this pest group. Some 50,000 parasitic and nonparasitic diseases of plants are listed as present in the "Index of Plant Diseases in the United States," Agr. Handbook No. 165, 1960.

32 THE VALUES AT STAKE

In addition to the economic values at stake, the Task Force is aware that there are significant environmental and esthetic values which are threatened by exotic pests and diseases. Given the public concern about these values, the Task Force wondered what impact they might have on future quarantine and pest control policies. A sociologist, Dr. James H. Copp of the Economic Research Service, provided his views on the outlook for the social value of the environment. Because of the importance of this question, his statement is included in its entirety.

32.1 Outlook for Social Value of the Environment.[2] How will people value the environment in the future? Although there is little concrete evidence to go on, it is possible to make some "informed guesses" that may be helpful in framing pest and disease control policy.

First of all, I think we will have to admit that environmental concerns are here to stay; they are more than a passing fad. Granted, there has been considerable fadism and much dissatisfaction with the social order in general displaced on environmental problems. The environmental issue has provided a convenient outlet especially for those youth who couldn't deeply identify with the problems of poverty or those of the blacks. Black activists have been particularly unhappy about the competition from the environmental movement and the way it has dissipated support of middle and upper class whites from their cause. The outlet-for-dissatisfaction interpretation is also supported by the observation that few blacks are involved in the environmental issue; they have a vital cause

1. C. H. Kingsolver, with assistance from C. G. Schmitt and K. R. Irish, PDRL. Particular thanks to R. W. Beardmore, APHIS, Dr. Magan Golden and Mrs. Virginia Harrington, Plant Nematology Laboratory, Bernard Lipscomb, Mychology Laboratory, ARS, and Dr. Keith Shea and Staff, Forest Disease Research, U.S. Forest Service.

2. This section was prepared by Dr. James H. Copp, now at the Department of Sociology and Anthropology, Texas A. and M. University, College Station, Texas.

much more near at hand. The environmental issue also has the attraction of being safer and more "proper" than protest against the Viet Nam War, which carries an implication of disloyalty and support of the enemy. Thus the environmental issue provides a much more legitimate and constructive outlet for the free-floating dissatisfaction of American youth and adults with the existing order.

Going beyond the ephemeral attractions of the environmental movement as an outlet for youthful dissatisfaction, the environmental concern is here to stay. It is here to stay because the environmental problem is rooted in the development of our economic and social system. It is a direct consequence of the pressure of people on the environment--a pressure based both on expanding numbers and a high level of economic development which consumes monstrous quantities of natural resources. We have come to a point in our economic development where the trade-offs between the quality of the environment and economic growth are becoming more obvious to and more demanding of the public.

The paradoxical thing about economic development is that it provides more people with the income levels and the leisure to appreciate the natural environment esthetically. Thus, at the very time our economic growth most threatens the existing environment we have arrived at a point where we treasure the natural order on a mass basis.

As a result of these tendencies, rooted in developments of our social and economic system, I do not see our concern with environmental issues decreasing. As the pressure to degrade or alter the environment increases, I see the conflict over environmental issues increasing because the trade-offs are going to become more costly for both the environmentalists and the economic development forces.

However, I think it is important to make some distinctions in environmental concerns. The public is most concerned about the pressures from economic exploitation and pollution. It is seen as a zero-sum game with heroes and villains. Here the "bad guys," the economic exploiters, are seen as profiting at the expense of the public and the environmentalists, the "good guys." The environmentalists see the issue as competition in which the exploiters are taking resources which the environmentalists feel are in the public domain, and hence for the use of all.

I feel the situation with regard to pest and disease control is usually somewhat different. Pest control is seen as a good thing. If pest control preserves the natural ecosystem it is good. Further, if success or failure in controlling pests disturbs the ecosystem, yet no group is seen to profit from the results, I suspect there will be relatively little uproar. I think the environmentalists are most concerned by those occasions wherein man disturbs the balance of nature to enrich some group at the expense of others. The real conflict in the environmental issue is one of the distribution of rewards. The environmentalist gets rewards from his esthetic and contemplative enjoyment of nature; he objects to the competition from resource exploiters who want to use nature for economic rewards.

Therefore, with the environmental issue continuing on the national agenda for the foreseeable future, I see a latent resource of good will supporting pest control as a positive force preserving the balance of nature. However, if pest control fails to protect a species I see relatively little uproar so long as no group is seen as profiting from this dislocation and no agency is found to have been derelict in duty.

On the other hand, the social prognosis is not clear at all if positive measures in pest and disease control by man have side effects that endanger other species. The conflict will be most bitter if it is clearly apparent that some particular group, rather than the public as a whole, benefits from the control of the original pest.

The pest controlling agency itself will become embroiled in the conflict as the scapegoat for the "blunder." Politicians looking for an issue to exploit will be attracted. Here about the only defense is improving the public's understanding of the interdependence of nature and of the impossibility of accurately predicting all the consequences so that the failure will be more likely attributed to ignorance (lack of scientific knowledge) than incompetence or willful malfeasance. The complexity of the problem and the contingency of error should be stressed in justifying research funds.

There is presently no good way of accurately predicting how the public will react to the trade-off of controlling one species at the cost of endangering another, particularly when benefits to private groups are unclear. Evaluation will have to proceed on a case-by-case basis. We have to recognize that certain species attract more concern from the public than others. We have our totems and we have our "varmints," wrong as the public may be about the nature of ecological balance. For instance, bald eagles may be over-valued, snakes and skunks under-valued. At times, though we may dislike the practice in principle, public opinion polls may be necessary in order to determine what kind of controls are politically feasible.

It is regrettable fact that many of the decisions about pest and disease control are going to be made in the political arena. There are genuine conflicts of interest that are not clearly resolvable on the basis of scientific evidence. The scientist is not the ultimate one who resolves conflicts over the distribution of rewards and costs in a society.

32.2 The California Model. In California, the Department of Food and Agriculture has developed a model for ranking those pests that are not established in the State. This was done as part of an assessment of California's plant quarantine program. Each pest was given a numerical score based on the following set of values:

Economic Impact (Includes damage and additional costs)

0 - No effect (Less than $100,000)
1 - Minor effect ($100,000 to $1,000,000)
2 - Major effect (More than $1,000,000)

Social Impact

0 - Affects up to one million persons
1 - Affects one million to five million persons (25% of California's population)
2 - Affects more than five million persons

Environmental Impact

0 - No effect
1 - Loss limited to damage only
2 - Loss of one or more species

Under this scheme, the higher the numerical score, the more dangerous the pest.

This model has the virtue of explicitly considering a wide range of values, which seem appropriate in a public program. It gives important weight to social and environmental impacts, rather than focusing entirely on those values determined in the market place. Two shade tree diseases not established in California, Dutch Elm Disease and Oak Wilt, were among the pests at the top of the list, whereas many of the traditional agricultural threats were rated lower, because their impacts were primarily economic.

33 THE MODEL FOR RANKING IMPORTANCE

33.1 The Conceptual Design. The Task Force considered the desirability of including social and environmental values in the model. However, in this first attempt at ranking it was decided to use only the economic values, since these are quantified and readily available and the use of a single scale of values would simplify the model. The ranking of pests might be quite different, as in the California Model (Section 32.2), if other kinds of values were incorporated.

A three-step procedure was developed for ranking exotic pests. First, estimate the probability of specific exotic pests becoming established in the United States. Second, evaluate the economic impact if those pests became established. Third, multiply the first value times the second; that is, the probability of an exotic pest becoming established times the economic impact of the pest if it becomes established. This value constitutes the expected score of economic importance of exotic pests in the U.S. and was labeled Expected Economic Impact (EEI). ("Expected" is used here in the statistical sense; i.e., "average" or "mean.")

In algebraic terms,

$$EEI = P \times E$$

Where EEI = Expected economic impact.
P = Probability of Pest becoming established in the U.S. during the next year.
E = Economic impact if pest became established.

The conceptual importance of this procedure is that it yields a quantifiable measure of economic risk. One important limitation of the model is that it is static rather than dynamic. For example, the rate of spread of an immigrant species through its ecological range is not taken into account. This is a significant time-related variable. However, the Task Force excluded it from the model, believing that the estimates required would have a wider confidence interval than the other variables in the model. There is an urgent need to obtain estimates of rates of spread for important pests in their overseas locations, in order to provide a basis for estimates of spread in the U.S. Obviously, the rate of spread for animal diseases is quite different than that of the insects and plant pathogens.

A brief description of how estimates were derived for the probability of a pest becoming established in the U.S. and the economic impact if a pest became established follows in Sections 33.1 through 33.4. A fuller and somewhat more technical description, prepared by Dr. Bert Levy of the Task Force, follows in Sections 33.5 through 33.7.

33.1 Probability of Pest Becoming Established. It was assumed that the probability of a pest becoming established was related to the volume of vector material imported into the U.S., hitchhiking potential of the pest, and the ease with which a pest becomes established after arrival. It was felt that impressions of the relationship could be estimated empirically with a second degree equation for the general relation.

$$P = G\ (f_1,\ f_2,\ f_3)$$

Where P = Probability of pest becoming established.
f_1 = Volume of vector material imported into the U.S.
f_2 = Hitchhiking potential of the pest.
f_3 = Ease with which a pest becomes established after arrival.

33.2 Economic Impact If Pest Became Established. The economic impact of an agricultural pest if it became established is used here as a marginal measure. It is the expenditures required to maintain production of the host crop. It is the summation of the added cost of pest control on old units,-plus the added cost of pest control on new units needed to maintain production, plus the added cost of raising the new units.

The formula used is:

$$E = VRT + V\left(\frac{URT}{100-U}\right) + W\left(\frac{URT}{100-U}\right)$$

Where:

E = The economic impact of the established pest.
R = The amount of the host grown.
T = The ecological range of the pest as a percent of the range of the host.
U = Percent loss in yield when normal controls are used.
V = Added control cost per unit per season for the pest.
W = Variable cost per unit for host. Amount of money required to increase growing area by one acre, herd by one head, etc.

33.3 Assembling the Information. In order to calculate the economic impact if a pest became established and to estimate the probability of a pest becoming established, the following information was assembled:

1. Countries or regions of the world presently infested.
2. The most important host materials.
3. Ecological range of pest in the United States as a percentage of the range of host crop.
4. Hitchhiking potential, ignoring quarantine programs.
5. Ease of colonization once pest has arrived.
6. Percent loss in yield in the United States for affected crops with expected methods of control.
7. Cost per acre per season of a normal pest control program needed for crops affected by this pest in the United States. Include cost of materials and application.
8. Probability of pest becoming established in the United States.

9. Level of host material shipments from an area where pests exist to areas in the United States where pests could become established.

10. Total acres of affected crops.

11. Variable cost per acre for crops affected.

12. Average yield of affected crop.

Table 3-2 provides some examples of the kind of information that was assembled for each pest.

The world regions are listed in Table 3-3 and outlined on the map, Figure 3-2. These areas are the world trade areas of the U.S. Department of Commerce, and statistics on the importation of agricultural commodities from each of these regions are available.

A listing of 171 crops and animals, together with estimates of the variable cost per acre or per animal unit was assembled for use in developing the EEI score. Table 3-4 provides 19 items from this list of hosts, as an example.

33.4 Explanation of Computer Documents. (These documents appear as appendices)

Computer Outputs

There are several computer listings which detail or summarize the information assembled about agricultural pests. Most of them are self-explanatory.

Ranking by Relative Risk

This listing is presented as a bar chart. The bar represents a 75 percent confidence interval for the "Expected Economic Impact" of the agricultural pest. The pests are listed in descending order of the upper end of the confidence interval. The lower end of the chart is zero millions of dollars. The upper end is 500 million dollars. Any value above 500 million has been truncated to 500 million. The upper end of a bar may be viewed as an estimate of the economic impact likely to be incurred if the pest were to become established. The length of the bar is a measure of the quality of the estimate. A short bar indicates a reliable estimate. A longer bar indicates a less reliable estimate.

Basic Input Data

The pests are listed alphabetically. Each pest is listed once for each host with which it is associated. There is an additional summary line, indicated by host 999. This line includes a total economic impact estimate, the sum of the estimates over the various hosts. The parameters previously discussed are identified and listed.

TABLE 3-2

EXAMPLES OF THE INFORMATION ASSEMBLED FOR USE IN THE RANKING MODEL OF ALL SIGNIFICANT EXOTIC PESTS

Pest or Disease	Expected No. of Years Until First Infestation	Regions of World Infected	Host Materials	Pest Range as a Percent of Host Range	Hitch-hiking Potential	Ease of Colonization	Added Control Cost	Percent Yield Loss
Animal Diseases:								
Foot and Mouth Disease	0.5-2.0	3,4,8,9, 11,12,13, 14,15,16, 17,18,19	All cloven footed animals	100%	High	High	Cattle $1.80 Swine $2.66	25%
Nairobi Sheep Disease	5-10	12,20	Sheep Goats	75%	High	Medium	Quarantine Control $0.25	40%
Teschen Disease	5-10	8,9,10 16,19,20	Swine	100%	Low	Medium	Quarantine Control $0.25	25%
Plant Diseases:								
Helicobasidium mompa (violet root rot)	5	15,16	104 species in 45 families and 76 genera	100%	High	High	$20	20%
Rosellinia quercina	4	8	hardwoods conifers	100%	High	High	$7-12	<5%
Sclerospora phillipensis (downy mildew)	6	16	corn sorghum teosinte	70%	Medium	Medium	$10-15	40%
Insects:								
Ceratitis capitata	-	9,11,13 14,16,17 18,20	citrus, pear peach, apricot	30%	High	High	$20	5%
Melanogromyza phaseoli	-	12,13,16 17,18,20	beans, including soybeans	30%	Medium	High	$5	5%
Trogoderma granarium	-	8,9,11,12 13,14,15,16 17,18,19,20	stored grain	100%	High	High	-	5%

TABLE 3-3

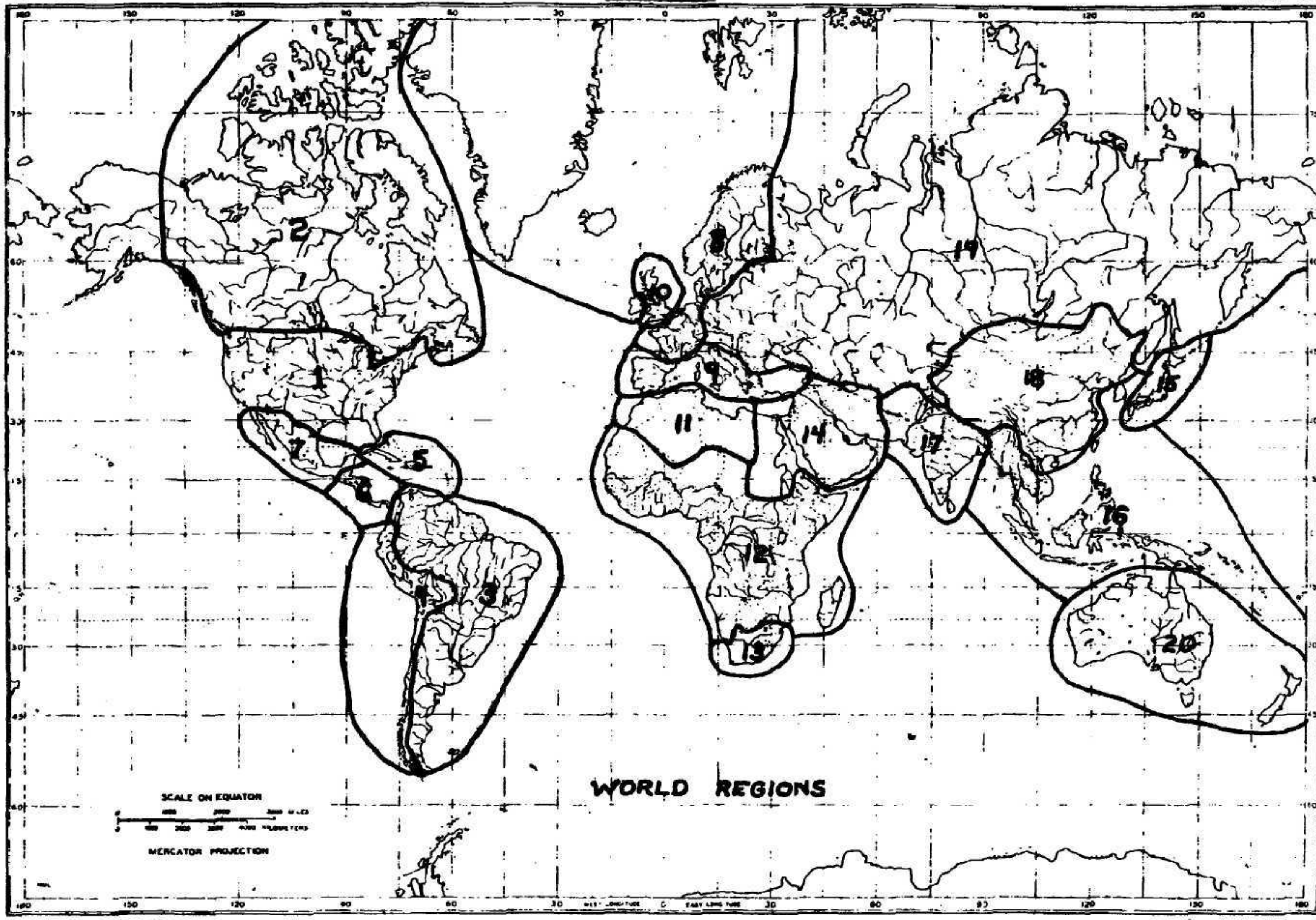
WORLD REGIONS

1. U. S. A.
2. Canada
3. Eastern South America
4. Western South America
5. Caribbean
6. Central America
7. Mexico
8. Northern Europe
9. Mediterranean Europe
10. United Kingdom
11. North Africa
12. Developing Africa
13. Republic of South Africa
14. Middle East
15. Japan
16. East Asia
17. South Asia
18. Communist Asia
19. Communist Europe
20. Oceania

WORLD MERCATOR

FIGURE 3-2

No. 1M



GOODE BASE MAP SERIES
DEPARTMENT OF GEOGRAPHY
THE UNIVERSITY OF CHICAGO
HENRY M. LEPPARD EDITOR

Prepared by Henry M. Leppard

TABLE 3-4

SELECTED EXAMPLES FROM THE LIST OF CROP AND ANIMAL ESTIMATES USED TO COMPUTE THE EEI SCORE

Crop or Animal	Acres, Trees, Vines, Plants, or Animal Units (thousands)	Variable Cost Per Unit (dollars)
Alfalfa	27,814	19
Almonds	205	439
Apples	600	450
Apricots	41	574
Artichoke	9	587
Ash	9,153	515
Asparagus	139	479
Avocados	2,118	3
Azalea	32,000	1
Barley	9,388	13
Beans - dry edible	1,481	52
Beans - green lima	83	876
Beans - snap	328	285
Beech	8,076	515
Beets - sugar	1,575	106
Birch	6,370	515
Blackberries	8	1,250
Blueberries	43	1,530
Cattle	96,669	244

3.5 Mathematics of the Ranking Model. (Those readers who are not mathematically inclined are invited to skip to Section 4 for a presentation of some of the results of the ranking procedure employed by the Task Force.)

A discussion of the "Proper" methodology for comparing the importance of foreign agricultural pests will be almost completely avoided here. Possible ranking criteria include economic, environmental, political and emotional factors. Little scientific information exists on these points and choices among models and criteria are necessarily subjective. A description of our approach follows, along with some rationalization of our choices. The criterion selected for ranking the agricultural pests is "Expected Economic Impact" of the pests on U.S. agriculture. The quantification of economic impact is the expenditures required to maintain agricultural production in the presence of the pest. The word "expected" is used in the statistical sense since some of the quantities in the model are random.

A simplified picture of the model which contains most of the ideas can be presented in an example. Consider a hypothetical agricultural pest not presently in the U.S. To simplify terminology we will assign him the common name "Sam." Sam is known to attack grains (wheat, rye, oats, and corn). Sam's economic impact on these crops are respectively fifty (50), eight (8), five (5), and twenty (20) million dollars. The probability that Sam will establish himself in this country within the next year is 0.02, two chances in a hundred. Sam's expected impact on U.S. agriculture is then:

$$0.02 \times (50+8+5+20) = 0.02 \times 83 \cong 1.7 \text{ million dollars.}$$

The general formula expresses the relationships symbolically,

$$(EC)_i = P_i \sum_j (EI)_{ij}. \qquad (1)$$

$(EC)_i$ is the expected economic impact of pest i. P_i is the probability that pest i will become established in the U.S. in the next year. $(EI)_{ij}$ is the economic impact of pest i on crop j.

The summation extends over all crops upon which pest i has significant adverse effect.

Formula (1) is not directly usable. The probabilities P_i and the economic impacts $(EI)_{ij}$ are unknown. The latter problem has been conviently avoided. It is our consensus that the errors made in ascertaining the economic impacts, $(EI)_{ij}$, are much smaller than those made in estimating the probabilities P_i. Therefore, as a practical matter, we assume the former quantities to be known exactly. Our problem is then determining estimates of the probabilities.

The number of pests under investigation is large. It is unreasonable to expect even the most knowledgeable biological scientists (entomologists, plant pathologists and veterinarians), to be able to ascertain the values for any sizable portion of the pests.

It was hoped that the probabilities were roughly predictable from some underlying factors which were observable. This seems to be the case. The underlying factors upon which we rely are:

1. Volume of vector material imported into the U.S. $(f_1)_j$

2. Hitchhiking potential of the pest. (f_2)

3. Ease with which pest will establish itself after arrival. (f_3)

It was necessary to quantify these factors. Each factor is assigned the value 1(low), 2(medium), or 3(high). The values are used in equations to obtain a pessimistically high estimate, $\overline{P}_i$, and an optimistically low estimate, $\underline{P}_i$, for the probability P_i of pest i becoming established. The estimates satisfy the relation:

$$\text{Prob } [\underline{P}_i < P_i < \overline{P}_i] = 0.75.$$

The methodology used to obtain these is discussed later.

These estimates may now be used in place of P_i in formula (1),

$$(\overline{EC})_i = \overline{P}_i \sum_j (EI)_{ij} \qquad (2a)$$

$$(\underline{EC})_i = \underline{P}_i \sum_j (EI)_{ij} \qquad (2b)$$

This gives us a pessimistic estimate, $(\overline{EC})_i$ and an optimistic estimate, $(\underline{EC})_i$, of the economic impact of pest i . The difference between those two estimates, $(\overline{EC})_i - (\underline{EC})_i$ is a measure of the degree of certainty in the estimation. A small interval indicates a close estimate, while a large interval indicates a great deal of uncertainty.

The pessimistic estimate, $(\overline{EC})_i$, is used to rank our list of agricultural pests. The length of the prediction interval is included as a bar graph to indicate the uncertainty in estimation. The results appear as an exhibit at the end of this article.

In the sections which follow, it will be seen that our procedures proved to be reasonably good. There is one class of pests, forest pests, which are a notable exception. The procedures tend to rank them too high. We surmise that this is caused by the trichotomization of the variable, ease of establishment, in the model. Virtually all of these pests are rated low in this attribute. The model is not sensitive enough to indicate how extremely low this attribute should be rated.

33.6 Predicting Probability of Establishment. It was hypothesized that the probability of establishment P_i would be simply related to three underlying factors. The first factor is the quantity of vector material upon which pest i can travel that is imported into the United States. The second factor is the hitchhiking potential of the pest. The third factor is the ease of colonization of the pest once it has arrived. Each factor is treated as having three levels, low (=1), medium (=2), and high (=3).

Thus, the quadratic predictive model for pest i is:

$$P_i = M + a_1 \cdot f_{1i} + a_2 \cdot f_{2i} + a_3 . f_{3i} + a_{11} . f_{1i}^2 + a_{22} . f_{2i}^2 + a_{33} . f_{3i}^2 + a_{12} . (f_{1i} . f_{2i}) + a_{13} . (f_{1i} . f_{3i}) + a_{23} . (f_{2i} . f_{3i}) + \epsilon$$

Each of the quantities $[f_{ji}]$ take on one of the values 1, 2, or 3 as is appropriate for pest i.

Confidence Intervals Computations

This listing is in two sections. The first section covers plant pathogens, pests assigned identification numbers less than 1000. The second section lists insect pests, pests assigned identification numbers greater than 1000. The sections are subdivided according to host with the artificial summary host 999 listed last. In each subsection, pests are listed in descending order of expected economic impact. The listing includes point estimates of the expected economic impact and probability of establishment of the pest. Fifty (50), seventy-five (75), and ninety (90) percent confidence intervals are included for each of these parameters.

Host Number Index

This index appears ordered numerically by the numbers assigned to the various hosts and alphabetically by host name. The two fields of numerical data are the ones previously designated R and W, respectively.

The coefficients, m, a, b, c, d, e, and g, were estimated using the least squares procedure. The estimation was performed twice--once for insect pests and again for plant pathogens. In each case the scientists of our Task Force provide approximately fifty samples. Each sample consisted of the scientists' best estimates of the four variables, the probability that the pest would become established within one year, the

TABLE 3-5

Probability of Establishment of Selected Insect Pests

Prediction Equation

$$P_i = 41.2793 + 33.4437\ f_{1i} - 77.1878\ f_{2i} - 17.6584\ f_{3i} - 6.8162\ f_{1i}^2 + 17.9378\ f_{2i}^2 - 5.4848\ (f_{1i} f_{2i}) + 17.0374\ (f_{2i} f_{3i})$$

(The coefficients of the terms f_{3i}^2 and $f_1\ f_3$ are zero.)

Inverse of covariance matrix B 1/

$b_{00} = 2.7231$, $b_{0,1} = -1.7906 = b_{1,0}$, $b_{0,2} = -1.4149 = b_{2,0}$

$b_{0,3} = -0.3572 = b_{3,0}$, $b_{0,4} = 0.3770 = b_{4,0}$, $b_{0,5} = 0.1193 = b_{5,0}$,

$b_{0,6} = 0.0 = b_{6,0}$, $b_{0,7} = 0.2222 = b_{7,0}$, $b_{8,0} = 0.0 = b_{8,0}$.

$b_{0,9} = 0.2734 = b_{9,0}$

$b_{1,1} = 3.7376$, $b_{1,2} = -1.1788 = b_{2,1}$, $b_{1,3} = -0.07383 = b_{3,1}$

$b_{1,4} = -0.8687 = b_{4,1}$, $b_{1,5} = 0.3035 = b_{5,1}$, $b_{1,6} = 0.0 = b_{6,1}$

$b_{1,7} =$ $= b_{7,1}$, $b_{1,8} = 0.0 = b_{8,1}$ $b_{9,1} =$ $= b_{9,1}$

$b_{2,2} = 2.8765$, $b_{2,3} = 0.1551 = b_{3,2}$, $b_{2,4} = 0.3366 = b_{4,2}$,

$b_{2,5} = -0.5293 = b_{5,2}$, $b_{2,6} = 0.0 = b_{6,2}$, $b_{2,7} = -0.1224 = b_{7,2}$

$b_{2,8} = 0.0 = b_{8,2}$, $b_{2,9} = -0.1991 = b_{9,2}$

1/ The reader may want to use this information to calculate the confidence interval for a pest not included in the analysis but one for which the values of the variables are within the range of these data.

TABLE 3- 5 (Cont'd)

$b_{3,3} = 0.3602$, $b_{3,4} = 0.9143.10^{-2} = b_{4,3}$, $b_{3,5} = 0.8331.10^{-1} = b_{5,3}$,
$b_{3,6} = 0.0 = b_{6,3}$, $b_{3,7} = -0.1919.10^{-1} = b_{7,3}$ $b_{3,8} = 0.0 = b_{8,3}$
$b_{3,9} = 0.2084 = b_{9,3}$

$b_{4,4} = 0.2182$, $b_{4,5} = 0.62749.10^{-1} = b_{5,4}$, $b_{4,6} = 0.0 = b_{6,4}$
$b_{4,7} = 0.9047.10^{-2} = b_{7,4}$, $b_{4,8} = 0.0 = b_{8,4}$ $b_{4,9} = -0.1490.10^{-1} = b_{9,4}$

$b_{5,5} = 0.1755$, $b_{5,6} = 0.0 = b_{6,5}$, $b_{5,7} = -0.3032.10^{-1} = b_{7,5}$,
$b_{5,8} = 0.0 = b_{8,5}$, $b_{5,9} = 0.5223.10^{-1} = b_{9,5}$

$b_{6,6} = 0.0$, $b_{6,7} = 0.0 = b_{7,6}$, $b_{6,8} = 0.0 = b_{8,6}$
$b_{6,9} = 0.0 = b_{9,6}$

$b_{7,7} = 0.8869.10^{-1}$, $b_{7,8} = 0.0 = b_{8,7}$, $b_{7,9} = 0.8869.10^{-1} = b_{9,7}$

$b_{8,8} = 0.0$, $b_{8,9} = 0.0 = b_{9,8}$

$b_{9,9} = 0.1488$

TABLE 3-5 (Cont'd)

Observation Number	Expert's Estimate of Probability	Model's Estimate of Probability	Discrepancy	90% Confidence Interval Lower	Upper
1	95	82	13	70	94
2	90	78	12	62	95
3	40	45	- 5	31	58
4	50	82	-32	70	94
5	30	26	- 4	12	39
6	30	28	- 2	11	44
7	50	45	5	31	58
8	30	28	2	11	20
9	98	82	16	70	20
10	30	45	-15	31	20
11	5	9	- 4	0	20
12	5	9	- 4	0	20
13	10	9	1	0	20
14	12	9	3	0	20
15	12	9	3	0	20
16	2	2	- 1	0	8
17	2	3	- 1	0	7
18	7	3	4	0	7
19	1	3	2	0	7
20	3	3	0	0	7
21	5	3	2	0	7
22	7	3	4	0	7
23	1	3	- 2	0	7
24	2	4	- 2	0	14
25	4	3	1	0	7
26	3	3	0	0	7
27	2	3	- 1	0	7
28	1	3	- 2	0	7
29	1	2	- 1	0	8
30	1	3	- 2	0	7
31	2	1	1	0	10
32	4	3	1	0	15
33	6	14	- 8	0	31
34	3	0	3	0	9
35	1	2	- 1	0	8
36	2	2	0	0	8
37	2	2	0	0	8
38	4	3	1	0	14
39	6	3	3	0	15
40	2	2	0	0	8
41	1	3	- 2	0	7
42	1	3	- 2	0	7
43	1	3	- 2	0	7
44	1	3	- 2	0	7
45	1	7	- 6	0	16
46	20	24	- 4	13	34
47	9	7	2	0	16
48	3	3	0	0	7
49	1	2	- 1	0	18
50	1	2	- 1	0	18

TABLE 3-6

Probability of Establishment of Selected Plant Pathogens

Prediction Equation

$$P_i = 20.7134 + 1.8800\, f_{1i} - 4.4577\, f_{2i} + 2.4455\, f_{3i}$$

(The coefficients of all higher order terms are zero.)

Inverse of covariance Matrix

$b_{0,0} = 1.9422$, $b_{0,1} = -0.02658 = b_{1,0}$, $b_{0,2} = -0.4158 = b_{2,0}$

$b_{0,3} = -0.2787 = b_{3,0}$

$b_{1,1} = 0.04695$, $b_{1,2} = -0.01316 = b_{2,1}$, $b_{1,3} = -0.0123 = b_{3,1}$

$b_{2,2} = 0.1457$, $b_{2,3} = 0.01054 = b_{3,2}$

$b_{3,3} = 0.09724$

TABLE 3-6(Cont'd)

Observation Number	Expert's Estimate of Probability	Model's Estimate of Probability	Discrepancy	90% Confidence Interval Lower	Upper
1	18	17	1	15	19
2	6	18	-12	16	20
3	18	17	1	15	19
4	10	25	-15	20	31
5	6	25	-19	20	31
6	28	17	11	15	19
7	5	24	-19	16	33
8	10	17	- 7	20	31
9	6	21	-19	13	28
10	5	25	20	20	31
11	15	14	1	12	16
12	12	17	- 5	15	18
13	18	17	+ 1	15	18
14	18	18	0	16	20
15	18	17	1	15	19
16	22	17	5	15	19
17	15	19	- 4	15	22
18	15	18	- 3	16	20
19	13	17	- 4	15	18
20	18	21	- 3	18	24
21	22	21	1	18	24
22	15	23	- 8	20	26
23	18	21	- 3	18	24
24	22	17	- 5	15	18
25	22	21	1	18	24
26	28	21	7	18	24
27	22	17	5	16	19
28	12	17	- 5	15	19
29	15	14	1	12	16
30	15	17	- 2	15	18
31	13	14	- 1	12	16
32	22	17	5	15	18
33	12	17	- 5	15	18
34	12	17	- 5	15	18
35	28	17	11	15	18
36	22	14	8	12	16
37	22	19	+ 3	15	22
38	28	20	8	17	24
39	15	14	1	12	16
40	15	14	1	12	16
41	15	16	- 1	13	19
42	18	17	1	15	18
43	13	17	- 4	15	18
44	15	20	- 5	17	24
45	10	12	- 2	7	16
46	12	14	- 2	12	16
47	28	21	- 7	18	24
48	10	17	- 7	15	18
49	10	18	- 8	13	19
50	6	17	-11	15	18
51	3	18	-15	16	20
52	4	17	-11	15	18

amount (high, medium, or low) of vector material imported into the United States, the hitchhiking potential (high, medium, or low) of the pest, and the ease (high, medium, or low) of colonization of the pest. The scientists included in the sample only those pests that they were quite familiar with. The sample reflects the group of pests in which there is likely to be a high degree of consensus among scientists. The coefficients were estimated from these data. Also estimated was the covariance matrix. This enables us to obtain interval estimates of future observations.

No adequate scientific evidence can be offered for the adequacy of this model. However, there are strong indications of its reasonableness. As indicated in Tables 3-5 & 3-6, the formula behaves well when the data used to establish the coefficients are used. If it did not, the model would have been abandoned immediately. Generally it reproduces the given values reasonably well. A secondary check was provided. The scientist members of the Task Force reviewed the ranking produced by the formula for reasonableness. With the exception, previously mentioned, of forest pests, the ranking produced is in agreement with the scientists' judgments. It is well to emphasize here that the model does not claim to predict the probability of establishment of a pest. It estimates what knowledgeable scientists believe this probability to be.

33.7 Infestation as A Poisson Process. During meetings of the Import Inspection Task Force, the concepts of "probability of establishment of an agricultural pest" and "number of years until a first infestation by the pest" were repeatedly discussed. Some problems are better phrased in one or the other. Also, some individuals seem to find it easier to think in one rather than the other. On an intuitive level the concepts are clearly related. This short paper presents a rationale for formalizing and relating the concepts. It also provides a convenient table for converting from one to the other.

Assume that the arrival of vector material capable of causing infestation via some specific organism is described by a Poisson process with parameter λ, the average number of infestations per year caused by this organism. Then the number of infestations K in a period of t years is governed by the Poisson probability mass function

$$f(K; \lambda, t) = e^{-\lambda t} (\lambda t)^{K} / K!$$

The rationale underlying the Poisson assumption is that the probability in any given shipment of vector material causing an infestation is very small, say, less than .01, and that infestations by different shipments are statistically independent.

If the probability of at least one infestation in a given year is p then

$$p = 1 - f(0, \lambda, 1) = 1 - e^{-\lambda}$$

Thus, $\lambda = -\ln(1-p)$. Also, it is derivable that the number of years T until the first infestation is then governed by an exponential probability law. Its probability density function is

$$f_T(t;\lambda) = \lambda e^{-\lambda t}, \quad t \geq 0, \quad \lambda > 0.$$

Thus, the average number of years until the first infestation is

$$E(T) = \frac{1}{\lambda} = \frac{1}{-\ln(1-p)}$$

Also, of interest are the numbers T_α, α = .10, .25, .50, .75, .90 defined by the relation

$$P[T \leq T_\alpha] = \alpha = \int_0^{T_\alpha} \lambda e^{-\lambda t}\, dt = 1 - e^{-\lambda T_\alpha}$$

Thus

$$T_\alpha = \frac{\ln(1-\alpha)}{-\lambda} = \frac{\ln(1-\alpha)}{\ln(1-\alpha)}$$

For example, the probability that the first infestation will occur before $T_{.10}$ years is 0.10. If the probability of infestation in any one year is $p = .40$, then

$$T_{.10} = \frac{\ln(.60)}{\ln(.90)} = \frac{-.51083}{-.10536} = 4.8$$

Table 3-7 lists the quantities p, λ, $E(T)$, T_α, α = .10, .25, .50, .75, .90, p = .01(.01).99.

TABLE 3-7

RELATIONSHIPS BETWEEN PROBABILITY OF ESTABLISHMENT AND TIME REQUIRED FOR ESTABLISHMENT

Probability of Establishment of An Agricultural Pest (P)	Average Pest Infestations Per Year	Average Years Until First Pest Infestation E(T)	Upper Limit of the Number of Years to Get an Infestation with Stated Probabilities 1/ — Percent Probabilities (T)				
			10	25	50	75	90
PERCENT	NUMBER	YEARS	NUMBER				
1	0.0101	99.49	10.48	28.62	68.97	137.94	229.11
2	0.0202	49.49	5.22	14.24	34.31	68.62	113.97
3	0.0305	32.83	3.46	9.44	22.76	45.51	75.60
4	0.0408	24.49	2.58	7.05	16.98	33.96	56.41
5	0.0513	19.49	2.05	5.61	13.51	27.03	44.89
6	0.0619	16.16	1.70	4.65	11.20	22.40	37.21
7	0.0726	13.77	1.45	3.96	9.55	19.10	31.73
8	0.0834	11.99	1.26	3.45	8.31	16.63	27.62
9	0.0943	10.60	1.12	3.05	7.35	14.70	24.41
10	0.1054	9.49	1.00	2.73	6.58	13.16	21.85
11	0.1165	8.58	0.90	2.47	5.95	11.90	19.76
12	0.1278	7.82	0.82	2.25	5.42	10.84	18.01
13	0.1393	7.18	0.76	2.07	4.98	9.95	16.53
14	0.1508	6.63	0.70	1.91	4.60	9.19	15.27
15	0.1625	6.15	0.65	1.77	4.27	8.53	14.17
16	0.1744	5.73	0.60	1.65	3.98	7.95	13.21
17	0.1863	5.36	0.57	1.54	3.72	7.44	12.36
18	0.1985	5.03	0.53	1.45	3.49	6.99	11.60
19	0.2107	4.74	0.50	1.37	3.29	6.58	10.93
20	0.2231	4.48	0.47	1.29	3.11	6.21	10.32
21	0.2357	4.24	0.45	1.22	2.94	5.88	9.77
22	0.2485	4.02	0.42	1.16	2.79	5.58	9.27
23	0.2614	3.82	0.40	1.10	2.65	5.30	8.81
24	0.2744	3.64	0.38	1.05	2.53	5.05	8.39
25	0.2877	3.47	0.37	1.00	2.41	4.82	8.00
26	0.3011	3.32	0.35	0.96	2.30	4.60	7.65
27	0.3147	3.17	0.33	0.91	2.20	4.40	7.32
28	0.3285	3.04	0.32	0.88	2.11	4.22	7.01
29	0.3425	2.91	0.31	0.84	2.02	4.05	6.72
30	0.3567	2.80	0.30	0.81	1.94	3.89	6.46
31	0.3711	2.69	0.28	0.78	1.87	3.74	6.21
32	0.3857	2.59	0.27	0.75	1.80	3.59	5.97
33	0.4005	2.49	0.26	0.72	1.73	3.46	5.75
34	0.4155	2.40	0.25	0.69	1.67	3.34	5.54
35	0.4308	2.32	0.24	0.67	1.61	3.22	5.35

TABLE 3-7 Cont'd.)

36	0.4463	2.24	0.24	0.64	1.55	3.11	5.16
37	0.4620	2.16	0.23	0.62	1.50	3.00	4.98
38	0.4780	2.09	0.22	0.60	1.45	2.90	4.82
39	0.4943	2.02	0.21	0.58	1.40	2.80	4.66
40	0.5108	1.95	0.21	0.56	1.36	2.71	4.51
41	0.5276	1.89	0.20	0.55	1.31	2.63	4.36
42	0.5447	1.83	0.19	0.53	1.27	2.54	4.23
43	0.5621	1.77	0.19	0.51	1.23	2.47	4.10
44	0.5798	1.72	0.18	0.50	1.20	2.39	3.97
45	0.5978	1.67	0.18	0.48	1.16	2.32	3.85
46	0.6162	1.62	0.17	0.47	1.12	2.25	3.74
47	0.6349	1.58	0.17	0.45	1.09	2.18	3.63
48	0.6539	1.53	0.16	0.44	1.06	2.12	3.52
49	0.6733	1.49	0.16	0.43	1.03	2.06	3.42
50	0.6931	1.44	0.15	0.42	1.00	2.00	3.32
51	0.7133	1.40	0.15	0.40	0.97	1.94	3.23
52	0.7340	1.36	0.14	0.39	0.94	1.89	3.14
53	0.7550	1.32	0.14	0.38	0.92	1.84	3.05
54	0.7765	1.29	0.14	0.37	0.89	1.79	2.97
55	0.7985	1.25	0.13	0.36	0.87	1.74	2.88
56	0.8210	1.22	0.13	0.35	0.84	1.69	2.80
57	0.8440	1.18	0.12	0.34	0.82	1.64	2.73
58	0.8675	1.15	0.12	0.33	0.80	1.60	2.65
59	0.8916	1.12	0.12	0.32	0.78	1.55	2.58
60	0.9163	1.09	0.11	0.31	0.76	1.51	2.51
61	0.9416	1.06	0.11	0.31	0.74	1.47	2.45
62	0.9676	1.03	0.11	0.30	0.72	1.43	2.38
63	0.9943	1.01	0.11	0.29	0.70	1.39	2.32
64	1.0217	0.98	0.10	0.28	0.68	1.36	2.25
65	1.0498	0.95	0.10	0.27	0.66	1.32	2.19
66	1.0788	0.93	0.10	0.27	0.64	1.29	2.13
67	1.1087	0.90	0.10	0.26	0.63	1.25	2.08
68	1.1394	0.88	0.09	0.25	0.61	1.22	2.02
69	1.1712	0.85	0.09	0.25	0.59	1.18	1.97
70	1.2040	0.83	0.09	0.24	0.58	1.15	1.91
71	1,2379	0.81	0.09	0.23	0.56	1.12	1.86
72	1.2730	0.79	0.08	0.23	0.54	1.09	1.81
73	1.3093	0.76	0.08	0.22	0.53	1.06	1.76
74	1.3471	0.74	0.08	0.21	0.51	1.03	1.71
75	1.3863	0.72	0.08	0.21	0.50	1.00	1.66
76	1.4271	0.70	0.07	0.20	0.49	0.97	1.61
77	1.4697	0.68	0.07	0.20	0.47	0.94	1.57
78	1.5141	0.66	0.07	0.19	0.46	0.92	1.52
79	1.5606	0.64	0.07	0.18	0.44	0.89	1.48
80	1.6094	0.62	0.07	0.18	0.43	0.86	1.43

TABLE 3-7(Cont'd.)

81	1.6607	0.60	0.06	0.17	0.42	0.83	1.39
82	1.7148	0.58	0.06	0.17	0.40	0.81	1.34
83	1.7720	0.56	0.06	0.16	0.39	0.78	1.30
84	1.8326	0.55	0.06	0.16	0.38	0.76	1.26
85	1.8971	0.53	0.06	0.15	0.37	0.73	1.21
86	1.9661	0.51	0.05	0.15	0.35	0.71	1.17
87	2.0402	0.49	0.05	0.14	0.34	0.68	1.13
88	2.1203	0.47	0.05	0.14	0.33	0.65	1.09
89	2.2073	0.45	0.05	0.13	0.31	0.63	1.04
90	2.3026	0.43	0.05	0.12	0.30	0.60	1.00
91	2.4079	0.42	0.04	0.12	0.29	0.58	0.96
92	2.5257	0.40	0.04	0.11	0.27	0.55	0.91
93	2.6593	0.38	0.04	0.11	0.26	0.52	0.87
94	2.8134	0.36	0.04	0.10	0.25	0.49	0.82
95	2.9957	0.33	0.04	0.10	0.23	0.46	0.77
96	3.2189	0.31	0.03	0.09	0.22	0.43	0.72
97	3.5066	0.29	0.03	0.08	0.20	0.40	0.66
98	3.9120	0.26	0.03	0.07	0.18	0.35	0.59
99	4.6052	0.22	0.02	0.06	0.15	0.30	0.50

1/ The interpretation of number 10.32 in last column is as follows -- If there is a probability of establishment of 20 percent, then there is a 90-percent probability that the first pest infestation will have occurred before 10.32 years.

4 THE EXOTIC PESTS AND DISEASES

The Task Force biologists provided essential information on 1,333 exotic pests and diseases which are a significant threat to the U.S. In all, there are 22 animal diseases, 551 plant diseases and nematodes, and 760 insects and mites. Direct estimates were made for the animal diseases, but for the other types the ranking model described in the last section was employed and a computer was used to handle the information and to make the calculations.

41 THE RANKING

The 100 top-ranking exotic pests are listed in Table 4-1, in the order of their Expected Economic Impact (EEI). The inclusion of the first 100 species in the table, rather than some other number, is arbitrary. All of the 1,311 species of plant pests and diseases have been ranked on the computer printout, but the inclusion of that large a quantity of information in the appendix would not serve the purpose of this report. However, the inclusion of this many, rather than a smaller number, provides a display of the variety of organisms involved. In addition, it illustrates how quickly the EEI declines in going down the list; from almost $4 billion for the first ranked species, to less than $40 million for the species ranked number 100, a decline of one-hundredfold. And finally, the list permits the inclusion of a significant number of insects which are somewhat scarce in the uppermost ranks. Altogether, the list of 100 species includes 16 animal diseases, 49 plant diseases and nematodes and 35 insects and mites.

The dollar values are not intended to be reliable estimates of the EEI for a particular species, but serve as a relative scoring device, believed to be within reason.

TABLE 4-1

THE 100 MOST DANGEROUS EXOTIC PESTS AND DISEASES
(Millions of Dollars)

Rank[1]	Species	Type[2]	Probability of Establishment[3]	EEI Mid-Point	EEI Range (Plus or Minus)[4] Confidence Interval 50%	90%	Direct[5] Estimate
1	Foot and mouth disease	A	H	3,987			1,500
2	Rosellinia radiciperda	P	H	3,126	282	698	
3	Helicobasidium mompa	P	M	2,703	118	291	
4	Cronartium himalayense	P	M	1,992	96	238	
5	Poria rhizomorpha	P	M	1,915	92	228	
6	African swine fever	A	H	1,825			686
7	Hemorrhagic septicemia	A	M	1,760			518
8	Fowl plague	A	H	1,751			488
9	Rinderpest	A	H	1,730			637
10	Cronartium quercuum	P	M	1,406	68	168	
11	Lumpy skin disease	A	M	1,394			410
12	Cont. bovine pleuropneumonia	A	L	1,144			382
13	Xanthomonas acernae	P	M	1,118	54	134	
14	Epizootic infertility	A	L	1,107			369
15	Phytophytora cambivora	P	M	1,093	81	201	
16	Louping ill	A	L	953			318
17	Lymantria monacha	I	L	945	468	1,159	
18	Bovine infectious petechial fever	A	L	837			279
19	Melampsora pinitorqua	P	M	662	32	79	
20	Ixodes persulcatus	I	H	622	65	166	
21	Rosellinia quercina	P	M	579	28	69	
22	Phakopsora pachyrhizi	P	M	551	35	87	
23	Rhizoctonia lamellifera	P	M	496	37	91	
24	Scleroderris abietina	P	M	440	33	81	
25	Hypodermella sulcigena	P	M	434	21	52	
26	Ephemeral fever	A	M	394			85
27	Agriotes lineatus	I	H	348	48	120	
28	Sirex noctilio	I	M	340	59	146	
29	Cenangium kozactstanicum	P	M	325	16	38	
30	Heterodera zeae	P	L	320	22	54	
31	Heterodera avenae	P	M	312	14	34	
32	Heterodera latipons	P	H	278	25	62	
33	Brunchorstia pini	P	M	258	34	85	
34	Aecidium glycines	P	M	222	10	26	
35	Pseudomonas syringae f.populia	P	M	221	11	26	
36	Cercospora pinidensiflorae	P	M	216	10	26	
37	Sclerospora sacchari	P	M	213	10	25	
38	Byctiscus betulae	I	L	199	107	265	
39	Malacosoma neustria	I	L	188	90	223	
40	Chionaspis salicis	I	H	185	39	96	

TABLE 4-1 (Cont.)

Rank	Species	Type	Probability of Establishment	EEI Mid-Point	EEI Range (Plus or Minus) Confidence Interval 50%	90%	Direct Estimate
41	Lepidosaphes tubulorum	I	L	183	89	219	
42	Heartwater (R. ruminantium)	A	H	178			50
43	Acanthostigma parasiticum	P	M	174	8	20	
44	Sclerospora philippinensis	P	M	161	12	30	
45	Sclerospora spontanea	P	M	152	7	18	
46	Scolytus scolytus	I	L	151	423	1,045	
47	Cerambyx cerod	I	L	151	104	258	
48	Tomicus piniperda	I	L	137	95	235	
49	Teschen disease	A	L	133			44
50	Maize streak virus	P	M	132	8	18	
51	African horse sickness	A	H	120			30
52	Mycosphaerella sojae	P	M	116	8	18	
53	Cerambyx scopolii	I	L	116	324	801	
54	Rice dwarf virus	P	L	115	8	20	
55	Septoria maydis	P	H	112	10	25	
56	Rift valley fever	A	M	112			33
57	Synchytrium dolichi	P	H	112	10	25	
58	Xanthomonas vaculorum	P	M	107	6	12	
59	Synchytrium umbilicatum	P	H	104	10	23	
60	Datura 437 virus	P	M	97	6	14	
61	Corynebacterium tritici	P	H	92	8	20	
62	Macrophoma mame	P	M	91	6	14	
63	Lepidosaphes newsteadi	I	L	91	45	111	
64	Dasychira pudibunda	I	L	87	162	399	
65	Ceratitis capitata	I	H	84	11	29	
66	Zabrus tenebrioides	I	L	83	44	109	
67	Agrilus viridus	I	L	82	231	570	
68	Colletotrichum zeae	P	M	80	8	22	
69	Zadiprion vallicola	I	H	78	2	11	
70	Operophtera brumata	I	L	71	35	85	
71	Maize stripe virus	P	M	71	4	10	
72	Heliothis armigera	I	L	67	27	67	
73	Trogoderma granarium	I	H	66	4	10	
74	Soybeans yellows mosaic	P	M	65	4	8	
75	Targionia vitis	I	L	63	25	63	
76	Pythium volutum	P	H	61	6	14	
77	Pseudomonas radiciperda	P	M	61	3	7	
78	Liothrips setinodis	I	L	60	30	74	
79	Diplodia zeicola	P	L	58	4	10	
80	Cucurbitaria piceae	P	L	56	4	10	
81	Eutetranychus orientalis	I	L	55	29	73	
82	Agriotes obscurus	I	L	54	22	54	
83	Sclerophtora raysiae	P	M	53	2	6	

TABLE 4-1 (Cont.)

Rank	Species	Type	Probability of Establishment	EEI Mid-Point	EEI Range (Plus or Minus) Confidence Interval 50%	90%	Direct Estimate
84	Amblyoma hebraeum	I	L	53	36	90	
85	Chrysomyxa deformans	P	M	52	2	6	
86	Chrysomyxa himalensis	P	M	52	2	6	
87	Agriotes sputator	I	L	50	20	50	
88	Nairobi sheep disease	A	L	48			16
89	Adelges japonicus	I	L	47	23	57	
90	Adelges tardus	I	L	47	23	57	
91	Spodoptera exempta	I	M	45	8	20	
92	Thecopsora areolata	P	M	44	2	6	
93	Ips typographus	I	L	43	57	136	
94	Physopella zeae	P	L	43	7	17	
95	Melanagromyza phaseoli	I	H	42	9	22	
96	Monolepta discrepens	I	L	42	53	131	
97	Macrosteles laevis	I	H	42	8	21	
98	Panolis flammea	I	L	40	17	41	
99	Heterodera rostochiensis	P	M	40	2	4	
100	Pucciniastrum padi	P	M	39	2	5	

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1. Rank is based on the midpoint of Expected Economic Impact (EEI)

2. Type and number of species

A = Animal diseases	16
P = Plant diseases and nematodes	49
I = Insects and mites	35
Total species	100

3. Probability of establishment is rated as High (25-99%), Medium (16-24%), and Low (1-15%).

4. Range is the distance from the mid-point to the maximum or minimum value.

5. The EEI range for the animal diseases was estimated directly rather than by use of the model.

The EEI mid-point is half way between the maximum and minimum estimate and is followed by the EEI range at 50 percent and 90 percent confidence intervals. For example, the EEI mid-point for Rosellinia radiciperda (the second ranked pest) is \$3,126 million, and the range is plus or minus \$282 million at the 50 percent confidence interval, and plus or minus \$698 million at the 90 percent confidence interval. For about 50 percent of the pests listed, the true EEI will lie within the 50 percent confidence interval (\$2,844 million to \$3,408 million for Rosellinia radiciperda) and for about 90 percent of the pests the true EEI will be in the 90 percent confidence interval (\$2,428 million to \$3,824 million).

The EEI ranges for the animal diseases were estimated directly rather than by use of the model, and therefore no confidence intervals are shown.

Ranking by the EEI mid-point, rather than by the EEI maximum at a selected confidence interval, or by some other method, is an arbitrary choice. If another method were chosen, this same body of information would yield a different ranking. It is important, therefore, that the precise ranking order not be interpreted too literally.

A brief summary of the important information on each of the most dangerous pests and diseases was prepared by the appropriate biologist. These 100 Pest Briefs were used by the Task Force in making the recommendations on program strategy that are included in the final chapter of this report. They are available as an appendix to this report. Below is the Pest Brief for Rosellinia radiciperda, the second ranked pest. It will serve as example of the information that was assembled.

Rosellinia radiciperda — New Zealand root rot

Ref: USDA Handbook 197

Distribution in World: 20 (New Zealand)

Life cycle: Ascospore germinates to form mycelium that can exist saphrophytically in soil or as a parasite in roots of hardwoods and conifers.

Hosts: Hardwoods and conifers

Stage of life at entry: Mycelium from ascospore

Ecological range in U.S.: In forests started in newly cleared land. Probably adapted throughout the country.

Limits to survival: Dry soils are inimical to it.

Rosellinia radiciperda (cont'd)

Technology of detection: Wilting of entire plants or terminal shoots, followed by death. Roots covered with white strands of mycelium, or between bark and wood. Later black ascocarps form.

Information useful in developing strategy for exclusion:

Outright prohibition of nursery stock since New Zealand is now only reported area.

For materials for scientific use fumigation and post entry quarantine and examinations.

No restriction on processed wood products.

One surprise to the Task Force was that so many forest pathogens turned up at the top of the list. It is customary to think of forest pests independently of those affecting annual crops. In fact, the values at stake in the forest are high because of large acreages and extended growing periods. The variable costs per acre for forest stands are hight compared to those of the annual crops.

The ranking scheme utilized the Expected Economic Impact (EEI) as outlined earlier in this report. Because of its components the forest values are high - where compared to those of annual crops - and correctly so. The EEI as here used does not take into account the drastic transient effect caused by major losses of an annual crop. While the ultimate loss caused by a forest disease is greater, there would be no abrupt shortage of forest products in a specific year. This is due to the relatively slow rate of disease increase in forest stands plus the fact that removal of diseased trees could be a part of logging removal. Conversely, the loss of a major part of our corn crop in a year would cause widespread disruption of prices, market export, etc. The recent southern corn leaf blight epiphytotic is illustrative.

In addition, the probability of establishment in annual crops is affected by the resistance of the infective propagule which may also affect the cost of control. For example, nematodes can survive in dry soil for extended periods and thus are very difficult to eradicate from soils once they are established.

4I.1 Expected Economic Impact. The entire universe of 1,333 species have been grouped, in Table 4-2, according to their Expected Economic Impact (EEI). Class I is a Very High EEI ranging from $401 million up to $4 billion, 1,000 times the magnitude of Class IV with its maximum EEI of only $4 million.

Only 25 species, that is less than 2 percent of the total, have a Very High ~~EEI~~, whereas Class IV with a Low EEI contains 75 percent of all the species.

As a group, the animal diseases have a higher proportion in the upper EEI classes, whereas the insects are concentrated, 82 percent of them, in the Low EEI. Although plant diseases are concentrated in the two lower classes (92 percent of them in Classes III and IV), they have the largest number of species in both Class I (13) and Class II (36).

TABLE 4-2

THE SIGNIFICANT EXOTIC PESTS BY SIZE OF EXPECTED ECONOMIC IMPACT

(NUMBER OF SPECIES)

Expected Economic Impact ($ millions)	Animal Diseases	Plant Diseases	Insects	Total	
				Species	Percent
I Very High ($401 to $4,000)	10	13	2	25	2
II High ($39 to $400)	6	36	33	75	6
III Moderate ($4 to $39)	4	128	100	232	17
IV Low (less than $4)	2	374	625	1001	75
TOTAL SPECIES	22	551	760	1333	100
PERCENT	2	41	57	100	

41.2 Probability of Establishment. The probability of establishment for each of the 1,333 species has been estimated. For convenience in presentation, the estimates for the top 100 species are grouped in Table 4-1 as low, medium, or high.

A low probability of establishment includes estimates ranging from 1-15 percent, and means that on the average the time until the first infestation will be more than 7 years. As shown in Table 4-3, more than one-third of the 100 most dangerous pests have a low probability of establishment and the bulk of these are insects.

Twenty-one of the top 100 species have a high probability of establishment, and this included six animal diseases, seven plant diseases and eight insects. Over 40 percent of the species are in a medium category, and most of these are plant diseases, where only 4 to 6 years is the average time until the first infestation.

TABLE 4-3

PROBABILITY OF ESTABLISHMENT FOR THE 100 MOST DANGEROUS SPECIES

(NUMBER OF SPECIES)

Probability of Establishment	Mean Time Until First Infestation*	Animal Diseases	Plant Diseases	Insects	Total Species
High (25-99%)	0-3 years	6	7	8	21
Medium (16-24%)	4-6 years	4	37	2	43
Low (1-15%)	7-99 years	6	5	25	36
	TOTAL	16	49	35	100

* See Section 33.7, Infestation as a Poisson Process.

41.3 The Limits of Knowledge. In assembling information on the exotic pests, the Task Force biologists often found that biological knowledge of key attributes was quite limited or missing altogether. This lack of information produced uncertainty about the possibilities for international movement and colonization and is responsible for the wide ranges of the EEI that are observable, particularly in certain insect species.

A number of the exotic pests with a very high EEI exhibit considerable uncertainty associated with that value. This means that while we believe these pests are very important, we are not very certain about precisely how important, and in cases of great uncertainty they may not be important at all! For example, in Table 4-1, number 17, *Lymantria monacha*, an insect, has a range in the EEI of $468 million, at the 50% confidence level, almost one-half the mid-point value of $945 million. This indicates a substantial amount of uncertainty. More biological knowledge is needed to provide an improved assessment of the potential danger.

Table 4-4 lists the 18 insects which are little known and need investi tion. The first group contains the insect mentioned in the preceding paragraph whose EEI is very high and about which there is moderate uncertainty. This pest, Lymantria monacha, is the highest priority for investigation. The second group contains six insects with a high EEI ($39 to $400 million), but with great uncertainty (EEI Range > Mid-Point). The third group contains 11 insects with a high EEI and moderate uncertainty. In individual cases these insects may be higher priority for investigation than certain species in Group Two.

As Oman has pointed out,[1] improving our knowledge of exotic species before they invade new areas not only contributes to improving our defense at ports of entry, but provides the information needed for eradication or control in the event of successful colonization. A similar list of plant pathogens could be developed.

41.4 Comparing the List. Apparently the Task Force compilation of 1,333 significant exotic pests and diseases is the largest and most comprehensive listing available to date. However, there are distressing inconsistencies when the list is compared to those available from other sources, as in Table 4-5.

In the Manual of Foreign Plant Pests, published in 1948, there are 1,172 species, yet only 151 of these can be found in the Task Force list of 1,311 plant pests. Have 1,160 new species been uncovered in the last 25 years? Why is it that 1,021 species in the Manual are not included as significant in the Task Force list? Is it because the Manual list includes many species that are relatively unimportant?

The same sorts of questions can be raised about the comparison with the other two lists. There are 87 insects listed in the Cooperative Economic Insect Report, (44 percent of the total in that report), which the Task Force did not consider of sufficient consequence to even list. On the ARS threat list, 31 out of the total list of 75 were found to be of so little consequence, or their hosts were of such little economic consequence, that they were not listed by the Task Force.

42 U.S. COMMODITIES AS TARGETS

The data bank established by the Task Force can also be used to assemble the list of exotic species of pests that would attack a crop or animal if they gained entry. Table 4-6 provides a sample listing from the data bank of 21 of the 171 hosts or commodities (the same listing as in Table 3-3). It shows the number of species known to attack each of the listed hosts.

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1. Oman, Paul, 1967, Prevention Surveillance and Management of Invading Pest Species, Bulletin of the Entomological Society of America, 14(2) 98-102, June 1968.

TABLE 4-4

EXOTIC INSECTS FOR INVESTIGATION*

Rank	Species	EEI ($ millions) Mid-Point	EEI ($ millions) Range (50% CI)
Group One (Very High EEI and Moderate Uncertainty)			
17	Lymantria monacha	945	± 468
Group Two (High EEI and Great Uncertainty)			
46	Scolytus scolytus	151	± 423
53	Cerambyx scopolii	116	± 324
64	Dasychira pudibunda	87	± 162
67	Agrilus viridus	82	± 231
93	Ips typographus	43	± 57
96	Monolepta discrepens	42	± 53
Group Three (High EEI and Moderate Uncertainty)			
38	Byctiscus betulae	199	± 107
41	Lepidosaphes tubulorum	183	± 89
48	Tomicus piniperda	137	± 95
63	Lepidosaphes newsteadi	91	± 45
66	Zabrus tenebroides	83	± 44
70	Operophtera brumata	71	± 35
78	Liothrips setinodis	60	± 30
81	Eutetramychus orientalis	55	± 29
84	Amblyoma hebraeum	53	± 36
89	Adelges japonica	47	± 23
90	Adelges tardus	47	± 23

* The relatively high EEI and the uncertainty associated with these exotic insects make them key species for biological investigation.

TABLE 4-5

COMPARISON OF LISTS OF IMPORTANT PLANT PESTS
(NUMBER OF SPECIES)

List	Total on List			Included in the 100 Most Dangerous			Included in the 1,333 Significant		
	Plant Diseases	Insects	Total	Plant Diseases (49)	Insects (35)	Total (84)	Plant Diseases (551)	Insects (760)	Total (1,311)
A	21	54	75	1	4	5	10	35	45
B	--	196	196	--	7	7	--	109	109
C	--	1,172	1,172	--	9	9	--	151	151

A "Examples of foreign pests and diseases of crops that have not gained entry into the Continental U.S. and are a threat to U.S. Agriculture," ARS undated list.

B Insects not Known to Occur in the United States, Cooperative Economic Insect Report, ARS, Consolidated Indices of Volumes 7 through 13 (1957 through 1963).

C Manual of Foreign Plant Pests, May 1, 1948 (Indices of Parts I through V).

TABLE 4-6

THE NUMBER OF EXOTIC PEST-SPECIES THAT WOULD
ATTACK U. S. CROPS OR ANIMALS (SELECTED EXAMPLES)
(NUMBER OF SPECIES)

Crop or Animal	Animal Diseases	Plant Diseases	Insects	Total Species
Acacia			10	10
Alfalfa		16	3	19
Almonds			8	8
Apples		15	61	76
Apricots		1	45	46
Artichoke		1	8	9
Ash		1	3	[illegible]
Asparagus			5	5
Avocadoes			24	24
Azalea			1	1
Barley		27	38	65
Beans - dry edible		19	26	45
Beans - green lima		2	20	22
Beans - snap		1	21	23
Beech			3	3
Beets - sugar		9	59	68
Birch			2	2
Blackberries			9	9
Blueberries			1	1
Cattle	10		15	25

To illustrate further, Table 4-7 shows the complete list of 29 pest species that would attack soybeans, ranked by their EEI. It also shows estimates of yield loss, ecological range (the percent of the soybean-growing area that would likely be occupied by the pest), and the cost per acre due to the pest. It should be noted that these expected losses and costs are not additive for a single crop.

42.1 Host Materials as Carriers. Having established a list of pests for each commodity, the Task Force turned its attention to those host materials which might provide transit. Known information on each of the important pests was carefully reviewed in the light of appropriate regulatory actions. As a result of this process of review and sifting it was possible to identify those materials most likely to harbor the high risk pests. The materials of highest risk vary, of course, according to the type of pest. That is, while soil connected to the roots of living plants is a very great risk for nematodes and plant diseases, it is not as high a risk as fruits or seeds in the introduction of insect pests of plants. The conclusions of the Task Force on the relative importance of host material by pest group are presented in Table 4-8.

43 THE WORLD DISTRIBUTION OF SPECIES

The 100 most dangerous exotic pests and diseases listed in Table 4-1 are distributed very unevenly in the world. As shown in Table 4-9, the largest concentration of these species are in Europe and Central Africa. Central Africa is a particularly acute problem because of the large number of animal diseases located there.

43.1 The Outlook for Introductions. The following discussion outlines the outlook for continued introduction from the major regions of the world.

Europe: While Europe has contributed the largest number of foreign pests now in the United States, it remains a high risk area. This is in large part because of similarity of climate and crops. Although agriculture and most of the basic crops originated in the Near and Middle East, many insect pests that originally occurred within these regions have long since spread to all climatically suitable parts of Europe. For reasons of culture and economics, commerce between Europe and the United States will remain at a high level. Therefore, the combined factors of similarity of climate, crops, and availability of pests potentially dangerous to the United States, suggest that Europe will continue to be a major source of pests dangerous to American agriculture and forests.

U.S.S.R.: The Soviet Union occupies a major part of the great biogeographic Palearctic Region. This Region includes all of Europe, North Africa, the Near East, Iran, North China, Korea, and the northern islands of Japan. Most of North America belongs to the Nearctic Region, which

TABLE 4-7

THE EXOTIC PESTS THAT WOULD ATTACK THE U.S. SOYBEAN CROP
(ESTIMATED ACREAGE: 40.9 MILLION)

Species	Plant Disease (P) or Insect (I)	EEI Mid-Point ($ Millions)	Expected Loss/Acre In Yield (%)	Ecological Range (%)	Cost Due to Pest ($/Acre)
Phakopsora pachyrhizi	P	$548	50%	100%	$20
Aecidium glycines	P	222	10	100	7
Micosphaerella sojae	P	116	5	100	12
Synchytrium dolichi	P	110	10	70	10
Synchytrium umbilicatum	P	102	10	70	10
Macrophoma mame	P	91	8	100	8
Soybeans yellows mosaic	P	32	15	20	12
Dactuliophora glycines	P	31	5	50	5
Ascochyta sojaecola	P	29	15	30	7
Mycosphaerella phaseolorum	P	28	5	50	4
Septogloeum sojae	P	28	5	50	4
Pyrenochaeta glycines	P	26	5	50	4
Sphaceloma glycines	P	25	15	20	12
Melanagromyza phaseoli	I	21	5	30	5
Zabrus tenebrioides	I	17	1	90	5
Monolepta discrepans	I	14	0	60	30
Heliothis armigera	I	14	3	90	3
Septoria sojina	P	10	5	20	4
Podisma pedestris	I	10	0	80	3
Ophionectria sojae	P	9	5	20	4
Spodoptera litura	I	7	2	100	6
Luperodis suturalis	I	7	0	60	3
Lampides boeticus	I	4	0.5	100	3
Oligonychus gossypii	I	4	1	20	3
Atrachya menetriesi	I	3	2	60	5
Scepticus insularis	I	3	0	80	4
Polia illoba	I	2	0	80	3
Heliothis gelotopoeon	I	2	3	30	3
Calliptamis italycys	I	1	1	20	1

Total Species: 29 (14 Insects, 15 Plant Diseases)

TABLE 4-8

HIERARCHY OF HOST MATERIALS BY LEVEL OF RISK IN EACH PEST GROUP

Plant Diseases

1. Living plants *
2. Soil connected to roots of living plants
3. Fruits of plants
4. Seeds
5. Soil not connected to roots of living plants

Nematodes

1. Living plants (roots)*
2. Soil connected to roots of living plants
3. Soil not connected to roots of living plants

Insect Pests of Plants

1. Living Plants*
2. Fruits
3. Seeds
4. Soil
5. Aircraft
6. Automobiles

Animal Diseases and Pests

1. Living animals
2. Fresh or frozen meat products
3. Animal byproducts
4. Contaminated garbage
5. Processed or cured meats

* It is significant to note the sources of introduction for live plants, as follows:

Category	Total Imports	From Canada	From Mexico
Fruit tree seedlings, layers and cuttings	217,300	146,300	
Fruit trees grafted or budded; fruit plant cuttings and seedlings	364,039	364,039	
Seedlings and cuttings of rose stock	0		
Rose plants, budded, etc.	217,717	217,040	
Live plants, suitable for planting	17,196,083	572,214	2,004,781

TABLE 4-9

WORLD TRADE REGIONS CLASSIFIED BY THE NUMBER OF DANGEROUS EXOTIC PESTS

		Number of Dangerous Pests			
Rank	World Region*	Total	Insects	Plant Diseases	Animal Diseases
1	Southern Europe and Turkey (9)	37	24	10	3
2	Northern Europe and Scandinavia (8)	37	22	13	2
3	Russia and Eastern Europe (19)	32	22	6	4
4	Central Africa (12)	29	7	9	13
5	Malay and Oceania (16)	27	9	12	6
6	India and Pakistan (17)	25	3	17	5
7	Near East (14)	22	11	3	8
8	Japan (15)	22	9	12	1
9	United Kingdom (10)	19	14	3	2
10	North Africa (11)	17	7	1	9
11	South Africa (13)	17	5	3	9
12	China (18)	16	7	5	4
13	Australia (20)	13	5	6	2
14	Canada (2)	8	4	4	
15	Eastern South America (3)	5		4	1
16	Cuba and the Antilles (5)	4		4	
17	Mexico (7)	2	1	1	
18	Western South America (4)	2		1	1
19	Central America (6)	1	1		

* A map of the World Regions is on page 39.

together with the Palearctic, makes up the Holarctic Realm. Many species of plants and insects are indigenous to both the Palearctic and Nearctic Regions. Most plant and animal genera are common to both Regions. This relationship between North American and Eurasian faunas becomes important, not only because of the dependence of American agriculture on crop plants and livestock that came originally from the Palearctic Region, but also because of a biological phenomenon associated with land area.

In all cases where ecologically homologous species come into competition, the species originating in the larger land mass may be expected to dominate. Since the Nearctic Region is much smaller than the Palearctic Region, indigenous North American species are at a disadvantage when confronted by competition from a species originating in Eurasia. This means that Palearctic species are commonly disruptive when introduced into Nearctic ecosystems and are often catastrophic when introduced into the basically Palearctic but less complex agro-ecosystems of North America.

As the largest land mass within the Palearctic Region the pest fauna of the U.S.S.R. constitutes the source of greatest potential danger to both the natural and agro-ecosystems of the United States. In a very real sense Europe is a hazard primarily because it serves as a way station for pests that originated in the heartlands of U.S.S.R. and the Near East. Despite a relatively small amount of commerce from the U.S.S.R. we have already acquired such pest problems as halogeton and Russian thistle. Any substantial increase in commerce from the U.S.S.R. is certain to expose the United States to a significantly increased risk of new pest problems. Soybeans are perhaps the most vulnerable crop, specifically to pests from the eastern part of the Palearctic Region which encompasses North China and Japan.

Orient: South China, the Indian subcontinent, and Indonesia, comprise the greater part of the oriental biogeographic realm. It is also an area of ancient agriculture and the source of many tropical fruit and vegetable crops as well as rice. Most of our pests of citrus and many ornamental shrubs came originally from the Orient. It remains an important reservoir for pests dangerous to many crops, particularly rice and subtropical fruits. The advent of air travel has greatly increased this hazard.

Australia: This geographically peculiar and isolated region is one of minimum hazard to the United States. However, the top ranking soybean rust (22nd in rank) is present in Australia. For the most part, Australian pest problems are, like ours the result of foreign introductions and many of the species are already major pests in the United States.

Africa: Africa is divided between a northern Palearctic area, already considered in the discussion of Europe and the U.S.S.R., a broad tropical belt south of the Sahara Desert, and the temperate region of South Africa. The indigenous fauna and flora of tropical and South Africa are very different from that of North America. In temperate South Africa many of the insect pests are introduced from Europe or other parts of the world and again many are already present in the U.S. The most dangerous element of the African fauna appears to be insects and ticks that attack livestock. Many of these are dangerous primarily as vectors of disease. Certain leafhoppers associated with grammacious crops, such as corn millet and sorghum, are also dangerous to agriculture in southern U.S., primarily as vectors of plant virus diseases not known in this country.

South America: Like Africa, South America is divided into tropical and southern temperate zones. However, the latter extends far north along the Andean Mountains and includes the center of ancient Incan agriculture where many potato pests occur that are not found in the United States. This temperate region has already contributed such pests as the imported fire ant, white fringed beetle, and the vegetable weevil. No doubt other potential pests occur there, but their number will be small when compared with Europe and East Asia. Few pests of the tropical region will be adapted to live even in southernmost U.S.

West Indies: Some species, often introductions from other tropical regions, may constitute a threat to sugarcane and tropical fruits in Florida, South Texas, and southern California, but the total number of potential pests is small. Most of those that would appear to constitute a real danger are already in Florida or have had ample opportunity to gain entry but have failed to establish there. Introduced pests, such as the Mediterranean fruit fly, which is found on certain islands, and in Venezuela as well as in Central America, make it necessary to maintain strict vigilance over fruit and other commodities coming from the Caribbean region.

Mexico: The long northern border of Mexico bisects life zones and agricultural areas common to both that country and the United States. Mexico has already contributed the cotton boll weevil and the Mexican bean beetle to our list of economic pests. The pink bollworm of Indian origin also gained entry to the U.S. via Mexico, and more recently the citrus blackfly and cattle fever tick have again moved into South Texas from the other side of the Rio Grande River. Mexico also promises to provide a pathway of entry for the African bee and the Mediterranean fruit fly. However, it seems likely that Mexico has few additional indigenous pests of serious concern to the United States. Those that could adapt to the more northern climate of the United States are here. Most of the others have had an opportunity but could not survive. The most important exception to this generalization is likely to be the insect pests of avocado which is a relatively new crop in northwestern Mexico, southern California and south Florida. The avocado weevils in particular could cause serious losses to growers in the United States. However, most of the pests associated with vegetables, flowers, cactus, and commodities other than fruit and nursery stock, are either already present in the U.S. or are unable to maintain populations beyond the borders of Mexico in other than greenhouse situations.

Canada: The life zones of northern United States, without exception, continue on into Canada. Any indigenous insects adapted to one of these life zones will be found in both countries. A foreign insect, once it gains entry to either Canada or the United States and establishes a population, will ultimately extend its range throughout the life zone to which it is adapted. Many pests have first become established in the U.S. and then moved into Canada. Examples are the European corn borer, the alfalfa weevil, the gypsy moth, and the rusts of cereals. Other species have first established in Canada and then moved south into the United States. The European March crane fly is a notable recent example of a pest that has moved from Canada to the United States. A current example of a plant pathogen in Canada but not yet in the United States is the oat nematode. Other European pests, such as the winter moth and two potentially dangerous species of wireworms, are established in the Maritime Provinces. Research by Canadian entomologists has already effectively neutralized the winter moth.

In relations with Canada it is important to coordinate foreign plant quarantine activities and research on control of invading pests in a way that will serve the interests of both countries. Internally, regulatory activities should be those normally applied by either country to confine or eradicate an invading pest.

Hawaii: The State of Hawaii presents a special problem. Because its extreme vulnerability to invasion by foreign insects it is perhaps second only to Europe as a potential source of pests dangerous to the 48 contiguous States. This danger is mitigated only by the fact that most of the pests entering and colonizing Hawaii (excluding those that originate from mainland U.S.) are coming from the tropical and subtropical regions of Southeastern Asia, Australia, and Oceania. Hawaii is thus a way station primarily for pests adapted to climates of southern United States. However, it is only necessary to cite such pests as the Mediterranean fruit fly, Oriental fruit fly, and the melon fly to indicate the danger of introductions from Hawaii. The danger has recently been accentuated by direct air flights from Honolulu to Florida and other inland locations in mainland U.S. All reasonable efforts should be taken to assure that aircraft leaving Hawaii are not carrying dangerous pests. Special pains should be taken to inform returning tourists of the danger associated with any fruits, flowers, or seeds that they might be tempted to smuggle into the mainland. Aircraft cargo and baggage compartments should also be routinely treated with a suitable fumigant at time of departure.

5 PROGRAMS FOR FOREIGN PROTECTION

51 SURVEY OF FOREIGN PROGRAMS

Almost every nation restricts or prohibits the movement of persons or materials likely to carry pests and diseases affecting domestic plants and animals.[1] Only 11 of the 171 countries reviewed have no form of regulation on either entering travelers or cargo.[2]

While most countries regulate the import of agricultural cargoes, a much smaller number have regulations concerning incoming travelers who may be carrying agricultural materials. As shown in Table 5-1, 82 percent of the countries regulate cargo, whereas only 22 percent regulate travelers.

TABLE 5-1

REGULATION OF TRAVELERS AND CARGO BY COUNTRIES OF THE WORLD

	Travelers		Cargo	
	Number	Percent	Number	Percent
Regulations	37	22	157	82
No Regulations	134	78	14	18
Total	171	100	171	100

Of the 157 nations that regulate cargo, only 34 of them also regulate travelers. Therefore, as shown in Table 5-2, only 20 percent of the countries in the world regulate both travelers and cargo; 123 countries regulate cargo only (72 percent), and 3 countries regulate travelers only (2 percent).

TABLE 5-2

TYPE OF REGULATION

Type	Number	Percent
Both Travelers and Cargo	34	20
Cargo Only	123	72
Travelers only	3	2
Total regulated	160	94
Not regulated	11	6
Total	171	100

1. Appendix 5-A contains a master list of countries, their rank and values in agricultural production and imports, their rank and number of foreign visitors, and an indication as to whether imports and visitors are subject to regulation.

   Much of the information in this section came from the Travel Information Manual, Amsterdam, Netherlands.

2. The unregulated countries are listed in Appendix 5-B.

No systematic information is available on the extent to which the prescribed regulations are enforced by the nations of the world. However, it is a common observation among U.S. travelers that baggage inspection of incoming passengers at U.S. ports of entry is one of the most intensive in the world. The regulations on the importation of agricultural cargoes for 117 countries specifically mention that such cargoes are subject to inspection on arrival. However, this provides no clue to the extent of actual inspection practices. Therefore, we do not know the extent of enforcement for either passenger or cargo regulations.

The techniquos used for inspection and enforcement by foreign nations include all of the following methods. These have been summarized from correspondence with nine U.S. Agricultural Attaches and two multinational organizations.[3]

--Sanitary certificates issued by qualified persons in the exporting country.

--Inspection at port of entry.

--Treatment at port of entry or as a condition of entry.

--Destruction when infestation is found and treatment is not feasible.

--Outright prohibition of certain items from specified countries.

--Quarantining for observation and examination both at ports of entry and on the premises of the importer.

--Inspection prior to time of departure from point of origin in exporting country.

--Processing requirements for elimination of pathogens

--Licensing of imports (permits).

--Establishing and reviewing standards of treatment or handling that qualify importers to receive certain commodities.

--Cleaning the clothes and shoes of people associated with farm animals.

All of these techniques are well known in the United States, and we regularly employ all of them in our programs, except the last one.

3. The correspondents are listed in Appendix B-C.

TRAVELERS

Perhaps the most interesting finding in our investigation of the handling of the risk of agricultural pest and disease introduction by foreign nations is the different views on the significance of travelers as "vectors" of pests and diseases. As previously noted, only 37 countries in the world currently restrict or prohibit the entry of agricultural products carried by incoming travelers. Nine countries have some kind of regulation concerning both plants and animals and their products. Nine countries regulate animals and animal products only, and 17 countries regulate plants and plant products only. These 37 countries are listed in Table 5-3.

TABLE 5-3

THE 37 COUNTRIES THAT RESTRICT OR PROHIBIT THE ENTRY OF AGRICULTURAL PRODUCTS CARRIED BY INCOMING TRAVELERS

Plants Only (19)	Animals Only (9)	Plants & Animals (9)
Antigua	Belgium	Australia
Barbados	Brazil	Cuba
Chile	Ethiopia	Israel
Comores Islands	Iceland	Japan
Fiji	Netherlands	New Caledonia
French Polynesia	New Guinea	Panama
Gilbert & Ellice Islands	Nicaragua	Surinam
Greece	Papua	United Kingdom
Kenya	Switzerland	United States
Liberia		
Mauritius		
Mozambique		
Nigeria		
Pakistan, West		
Philippines		
United Arab Republic		
Uruguay		
USSR		
Venezuela		

There is great variation among the countries in the type of regulations that exist. In some cases; e.g., United Arab Republic, the regulations consist of a complete prohibition against a single plant species, cotton. In other nations; e.g., the United States or Australia, there are extensive listings of restricted and prohibited materials.[4]

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4. A summary of the regulations in force on travelers is in Appendix 5-D.

In 1970, only 25 million (17 percent) of a reported total of 168 million foreign visitors, arriving in 48 major countries, were subject to regulation. Thirteen million, or more than one-half of those regulated, entered the United States. As shown in Table 5-4, among the 12 most visited countries (that receive three-quarters of all visitors) only the United States and the United Kingdom restrict or prohibit the entry of agricultural products carried by incoming travelers.

TABLE 5-4

FOREIGN VISITOR ARRIVALS BY COUNTRY, 1970

Rank	Country	Arrivals* (Millions)	
1	Spain	23	
2	Canada	15	
3	Italy	14	
4	France	14	
5	United States	13	Regulated
6	Austria	9	
7	Germany, West	8	
8	Hungary	6	
9	Yugoslavia	5	
10	United Kingdom	4	Regulated
11	Czechoslovakia	4	
12	Bulgaria	2	
	36 Other Nations	51	
	Total	168	

* Source: International Union of Official Travel Organizations (IUOTO) and the Tourism Committee of the Organization for Economic Cooperation and Development (OECD), as reported by U.S. Travel Service, Department of Commerce.

From the standpoint of quarantine protection, it is the total number of arrivals that matters and not just the foreign arrivals. Unfortunately, data on total arrivals for each country are not available. It is known, however, that citizens of the United Kingdom, Germany, France, Japan, and the United States are the leading intercontinental travelers.

Why is such a small proportion of foreign visitors subject to regulation? Apparently, the adoption of regulations is not related to the volume of visitor traffic. Why have such a small number of countries adopted regulations on travelers? What is the fundamental reason for the adoption of regulations in these countries where they exist?

Four factors will be considered that might explain the present pattern of regulations:

Vulnerability. Countries that have insular biota[5] are particularly vulnerable to the introduction of pests and diseases, since ecological niches for establishment are more likely to exist than on continental land masses. As shown in Table 5-5, among the 54 countries, or separate political jurisdictions, that have insular biota, 15 of them, or 28 percent, have regulations on travelers. This proportion is only slightly higher than the 22 percent of all countries that have traveler regulations (see Table 5-1).

TABLE 5-5

REGULATION OF TRAVELERS AND CARGO BY COUNTRIES WITH INSULAR BIOTA

	Travelers		Cargo	
	Number	Percent	Number	Percent
Regulations	15	28	51	94
No Regulations	39	72	3	6
Total	54	100	54	100

However, 94 percent of the insular countries have cargo regulations, whereas only 82 percent of all countries have them.

A comparison of the type of regulation, as shown in Table 5-6, indicates that the proportion of insular countries that choose to regulate both travelers and cargo (24%), cargo only (66%), and travelers only (4%), does not differ very much from the type of regulations employed generally (20%, 72%, and 2%, respectively - see Table 5-2).

TABLE 5-6

TYPE OF REGULATION IN COUNTRIES WITH INSULAR BIOTA

Type		Number	Percent
Both Travelers and Cargo		13	24
Cargo only		36	66
Travelers only		2	4
	Total regulated	51	94
	Not regulated	3	6
	Total	54	100

5. Countries with insular biota are indicated on the master list in Appendix 5-A.

It appears, therefore, that countries with insular biota foster cargo regulations as a means of protection, in about the same proportion as other countries and have no more reason to regulate travelers than do countries of the world generally. There is no evidence that those countries which are particularly vulnerable by reason of their insular biota have chosen to regulate travelers as a means of risk reduction.

Values at Stake. Certain nations have a particularly large stake in agricultural production and might therefore be expected to have an extraordinary concern about the importation of exotic pests and diseases by visitors. However, as shown in Table 5-7, there is no apparent relationship between the magnitude of agricultural production and the imposition of passenger regulations.

A Reaction Against a Particularly Acute Pest. The U.S.-Mexican Border program began as an attempt to exclude pink bollworm (an attempt that was unsuccessful).

The Real (?) Danger. Since commercial cargoes can be effectively treated, and are usually moved under some form of inspection and certification, the real danger must be in the small lots of infested materials carried by travelers!

Status, Wealth, Capability. Some programs are created in emulation of the existing program in the United States.

53 PROGRAM ASSESSMENT

None of the nine U.S. Agricultural Attaches with whom we corresponded were able to locate any assessment of the quarantine programs that were being carried out in the countries to which they were assigned. However, it may be that such studies exist, even on an informal basis, and they are closely held within the administering organizations.

That quarantine programs are efficacious and valuable is usually accepted by the persons engaged in them on the basis of the presumptive evidence available; e.g., identification of pest "A" in infested cargo, availability of apparently suitable environment and food for pest "A" in the importing country, and failure to find that pest "A" has become established.[6]

Dr. Robert Kahn, a member of the AC staff in charge of the East African Community Plant Station under PASA, is of the opinion that there is no satisfactory way of evaluating quarantine programs, and by way of explanation, indicated the difficulties involved in simply stating the objectives of such programs

6. For an example of this reasoning see: Reagan, E.P. 1969 "Preventive Pest Control Measures" in Scientific Aspects of Pest Control, pp. 185-192. Publ. 1402, NAS/NRC, Washington, DC.

TABLE 5-7

MAJOR AGRICULTURAL COUNTRIES AND THE REGULATION OF VISITOR ARRIVALS

Agricultural Production (By Economic Size Class)	Number of Countries	Foreign Visitor Arrivals (Hundreds of Thousands), 1970			
		Not Regulated		Regulated	
Class I ($5-50 Billion)	7	France (137) West Germany (77)	India (3) Poland	United States (132) USSR	Japan (8)
Class II ($3-5 Billion)	6	Canada (148) Turkey (4)	Italy (142)	United Kingdom (45) Australia (3)	Brazil
Class III ($2-3 Billion)	8	Spain (226) Yugoslavia (47) Czechoslovakia (35) Romania (23)	Mexico (22) Argentina (6) East Germany	Nigeria	
Class IV ($1-2 Billion)	16	Hungary (63) Bulgaria (25) Denmark (25) Sweden (16) Iran (3) Colombia (2)	Indonesia (1) South Africa Korea Bangladesh New Zealand	Netherlands (24 Belgium (14) United Arab Republic (4) Philippines (1)	West Pakistan

Summary, number of countries:		Not Regulated	Regulated
Major (from above Table 5-7)	37	25	12
Minor (all other countries)	67	42	25
Total	104	67	37

Mr. Gideon-Cohen, former Director of the Plant Protection Service in Israel, is now their agricultural attache in Washington. His comments on the desirability of plant quarantine programs were tempered by a degree of skepticism as to their efficacy. Despite the gaps in their quarantine efforts, he believed them to be worthwhile. The doubters were mostly to be found among the researchers, and he regretted the lack of data which would put the argument to rest.

In our correspondence with U.S. agricultural attaches and quarantine officials of foreign nations, a number of other references were made to the efficacy of quarantine efforts. Most of these are simply assertions of its value, unsupported by any objective evidence.[7]

All over the world, quarantine programs appeared to be based on authority without scientific support or verification. Quarantine actions are a matter of public policy and the usefulness of these activities has not been verified. Most responsible officials assert its validity, an expected attitude for one charged to administer laws and regulations. Even so, skepticism is sometimes expressed, even by regulatory officials.

54 EUROPEAN EXPERIENCE

To prevent the introduction of diseases and pests, inspection regulations are in force in all 27 European countries, except the Faeroe Islands. Only 6 countries[8] (22 percent) regulate travelers.

The riskiest items from the standpoint of agricultural pests and diseases are considered to be seeds, bulbs, and living plants and animals. Travelers are regarded as low-risk vectors, and consequently passengers, ships and planes are generally ignored. Airplane inspection is regarded as ineffectual. The focus of inspection is on agricultural cargoes, but the intensity of this inspection varies considerably from one country to another. Generally, it is the imported product that is quarantined or treated at the country of destination, rather than at the port of entry to the Continent; e.g., wheat entering Amsterdam destined for Austria is inspected in Austria.

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7. Excerpts from correspondence with U.S. agricultural attaches and quarantine officials of foreign nations relating to program assessments are included in Appendix 5-E.

8. European countries regulating travelers are Belgium-Luxembourg, Greece, Iceland, Netherlands, Switzerland, and United Kingdom (see Appendix 5-D).

Apparently, no attempt has been made to evaluate the overall success of failure ~~of~~ these European inspection efforts, and the problem of doing so is regarded as too complicated. Nor were any studies found of the effectiveness of inspection procedures in uncovering infestations. Furthermore, there is no organized, systematic effort to detect foreign insects which may have arrived in Europe or begun to colonize.

At present, the European and Mediterranean Plant Protection Organization (EPPO) is (1) establishing a list of "those dangerous quarantine pests and diseases not yet introduced into Europe and the Mediterranean area, ~~such as Popillia japonica, Rhagolethis pomonella, and Pierce disease~~ virus on grapes;" (2) establishing a list of "those dangerous quarantine pests and diseases already introduced in one of the EPPO member Countries, requiring (or having required) action for control by official governmental plant health bodies (eradication or other controls);" (3) trying to bring order out of the jumble of regulations which are different in every European country; and (4) pushing the idea of preinspection in the country of origin, especially for containerized shipments.[9]

9. Interview with Dr. G. Mathys, Director-General, European and Mediterranean Plant Protection Organization, 1, rue Le Notre, 75, Paris, 16e, France, May 22, 1972, by Richard D. Butler, APHIS, USDA. EPPO was founded to carry out the provisions of the International Plant Protection Convention established by FAO in 1951 for the joint control of plant pests and diseases, while eliminating the obstacles which hamper internation exchange of plant products.

6 PROGRAMS FOR U.S. PROTECTION

61 HISTORY

Introductory Note - The Task Force found no historical account of the development of foreign inspection and quarantine in the United States. In the belief that such an account would provide useful perspectives for the review of policies and programs, Dr. Vivian Wiser of the Agricultural History Branch, Economic Research Service, was requested to prepare a history. The following section is a summary, prepared by Dr. Wiser, of her more extensive historical account.[1]

INSPECTION AND QUARANTINE WORK

An Overview
By Vivian Wiser[2]

When the American colonial legislatures enacted measures to prohibit ships from discharging ballast along the rivers, their primary motive was to prevent channel obstructions to shipping. Unknowingly, they were, at the same time, protecting their agriculture from plant diseases and pests concealed in the material, for later writers have speculated that such waste materials brought in insects and diseases that the American farmer struggled against. Colonials also, no doubt, introduced potential problems with seeds and plants brought or bought from overseas. Even their imported livestock may have been carriers of disease that infested domestic animals.

Military movements have also been a factor from the time when Hessian soldiers, hired by the English during the Revolutionary War, introduced the Hessian fly in straw for their horses. In more recent years, the military departments have been concerned and cooperated with the Department of Agriculture by issuing regulations to prevent introduction or spread of animal and plant pests and diseases. However, these have not always been implemented. Civilian departments, along with other groups interested in introducing new plants, probably have unknowingly contributed to the problem from the time when the Secretary of Treasury, on March 26, 1819, urged consuls to send home plants and seeds to improve America's agriculture. Nearly forty years later, a number of the boxes of plant materials collected by Townend Glover contained cane borers, evoking criticism from the agricultural press.

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1. The complete history, entitled "Protecting American Agriculture: Inspection and Quarantine" is Appendix 6-F.

2. The author is Historian, Agricultural History, Economic and Statistical Analysis Division, Economic Research Service, U.S. Department of Agriculture.

It was in the area of animal disease and quarantine that the greatest furor arose. Aware of the impact of the quarantine and destruction efforts of the Commonwealth of Massachusetts before it eradicated pleuropneumonia in 1865, the United States Congress enacted legislation to prohibit the importation of cattle in December that year. A decade passed before the Secretary of Treasury, who administered the law, issued the first quarantine, against Spanish cattle and hides. Subsequently, he directed customs inspectors to quarantine any imported European cattle at the owner's expense. The cattle commission, appointed to resolve some of the problems of disease control at home and abroad, urged and obtained sites for four quarantine stations where such animals could be kept. In 1884, these installations were transferred to the Department of Agriculture and to the newly established Bureau of Animal Industry. Customs agents and BAI inspectors worked closely in implementing the program.

Although the first meat inspection law of 1890 was geared to protect our foreign trade by insuring disease-free exports, it also provided for the inspection and quarantine of certain imported animals to protect our livestock against communicable disease. In less than two years, Secretary Rusk, using this authority, suspended import permits for English livestock because of an outbreak of foot-and-mouth disease in Britain.

Similar problems had developed for plant materials. Unfortunately, while damage from plant diseases and pests was extensive, it was not as dramatic as livestock losses, nor was there as powerful a pressure group to promote national protection. The California State Legislature led the way, when, prompted by the extensive damage inflicted by the San Jose scale, it instituted a system of plant inspection at ports of entry in 1881. Meanwhile, State and Federal entomologists were conducting research in controlling plant pests and diseases, making a real breakthrough when they found that the Vedalia ladybird provided biological control for cottony cushion scale. However, a number of ther countries, no doubt with the dual objective of protection and trade restriction were prohibiting the entry of American fruit and living plants. On the basis that many of the pests and diseases were of foreign origin, a demand for Federal inspection and quarantine system gained momentum in the United States during the 1890's. The next step was taken when the Department of Agriculture inaugurated an inspection program in 1906 for its imported plant materials. Soon it urged commercial outlets to cooperate.

A Federal inspection and quarantine system was finally provided for in the Plant Quarantine Act of 1912, prompted by the alarm sounded when the gift of Japanese cherry trees was found infested with oriental fruit moth. The Federal Horticultural Board, composed of representatives from the Bureau of Entomology and Plant Industry and from the Forest Service, administered the foreign and domestic inspection system and control and eradication measures. The law permitted the importation of nursery stock from countries having inspection service. State inspectors, acting as collaborators, conducted most of the inspection work.

Soon the United States economy was expanding to meet increased demands of World War I, but this had little positive impact on the import inspection and quarantine work. The Post Office Department's effort to prevent the introduction of pests through the mails did not keep out infested nursery materials. The unsettled state of affairs in Mexico created problems with tick carrying cattle; this and the pink bollworm threat in 1916 provided a precedent for greater cooperation between the United States and Mexico in the Post World War I years. A week after the Armistice was signed in 1918, the Secretary of Agriculture announced his intention to issue a quarantine tightening controls over imported seeds, nursery stock and other plants, to go into effect June 1, 1919. Anxious to close a loophole, the Secretary of Agriculture appealed to the Secretary of the Navy to alert fleet officers of the quarantine regulations on importation of plants and animals, but officers showed little concern.

The 1920's saw a continuation of the controversy over the merits of extending foreign as well as domestic quarantines for plant pests and diseases, a discussion that became involved with the whole question of trade restriction and tariff legislation. Thus in 1922, a provision of the Fordney-McCumber Tariff Act related to certification of breeds of imported animals. Six years later, the League of Nations, the predecessor of the United Nations established a committee on reducing the effect of sanitary regulations on imported animals and animal products.

The Hawley-Smoot Tariff of June 17, 1930, included an embargo on livestock and fresh meat importation from countries having foot-and-mouth disease. Mexico and the United States had only six months earlier exchanged ratifications of an agreement restricting movement of livestock to prevent introduction or spread of contagious diseases, an agreement violated by both sides. Meanwhile, Federal inspectors, whatever their departmental ties, were important agents as they prevented the entrance of diseases and pests, such as the Mediterranean fruit fly that had required Federal and State cooperation for its control and eradication in 1929, or foot-and-mouth disease.

The 1930's saw a shift in emphasis in the work of the Department of Agriculture under the New Deal. The Department's scientists, supported by Secretary Wallace, sought to hold the line against allowing the question of inspection and quarantines to be included in the discussions of reciprocal trade agreements. At the same time, they were aware of the fact that some, especially nurserymen and bulb producers were benefiting from the restrictions and the Plant Quarantine Act was amended in 1936 to require disinfection. During this same year, the United States and Mexico took a real step forward when an informal agreement was reached for cooperation in an effort to eradicate the pink bollworm, a foundation for the joint program developed the following year.

The 1940's were years of greater stress and challenges to a program to protect America's agriculture from foreign pests and diseases. The Mexican Border Act of January 31, 1942, clarified earlier legislation for inspecting, cleaning, and disinfecting railroad cars, other vehicles, baggage, etc. Problems of the increasing involvement of the United States in World War II highlighted the increasing complexity that such action entailed, with the military services issuing regulations. Then an interdepartmental quarantine commission cooperated in developing workable procedures. The task of inspecting packages sent home by U.S. servicemen abroad was almost impossible and only about 1 percent were so processed.

Even under these strains and stresses groundwork was laid when the Mexican-United States Agricultural Commission met in Mexico City in 1944, for the subsequent all-out campaign to eradicate foot-and-mouth disease within Mexico. This was successfully completed, with the last outbreak occurring in 1953.

The postwar years saw a greater emphasis on eliminating trade barriers, accentuating problems for administration of inspection and quarantine regulations. Similarly, the shift to air transportation increased the pressures. Thus as some were opposing continued stringent control, the Department held hearings to determine those most needed.

Following the invasion by North Korea in 1950 and the involvement of United States forces in South Korea, the military issued joint regulations covering plant and animal quarantine and inspection. Along with the large-scale movement of troops, civilian air traffic rapidly increased, especially after worldwide coach service was inaugurated in 1954. Two years later, the groundwork was laid for increased surface travel when the Federal Highway Act authorized an interstate system of highways. After a lapse of three more years, the St. Lawrence Seaway brought ocean vessels into the heartland of the Continent.

The 1950's saw the aggressive program of combating insect intruders exemplified in the continuation of the campaign for the eradication of the foot-and-mouth disease in Mexico under the joint U.S.-Mexican Commission and the 1956 all-out program that eradicated a new infestation of the Mediterranean fruit fly in 18 months.

On the research side, the Department in 1952 selected Plum Island as the site for a station where foot-and-mouth disease as well as other highly contagious diseases might be studied. Two years later, other scientists accomplished a real breakthrough when they used laboratory sterilized flies to eradicate screwworms in Curacao, a technique later used to eradicate screwworms from Florida and to effectively suppress this pest in the southwestern U.S.

Such defensive measures were especially important in years when the Department found that it must assume greater responsibility for the inspection work as Federal Customs officials, in 1953, and Florida, in 1957, notified the Department of Agriculture of their inability to continue such activities. New legislation in 1957, the Federal Plant Pest Act, facilitated this by providing more effective control over movement of plants and pests. Moreover, pre-inspection at some ports, such as Hawaii, Puerto Rico, and Canadian rail and air terminals was instituted.

International travel, increased trade in agricultural commodities, technological changes such as containerization, and the continuation of U.S. involvement in Vietnam continued to exert pressure on inspection and quarantine procedures during the 1960's. To relieve this, in part, military personnel were deputized in 1961 to enforce regulations. But the following year Congress extended the potential coverage of the animal and poultry import inspection controls. Then in 1967, California notified the Federal Government that, as an economy measure, it would no longer inspect imported plants. Because of the increased number of travelers coming in, the Government instituted an accelerated inspection system at the John F. Kennedy International Airport, in 1968, under which a single officer represented the Customs Service, Public Health Service, Immigration and Naturalization Service, and the Department of Agriculture. After extending this system to other airports, other efforts were used to speed up the ever increasing traffic.

While much of the emphasis has been on inspection at ports of entry, a great deal of the commercial trade in plant and nursery materials is inspected abroad by U.S. personnel or by comparable representatives of other countri Moreover, the Department has cooperated with other countries as they have urged an international approach. Thus in 1968, U.S. representatives attended the first session of the Caribbean Plant Protection Commission, as well as cooperating with the International Plant Protection Convention, although not a signatory nation at the time.

In 1971, the Agricultural Research Service established the Plant Disease Research Laboratory at Frederick, Maryland, to do research on foreign plant diseases of concern to the agriculture of the United States. This Laboratory has access to an personnel skilled in handling exotic pathogens of crop plants under containment--without danger of escape of such pathogens. It is parallel in a sense to the Plum Island Animal Disease Laboratory, providing the Department of Agriculture with a capability to investigate foreign plant pathogens.

Developments in the 1970's seem confusing; on the one hand, the Secretary announced on December 15, 1971, the selection of Fleming Key, off the Florida coast as the site of a maximum security animal quarantine station. Finally, on June 12, 1972, two decades after the International Plant Protection Convention was drawn up to provide a forum for discussing problems arising from the quarantine and inspection work, the United States Senate ratified it. On the other hand, while environmentalists are forcing the abandonment of the use of certain pesticides, questions have been raised concerning the efficacy of the controls over introduction of animal and plant pests and diseases.

For years, the animal quarantine work was implemented by the Bureau of Animal Industry. The Federal Horticultural Board, established under authority of the 1912 Plant Quarantine Act, had been under criticism years before it was abolished in 1928 and its regulatory work assigned to the newly established Plant Quarantine and Control Administration. This was replaced four years later by the Bureau of Plant Quarantine. In turn, in 1934, this was combined with the Bureau of Entomology. Following the reorganization of 1953, when the Bureaus lost their identity in the Agricultural Research Service, a Deputy Administrator for Regulatory Programs was appointed, assisted by Directors for Crops and Livestock Regulatory Programs. In 1965, meat inspection functions were transferred to the Consumer and Marketing Service and animal inspection and quarantine activities were shifted to the redesignated Animal Health Division. In 1970, the regulatory/control work was given more status when the positions of Associate Administrator for Regulatory and Control and two Deputy Administrators, for Livestock Health Programs and Plant Protection and Quarantine Programs, were established. Much of the work was further consolidated when the Animal and Plant Health Service was established on October 26, 1971. On April 2, 1972, the Service was redesignated Animal and Plant Health Inspection Service, following the transfer of the meat inspection work from the Consumer and Marketing Service. Reflecting a general shift in emphasis, the inspection and quarantine work was transferred to the Assistant Secretary for Marketing and Consumer Services.

Animal diseases and plant pests and diseases have shown no respect for the geographical boundaries that modern transportation has been virtually obliterating. Speed of travel has removed some of the built-in protection that was concomitant with slower movement by train, ship, or horse-drawn vehicles. Greater affluency with these changes has added another facet to increased traffic. Producer pressure groups, industry, and other government agencies have played important roles in policy development and implementation. However, the public is still the important and unpredictable factor.

62 FEDERAL INSPECTION AGENCIES

At the present time, Customs is inspecting 100% of hand baggage and somewhere between 40 and 60 percent of hold baggage. The strategy on hold baggage is "selective inspection." That is, on "garbage runs" - flights that customarily contain large amounts of agricultural contraband, and on high risk runs - those where drugs are likely to be present, 100% of hold baggage is inspected. This represents a marked improvement over rates of inspection prior to the drug crack-down. At Kennedy International Airport in the 1960's, the rate at which baggage was inspected was close to 20%.

The "one-stop" system installed at Kennedy and other airports in 1968 has now been abandoned in favor of this "selective" approach, which was a method of "modified" random sampling hold baggage, that is, the sample was increased beyond the normal random number whenever the primary inspector has a reason to be suspicious and wanted to insure inspection of a particular person's baggage.

When narcotics began to be a problem, Customs found this method inadequate and began to abandon it. As a result of complaints from PHS, a group was selected to followup. The group did not object to Customs' plans for selective inspection, and so it was adopted.

The recent study group recommended more preclearance. It was found effective by both Immigration and Agriculture. From the Immigration point of view, there is a real savings, because the illegal entrant can be stopped before he arrives in the U.S. Once he arrives in the U.S., he acquires certain rights. In addition, airlines must often pay his return fare.

Customs doesn't favor preclearance, apparently because foreign ports of entry are seldom adequately secure. The study group, however, proposed an insistance on airport security as a part of the port of entry arrangement. However, Customs was adamant. The group did not feel that having inspection on both ends would be acceptable to carriers <u>or</u> passengers and is therefore not in a position to push, particularly since the Senate Appropriations Committee put language in the 1973 Appropriation Act banning Customs from using funds for preclearance after March 1973.

Customs alleges that the main reason for being against preclearance is narcotics, but actually they have long opposed it.

Having AQI men called when a Customs' man finds a contraband item does not protect us from exotic pests. Maximum protection would result from automatic confiscation by Customs followed by immediate destruction. The AQI man, when dealing with travelers, does no more than provide a service to the traveler. This service consists of the discretion of "yes, you can bring that in," or "no, you can't bring it in." It should be recognized that this service is just that, and has nothing to do with keeping exotic pests out, which Customs could do perfectly well without the assistance of Agriculture.

A number of Federal agencies are concerned with the inspection of personnel and cargo entering the U.S. These activities are uncoordinated and there is no mechanism by which these agencies meet on a regular basis to consider their common problems.

<u>Agriculture</u>

Animal and Plant Health Inspection Service

Agricultural Quarantine Inspection Program
Animal Health Programs
Meat Inspection

Import-export inspection of animals and animal products (excluding meat); foreign meat establishment inspection.

Commerce

U.S. Travel Service

Works with U.S. Government agencies to reduce official barriers to travel.

Health, Education and Welfare

Food and Drug Administration

Inspection of imported foods.

Public Health Service

Inspects persons and importations to prevent the entry of quarantinable and other communicable diseases.

Interior

Bureau of Sport Fisheries and Wildlife

Regulates importations and excludes endangered species.

Justice

Immigration and Naturalization Service

Controls the admission, exclusion, deportation and naturalization of aliens.

Treasury

Bureau of Customs

Processes all persons arriving in the U.S. and all merchandise imported; enforces the laws of other government agencies.

63 OBJECTIVES AND STRATEGY

"The major objective of the Service (APHIS) is to protect the animal and plant resources of the nation, through a series of plant and animal disease and pest control programs, and through cooperation with States and local agencies and foreign governments."3

The major objective, "protection," is not modified or further defined. It is not stated as "complete protection" or as "adequate protection." Protection may be defined as a particular amount of risk reduction, or reduction of risk to an acceptable level. This approach permits quantitative measurement of protection, i.e., the supply of protection.

It is also worth noting that the phrase, "to protect the animal and plant resources," must necessarily encompass environmental considerations as well as the interests of agricultural enterprise.

The objectives of the plant and animal quarantine programs are more limited:

> Plant Quarantine Programs ". . . are designed to keep out of this country, by inspection at ports of entry, those harmful insects, plant diseases, nematodes, and other pests that cause great damage abroad."
>
> Animal Quarantine Programs ". . . are conducted to keep communicable diseases of foreign origin from entering this country."4

The objective of the Plant Quarantine Program is unduly restrictive in three respects:

- It speaks of exclusion ("to keep out"), thereby limiting activities to only one of the two widely practiced strategies to achieve protection. The other strategy is restriction, which is in fact an an important feature of the program. Thus the statement is not only limiting, it is incomplete.
- It refers to only one program technique ("by inspection at ports of entry") when a number of techniques are in use (e.g., preclearance - inspection at port of embarkation).
- It refers to "those harmful. . .pests that cause great damage abroad" whereas the universe of concern ought to be those pests expected to cause great damage in this country. From the operational perspective, this requires a scientific prediction of post entry domestic behavior which although very complex ought to be an important program component.

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3. The Budget of the U.S. Government Appendix, Fiscal Year 1973, p. 122.
4. The Budget of the U.S. Government, Op. Cit., p. 122.

The objective of the Animal Quarantine Program, on the other hand, is too broad. To exclude all communicable diseases of foreign origin without regard to their relative importance is probably unnecessary as well as impractical. Unnecessary because the cost of living with some of these diseases might be less than the cost of exclusion. Impractical because the actions required to insure the complete exclusion of all such diseases may be unduly restrictive of international trade and commerce.

Obviously, neither the plant nor the animal program has achieved its objective of exclusion, since a number of pests have entered the country in spite of the efforts of the programs to keep them out.[5] This is because exclusion is not an attainable objective. It may, however, be a useful strategy, in the case of a particular pest.

In foot-and-mouth disease, for example, the exclusion of all live cloven-hoofed animals and their untreated products from infected countries has served to reduce the probability of entry. However, the disease has not been excluded, having been found in the U.S. four times since the Act of December 18, 1865, excluded the importation of cattle. What has been achieved by the program is an amount of protection that may or may not be regarded as "adequate."

When these programs were designed initially, exclusion may have been a realistic objective. But given the rapid changes in transportation technology and the increased volume of trade and commerce, it would be wise to revise the objectives to describe a condition that is, in fact, attainable.

The objectives of both the plant and animal programs should be protection consistent with the major objective of APHIS. The degree of protection sought can be defined in terms of the specific pest, in a way that makes the attainment of a particular objective possible.

The statement of program objectives should explicitly recognize the two strategies that are in common use, not only in the United States, but in many other parts of the world. These two strategies are exclusion and restriction. They apply to goods and materials, as well as to the pests themselves. Restrictions based on good scientific techniques for the alteration of the condition of goods and accompanied by well-designed sampling schemes can be an extremely powerful approach in achieving an adequate level of protection.

The objective should recognize, implicitly, that the introduction and establishment of some exotic pests is of more consequence than others.

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5. There is a continuing stream of new pest introductions and establishments, as discussed in Chapter 3.

Clearly, the legal authority available to APHIS is broad enough to permit action against the entry of any exotic pest or disease. Presumably, it is useful to have such broad authority available. It protects employees in case a seizure or treatment is challenged, and it removes the necessity to go back to Congress for revisions as changes in pest risk arise. However, the program leadership must take care that operating strategies are well defined and that the existence of broad authority does not lead to widely diffused efforts. As a practical matter, we know that introduction and establishment of exotic pests and diseases will continue and it becomes ~~a matter of how many and what kinds of pests we are going to tolerate.~~

The inclusion of particular techniques in a statement of objectives (e.g., "by inspection at ports of entry") is not appropriate and may only tend to restrict the options of program managers.

Finally, since the program regulates foreign commerce, attention should be given to the necessity of avoiding restrictions that hamper commerce without achieving commensurate benefits in pest protection.

The following objective is recommended:

> The objective of plant and animal quarantine programs is to provide adequate protection to the plant and animal resources of the nation, while avoiding unnecessary restrictions on international trade and commerce. This will be done by encouraging shipments of clean cargo, fostering inspection at source, and by excluding or restricting goods, materials, or carriers as necessary to prevent the entry of those exotic plant and animal pests and diseases expected to cause great damage.

The adoption by APHIS of such an objective will aid in developing a more realistic understanding of the program. In addition, it will encourage the use of specific quantitative action objectives and tasks that can be achieved by the organization.

For example, "adequate protection" against a particular pathogen might be defined as reducing the probability of entry and establishment in any one year by 75%, and appropriate program tasks could then be designed and implemented to achieve that action objective.

64 REGULATIONS AND PROCEDURES

This section will consider the scope and adequacy of quarantine regulations, and their operational feasibility in terms of the major international threats. It will also consider whether existing legislation is adequate to permit the action needed on the part of carriers and the government inspectors. Is the inspection procedure at points of entry designed and carried out to insure that the requirements of the quarantine regulations have been met?

64.1 Plant Pests and Diseases. The Plant Quarantine Act of 1912, as amended, is the basic legal authority for the import inspection and quarantine program. This legislation has been buttressed by the passage of other laws, but the bulk of the rules and regulations are issued pursuant to the Act of 1912. The quarantines and restrictive orders regulating trade in plants and plant products to prevent the importation of injurious plant pests and diseases promulgated under the authority of the Acts are published in the Federal Register and become part of the Code of Federal Regulations.

For the purposes of actually carrying out the intent of the law, interpretations of the quarantines, restrictions, and rules and formal operating procedures have been prepared for use by inspectors at ports of entry. The Plant Quarantine Manual is comprised of all of these documents.

The titles of most quarantines indicate that they have either a geographic or a commodity or a plant disease orientation. Generally speaking, it is necessary to read both the quarantine and the interpretations thereof contained in the Manual before one can make the connection between commodity, pest, and country. However, the language of the Federal Plant Pest Regulations is broad enough to apply to any plant pest or disease which may be found in or on any imported item. Thus, it appears that AQI has the authority to prevent the introduction of all plant pests and diseases.

As a reference for program execution in the field, these quarantine documents must be very difficult to use. To an outsider, the organization of material appears to be chaotic.

Enforcement of the quarantines is made even more difficult (or so one would suppose) by a gaping hole in that part of the Manual dealing with operational procedures: there is literally no guidance provided on how to proceed with carrier or cargo inspection. These points are covered after a fashion in the training given to new employees. But the lack of any formalized procedures in the Manual leads one to suspect that the processes of inspection, sampling, etc., are different at every port and that, at each location, they have acquired the status of a ritual handed down from one generation of inspectors to another.

The Task Force recommends that the Manual stand alone as an operating prescription for carrying out the intent of the quarantines. In our opinion, systematizing the available information and preparing appropriate instructions on carrier and cargo inspections would go far toward achieving this objective. Ideally, the Manual should contain a step-by-step outline of what inspectors should do from the time the carrier arrives until inspection of carrier and cargo has been completed in a manner which will result in reducing "pest risk" to a level acceptable to program managers.

Here, for example, are the suggested headings for a cargo inspection guide:

Country (State or Territory) and Commodity	Prohibited Yes	Prohibited No	Condition of Entry and Documents	Type of Inspection Required	What to Look For	Forms to be Completed: If un-infes-ted	Forms to be Completed: If infes-ted	Action to be taken if found infested

Extensive use of references to an appendix where, for example, details of different types of inspection and sampling procedures and actions to be taken could be presented, would eliminate space-consuming redundancy and keep the number of pages down to manageable proportions.

Similar tables could easily be developed for inspection of the different kinds of carriers.

Dr. Richard Daum of APHIS has suggested that an alternative to a revised manual would be to computerize instructions for the whole inspection procedure. That is, the port inspector would tell the computer the name of the commodities and countries of origin (from the ship's manifest) and in return the computer would print out a set of directions on what to do, similar to those shown on the proposed format. This would permit more rapid adjustment to changing disease conditions worldwide. The costs and benefits of such a system ought to be investigated by APHIS.

64.2 Animal Pests and Diseases. The basic legal authority for regulating the importation of animals and animal products into the U.S. is contained in Public Law 57-49 of 1903 and Public Law 71-361 of 1930. These Acts provide the Department with broad authority to restrict and, in some cases, prohibit the entry of specified animals and animal products in order to prevent the introduction or dissemination of any contagious infections or communicable diseases of animals.

For years, instructions relating to enforcement of these statutes were sent to personnel at ports of entry in the form of Division Memorandums supplementing and complementing the prescriptions set forth in 9 CFR 92, the basic enforcement document. No attempt was made to consolidate the information contained in these items into an operating manual for field use until 1971, when the animal products import inspection work was merged with the Plant Quarantine Division to form the Agricultural Quarantine Inspection Division.

At that time, because of the need to educate and train former Plant Quarantine personnel in animal products inspection work, an Animal Products Inspection Manual was prepared. The prohibitions, restrictions, and operating procedures set forth therein seem to be much more straightforward than those in the Plant Quarantine Manual; and the new manual appears to be usable as a field guide. This is not to say that improvements can't be made, however. A format similar to that recommended for plant and plant products quarantines would further simplify the presentation.

There is no operating manual covering the importation of live animals. Instructions to field personnel consist of the aforesaid memorandums and 9 CFR 92.

04.3 Initiation, Modification, and Termination. The issues and processes involved in starting, stopping, and modifying quarantines were described by AQI in response to a series of questions posed by the Task Force.

> Task Force Question: How do quarantines get started; that is, what events must occur before new quarantines are deemed necessary, and what are the procedures for their issuance?
>
> AQI Answer: "A plant quarantine is an order that bars or restricts the existence or transportation of specified plants, plant products, soil, plant pests, or other articles known or suspected of harboring or being carriers of plant pests. The objectives are to prevent the introduction or spread of a plant pest and to aid in the retardation, eradication, or control of a plant pest already introduced. Establishment of a plant quarantine rests on four fundamental prerequisites:
>
> 1. The pest must be of such a nature as to offer an actual or expected threat to substantial interests;
> 2. The quarantine must represent a measure for which no substitute action involving less interference with normal activities is available;
> 3. Attainment of the objective must be reasonably possible; and
> 4. The economic gains expected must outweigh the cost of administration and interference with normal activities."

Once it has been decided that a quarantine against a particular pest, disease, or vector thereof should be invoked to achieve the objectives of the Plant Quarantine Act, a notice of intent is published in the Federal Register and interested parties are invited to express their views at a public hearing. If the need for a quarantine is affirmed and no scientific basis is established that such a quarantine would be inappropriate, then the quarantine document is prepared by the program people and checked for legal sufficiency by the Office of the General Counsel. Then it is signed by the Administrator and published in the Federal Register.

Comment: The prerequisites are sound. Yet, no evidence can be found of an objective attempt to measure economic gains against the costs of administration and interference. If this principle is being followed, it must be a very subjective determination. No events are outlined as requested, and no information has been provided on issuance procedure within AQI. For example, by what means is the judgment of competent biologists outside the agency obtained?

Task Force Question: How do quarantines get stopped; that is, what events must occur before an existing quarantine is deemed to be obsolete and what are the procedures for its revocation?

AQI Answer: "One of the principles of plant quarantine management decrees that if the progress of events has clearly proved that it is biologically unsound or that the desired end is not possibly attainable by the available restrictions or methods, the quarantine should be promptly revoked. An example of an uneventful revocation of a quarantine is Dutch Elm Disease. A notice of rulemaking concerning the proposal to revoke the Dutch Elm Disease Quarantine was published in the Federal Register with an open period for comments. After due consideration, the Quarantine was repealed by a revocation notice in the Federal Register."

Comment: No explanation is provided on how a quarantine could become "biologically unsound" through "the progress of events." Nor are we advised how it might be determined that "the desired end is not possibly attainable." The example given, the Dutch Elm Disease Quarantine, was presumably revoked because available technology failed to contain the disease once it became established in the U.S. Are we to infer that this is the only circumstance under which a quarantine will be revoked? What is the significance of the statement that the Dutch Elm revocation was uneventful?

Task Force Question: What events trigger revisions in the quarantines and in the Plant Quarantine Manual?

AQI Answer: "Quarantine revisions are triggered by many events, including:

1. Requests by commercial importers to import additional kinds of plants or plant products;

2. Adding alternate commodity treatments when developed through research;

3. Rescinding the entry of commodities due to the establishment of a dangerous pest in a foreign country;

4. Removing restrictions on the movement of plant materials due to the eradication of a pest in a regulated area;

5. Eliminating an approved entry port because treatment facilities are no longer available;

6. Relieving treatment requirements when a product is imported through certain ports; and

7. Adding foreign nursery names to the list of eligible nurseries certified to ship designated fruit stock to the United States.

The Plant Quarantine Manual may be revised because of changes in policy, operating procedures, quarantines, treatments, forms, and other reasons with respect to operating procedures."

Comment: It is significant to note that no mention is made of the possibility that an exotic species formerly thought to be relatively harmless, has now been found to be a significant pest in its overseas circumstances. Or, alternatively, investigation has disclosed that a particular exotic species, formerly thought to be harmless if it entered the U.S., has now been identified as a significant potential pest under U.S. ecological conditions.

Note that the term "operating procedures" does not refer to actual inspection procedures in the field, since procedures do not exist, as pointed out earlier.

Task Force Question: How many quarantines have been revoked in the last 30 years?

AQI Answer: Two, Dutch Elm Disease and bananas.

Comment: Is adequate attention being given to real events? During the last 30 years more than 250 new immigrant species of insects and mites alone have become established in the United States.

In conclusion, it seems apparent that the initiation, modification, and termination of quarantines needs more systematic attention. The continuing flow of new arrivals and the rapid changes in trade and transportation technology calls for a continuing review of all U.S. quarantines that includes consideration of the latest scientific information on world pest conditions.

65 NEW TRANSPORTATION TECHNOLOGY[6]

65.1 Containers. Containerization is revolutionizing ocean shipping. It is transforming international markets, ports, land transportation, shipbuilding, trade prospects of underdeveloped nations - and dramatically increasing the threat of entry of exotic pests into the United States.

This revolution stems from the capability of moving goods swiftly, safely, and reliably in containers. Nation's Business (May 1970) states that

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6. This section was prepared for the Task Force by Herbert E. Pritchard.

"The gains are so dramatic that they are being hailed in the shipping industry as the equal of the transition from sail to steam, from wood to steel hulls."

Container shipping has developed on a global scale only in recent years. Sea-Land Service, Inc., inaugurated the first transatlantic service in full containerships in April 1966. Matson Navigation Company soon followed with service in the Far East.

By transforming cargo to uniform size and shape characteristics, the container creates pseudo-bulk cargo out of break-bulk cargo.

The major advantage of containerization lies in its potential for greatly reduced unit costs versus conventional service. The container system gains much of its economic benefits from the efficient substitution of capital for labor--offshore, longshore, and overland. Furthermore, capital is used more efficiently in a container system than in a conventional system. The container system requires less investment and much less labor than the conventional system for an equal trade volume.

In the marine segment, the increases in the productivities of capital and labor are so high that the container system capital and operating costs combined are lower than the operating costs alone for a conventional system. In effect, conventional ships and terminals have a net negative economic value; to use these assets in transport services rather than replace them with container facilities would be more costly than to abandon them.

Container service has improved product protection significantly. The container limits vertical stowage of cargo and reduces the risk of crushing. Load control systems and solid loading and bracing inside the container reduce the cargo damage during ship operation in heavy seas and during ship loading and unloading.

Containers also provide protection against pilferage which, with reduced damage, should reduce insurance costs. A study by the American Institute of Merchant Shipping reported twelve leading liner operators had carried 330,000 containers in one year with only one incident of loss or damage to the cargo per 11,400 containers. Wide-spread introduction of well-designed container ships further reduce container damages; much of the damage occurs on containers improperly lashed and stowed, thus hazardously exposed to wave action on decks of conventional ships and some converted ships.

Containerized export shipments can ususally use domestic packaging. Much of the product sent in break-bulk ships has to be specially crated, which not only involves direct labor and material expense but often requires an extra step in the distribution process.

Refrigeration temperature can be adjusted to specific cargo requirements, an impossible task in conventional reefer cargo spaces. Atmospheric control is more versatile and more effective with containers. Protection from dirt, especially during handling, and from contamination by other cargo is also more effective.

In short, there are several reasons why containers are not only here to stay, but will continue to grow in importance as they absorb greater portions of break-bulk tonnage.

The virtues of containerization are apparent. Efficiency and economy are enhanced by swift reliable portal to portal transport of containerized cargo. These efficiencies are not to be dismissed lightly since the economic repercussions are considerable.

The effect containerization may have on the threat of introduction of exotic pests is less apparent. Two points come readily to mind, (1) containers make cargo less accessible for inspection, and (2) containers carry cargo into the interior of the country. On the surface this would appear to increase the threat of pest introduction. However, containerization reduced the threat of pest introduction between the port of entry and destination since the likelihood of a pest exiting a container is almost nil. If the destination is inhospitable to the pest, the likelihood of introduction is likely to be negligible even in the absence of inspection. Examples of this might be tropical products shipped to northern states or animal by-products shipped to approved processing plants. Where a break-bulk shipment might be split at an interim point and sent to various destinations, the same cargo in containerized mode is likely to arrive at the various destinations in the original containers.

To the extent that the final destination for a container can be determined, selective inspection can be enhanced. Containerized cargo unloaded on the West Coast and bound for New York City could possibly be considered a negligible risk for most types of cargo.

In some instances, inland container terminals may be designated rather than final destinations. It may be justifiable to provide permanent inspectors at such terminals to selectively inspect cargoes.

This would offset to some degree, the savings in manpower which could result from increased selectivity of inspection at ports of entry.

On balance, containerization may or may not increase the threat of pest entry, but it does offer an excellent opportunity for increasing the selectivity of inspection with reasonable confidence that introduction will not occur during overland transport.

Where inspection is necessary, it may, in certain circumstances, be reasonable to select items which are readily accessible from the container. Unloading the container to get unaccessible items may not be warranted.

65.2 Ships. There are technological developments in the construction of ships which impact upon AQI activities. Predominant among these developments are containerships, barge-carrying ships and ore/bulk/oil (O.B.O.) ships.

In June 1969, the Maritime Administration announced it would develop a series of standard ship designs suitable for multi-ship, multi-year production. Subsequently, a research program was established with the goals of determining the types of ships and fleet mix needed over the next ten years.

Two teams were established with a potential prime contractor providing the nucleus of each team. The team assembled by Newport News Shipbuilding and Dry Dock Company produced four ship designs, including one O.B.O. and one containership designed to carry 1,540 twenty-foot containers at a speed of 23.3 knots.

The second team, formed by Bath Iron Works Corporation, produced five ship designs including an O.B.O. and three ships which are capable of serving as containerships. The Penobscot class containership is designed to carry 1,468 twenty-foot containers (including 240 refrigerated containers) at a speed of 23.4 knots. A lengthened version increases the carrying capacity to 1,636 twenty-foot containers at 23 knots. The Merrimac/Allagash class represents Bath's concept of a transition-type ship capable of serving either as a conventional break-bulk ship or a small containership. As a containership it is designed to carry 666 twenty-foot containers at 21.2 knots. The Kennebec class multi-purpose ship was designed primarily as a carrier of grain, coal and light bulk but was kept suitable for carrying 570 twenty-foot containers at 16 knots.

In addition to the above teams, the Maritime Administration developed its own designs for needed ships. The five designs produced by the Maritime Administration include a barge carrier, an O.B.O., two containerships, and one general purpose ship capable of carrying containers. The PD-162-LASH barge carrier is capable of carrying 82 lighters at 23.5 knots. The PD-160 containership is designed to carry 1,672 twenty-foot containers at 24.1 knots. The PD-161 twin-screw containership is designed to carry 2,294 twenty-foot containers at 26.7 knots. The PD-159 general-purpose cargo ship is capable of carrying 348 twenty-foot containers at 18.9 knots.

There appears to be little consensus as to the approximate mix of ship types to be produced over the next ten years. Containerships in service, under construction, or in the planning stages range widely in size, speed and configuration. The size ranges from 220 to about 2,300 twenty-foot containers; the speed ranges from 12 to 33 knots. The method used to load and discharge containers distinguishes the configuration:

Lift on/Lift off (LOLO)
Roll on/Roll off (RORO)

Carry-on/Carry off (COCO)
Lighters (LASH, SEABEE, etc.)

The difference between RORO and COCO is that RORO containers remain on wheels (chassis) whereas COCO containers are carried on by some device such as forklift, crane, etc.

There are 1,109 full or partial containerships in service or under construction to be delivered on or before December 31, 1974. About 20 percent of these ships are under the U.S. flag. The U.S. flagships average 599 container slots per ship (twenty-foot equivalents), the foreign ships 310 slots. The 1,109 includes 431 full container ships, 104 RORO ships with trailer and container capabilities, 18 LASH ships, and 556 partial container ships. The foreign-flag container operators have 886 ships in service and under construction, with nearly 275,000 slots set up almost entirely for twenty-foot and forty-foot container lengths.

The eight largest ships will be Sea-Land's twin screw, 33-knot, LOLO container ships with 1,086 slots for thirty-five-foot containers (2,018 twenty-foot equivalents). Five of these ships were constructed in Dutch and German yards and delivered in 1971 and in 1972. Three more are to be delivered in 1973 and 1974. Hapag-Lloyd, Overseas Container Lines, Scandinavian Service, NYK Lines, and Seatrain Lines will operate ships with between 1,500 and 2,000 containers in the early 1970's.

Third generation containerships are being considered. Meeusen Consultants of Holland predicts that draft and stability problems which presently limit the size of containerships will be overcome by closed decks and storing containers in horizontal lanes instead of vertical cells. This will possibly enable vessels to carry up to 3,000 containers. Rapid horizontal loading/unloading would greatly reduce port time and the need for giant cranes.

New container ships designed for transocean service commonly have a speed of 20 to 25 knots and capacity between 1,000 and 1,500 twenty-foot containers. However, an increasing proportion of the new orders are in the 1,500 to 2,000 container range. The ships have lengths up to 1,000 feet, beams as large as 105 feet and drafts up to 40 feet. While the size of containerships has grown spectacularly over the past few years, they are not expected to get much larger due to canal and port constraints.

Great impact on shipping is expected with introduction of barge-carrying ships. They will carry medium-sized barges called lighters -- hence the term LASH for lighter aboard ship -- or larger barges in the case of the Sea Barge (SEABEE).

Barge-carrying ships vary in size, in capacity of the mother ships, and in lifting equipment; LASH ships will carry cranes to lift the barges on and off while the SEABEE will use an elevator.

Both types differ from the full containership, which carries no lifting equipment and must depend on giant cranes and other costly support at developed major ports. Barges thus can provide access to shallow and undeveloped pprts as well as to loading points on inland waterways that large ships can't reach. The first tariffs covering the transportation of ocean borne cargoes into inland areas of the U.S., by means of LASH operations, have been filed for points as far inland as Cairo, Illinois.

While containerships tend to concentrate the flow of goods through major developed ports with extensive links to land transportation, barge carriers can serve many ports of call without being tied up for loading. In addition addition to conventionally crated cargoes, they can handle containers, bulk solids or liquids, or freight transported on pallets.

LASH ships were delivered through 1972 for Prudential Lines (five) and Pacific Far East Line (six). SEABEES are being built for Lykes Bros. Steamship Company (three).

A Litton Industries study makes the point that barge-ship flexibility is especially attractive for developing areas without full harbor facilities.

These attributes raise the question of how AQI can best protect against foreign pests while not significantly reducing the efficiencies made possible by this technological innovation.

In terms of volume, bulk cargoes constitute 95 percent of all U.S. imports and exports. For these cargoes, the world is figuratively shrinking from the point of view of transportation economics. For example, a 130,000 ton bulk carrier makes Sidney, Australia, closer to Los Angeles than Los Angeles is to Fresno. The modern bulk carrier can transport a ton of cargo 6,500 miles for $2.00; for that price rails can transport the same cargo only 200 miles.

Bulk vessels in excess of 300,000 deadweight tons are already in operation and plans are being considered for special purpose vessels as large as 500,000 - 1,000,000 tons. The O.B.O. vessel is capable of carrying ore, bulk, or oil in the raw state or processed into liquid form. With such a tanker configuration, coupled with the ability to stand offshore and to pump cargo through a submarine pipeline, these new type vessels will probably attain the mammoth sizes of today's petroleum tankers.

One impact of containerships and O.B.O.'s will be that inspection of the holds of these ships will not be necessary. This could result in a considerable reduction in workload, considering that a large vessel of either type will replace several conventional ships.

65.3 Ports. The employment of containerships, and consequent changes in techniques of cargo handling, have resulted in the re-equipment of ports to serve as container terminals. Virtually all major general cargo ports in the United States and Europe now have container handling facilities. The present trend in port development is one of consolidation and expansion. Although many ports have only recently brought container terminals into service, the speed of development has led to plans for further expansion in a great many ports. The most important recently reported are those for New York, Philadelphia, Baltimore, Southhampton, and four main Japanese ports.

Giant cranes costing $750,000 and up are used to load and unload containers from ships. This is a radical departure from the conventional break-bulk methods in which consignments are hoisted aboard in a cargo sling and stowed piece by piece. It reportedly takes about two and a half man-hours to move a ton of break-bulk cargo, but only one-tenth to one-half man-hour to move a ton of containerized cargo. Port container storage varies from stacking to positioning in multistoried frameworks. To speed cargo movement and minimize handling, Sea-Land's containers are stored on wheels rather than stacked.

The May 1970 issue of Nations Business reports commercial container shipping on the North Atlantic routes at 400,000 tons per quarter. Commercial container shipping between the Pacific Coast and the Far East rose dramatically from 33,000 tons in the first quarter of 1968 to 244,742 tons in the first quarter in 1969. The Engineering News Record (April 9, 1970) reports that rapidly growing containerization of cargo has led the Maryland Port Authority to revise its 10-year master plan for the Port of Baltimore. The new plan calls for committing $48.8 million beyond the $15.7 million already spent and sets a 1977 completion date.

The port's tonnage is growing five times as fast as first predicted. In competition to beat out Norfolk as the nation's second largest container port, Baltimore boosted its annual container tonnage from 200,000 in 1967 to over 500,000 in 1971. The new berths will double containership facilities at Dundalk on the harbor's eastern side.

Unfortunately, containers and break-bulk cargo do not mix well, either in the same ship or on the same pier. Sixty percent of all general cargo on the North Atlantic now moves in containers, up from only five percent in 1964. As a result, significant shifting of tonnage is taking place among ports. Manhattan's cramped littoral cannot accommodate the container trade. There are container facilities in the works in Brooklyn, but Brooklyn suffers from some of the same disabilities as Manhattan. The result has been a large shift of tonnage to Staten Island and the container terminals of Port Elizabeth and Port Newark in New Jersey. In 1965, New York spent $7.3 million building Pier 36 and on the East River, a break-bulk facility, only to have it fall almost immediately into disuse.

To maximize the economics of containerization, and to justify the high speed and large capital investment required for containerships, port calls should theoretically be kept to a minimum. As several ports in a region

TABLE 6-1

1982 Projection of New U.S. Ships

Ship Type	Number of Ships	
	Newport News Estimate	Bath Estimate
Container ship	22	65
General cargo ship	173	15
Utility cargo ship	0	90
O.B.O. (ore/bulk/oil)	83	80
Tanker	22	25
Barge Carrier	0	25
Total	300	300

TABLE 6-2

Containerships and Slot Capacities by Trade Routes in 1974

Trade Route	Ships		All Flags Slots (20-foot) container equivalents	
U.S. West Coast to:				
Hawaii	16		10,166	
Alaska	6		3,524	
Puerto Rico	5		2,500	
Europe	13		6,464	
Australia/New Zealand	4		3,000	
Far East	86		43,501	
Subtotal		130		69,155
U.S. East Coast/Gulf to:				
Puerto Rico	12		5,996	
South America	23		3,400	
South Europe	15		12,367	
North/Central Europe	100		72,096	
Australia/New Zealand	16		11,932	
Far East	15		8,750	
Subtotal		181		114,541
U.S. All Coasts N.E.C. to:				
Africa	10		2,598	
Far East	14		13,520	
Subtotal		24		16,118
Totals		335		199,814

TABLE 6-3

World Container Fleet and Capacity
(In Service and On Order for Delivery by 1974)

	Number of Ships		Number of Slots		Av. Slots
	Units	Percent	Units	Percent	Per Ship
Assigned by Trade Route					
U.S. Flag	206	50	129,000	46	626
Foreign Flag	206	50	152,000	54	738
Subtotal	412	100	281,000	100	682
Unassigned by Trade Route					
U.S. Flag	17	2	4,600	4	272
Foreign Flag	680	98	122,700	96	180
Subtotal	697	100	127,300	100	182
Totals	1,109		408,300		368

TABLE 6-4

Capacity Distribution of Full Container Ships
(In Service or On Order for Delivery by 1974)

Container Capacity*	No. of Ships	Percent	No. of Slots	Percent Total
>2,000	8	2	16.8	7
1,500-2,000	27	7	46.5	19
1,000-1,500	53	12	65.1	26
500-1,000	109	25	83.9	33
200-500	70	16	21.9	9
< 200	164	38	17.0	6
Total	431	100	251.2	100

*Twenty-foot equivalents

TABLE 6-5

Annual Round-Trip Container Capacity*

Trade Areas and Flag
(1,000 20-Foot Ctr. Equiv.)

	In Service (1970)			In Service (1974)		
	U.S.	Foreign	Total	U.S.	Foreign	Total
U.S. West Coast to:						
Hawaii	179		179	179		179
Alaska	65		65	65		65
Puerto Rico	29		29	29		29
Subtotal (Domestic)	273		273	273		273
Europe		28	28		51	51
Australia/New Zealand		25	25		25	25
Far East	104	130	234	266	142	408
Subtotal (Foreign)	104	183	287	266	218	484
TOTAL	377	183	560	539	218	757
U.S. East Coast/Gulf to:						
Puerto Rico	143		143	143		143
South America	40	10	50	40	10	50
South Europe	83	22	105	116	22	138
North/Central Europe	398	344	742	509	406	915
Australia/New Zealand	15	13	28	36	46	82
Far East	52	1	53	52	1	53
TOTAL	731	390	1,121	896	485	1,381
Both U.S. Coasts to:						
Africa	18	.9	27	18	9	27
Far East	51	25	76	51	25	76
TOTAL	69	34	103	69	34	103
TOTAL U.S.	1,177	607	1,784	1,504	737	2,241
Canada to:						
Europe		101	101		101	101
Alaska		29	29		29	29
TOTAL		130	130		130	130

*Annual capacity = voyages per year times vessel capacity.

Number of voyages computed from sailing schedules or estimated from the vessel and trade route characteristics.

equip themselves to handle a larger cargo volume and serve a wider hinterland, it seems likely that port competition will intensify. The Port of Portland, Oregon, has recently been involved in four suits in an effort to maintain its relative portion of cargo.

The above discussion points out that a transition of tonnage is occurring both in terms of type and location. It is important that AQI be aware of these changes in workload so as to allocate manpower in accordance with changing needs.

65.4 Planes. The first commercial jumbo jet freighter landed in New York in 1972. This Boeing 747-F of the Lufthansa German Airlines is scheduled to make one round-trip per day, six days a week, between New York and Frankfurt, Germany. Although air freight is commonly unitized (pallets, igloos), this will be the first instance of intermodal containers carried in commercial air freight. The 747-F is capable of carrying all sizes of containers and has a New York/Frankfurt cargo capacity of 200,000 pounds. This capacity is close to three times that of any other existing commercial freighter. The Lufthansa 747-F replaced what otherwise would have been three 707's providing this service.

A few European and Asian companies are reportedly interested in the 747-F. However, no U.S. air cargo carriers placed orders as of early 1972. Hellmuth Klumpp, Lufthansa's General Manager, Cargo, is quoted in Container News (January 1972), "Our decision to buy the 747-F is the result of careful research into future air cargo needs. The trend in freight aircraft will follow the trends in passenger aircraft: It will move towards the wide-bodied jumbo jets with greater capacity and versatility, and consequently better economics." If Mr. Klumpp is correct, it will mean the number of international cargo planes will eventually be about one-third the number which otherwise would exist. Plane inspection and treatment would be affected proportionately.

66 DETECTION DEVICES AND CONTROL METHODS[7]

66.1 Present Detection Devices. At present the principal means of detection is visual inspection. This is true for all areas of activity; i.e., permit material, miscellaneous cargo, passenger baggage, etc. X-ray devices are used to supplement visual inspection, notably to detect insects in conifer seeds which are too small for unaided visual detection. These devices are located at Hoboken, Seattle, and Washington, D.C.

66.2 Present Control Methods. Control technology now in use pertains to specific treatments for specific pests. Principal treatments are fumigation and temperature controls. For example, constant temperature within a certain range for a prescribed period of time will assure that the Mediter-

7. This section was prepared for the Task Force by Herbert E. Pritchard.

TABLE 6-6

Major U.S. Ports
LOLO Specialized Container Facilities
(As of 12/31/70)

Ports	Berths	Container Cranes*	Capacity Ctr.-Turn/Year** (Thousands)
North Atlantic			
Boston	2	2	83
New York	22	19	790
Philadelphia	1	1	42
Baltimore	3	2	83
Hampton Roads	4	4	166
Total	32	28	1,164
South Atlantic			
Charleston	1	0	0
Savannah	2	1	42
Jacksonville	3	2	83
Miami	0	0	0
Total	6	3	125
Gulf			
Port Arthur	1	1	42
Houston	2	2	83
Galveston	2	0	0
Total	5	3	125
Pacific Coast			
Long Beach	4	3	125
Los Angeles	11	4	166
Oakland	8	8	333
San Francisco	2	1	42
Portland	3	2	83
Seattle	7	5	208
Tacoma	1	1	42
Total	36	24	999
TOTAL MAINLAND	79	58	2,413
Puerto Rico, San Juan	3	4	166
Hawaii, Honolulu	3	5	208
TOTAL (ALL)	85	67	2,787

*Specialized gantry cranes designed and installed specifically for handlin[redacted] containers.

**Ten container-turns/hours, crane, 16 hrs/day, 260 days/year.

TABLE 6-7

Terminal Capital Requirements

Assumption: single berth, single crane, 7 acres of land, 250,000 ton/year throughput

New Container Terminals*

Land, fully improved	$ 560,000
Pier	1,400,000
CEM shop and offices	60,000
3 straddle carriers	400,000
1 gantry	900,000
4 tractors	60,000
	$3,380,000

New Conventional Terminal

Land	$ 280,000
Pier	900,000
Pier shed	2,100,000
Gear room and offices	80,000
30 forklifts	210,000
1000 pallets	10,000
Misc. gear & misc.	80,000
	$3,660,000

Container Terminal Converted from Conventional Terminal

Land	$ 280,000
Pier - add crane rails	280,000
Pier shed - demolish	180,000
CEM shop and offices, straddle carriers gantry, and tractors, as above	1,320,000
	$2,060,000

*Trailers are assumed to be carrier-supplied.

ranean fruit fly is controlled. Temperature recording devices are used to assure that proper temperatures have been maintained. Satisfactory cold treatment for a specific pest does not, however, mean that inspection will be avoided. In some instances, inspection is made to determine if other pests are present even though the specific pest treated for is no longer a threat. The Methods Development Staff, AQI utilizes existing technology in determining the type and level of treatment necessary to provide satisfactory control over specific pests.

66.3 The Potential of Sniffers. Among the scientists and technical experts consulted, the general consensus was that sensing devices commonly referred to as "sniffers" have great potential for meeting our needs. These devices detect, or react to, trace elements in the air to determine if sought after matter is present. In recent years there has been considerable research and developmental work in this area. Much of this work has been oriented toward the detection of explosives, narcotics and marijuana. Of these, the detection of explosives is the most advanced. At present, dynamite can be detected in jungle caches by helicopter fly-by, on the hands of people previously handling it, and in closed suitcases.

Detection of narcotics and marijuana is progressing, but is hampered by higher false alarm rates. Marijuana, for example, is reportedly difficult to distinguish from dirty socks. The basic question to be answered is, specifically what odor-causing compounds are we trying to detect? Considerable effort is being made to answer this question in regard to narcotics and marijuana. Dr. Melvin Lerner of the Bureau of Customs is presently involved in this effort as are several private corporations.[8] He reports that "there may be a breakthrough at any time." Present detection devices are highly sensitive. The desired "breakthrough" will assure that they are also sufficiently selective. Customs is monitoring developments in this area.

It is estimated (in early 1972) that Customs presently opens about one suitcase in five for visual inspection. In addition to this visual inspection, it is reasonable to anticipate that Customs will "sniff" virtually all baggage at major ports of entry. This procedure may be initiated within the relatively near future. It is possible for Agriculture to "ride on Customs' coattail" with such a procedure. In other words, when Customs sniffs for marijuana they can sniff for citrus at the same time.

What must Agriculture do to assure maximum benefit from this enhanced detection capability should it come to fruition? First, Agriculture should make known its interest and intent to the Bureau of Customs. Although there are basic designs common to the various types of devices,

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8. A list of the names and addresses of persons contacted in this survey is Appendix 8-X.

special devices are developed to meet specific requirements. Agriculture should be involved in the beginning to assure that its requirements will be met by Customs. It would be unfortunate, for example, if Customs settled on a device which would simultaneously detect only three items of interest to them if the combined Customs-Agriculture requirement were for six items.

Secondly, Agriculture must determine specifically what to look for with detection devices. A nationwide air baggage study conducted in 1966 showed that contraband consisted of: fruit (62%), meat (16%), vegetables (7%), plants (7%), other (8%). In August 1971, a request was made to Kennedy International Airport to estimate the percentage occurrence of principal items of contraband. The most frequent types of contraband are citrus (25% to 40%), mangos (15% to 20%), and meat, commonly salami, (5% to 10%).

Scientists working in the Citrus Composition Investigation at Winter Haven, Florida, have done a great deal of work isolating and identifying the chemical components of citrus oils. The hydrocarbon d-limonene is common to <u>all citrus</u>. It is the principal component making up 95% of all citrus oils. <u>And significantly</u>, for our purposes, it has an enormous GLC (gas liquid chromatograph) peak. This hydrocarbon is present in most tropical fruits including mangos, and in many temperate fruits and vegetables such as celery.

Work similar to that being done at the Citrus Composition Investigation is being conducted elsewhere in ARS on a variety of fruits including apples, peaches and pears.

Ethyl acetate is reportedly present in <u>all</u> fruits.

Pepper is a common ingredient in salami. The pungent crystalline compound capsaicin which is a principal of cayenne pepper should be readily detectable.

The more securely closed the suitcase is, the more difficult the contraband will be to detect. It therefore may be necessary to loosen one latch of a suitcase and put the sample collector to the crack. However, the air baggage survey previously referred to indicates that about three-fourths of the contraband is hand carried from the plane. Such contraband would likely be in flight bags, shopping bags, and other containers less tightly sealed, thus facilitating detection.

There is apparently no doubt that a large percentage of baggage contraband can be detected by sniffing devices.

Two basic types of sniffing devices appear promising. They are (1) biological systems and (2) electronic systems incorporating mass spectrometers. Before describing these systems, let us consider what characteristics a device must possess to be operationally feasible. A device must be sensitive enough to detect minute amounts of molecules in the air. It must be sufficiently selective to keep false alarms at an acceptable level. For baggage inspection a device must give rapid responses to repeated challenges and be portable enough to be operated at Customs inspection stations.

Biological detection systems utilize living, bioluminescent bacteria. These bacteria are isolated from marine sources and reared to develop strains which are sensitive to sought after matter. The biosensor element containing these organisms is placed in an electro-mechanical apparatus equipped with a photocell which monitors the light generated by the bacteria. An air pump pulls ambient air across the surface of the biosensor. If the air is free of molecules to which the bacteria is sensitive, the light emission remains constant. If the air contains vapors of the substance the sensors were selected to detect, the alarm (visual and/or audible) will be activated.

RPC Corporation has run preliminary tests with oranges, mangos, and apples, and reported that they can detect these items in suitcases with one latch opened.

The biosensor devices are small and very portable. They may be the size of a hair spray can. RPC Corporation is developing a vest incorporating biosensors for the New York Police Department. They are very sensitive devices and give a rapid response. They are capable of repeated challen[illegible] Negative factors are possibly high false alarm rates. The Army Land War[illegible] Laboratory reported biosensors will respond to heroin vapors of such minute density that they were not detectable by mass spectrometers--however, the biosensor responded to too many other things.

Also, bacterial elements must be replaced periodically. The NYPD replaces elements every eight hours. The refills, however, are inexpensive. Cost of the device would be approximately \$2,000 to \$5,000 per instrument and refills cost \$1.00 each.

The second basic type of sniffing system consists of electronic devices incorporating mass spectrometers or gas chromatographs. Two such systems are described below.

<u>The Varian Chemical Vapor Analysis (CVA) System.</u> This system combines a mass spectrometer with a patented membrane inlet that enriches the "non-air" constituents of the air sample up to 1000 times per separator stage. It is capable of detecting any of a large number of compounds, primarily organic, which may be present in the air in concentrations as small as a few parts per billion. Sample preparation is not required, nor is any special carrier gas used to transport the sample to the instrument. The sought after matter is present if one or more signature peaks are detected in the mass spectrometer output.

The mass spectrometer may be swept through its mass range of 20-300 automatically and its information output either recorded on a chart or analyzed by a small optional digital computer. Output can be in the form of lights and a similar GO/NO-GO indications, or analyzed further just as can any computer output. The computer program can be changed to reflect changes in application useage. A full sweep of the mass range would not be likely in actual use due to the necessity of a restricted time frame.

The basic CVA system is contained within a 19" x 25" x 44" cabinet with the optional computer control/output function requiring similar space.

Dr. H. W. Bruce, CVA Product Manager, stated that the size and price of the system could be reduced "drastically" if the application were well defined and we accepted limitations in flexibility. Total system costs (including computer) is about $50,000. This could be reduced to about $20,000 for a basic unit capable of detecting only about six items. Such a unit might be the size of an attache case. Units have been developed which are transported by a man-carried pack frame.

A problem with this system is little success in detecting heroin in air samples.

The Franklin GNO Plasma Chromatograph-Mass Spectrometer System. This system involves an ion-molecule reactor coupled with an ion drift spectrometer which produces a plasmagram of separated ion-molecule peaks from a sample mixture. Individual peaks of the plasmagram can be directed into a gradrupole mass spectrometer to identify the molecules present. Response time is limited to the seconds necessary to collect the air sample.

The present system is designed for laboratory use. Developmental work is required to convert this system into a detection device suitable for our purpose. Such a detection device has been developed for the Army Land Warfare Laboratory for detection of explosives. This device weighs approximately 40-50 pounds. Dr. Martin Cohen, of Franklin GNO, anticipates the size of the plasma chromatograph to be reduced to about 5 pounds within five to ten years.

66.4 The potential for Traps. Traps utilizing the sex attractant pheromone are being used experimentally in ships holds, storerooms, etc., to detect boll weevils and khapra beetles. The effectiveness of these traps is presently being researched. A possible problem is that the khapra beetle is slow moving and may not make it to the trap. However, although an empty trap may not mean an uninfested hold, a trapped significant insect would justify fumigation. Developmental work is being conducted by Dr. W. Burkholder, MQ, Stored-Products Insects Research Branch (University of Wisconsin, Entomology Department).

66.5 The Potential for Listening and Other Devices. Listening devices have been developed which are capable of detecting wood borer termites in wood. The Army developed a device for listening to the sounds made by starved bed bugs in order to detect the presence of humans. The failing of devices of this nature is that the insects must be active. Insects may be inactive due to life stage, temperature, rest cycles, chance, etc., and this imposes limitations on the use of the device.

For further information on detection of gnawing insects, Insect Control and Research Inc. of Baltimore, Maryland, should be contacted.

Various other detection systems are available. These include electromagnetic, x-ray, ferrous detectors, and heat detectors. These devices have little or no potential for quarantine and inspection purposes. The most likely of these devices is the x-ray; but the low density of fruits, their common shapes, and damaging of film in baggage would cause significant problems.

66.6 Remote Sensing. Remote sensing does not at present have much likelihood of aiding port of entry operations per se. In the long run, however, remote sensing could possibly have an impact on our quarantine program. This impact would result if remote sensing sufficiently developed the capability of crop vigor analysis. Identification of crops affected by insects or diseases could lead to more rapid identification of infestations of foreign pests. Increased ability to detect and control pest infestations would decrease the threat of foreign pests and thereby decrease our need to exclude them. At least two factors may limit the application of space sensors for this purpose. First, crop vigor analysis is dependent to some extent upon crop identification which is described as only "possibly feasible." Second, while remote sensors are good indicators of loss of plant vigor, they are generally poor indicators of the causal agent.

While developments in the area of remote sensing are worth monitoring, it is too problematical to play a part in program planning at this time.

66.7 Control by the Irradiation of Commodities. It is possible that irradiation of agricultural material will become an accepted practice in the distant future. However, widespread application of this technique in the next decade or two for preserving freshness and destroying insects through sterilization is not likely for two important reasons: irradiation cannot compete economically with other methods of preservation; and in the case of fresh fruits and vegetables, the dosage required to kill spoilage organisms also impairs the quality of the produce. These major handicaps have not been overcome despite years of research enthusiastically supported by the Atomic Engergy Commission.

Although the outlook for irradiation as a food preservation technique is not bright, it is being employed to a limited extent in certain countries (Israel, USSR) for a few items such as potatoes and fish.

If irradiation ever becomes widely used it would have a significant impact on AQI quarantines and activities. Present quarantines and treatments would in large part become obsolete. Large volumes of commodities could enter with no inspection beyond proof of appropriate irradiation. Containers carrying irradiated commodities could safely be opened without inspection at their final destination.

66.8 Control by the Irradiation of Passenger Baggage. In 1970, AQI considered the possibility of utilizing irradiation to eliminate the threat of contraband in passenger baggage at Honolulu airport. Dr. A. M. Dollar of the Hawaii Development Irradiator Program prepared an appraisal of baggage disinfestation by ionizing radiation. His analysis showed that the procedure would be effective. The cost of the facility alone was estimated at $2,400,000. Baggage would have to be delivered to the facility well in advance of departure. Such sensitive materials as film, medication, and optical equipment would need to be excluded. It was concluded that such a system would not be installed.

North American Rockwell is working under contract to FAA to develop a process for the detection of explosives in luggage. This detection device utilizes neutron irradiation. Although the system detects explosives, the false alarm rate due to copper in electrical appliances is too high at present. The combined neutron and gamma radiation is of relatively low dosage. However, there is a possibility that insect impairment or kill may result from the detection process.

67 SAMPLING [9]

The procedure of sampling has been applied in agricultural quarantine and control programs for over fifty years. The rationale for doing so is clear. There is neither sufficient funding nor trained manpower to inspect all pest hosts or even a large proportion of them. The costs and benefits in sampling are complex and, I suspect, not clearly understood by those who implement them in our agriculture programs.

It would be presumptuous here to provide a thorough analysis of the subject. In its most general form, mathematics, the subject of sampling, requires volumes to address even the more elementary situation. The application to specific agriculture problems would require still further exposition. However, the underlying ideas and concepts may be discussed without undue attention to the important, but complex, technical details.

In regulatory work, important and often costly decisions are made each day. They are best made from knowledge of the entity being controlled, a shipment of agricultural produce, the manufactured products of a factory, the conditions of a mine, etc.

We are thus concerned with describing the entity, hereafter referred to as the population, as best we can within the limits of our resources.

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9. This section was prepared for the Task Force by Dr. Bert Levy, APHIS.

It should be evident that the best description is obtained from an exhaustive inspection. We can summarily dismiss this approach. The next best description is obtained through representative sampling.

As its name implies, with "representative sampling." one may select a portion of the population that is representative of it. The sample has the same characteristics as the population. Suppose we wish to determine whether the hams from a processing plant are thoroughly cooked. It is known that the cookers used heat uniformly throughout and that the hams are trimmed to the same size before cooking. We, therefore, need only to inspect one ham from each cooker lot. Each ham is representative for the purpose of determining thoroughness of cooking. When such representatives are available, they should be used. The subject is mentioned here for completeness. It is inapplicable to most of our problems. We may emphasize its efficacy, when it is applicable, by noting that it is not a statistical procedure.

Let's now consider the type of description that statistical sampling can provide. The following contrived conversation between Mr. A(dministrator) and Mr. S(tatistician) highlights the main points:

A. How much of this shipment of oranges do we have to examine to be sure that it is free of Mediterranean fruit fly?

S. All of it. That's the only way you can be absolutely sure. I am assuming our inspector will find the larvae (pupae) if it's in an orange he examines.

A. I can't have them all checked! Suppose I only want to be 95% sure?

S. Then the inspector has to check only 95% of them. To bring the sample size to a more reasonable number you have to specify an infestation level that is acceptable. For example, will you accept the oranges if one percent of them have a fruit fly larvae or pupae?

(This space is allowed for Mr. A. to yell and scream and to cool down again.)

A. There is no way of knowing what an acceptable level is. In the past, about 0.25 percent of the oranges have been infested. There haven't been any major outbreaks. We'll try that. What sample size do we need now?

S. There are a lot of other questions that have to be answered before I can give an answer. However, it should be in the neighborhood of 8,500 oranges.

The key points in the above conversation are the tolerance level and the degree of assurance required that must be set. Setting the values that should be assigned to these is not a statistical or mathematical problem. It is a scientific or at least an administrative problem. The numbers should be interpreted in agricultural terms - loss of crops, control program costs, etc. Mathematical assistance is available. The relations among tolerance level, assurance level, and sample size can be displayed in an easily read table or chart.

It is implied in the above discussion that inspection of the population will stop as soon as one inimical organism is found. Thus, if no organism is found, all we may say about the population is that it is most unlikely to be infested at a level higher than the one established. With this type of sampling scheme, we are likely to find organisms in populations with much lower infestation (tolerance) levels than our established tolerance.

When we left our discussants a paragraph or two back, Mr. A was smiling contentedly at the prospects of the economies realized by sampling.

A. We could unload the first 20 cases of oranges and have them inspected immediately. That involves very little inspectors' time and does not unduly interfere with the longshoremen.

S. You can't do that! That's not sampling. I mean, that's not random sampling. The sample size estimate depends upon the sampling being performed randomly.

A. I can't understand why that's necessary. But, we could have the inspector stop the longshoremen every so often and take a box.

S. Unfortunately, what you describe is not random sampling. It's haphazard sampling. "Random" has a more specific technical meaning here. In the context of this conversation, it requires that each orange in the shipment must be equally likely to be included in our sample to be inspected.

A. But our inspector wouldn't choose the same pattern each time. Why isn't that adequate?

S. People tend to have biases in their selection pattern. Suppose I put five coins on your desk in a row, would you be as likely to choose the end one as any of the others? Most people would bias their choice toward a center one. We can provide selection tables to aid the inspector.

The point of this conversation is that "haphazard" is not equivalent to "random." It is only with random sampling, sometimes called probability sampling, that we can come up with a description of the population under consideration. The randomness of selection must be built into any sampling scheme adopted.

In addition to the tolerance level, the assurance level and the randomness criteria, there are many more minor considerations. If each sampling unit (viz. orange) is not equally likely to be infested, that is, if units close together tend to be similar, we must adjust our sample size upward to take care of this clustering effect. It is sometimes possible to perform sampling without setting the size in advance. When this sequential sampling can be performed, it is generally advantageous.

Before ending this exposition, a bit more should be said about the population. In the preceding discussion, it was implicit that our population consisted of a shipment of material, a shipper's lot, a carload, a shipload, etc. It is possible that some other unit is more appropriate. It is historically accurate that produce shipped into the United States from Mexico is extremely pest free. The infestation rates are much smaller than any for which we could economically sample on a truckload lot basis. However, if we consider our population as all produce grown in Mexico for the U.S. market, we may set rather low sampling rates to accomplish our description. Information about this population could be used to make decisions about Mexican produce. It should not be used to make decisions about individual shipments.

Sampling provides no panacea for the administrator. It does provide him with one more way to describe the entity under his charge. Hopefully, it contains not only a different view of it than a scientific description or an English narrative description, but also some new information. As with these other descriptive looks, the statistical approach requires some understanding and work on the part of the user. The setting of tolerance levels, assurance levels and even defining the population of interest are strongly interrelated with the type of decisions that are likely to be made. They are also interrelated with the information in other descriptions.

A final statement of warning is in order. Unlike the scientific description, the statistical description obtained <u>will</u> be wrong occasionally. How often and by how much are controlled by the values set for the various parameters. This error is the price paid for the economies yielded by sampling.

7 THE ASSESSMENT OF U.S. QUARANTINE EFFORTS

71 BAGGAGE INSPECTION

Baggage inspectors intercept substantial quantities of exotic pests. It is obvious that some proportion of international travelers are deliberately or inadvertently bringing in contraband materials. Some proportion of those introductions that come through ignorance of the possible consequences could be deterred if the travelers were informed. Recognizing this possibility, the Information Division of APHIS provides program support. Their suggestions and actions have had a mixed history of success and failure. The Task Force requested Mr. Val E. Weyl to discuss this recent history at one of its meetings. The following exposition of the experience with the information program is based primarily on that event, and on followup discussions with Mr. Weyl and others.

The public information program supporting foreign plant quarantines began in 1960. An attempt was made to saturate the public media in order to reach the 165-200 million travelers entering the U.S. on foot, by automobile, aircraft or ship. The overall strategy behind the program was to use the public media to build general awareness and to alert the public to the threat of plant pests and diseases, and to use the direct message to the traveler to deter the carrying of contraband.

The Smokey Bear campaign of the Forest Service used a similar strategy - public media saturation for awareness and direct message at point of contact to influence behavior in the woods. The success of that campaign is due to two important phenomena, among others. First, the endorsement of the Advertising Council, and second, control at "the point of contact."

APHIS has achieved neither of these. Paradoxically, pests and diseases today destroy many times more of the forest resources than fire, yet the Forest Service has shown little interest in the information campaign to prevent the entry of exotic pests.

The plant quarantine effort was staffed by a single information officer, except for the period 1967 through 1969, when two men were assigned. At its peak of activity $60 to $70 thousand a year was expended.

Among the activities undertaken were the following:

- exhibits and publications
- foreign language flyers for overseas distribution (especially in southern Europe and Japan)
- inclusion of information on the Customs declaration

- inclusion of information on the back of the passport
- development of a symbol as an attention-getter
- development of a working relationship with the Department of Defense on retrograde cargo
- development of a motion picture for returning service people, and getting it into use
- encouraging airlines to distribute a flyer at the time of tick pickup by the passenger
- producing consumer-interest features for use in printed media and radio-television
- training and assisting port inspectors to upgrade and increase publicity
- obtaining space for messages in travel guides

This program of contraband deterrence through information and education made some significant contributions to the program objectives which still continue. In addition, some important lessons were learned. On the oth hand, some useful efforts were stalled.

"Pestina" was designed as an identifying symbol for use in public media communication and in the direct message work. She is regarded as only mildly successful. The hitch-hiker has an attractive feminine form - the symbol is inconsistent with the message - "don't pick her up" (see Figure 7-1).

For a while, radio and TV carried the announcements, and although no formal survey was conducted to determine the effectiveness of the approach, Mr. Weyl is of the opinion that it helped materially to prevent increases in contraband being carried by travelers. In any event, TV stations that had been carrying the message stopped providing public service time during the last five years. Radio outlets were stepped up, but did not fully replace the TV announcements.

Apparently, the television stations stopped carrying the message because it was not endorsed by the Advertising Council. TV uses this endorsement in judging the suitability of a message for the use of public service time. Recognizing this, two attempts were made to obtain the endorsement of the Advertising Council. Both failed. The reasons for the failure are not clear, but apparently involve the Department's presentations to the White House by the USDA Director of Information.

A direct message was included in several of Frommer's travel guides, and

FIGURE 7-1

these people were very cooperative in supplying space without charge. However, this has not been followed up by the Information Division. Mr. Weyl believes that other travel guides such as Cook's would cooperate, if requested to include a message. He estimates that 30 percent of travelers consult these books, and they often do so when planning a trip, an effective time to reach them with a message. As one airline official noted, "the time to tell the foreign visitor about agriculture contraband, is before she kills the donkey and makes it into sausage to bring to her daughter in New York."

The Passport Division of the State Department cooperated in having a direct message printed in the back of the passport.[1] In addition, a flyer has been given out with the passport in recent years.

The Defense Department places the message in the orders given to personnel on their movement and an enforcement officer, who has been trained by AQI, inspects baggage and supervises packing.

On the Mexican border the direct message program includes signs, featuring "Pestina," together with the use of flyers and notices. According to Mr. Weyl, this program has resulted in a significant drop in the amount of contraband being brought in, but no objective evidence is available.

To test the effectiveness of using direct message with airline travelers two trials were conducted. In the first test involving United Air Lines flights to and from Hawaii, the amount of prohibited materials was "appreciably reduced." In the second test, with incoming foreign nationals from Santo Domingo on Pan American, the passenger response was generally favorable. However, neither Pan American nor the AQI personnel fully carried out the program as designed.

As a result of these evaluations, and other experience, Mr. Weyl concludes that:

> The direct message seems to be the best and most economical approach to reach travelers if the message can unfailingly be

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1. The passport message is as follows:

> "Agriculture
> Do not bring foreign meats, fruits, plants, soil, or other agricultural items when you return to the United States. To do so will delay you at the port of entry. It is unlawful to bring in foreign agricultural items without permission, because they carry destructive plant or animal pests and diseases. General information is contained in "Customs Hints." For specific information, write to "Quarantines," U.S. Department of Agriculture, Washington, D.C. 20250.

> included in official document packages or with the ticket at some time when the traveler can consider it at leisure in planning a trip. A message just at departure or on the aircraft are poor times to attain proper attention.

The international air carriers were requested to distribute AQI leaflets to passengers bound for the U.S., at their offices throughout the world. The idea was that these leaflets would provide a direct message to the U.S. traveler at the moment of ticket acquisition. For awhile, some airlines did stack leaflets on the counter, but the practice soon fell by the wayside, and the airlines ceased to cooperate. The airlines apparently felt that these methods were ineffective in reaching the incoming international traveler, since 85 percent of tickets are sold by travel agents. On the other hand, the airlines have shown a reluctance to ask the travel agents to serve as distributors. The travel agents say it is the responsibility of the airlines, and even though the leaflets were to be printed at government expense, they declined to distribute them.

The airlines were also requested to print information on the ticket envelopes, but have not done so.

Many of these efforts were unilateral on the part of USDA. A better approach would be for all of the inspection agencies to develop a joint information program as proposed in the Pfleger Report:

> The Federal inspection agencies in the past have individually provided the carriers, terminal operators, and others with information brochures on entry requirements. In some instances separate information programs have been initiated without touching base with sister agencies. Public information programs in risk areas both at home and abroad on entry requirements could be intensified through travel and carrier ticket agents and the State Department network of passport offices, consular offices, trade and industrial journals, and information media that will reach travel clubs, etc. The information should specify and stress liquor allowances, vaccination requirements, and general prohibitions on agricultural products. Recommendation No. 8 - Inspectional agencies should develop multiagency handout information for use by carriers, terminal operators and others on entry requirements.[2]

No evidence was found that this recommendation has been implemented. In fact, Mr. Weyl reports the failure of an attempt at implementation, as follows:

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2. Bureau of the Budget, Executive Office of the President, Interagency Report on Inspection at Ports of Entry, May 1968, 56 pages mimeo.

> When the "one-stop" inspection was proposed and initiated in 1968[3], the Information Division (ARS) proposed to encourage the adoption of the "Direct Message" approach as part of the package, with sufficient public information to alert the traveling public. An interagency committee was set up to develop a single flyer for all services to use. This was developed and agreed upon (in August 1968). But before the material was submitted to the Secretary-level task force (Customs, Immigration, Public Health, USDA), the proposed flyer concept and direct message approach was leaked to the airlines who opposed it actively. The information proposal was never seriously discussed at the Secretary-level task force meetings, so far as is known. The idea and the action drifted into obscurity in the next year (1969) and no further consideration was given to the proposal in spite of appeals by the Information Division[4].

Mr. Weyl also believes that, since 1968, when the Government began to encourage foreign visitors to the U.S. (as a Balance of Payments measure), any messages which might be interpreted as an encumbrance to travel have been frowned upon.

As a final step, prior to inspection and enforcement, travelers are now asked to declare on the U.S. Customs Form whether they are carrying any fruit, plants, meats, other plant or animal products, or pets, and to certify their answer by signature (see Figure 7-2). This does not serve as a deterrent on the existing trip, but does build awareness for next time. This practice was initiated in 1971 with the cooperation of the Bureau of Customs. Non-residents and returning residents bringing in less than $100 worth of goods may make an oral declaration and need not use the form. However, the form is given to all airline passengers and they become aware of the agriculture message for the next trip, even if the form is not used.

On January 25, 1971, Dr. Francis Mulhern, then Deputy Administrator of ARS for Regulatory and Control, recommended to ARS Administrator Dr. George Irving, "application of the direct message concept in mandatory legislation requiring carriers to inform the traveling public concerning agricultural quarantine regulations." He noted that further efforts to enlist the cooperation of air carriers in any effective voluntary programs do not appear to be worthwhile. (The direct message study confirmed that

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3. "One-stop" inspection was a recommendation of the Pfleger Report, 1968 op. cit.

4. Personal communication from Mr. Wal Weyl, Information Division, APHIS, April 25, 1972.

FIGURE 7-2

U.S. CUSTOMS DECLARATION

Present to the Immigration and Customs Inspector

EACH ARRIVING TRAVELER OR HEAD OF A FAMILY MUST WRITE IN THE FOLLOWING INFORMATION

Please Print:

FAMILY NAME	GIVEN NAME	MIDDLE INITIAL

DATE OF BIRTH *(Mo./Day/Year)*	VESSEL, OR AIRLINE & FLT. NO.

NON-CITIZENS ONLY→	U.S. VISA ISSUED AT *(Place)*	VISA DATE *(Mo./Day/Year)*

CITIZEN OF *(Country)*	RESIDENT OF *(Country)*

PERMANENT ADDRESS IN UNITED STATES OR ABROAD

ADDRESS WHILE IN THE UNITED STATES

NAME & RELATIONSHIP OF ACCOMPANYING FAMILY MEMBERS

ARE YOU OR ANYONE IN YOUR PARTY CARRYING ANY FRUITS, PLANTS, MEATS, OTHER PLANT OR ANIMAL PRODUCTS, OR PETS? YES ☐ NO ☐

I certify that all statements on both sides of this declaration are true, correct and complete.

SIGNATURE:

In addition, the laws of the United States require that you *declare* ALL *articles acquired abroad (whether worn or used, whether dutiable or not, and whether obtained by purchase, as a gift, or otherwise)* which are in your or your family's possession at the time of arrival.

Nonresidents may make an oral declaration. Returning Residents may make an oral declaration if the total value of articles declared *(price actually paid or, if not purchased, fair retail value)* is not more than the sum of $100 per person. Otherwise You Must List In Writing On The Reverse Of This Form All Articles Acquired Abroad Which You Are Now Bringing Through Customs.

All your baggage *(including handbags and hand-carried parcels)* may be examined. False Statements Made To An Inspector Are Punishable By Law. Consult "U.S. Customs Hints" and your inspector for full information.

FOR OFFICIAL USE ONLY

NO. PIECES BAGGAGE EXAMINED	TIME COMPLETED	STAMP NOS.
INSPECTOR		
DATE	BADGE NO.	

The Department of the Treasury
Bureau of Customs

CUSTOMS FORM 6059-B
JULY 1971

FORM APPROVED
OMB NO. 48-R0386

a voluntary arrangement with carriers tends to break down without intensive monitoring.)[5]

There is an alternative approach which has apparently not been pursued to date. The U.S. Travel Service "conducts an active facilitation program to reduce barriers to foreign visitor travel to the U.S. Specific goals include the removal of restrictions, easing of visa requirements, and simplification of entry procedures for international visitors within the framework of U.S. laws."

To aid in fulfilling these objectives it would seem logical for USTS to distribute information about all U.S. entry requirements, including those related to agriculture, in a clear and simplified form designed to reassure travelers concerning ease of entry to the U.S. USTS appears well equipped for the distribution of such information since they maintain eight regional offices overseas and "work closely with carriers, travel agents, hotels, Federal, state and local government travel organizations, travel trade associations, trade union groups, chambers of commerce, civic and professional groups, and international and regional organizations which promote travel and tourism throughout the world."[6]

The Information Division does not appear to be heavily involved in the further development of the quarantine program. There was, for example, no work plan for 1972, and only one person had been assigned. Since the deterrent effect that could be produced by a viable information and education program is an important program alternative, steps should be taken to remedy the situation.

Advertising in the flight magazines of international carriers and making an ample supply of flyers available in waiting rooms at points of departure might help deliver the message.

The Task Force had planned to do a survey of traveler's awareness and attitudes, but finally decided that it was too expensive and time consuming. Among the questions to be pursued were these:

- To what extent are travelers aware of the existence and purpose of agricultural quarantines?

- Of those who are aware, how did they learn about quarantines? What role did the APHIS "advertising campaign" play in informing them?

- What is the attitude of travelers toward bringing in contraband?

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5. Arnold, John S., Information Plan of Work; Support for Agricultural Quarantine Inspection Division Program--1971. ARS Information Division March 1971, 8 pages, mimeo.

6. U.S. Travel Service, 1972, Stimulating Business and Pleasure Travel from Abroad, 15 pages, July 1972, U.S. Department of Commerce.

- To what extent is the introduction of contraband reduced by the knowledge that quarantines exist, that inspection will occur, and that punitive actions may be taken against offenders?

- In summary, is there an effective information program to aid compliance and thereby reduce the necessity for enforcement?

In conclusion, the proportion of travelers who receive the message, which the information channels struggle to deliver, is unknown. But for those travelers who do receive the simple, hard-hitting message:

- "don't bring in foreign agricultural items"

there are two important incentives for non-compliance:

- "it's okay, if Customs doesn't find it"

and even if they do:

- "the Customs or Agriculture inspector often allows it."

The first of these incentives involve the gambler's calculation of the probabilities of non-discovery. In addition, the sanctions on discovery, may be assessed, and these are known to be trivial, if any. In dealing with this incentive, increasing the sanctions, and their visibility, will probably be more cost effective than reducing the chances of non-discovery. That is, dollars spent to levy fines and to publicize the fines and their application will yield more compliance, than increasing the number of inspectors.

The traveler readily observes that not all agricultural items are, in fact, prohibited, and since the reasons for the exceptions are obscure (they are, after all, quite complex), the traveler has a second incentive against compliance. The item that he has selected for entry may be permitted, after all, even if it is found, and the only sanction is loss of the item, which is typically not of high monetary value.

To whatever extent the foreign agricultural items entering the U.S. with international travelers constitute a risk, then AQI is increasing that risk by actions that foster the very existence of this second incentive. Recent studies at Kennedy Airport indicate that if agricultural items are present there is an even chance that they will not be found by Customs. When found, AQI provides a college graduate biologist to judge whether the traveler's item may be considered "safe," and thereby permit entry. By this means, exceptions to the law are made convenient. ("It is unlawful to bring foreign agricultural items, without permission, because they may carry destructive plant or animal pests or diseases.") This "convenience" is actually a service provided to the traveler consisting of the discretionary judgment, "yes, you can bring that in," or "no, you can't bring it in." Providing such a service to the traveler at the expense of the general taxpayer is a questionable public policy. But when it also provides a positive incentive that defeats the objective of the overall program, it is clearly counter-productive. This government subsidy for the importation of possibly dangerous contraband should be abandoned. Maximum protection will result from automatic confiscation by Customs, followed by immediate destruction.

If an alternative to eliminating this service is desired, it could be provided at cost to the traveler. A traveler who wished to contest the confiscation of an item could pay a reasonable fee for AQI consideration and/or inspection. This would (1) vastly reduce the need for AQI time at passenger terminals, (2) reduce the amount of contraband carried, and (3) eliminate the possible danger from passing a dangerous item.

72 DETERRENCE[7]

The problem that has risen repeatedly in attempts to evaluate our agricultural quarantine program is the paucity of data that could throw some light on the effectiveness of our efforts. This is particularly true in the case of plant quarantines.

Because of the biological nature of exotic plant pests and diseases, their arrival in this country is unheralded and their presence often goes undetected for years. This, coupled with changes over time in the intensity with which we look for them beyond ports of entry, makes the record of new "finds" virtually useless as a "big picture" measure of program effectiveness. Besides, even under the best of circumstances, it would be exceedingly difficult, if not impossible, to associate a particular "find" with a particular event at a port of entry. In any case, program managers have never been able to agree on the annual number of pest introductions they would tolerate.

Moving away from the overall view of program accomplishments to an evaluation of cargo inspection operations, we find a similar lack of meaningful data. For a number of reasons (economic, impact of the quarantines and their enforcement, etc.), the evidence indicates that the level of infestation occurring in imported agricultural products is apparently very low. Just how low is not known because, up to now, inspection and the data flowing from it have not been systematized to the point where statistical reliability can be established. But it seems safe to say that a huge addition to the AQI inspector force would be required to detect the low levels of infestation that do occur. A workable alternative would be to statistically

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7. This section was prepared by Mr. Richard D. Butler of the Task Force.

sample incoming shipments to the point where it could be said that the level of infestation does not exceed X percent. Here again, program people have declined to stipulate any tolerances for infestations.

The data situation with respect to the effectiveness of inspection of passengers and their baggage at international airports is much better. Kennedy International Airport is the gateway into the U.S for nearly half of the people entering the U.S. from overseas, and it is one of the few ports of entry where we have attempted to evaluate our procedures for intercepting contraband articles from arriving passengers. This was done by making an exhaustive examination of a small random sample of passengers to establish the rate at which contraband was intercepted using current inspection procedures. The result was the discovery that about half of the contraband carried by passengers was slipping through undetected and that the number of passengers carrying such contraband was small--fewer than three per 100.

Since:

1) it is unthinkable that the half that was intercepted contained all the pest and disease organisms,

2) the vast majority of the travelers are city bound,

3) we do not appear to be overrun with recently introduced pests,

then it seems that the risk of introducing foreign pests and diseases via this route is very low. Here again, it would require a considerable increase in manpower to intercept all the contraband.

The absence of useful measures of program effectiveness, coupled with the finding that an enormous addition to our inspection force would be required to detect the low levels of infestation occuring in imported agricultural products and to intercept contraband carried by travelers, leads us to believe that the major issue involved in enforcing agricultural quarantines is that of deterrence. It follows that the major problem of program managers is determining the number of policemen (inspectors) required to limit the number of attempts to bring in contraband or infested products. But even this determination ought to be based on some objective measures of what is happening both at ports of entry and in the agricultural hinterland beyond them.

We believe that the importance of the Kennedy study lies as much in the data showing the frequency with which passengers carry contraband as in the data showing the effectiveness of our interception efforts. These data could be used as a benchmark for measuring the consequences of program changes such as:

- A greatly expanded effort to make the traveling public aware of the possible economic and environmental impact of bringing in infested agricultural products.

- A cutback in the number of AQI baggage inspectors.

- Delegating to Customs the authority and responsibility for taking from incoming travelers all the agricultural contraband they can find.

  We believe that planned experiments should be undertaken to determine the efficacy of our recommendations and that this can be done without significantly affecting the risk of pest introduction.

While our inspection force deters wholesale attempts to violate quarantine requlations with respect to imported agricultural products, it is doubtful that it has a similar impact on contraband agricultural products brought in by passengers. We can say this with confidence because the traveling public is simply not aware that is improper to bring such items into the country. There can be no deterrence when knowledge of the regulations is lacking.

The ignorance on the part of the traveling public of our rules against bringing in certain agricultural products has been suspected for years; but it was an information man, John Arnold, who finally undertook an experiment to educate the public and to measure the consequences of that education on the proportion of incoming contraband recovered.[8]

Judging from the action taken on his proposals, AQI program managers regard informing the traveling public as either a matter of no consequence or impossible. Here again, one observes a great reluctance to innovate or to change established practices. Even something as simple as revising the Customs Declaration to include agricultural questions in a prominent place took many months to achieve.

We see no valid reason for not attempting to inform the traveling public, via direct message, of our regulations concerning agricultural products. It certainly offers the prospect of being more efficient than programs, leaflets, etc., broadcast or sent to the general public.

In pursuing the issue of deterrence, we talked with analysts in the Washington, D.C., Police Department and in the National Institute of Law Enforcement and Criminal Justice. From these discussions, we found that there is no literature in the learned journals on the theory of deterrence,

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8. A summary of Mr. Arnold's findings and recommendations is Appendix 7-X

conditions for its application, or how to optimize its effect in any given situation. But in these conversations, we did acquire a conception of the conditions necessary for deterrence to work:

1. The objectives of the law must be clear, and these objectives should be agreeable to most of the population.

2. The regulation or law must be unambiguous and capable of being stated in language that is simple and easily understood.

3. The regulation or law must be enforceable.

4. The affected persons or firms must know that the regulation or laws exist and what they must do to observe it.

5. There should be an incentive for the affected persons to observe the regulation. If the incentive is negative, the cost should exceed the advantage of ignoring the regulation.

6. The enforcement agents must have high "visibility" to remind persons or firms of their obligation.

7. There must be a monitoring system to identify trouble spots and to provide information about the overall effectiveness of the regulations and the deterrent forces.

8. Deterrent forces should be mobile enough to deal with trouble spots as they are found.

Penalties for violating AQI regulations are summarized in the following exchange of correspondence.

Task Force Question: What penalties does the law allow to be imposed on persons or organizations who violate the regulations issued by AQI?

AQI Answer: Plant quarantine statutes enforced by AQI which specify penalties are the Plant Quarantine Act, Federal Plant Pest Act, and the Honeybee Act (marked copies enclosed). The same penalty is given for the three Acts. It is a misdemeanor punishable by a fine not to exceed $500 or by imprisonment not exceed one year or both.

Minor penalties which are allowed under the regulations when violations are found, include cancellation of permits (see enclosure A, Part 330--Federal Plant Pest Regulations), cancellation of mill utilization agreements (see enclosure B, Quarantine 8, Foreign Cotton and Covers), and destruction or immediate export (see enclosure C, Part 322--Adult Honeybee Regulations).

(For your information: The Customs Bureau, under its laws, assesses penalties in the form of small fines, from $1 to $15, against individuals detected carrying small quantities of prohibited fruit or other plant material across the Mexican border into the United States. Such fines are assessed for failure to declare or for making a false declaration, and the amount is based upon the domestic value of the prohibited material as established by the inspector.)

Task Force Question: What costs can we force persons or organizations to bear who are caught violating AQI regulations?

AQI Answer: Under cases in which violators of AQI regulations are successfully prosecuted, court costs, etc., must be borne by the convicted individual the same as any other type of court case.

AQI regulations also require, in most instances, that costs (including those that may be incurred by the Government or the owner) incident to handling, cleaning, safeguarding, treating, or other disposal of conveyances or products shall be borne by the owner when a violation occurs. (Costs for the services of an inspector during regularly assigned hours of duty are excepted when required for supervision or other necessary action. [See pages 4 and 6 in enclosure A for an example of references to the above.])

Task Force Question: Are these penalties widely understood by domestic importers and foreign exporters of agricultural products, common carriers, and the traveling public?

AQI Answer: Copies of regulations containing references to the payment of costs by the owner are widely distributed principally at the time replies to letters of inquiry regarding the importation of plants and plant products are made. We believe such references are clearly understood by importers, common carriers, and the traveling public.

Task Force Question: Does AQI believe that these penalties and/or costs constitute an effective deterrent to the illegal importation of agricultural products?

AQI Answer: We agree that penalties and/or costs constitute one of several effective deterrents necessary to discourage illegal importations.

Task Force Question: What efforts has AQI made during the last 10 years to change the penalties (legal or economic) for violating its regulations?

AQI Answer: None.

Task Force Question: How many times in the past 10 years have we attempted to assess the penalties the law provides for violating AQI regulations?

AQI Answer: One violation of the Plant Quarantine Act was prosecuted in

1967. The person was convicted and fined $200 for failure to obtain a Plant Import Permit. In addition, the same person was penalized under Customs' laws and was required to forfeit $1,400, the appraised value of the vehicle in which the violation occurred, plus, the nursery stock involved in the violation.

Under minor penalties assessed, AQI has cancelled approximately six import permits because of violations.

Most penalties assessed for violations of plant and animal quarantine regulations are initiated by Customs under authority of the Customs' laws upon request by AQI. Under Customs' regulations, Customs officers perform such functions as are necessary to carry out plant and animal regulations. The number of individual penalties assessed by Customs at ports of entry along the Mexican border number 14,060 for a total value of $42,936 over the past 10-year period. The Mexican border penalty procedure is unique, however, since similar situations do not occur at other border areas.

73 QUARANTINE IMPACTS

73.1 Trade Barriers:[9] Quarantine, health, sanitary, and related laws and regulations from the standpoint of a trader are often viewed as trade restraints, However, from the viewpoint of the country imposing such laws and regulations, they are considered necessary precautions for protecting agricultural producers and consumers. Both points of view are recognized under the General Agreement on Tariffs and Trade (GATT) which prohibits such measures when applied on a discriminatory basis or with the aim of restricting trade, but clearly recognizes their necessity to protect human health or animal and plant life. Because there are often two distinct points of view, questions do arise as to whether or not such measures are non-tariff trade barriers which unjustifiably restrict trade.

It is ordinarily not difficult to demonstrate that tariffs and other monetary levies on imports restrict trade. This is also the case with quotas, licensing requirements, and embargoes. However, this does not hold true for quarantine, health, sanitary, and related laws and regulations because no matter how indefensible a measure may appear on the surface, some justification for its existence usually can be made.

Article XX of the General Agreement on Tariffs and Trade (GATT) provides that member countries may adopt or enforce "measures necessary to protect human, animal or plant life or health." It is provided further, however,

9. This section was prepared for the Task Force by Mr. Paul Ferrie, of the Foreign Agricultural Service, USDA

that such measures should not be applied in a discriminatory manner nor as "a disguised restriction on international trade."

In 1970, the GATT conducted a survey of "import measures" including health and sanitary regulations. The compilation of these latter regulations was published by the GATT in document COM.AG/W/68/Add.4, dated December 10, 1970. The document, which has nearly 500 pages, sets forth the regulations of twenty-nine countries, including the United States. Arguments for and against various measures are also provided. It would appear that merits of these arguments vary but in nearly all cases "scientific" proof (pro and con) is utilized as the basis for the position.

JAPAN: Salmonella Test on Poultry - On June 28, 1971, the Food and Hygiene Division, Japanese Ministry of Health and Welfare, began to test all imports of poultry meat for the salmonella bacillus. This action was taken without prior notice to exporting countries. The condemnation of shipments found to be positive is disrupting U.S. (and other countries') poultry meat export trade with Japan. Moreover, the Japanese Government has provided no information which would indicate that the same test procedures are being applied to domestically-produced poultry.

UNITED KINGDOM: Hog Cholera Prohibition - The British Government does not accept as effective the method which the U.S. has used to eradicate hog cholera, since a different method of eliminating the disease is employed in the U.K. For this reason, it has banned imports of all U.S. fresh and frozen pork, even though large areas of the U.S. have for some time been free of hog cholera. The U.S. can now certify its pork as being from cholera-free areas; however, the U.K. refuses to accept our pork on this basis.

UNITED KINGDOM: Newcastle Disease Precautions - For a number of years, the U.K. has maintained a prohibition against imports of other than fully cooked poultry meat from countries using live Newcastle vaccine. The U.S objected that this was an unreasonable precaution that went beyond requirements for protecting the British poultry industry. The U.S.considered the ban on uncooked poultry an unjustified barrier to trade and this belief was emphasized when the U.K. maintained the restriction after it also began late in 1970 to utilize live vaccine against Newcastle. In October of 1972, the U.K. finally authorized the importation of fully eviscerated poultry carcasses from the U.S., without offal and when accompanied by specific veterinary certification as to inspection and freedom from disease. At the same time, however, the U.K. initiated a minimum import price and levy arrangement to protect its poultry industry.

FRANCE: Trichinascopic Certificate for Hams - For the importation of green hams for further curing, France will generally accept any U.S. freezer certificate indicating that the product was held at prescibed temperatures for a specific period and therefore safe from trichina infestation. At certain other times (supposedly when it wishes to curtail imports), France requires a trichinascopic certificate that involves additional time and cost and can be obtained only from one laboratory in Georgia.

SWEDEN: Hormone Certification - In order to permit the importation of meat from any country which employs growth hormones in feeds, Sweden requires certification of an official veterinarian that the animals from which the meat was derived were at no time fed hormones. The U.S. is not able to make this certification. We also consider the requirement unnecessary and excessive for the specified purpose of protecting human health.

FRANCE: Honey Requirements - Although the disease nosema exists in France, imports of honey must be accompanied by a certificate indicating that the honey was produced within an area free of this disease.

UNITED STATES: Alleged Restrictions - The United States receives its share of criticism from other countries regarding its own quarantine, health and sanitation requirements. Some of these involve cases where certain state regulations and inspection procedures differ from Federal requirements. Canada has objected in particular to the requirement of some northeastern states that state inspectors must personally approve milk and cream production and handling facilities for export. Reportedly, the state inspectors refuse to travel beyond their area, thus cutting off Canada's possibility of qualifying for exports. Japan has similarly claimed that Maryland's regulations concerning imports of shellfish are unduly rigid. Belgium, which cannot export potted azalea plants to the United States because of the danger of introducing nematodes in the soil, has asked that U.S. regulations be changed to permit the growing and shipping of azaleas in a sterilized medium. Action has not yet been taken, and the Belgians consider the continuing prohibition a restriction to trade. Some EC member countries have also objected that the U.S. requirement of a second compulsory fumigation for bulbs, tuberous roots and rhizomes from certain countries is trade discriminatory. Israel has also registered with the GATT Agricultural Committee its concern that prior conditions for exporting melons to the U.S. would entail involved experimentation and excessive expense. Various countries view parts of the Wholesome Meat Act as unduly burdensome and U.S. precautions concerning foot-and-mouth disease as excessive. Though U.S. regulations only permit fresh meat entry from countries which it has declared to be entirely free of foot-and-mouth disease, many countries believe the U.S. should accept meat exports from clean or disease-free areas within their borders.

United States regulations governing quarantine, health and sanitary matters are generally believed to be rational and justifiable. Officials responsible for administering these regulations are always ready to discuss inspection and quarantine procedures, and particularly wish to dispel concern that any of them are trade restrictive. Where some changes in the laws or procedures appear to be needed because the situation has altered, these changes can be affected or recommended by the authorities responsible.

As has been stated above, the GATT endeavors to prevent quarantine, health and sanitation measures from being applied in a discriminatory manner or as restrictions to trade. Even though some examples of health and sanitary requirements allegedly being used as restraints to trade have been discussed and listed by GATT committees, it is doubtful that such non-tariff trade barriers will be negotiable on a multilateral basis. As yet, there has been very little international effort to standardize quarantine, health, and sanitary laws and procedures, such as has been undertaken by the GATT regarding standards for certain industrial products in international trade or by the FAO and WHO in its Codex Alimentarius for food products.

The United States has taken the lead in the international forums noted above with the objective of rationalizing the application of quarantine, health, and sanitary laws and regulations to facilitate international trade. In addition, the United States has worked intensively with the Latin American countries, to explain its import requirements, including health and sanitation measures, in order to facilitate Latin American exports to the United States and other countries.

During 1970 and 1971, several meetings between U.S. and Latin American specialists were held under the auspices of the Organization of American States. It is hoped that future meetings of this nature may lead to a discussion of quarantine, sanitary, and health measures employed by the Latin American countries. Such a frank exchange and airing of mutual problems concerning inspection and quarantine procedures may eventually lead to some harmonization of import requirements and a simplification of trade.

73.2 The Viewpoint of Carriers. A set of four interviews was conducted with key airline personnel at Kennedy International Airport. This was done to assess program impacts on airline activities, and the attitudes of such personnel toward the quarantine program.[10]

The regulation of incoming travelers and cargo by USDA creates costs and thereby decreases the efficiency of transportation. These costs are in the form of additional facilities, the conduct of inspection and clearance operations, and in the delay of traffic.

From the point of view of air carriers, the additional costs resulting from the imposition of regulations can be dealt with (1) by insuring that government pay all of the direct costs of the inspection process, including the provision of space and facilities, (2) by passing certain costs directly to shippers and passengers, (3) by passing along the cost indirectly through higher prices for transportation service, (4) by absorbing the costs as a regular part of doing business, and (5) by absorbing the costs associated with unexpected delays or interference.

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10. A copy of the questionnaire, together with a list of the persons interviewed is in the Appendix.

In the latter two categories of costs which are to be absorbed, those that can be programmed; i.e., managed, are not of such great concern, as those that are unexpected. The programmed costs do not influence competition among the airlines. They are of general concern in the sense that they influence competition with other forms of transportation.

The ability to pass along costs is limited by governmental regulations of fares. Consequently, a proposed change in regulations which affects costs may result in additional absorption of costs and a consequent drop in profits.

As an example of cost-sharing, this is the distribution of costs for incoming air cargo:

Activity	Performer	Bearer of Cost
Promulgate regulations	USDA	U.S. Taxpayer
Provide information to shippers	Carriers & forwarders	Carriers & forwarders
Cargo modification	Shipper	Shipper (passes to consignee?)
Certification	Foreign Government	Foreign taxpayer
Verification	Carrier	Carrier
Inspection	USDA	U.S. Taxpayer

"Dwell time," the period during which incoming cargo sits while awaiting transshipment, is an important measure of efficiency used by the airlines. In one airlines operation, more than 80 percent of the incoming cargo is moved out the same day it arrives, and about 95 percent is transshipped within two days. Since this cargo crosses the Atlantic in a few hours, a delay of more than 24 hours seems excessive, and the airlines strive to minimize the dwell time on incoming cargo. One official believes that present dwell times could be cut in half if government inspectors were more efficient. It is contended that airlines operating on purely domestic routes handle significantly larger amounts of cargo in relation to their investment in aircraft, facilities and personnel because of lack of delays by government inspectors.

It is understood that agricultural cargoes have longer dwell times - how much longer depends upon the availability of AQI inspectors. However, so long as the additional dwell times are not excessive, and the airlines are treated on an equal basis, this is accepted as an unavoidable part of doing business with agricultural cargoes.

Manifests can now be delivered to the broker before the plane arrives. In England and France, the computerization of manifests is being used to obtain Customs clearance of cargo prior to arrival of the aircraft.

Hopefully, such a system will be adopted in the U.S. The availability of such timely notice should aid AQI inspectors in planning their work, and they should recognize that (1) dwell time is an important matter to the airlines, (2) that equitable treatment among airlines is essential, and (3) that they are in competition with other government agencies.

Several interviewees proposed that a U.S. government person be on board all incoming flights to facilitate various regulatory matters, including the collection of agricultural contraband.

"Stripping" an aircraft; i.e., cleaning and preparation for a return flight, may require 1-1/2 hours. Since this cannot be done until the aircraft and galley have been inspected, the delayed arrival of an AQI inspector may be costly. Numerous instances of delay were cited.

About one-third of incoming flights have meals that were prepared from U.S. foods. When foods are obtained overseas for in-flight service they are procured and prepared under detailed instructions provided by an airlines commissary manual. Given these circumstances, it is not known whether incoming airline galleys constitute an important risk for the introduction of pests and diseases.

Under the Geneva Convention the carrier is not responsible for the transportation of contraband, so long as the shipper provided the certificates required by law.

In general, airline officials have learned to live with agricultural regulations, and they are an accepted part of doing business, as are the regulations administered by such other Federal agencies as Customs, the FBI, the Fish and Wildlife Service, and the Food and Drug Administration. But air cargoes are increasing rapidly (1972 volume is 30 percent above 1971) and Federal agencies will continue to be pressed for prompter service.

<u>73.3 Inspectors' Comments.</u> The Task Force requested all agricultural inspectors to provide their comments, complaints, and insights into the program. Replies were mailed to the study director, Dr. McGregor, and confidentiality was guaranteed.[11]

A total of fifteen replies was received. While this was a disappointingly small number of responses, the quality was high, and they were remarkably free of gripes. As a group, the respondents seem convinced of the importance of inspection for the protection of U.S. agriculture. This healthy attitude probably indicates that they get satisfaction out of their jobs.

One area of concern throughout the letters is the relationship between agricultural inspection and Customs inspection. The problems involve

11. The letter of request to inspectors is in the Appendix.

differences in qualifications, differences in administrative procedures and the location of enforcement power in Customs.

The subjects which came in for greatest attention were the following:

--the sealing of ship's stores in galleys on freighters.

--the lack of scientific information about agricultural pest establishment.

--the need for a global approach to agricultural pest problems.

--the background required of inspectors.

--preclearance.

--compliance agreements.

Here are some examples of especially interesting comments:

...we rely upon regulations and laws of the Customs Service for enforcement and control...we become supplicants to Customs for our enforcement...and Customs lacks interest in our problems.

...better to stop or retard new pests than conduct long, expensive, and environmentally questionable programs of control or eradication.

...meat in ships stores for consumption on board a vessel with garbage properly safeguarded poses a minimum pest risk ...sealing meat in stores is the greatest overtime bonanza...

Agriculture, Customs, and Immigration overtime pay are each based on a different set of charges...we are required to work the same hours, perform the same duties, yet receive less pay for overtime service...

...much of our activity is...non-agricultural...having to perform Immigration, Public Health and Customs inspection... this money could be used more productively in staffing some of the interior ports and airbases...

...sampling procedures for cargo inspection are based on an unrealistic evaluation of the pest risk. This results in a hit or miss method of pest findings. If risk is great, compulsory treatment should be required. If not, entry requirements should be relaxed.

...each interception is sorted five times and packaged, mailed or otherwise transported eight times before it is returned to the port of origin. This excessive handling causes the loss of many specimens...

...it is difficult to believe that the risk of a Foot and Mouth infection from these tankers (stores) is great enough to warrant the expenditure in money and man-hours, or in personal safety, that these boardings require...

Good morale is not promoted: 1. When dictators are in charge of a port, 2. when communications between management and inspectors is bogged down, 3. when good suggestions by the inspectors are consistently rejected, 4. when health and safety conditions are ignored, and 5. when enforcement is so hit or miss and inconsistent that no one believes in their job role anymore.

Eliminate the mandatory boarding of aircraft arriving from foreign countries for purpose of collecting fruit, vegetables and meat provisions. A cooperative agreement with the air-lines to dispose of all food stores...in a manner authorized by APHIS, should effectively prevent the risk of pest introduction...

There is no record or forms for keeping track of garbage... it is impossible to follow a ship from port to port, but a record...of service by scavengers should be kept.

The single most important item we need now is formal legis-lation requiring a means of conveyance to meet our entry requirements prior to U.S. Customs permitting the vessel to begin discharge of its cargo.

The glut of people flowing through our international airports staggers the imagination. When several hundred passengers are suddenly dumped in the Customs inspection area, we can't possibly perform any adequate inspection.

Would it be so costly to send inspectors to handle problems at origin rather than additional men on the payroll trying to find the bug when cargo arrives here? There should be more communication with the importers. In many cases they would gladly pay the expense of a PQ Inspector abroad.

74 THE ASSESSMENT DILEMMA

Although it was not a major objective of this study to assess the validity of ongoing quarantine efforts, the Task Force has assembled information and viewpoints that may prove helpful.

In the United States, as in other nations, regulatory officials customarily affirm the efficacy of inspection and quarantine actions. Yet little, if any, evidence is provided and no attempt at systematic assessment has been found.

Philosophically, there are two general approaches. First, the indirect approach - compare events with and without the quarantine and inspection program. Second, the direct approach - examine the actions of the program itself to assess what is being accomplished. Although each of these approaches has major drawbacks, the Task Force has assembled some useful information for each of them that is presented in the following section.

74.1 Indirect Assessment. Since it is not practical to turn regulatory efforts on and off to see what happens, it is necessary to compare the period prior to establishment of the program with the period since 1912, thereby introducing many anachronisms.

Has the continuing flow of insects and diseases into the U.S. been altered in any significant way by the establishment of a quarantine program? The null hypothesis states that the existence of the quarantine program has not altered the rate of introduction. For insect pests of crops no evidence could be found to disprove that hypothesis. This does not mean that we can say positively that the program has made no difference, but only that if it has made a difference, no evidence is available to demonstrate that fact.

Of the 955 immigrant species of insects whose dates of establishment are known, 387 (41 percent) show dates of 1912 or earlier, while 568 (59 percent) were first collected in 1913 or later. Assuming that insects began to reach the U.S. with the earliest permanent colonists about 1620, an average of 1.3 species per year arrived during the prequarantine era prior to 1913, while 9.5 species have accrued annually since the start of quarantine in 1912.

The number of "new arrivals" since 1912 acquires even greater significance when those of the last 60 years are compared with the number arriving during the years 1882-1912. During the later period 235 species are recorded, thus providing an annual increment of 7.8 species as opposed to 9.5 species for the period since 1912. From these figures alone it could be concluded that quarantine inspections have failed to curtail the number of foreign insects that annually reach and successfully establish colonies in the United States. There is, however, another factor involved. This relates to the amount of commerce and travel into the United States. Here, assuming that probability for entry of foreign insects as well as the number of human travelers are linearly related to the volume of commerce entering the United States, we might expect the number of new insect arrivals to change in proportion to the change in the volume of commerce. Table 7-1 shows the volume of commerce in constant dollars for the 30-year period immediately preceding 1912, and the most recent 30-year period, 1942-1972, in relation to the actual and expected arrivals of immigrant species.

TABLE 7-1

EXPECTED NUMBER OF IMMIGRANT INSECTS
IN RELATION TO ACTUAL ESTABLISHMENTS

Period	Average Annual Imports (Adjusted to Constant Value) ($ Billions)	Foreign Insects Established Annually in the United States (Number of Species)	
		Actual	Expected*
1882-1912	3.44	7.8	7.8
1942-1972	20.75	9.5	47

* In the absence of quarantine.

Some factor, operating since 1912, resulted in only 9.5 species becoming established each year instead of the 47 expected on the basis of the data for the period 1882-1912. If this factor is implementation of the 1912 Plant Pest Act it would follow that quarantine and other regulatory activities have excluded an average of 37.5 species each of the past 60 years. Should this indeed be true, a further extrapolation is possible. Of the 987 alien species not purposely introduced 20 percent are known to be pests of some importance. Then, assuming absence of quarantine, we should have had added to our insect fauna 2,818 species instead of the actual 568. If 20 percent of difference (2,250 species) were injurious, it would follow that quarantine and other regulatory activities have excluded 450 pest species in the past 60 years.

Unfortunately, this simple conclusion is untenable in the light of other evidence. As discussed in Section 24, there has been a stabilization in the rate of overall introduction of insects and mites that began about 1920. However, in the immediately preceding 20-year period, there had been a rapid filling of ecological niches which might have led to a subsequent decline in any case. Furthermore, there is no information available on the extent of infestations in agricultural cargo during the periods being compared, although one might expect that significant infestations may have declined as a proportion of total volume.

Looking at other evidence, among the three dozen insect pests that currently cause 75 percent of all crop damage, there were about as many established in the 50-year period prior to the start of the Agricultural Quarantine Inspection Program as have come in since that time. In addition, some of our most damaging insect pests have entered since the initiation of quarantines in 1912. New exotic pests of economic significance are discovered with nearly predictable regularity. Table 7-2 shows the year of introduction and the present rank in terms of damage among the principal crop pests.

To determine the economic value of the quarantine program would require specific data on the delay or the successful exclusion of exotic introductions and knowledge of the damage their introduction would cause. In the case of animal diseases, the U.S. has apparently been successful in its exclusion policy, and livestock production undoubtedly enjoys some increased efficiency because of the absence of these diseases.

Records on plant pathogen introductions prior to 1920 were compiled by J. A. Stevenson. Of his list of 120, 47 were introduced in the 25-year period prior to 1913. Hunt of the Division of Foreign Plant Quarantines prepared a listing of introductions recorded during the period 1913-1938. There are 75 pathogens on this list. Both authors emphasize that their lists were "best available information" but state that they do not consider them to be entirely accurate. The Plant Quarantine Act was passed in 1912; thus we have a comparison of introduction the 25 years prior to and the 25 years after passage of the legislation and for periods of time more nearly comparable than periods more recent or earlier. The obvious conclusion would seem to be that quarantine enhanced introduction. This is clearly incorrect. Even in these two periods of time, dramatic changes in the amount of commerce occurred; the sciences related to Agriculture were gaining ever-increasing momentum--these are only examples of the differences in the two periods. More important is the application of the quarantine act itself. Until about 1930 specific quarantine application was not widespread. In addition, not all recorded entries were subject to quarantine and the assumption cannot be made that inspection for all these pathogens was carried out with consistent effect during the period. In short, there is no valid basis of comparison. The data do indicate that from 0-6 pathogens entered per year during the 1912-1938 period with an average rate of slightly less than three per year.

Another means of indirect evaluation is to compare the performance of the U.S. program with that of another country. Such a method has the obvious limitation that the geographic and ecological circumstances are quite different. As noted in Section 53, in most countries of the world quarantine actions are a matter of public policy and the usefulness of these activities has not been verified. However, the comparison between Hawaii and the mainland U.S. of the rate of colonization of

TABLE 7-2

INTRODUCTIONS OF THE MAJOR INSECT PESTS OF CROPS, WITH AND WITHOUT QUARANTINE

THE FIRST CENTURY (1762-1862)

Year Introduced		Rank*
1778	Hessian fly	7
1850	Mexican bean beetle	14
1860	Cabbage worm	10

50 YEARS WITHOUT QUARANTINE (1862-1912)

Year Introduced		Rank*
1869	Orange scale insects	13
1879	Green peach aphid	-
1880	Orange scale insects	13
	Alfalfa seed chalcid	16
1881	Orange scale insects	13
1887	Wheat stem sawfly	8
	Green bug	4
1892	Onion thrips	15
	Boll weevil	1
1897	Orange scale insects	13
1899	Wheat stem sawfly	8
1900	Pea aphid	6
1904	Alfalfa weevil (west)	5
1910	Orange scale insects	13

50 YEARS WITH QUARANTINE (1913-1963)

Year Introduced		Rank*
1913	Orange scale insects	13
1916	European corn borer	2
1918	Orange scale insects	13
	Apple mites	9
	Orange mites	12
	Brown wheat mites	11
1921	Orange scale insects	13
1934	Orange mites	12
1949	Orange mites	12
1951	Alfalfa weevil (east)	5
1954	Spotted alfalfa aphid	3
1963	Cereal leaf beetle	-

**Rank represents the relative importance of the insect in causing crop damage in the U. S.*

Source: USDA, ARS, 1965, Losses in Agriculture, Agriculture Handbook, 291.

immigrant insect species, given in Section 25, suggests some interesting conclusions. Even though the quarantine efforts in Hawaii are more intensive than those on the mainland U.S., the rate of establishment is many times greater in relation to the land area or the volume of trade. The inescapable conclusion is that ecological factors relating to climate, area-dispersal, and biotic resistance are very much more important barriers to colonization than are quarantine inspection activities at ports of entry. There appears to be an almost total absence of environmental resistance in Hawaii and an extremely high order of resistance in North America. Finally, it should be completely obvious that no quarantine program can provide complete protection against the entry of new pests.

Yet all of this discussion is speculative, with little scientific or statistical basis. It is a serious of rationalizations after the fact designed to explain the observed phenomena. Unfortunately, this is all that can be done in the way of evaluation and should be a lesson for the future. Goals, action objectives, and tasks must be specified, for only then does systematic evaluation become possible.

74.2 Direct Assessment. The effectiveness of the plant pest program is usually measured by the number of interceptions of pests that are detected at ports of entry. The presumption is that the number of pests denied entry is a measure of exclusion capability.

Unfortunately, this approach is wholly without merit (except possibly as a work measure). There are a number of reasons why this is so.

--No estimate is available of the volume of exotic pests that are crossing our borders. In the absence of such an estimate, it is not possible to assess the value of a particular number of interceptions.

--The number of pest interceptions does not represent the total number of challenges, but only the number that were detected, that is, those entries that were seen, counted, and reported. There is a larger number of pest entries, including those not found because of failure to examine contraband, or because of incomplete examination of contraband. No estimate is available on total pest entries.

--Some proportion of the interceptions were not identified. They were reported only as insect fragments, for example, and this is counted as an interception without determination of species. Thus, no evaluation of hazard avoided is possible.

--A proportion of the interceptions found were dead, and constituted no risk of introduction. No estimate is available of the numbers of interceptions that were actually DOA (dead-on-arrival), or if plant pathogens - nonviable.

--Interceptions are classified as "cosmopolitan" or "quarantinable," the only distinction being the degree of commonness.

As shown in Table 7-3, more than two-thirds of the interceptions were classed as "cosmopolitan" and are already present in the U.S. These constitute a different order of risk than those not now present.

TABLE 7-3

*INTERCEPTIONS AT PORTS-OF-ENTRY, 1971**

	Number	Percent
Cosmopolitan	87,549	68.3
Quarantinable:		
Baggage	13,963	10.9
Carriers**	13,288	10.4
Cargo	12,197	9.5
Local***	1,171	0.9
TOTAL	128,168	100.0

Source: AQI, APHIS.

* The annual total of interceptions is relatively constant.

** Carriers include airplanes, ships, boxcars, autos, etc.

*** Local means found in the vicinity of the port-of-entry, origin unknown.

Among those classed as quarantinable in 1970, there were only 12,518 separate interceptions (not species) that were considered "significant" (not defined). Of these 12,518 "significant quarantinable" finds, a total of 917 separate species were found - 737 insects and mites and 180 plant diseases and nematodes.

How many of these 917 intercepted species are important? Table 7-4 compares these interceptions with the five available lists of important species. Between 1 percent and 10 percent of the intercepted species are on the lists. Six of the interceptions are on the Task Force list of the 100 most dangerous species. This is a very tiny percentage of total interceptions and further illustrates the fallacy of regarding interceptions as a matter of significance. The Agricultural Threats list may have been developed from the pattern of interceptions since more than one-third (26 out of 75) of the species on that list were among those intercepted.

One kind of logic says that the risk of pest invasion is increasing since "the means of bringing foreign pest dangers to the U.S. - people, their baggage, carriers, cargo, and mail - continue to increase more rapidly than agricultural interception rates. For example, during FY 1970 air passenger arrivals rose 9 percent, air baggage inspection rose 17 percent, and air cargo inspections rose 14 percent over FY 1969. Plant pest interceptions and quarantine material interceptions rose only 4.7 percent and 4 percent respectively."[12]

Such a conclusion contains the following assumptions:

--That there is a positive correlation between the amount of inspection and the number of interceptions. (This may be true since the more one inspects, the more one finds, albeit at a lower rate. This yields a positive correlation. The trouble with the statement is that it is used as a justification for increased inspection.)

--That there is a positive correlation between the number of interceptions and the threat of pest invasion.

--That there is a relatively fixed proportion of traffic that is infested.

--That each interception is of equal consequence as a threat.

--That an overall increase in traffic, regardless of origin, constitutes an overall increase in risk, or threat.

Little or no evidence can be found in support of any of these assumptions. But even if all of these statements were valid, one has little basis for their use in program formulation. Consider the following rationale. Infestation rates in imported materials are very low. Inspection, even at the rates economically conceivable, would intercept very few of the infested shipments. The vast majority gets through. The problem is not these assumptions but the unwarranted conclusions from them. Shipment by shipment exclusion policy offers very little protection.

A review of recent statistics on the number of inspection man-years available in relation to the number of pest interceptions shows little if any relationship. There are too many other variables involved. For

12. Arnold, John S., 1971, "Information Plan of Work; Support for Agricultural Quarantine Inspection Division Programs--1971," March 1971, 8 pages.

TABLE 7-4

THE IMPORTANCE OF PLANT PEST INTERCEPTIONS (NUMBER OF SPECIES)

List	Total Species On List	Number and Percent of Interceptions Found on List			
		Plant** Diseases	Insects**	Total Number	Percent
Interceptions,* 1970	--	180	737	917	--
A Agricultural Threats	75	7	19	26	3
B 100 Most Dangerous	84	3	3	6	1
C Insects Not Known	196	--	33	33	4
D The Manual	1,172	--	46	46	6
E 1,333 Significant	1,311	17	73	90	10

A "Examples of Foreign Pests and Diseases of Crops That Have Not Gained Entry into the Continental United States and are a Threat to U.S. Agriculture"--ARS Undated List.

B The list of the 100 Most Dangerous Exotic Pests and Diseases developed by the Task Force, which includes 84 plant pests (see Table 4-1).

C Insects Not Known to Occur in the United States, Cooperative Economic Insect Report, ARS, Consolidated Indices of Volumes 7 through 12 (1957 through 1963).

D Manual of Foreign Plant Pests, May 1, 1948 (Indices of Parts I through V).

E The List of 1,333 Significant Exotic Pests and Diseases developed by the Task Force, which includes 1,311 plant pests.

* These are "selected" interceptions. No basis for the selection is stated. In 1970 there were 12,518 separate interceptions (not species) that were considered "significant" (not defined) out of a total of 42,589.

** Plant diseases includes nematodes; insects includes mites.

example, the number of insect infestations found is partly a function of the available "down time" (noninspection) time that is available. As traffic increases the number of "finds" may decrease while the amount of contraband seized has increased.

The number of interceptions is worthless as a measure of risk. There are a number of reasons why this is so.

--The relationship between the number of contraband articles removed from the traffic and the number of pest or disease organisms intercepted by that action is not known. This is because only a small proportion of the contraband is examined for pests and diseases, and that is done on an irregular (nonsystematic) basis.

--A large number of the pest organisms identified are already present in the United States, and their removal from traffic has no effect on the threat from exotic pests and diseases.

--Among the exotic pests and diseases intercepted and identified there is a wide variation in their ability to colonize and establish themselves in the United States. Without information on the intended destination of the material, it is not possible to assess whether the risk of colonization is high or low.

--Among the exotic pests and diseases intercepted which may have the ability to establish themselves at the intended destination of the material, there is a wide variation in the damage that would occur. Most exotic pests and diseases, even those that are well known to scientists and pest control experts, have a relatively low capacity for damage, as discussed in Section 41.1.

There is a wide variation in the risk of a given volume of traffic that depends primarily on its point of origin. Other variables include season of the year, degree of infestation at point of origin, and quarantine and inspection procedures at point of origin.

75 EVALUATION TECHNIQUES

A guide to the design of more effective programs should provide a basis for deciding the amount of public funds to be expended to achieve an agreed-upon level of risk, or conversely, how to get the maximum amount of risk reduction for a given expenditure. A conceptual approach to this problem is available, even though data has not been obtained to provide any direct options to management.[13] It is significant because

13. "A Microeconomic Analysis of Exotic Pest Introduction," by Herbert E. Pritchard is Appendix 8-X.

it helps focus attention on the two most important pieces of information required for rational program design: a ranking of exotic pests in order of the quantified risk they represent to the U.S. and a quantification of the effectiveness of all feasible measures that might be employed to reduce the likelihood of entry and establishment to some agreed-upon standard that will be tolerated.

The model developed in Chapter 3, that was used to identify the relative importance of pests to be kept out of the country, is a crude beginning on the risk model that is needed. It needs to be broadened to include information that is not now available, adding to its precision. Or it could, for example, provide for an estimate of the time required for pests to reach their ecological range. What needs to be done is to establish quantified relationships between program activities and their cost on the one hand, and their effectiveness in keeping out specified high risk pests on the other.

The construction of such a model required many more man-hours of biometrical talent than the Task Force had available and perhaps more biological and ecological knowledge than is available - additional research is needed. But of even more importance, the activity being evaluated must be systematic and uniformly applied. The Task Force review of activities at ports of entry, the training material, and the Plant Quarantine Manual found that the present inspection activities have neither of these attributes. Thus, it is presently impossible to make a quantitative assessment of what is being achieved by way of protection through the activities of AQI employees.

The import inspection program would benefit from a substantial increase in biometrical inputs. But for these to be effective, certain decisions will have to be made. For example, what degree of infestation of host material by each important pest is tolerable? Once this determination has been made, it is possible to design and cost out inspection procedures which will effectively detect the presence of the pests down to the tolerable level. Right now, we are living with a certain level of infestation of incoming vectors, but we don't know what that level is, and, given the lack of uniformity of procedures, there is no good way of finding out. Biometry is the pathway to take for evaluating the effectiveness of most workable procedures for keeping exotic pests and diseases at bay, including export certification by foreigners, compliance agreements, treatment procedures, and detection efforts.

8 CONCLUSIONS AND RECOMMENDATIONS

The Task Force believes that Federal Regulatory action should be designed to achieve the maximum reduction of risk that is possible with whatever resources are available. At the present time, major changes in the existing program are needed. Certain efforts should be realigned, others eliminated, and wholly new actions are needed. The following sections outline these proposed changes.

Overall, a significant reduction in the present level of risk can be achieved within existing resources and protection increased. There are two options. One is to reduce the existing use of manpower and funds, and maintain, or possibly, enhance the level of protection. The other is to increase resources, while making the proposed shifts, and reinforcing some of the actions proposed, thereby increasing the level of protection. The Task Force can make no recommendation on these options, since no standard of acceptable risk has been adopted.

Here is an outline of this Chapter:

81 PRINCIPLES

The Task Force believes that it has provided new and important information that will permit the immediate adoption of these eight principles by USDA.

81.1 Emphasize Global Movements. The worldwide movement of pests should receive primary attention, since domestic control/eradication efforts are almost always a less desirable alternative.

81.2 Adopt Balanced Objectives. APHIS should revise its objectives so as to provide a more balanced and realistic goal, as discussed in Section 63:

> "The objective of plant and animal quarantine programs is to provide adequate protection to the plant and animal resources of the nation, while avoiding unnecessary restrictions on international trade and commerce. This will be done by encouraging shipments of clean cargo, fostering inspection at source, and by excluding or restricting goods, materials, or carriers as necessary to prevent the entry of those exotic plant and animal pests and diseases expected to cause great damage."

81.3 Concentrate on the Highest Risks. As presented in Section 4, the ranking of exotic pests and diseases reveals that there are a very small number that are likely to cause relatively large losses in the U.S. This high concentration of risk in a few species suggests that APHIS concentrate all available resource on high-risk pests. Concurrently, research is needed to refine the list of high-risk pests and diseases. Program personnel should be familiar with these pests, and all available information should be assembled on host commodities, world regions where these pests are located, seasonal variation in populations, and other factors useful in inspection operations.

Present inspection resources and practices do not provide complete coverage, anyway. Therefore, the rational thing to do is concentrate on those commodities and conveyances most likely to harbor the target species. Regulations should be examined and revised as necessary and detailed inspection procedures should be instituted at once.

81.4 Reduce Biological Uncertainties. A number of the exotic pests with a very high maximum EEI exhibit considerable uncertainty associated with that value. This means that while we believe these pests to be very significant, the certainty of that belief is relatively low. Immediate steps should be taken to expand knowledge of these pests. The research facilities of ARS and the land-grant colleges should be employed to conduct investigations into those characteristics of these species that are key factors in their international spread; e.g., present distribution, survival in transit, colonization characteristics. Those insects needing particular attention are in Section 41.3. The plant pathogens requiring particular attention are those high on the list of 100. A key animal disease proposal is in 83.5

81.5 Emphasize Compliance. Compliance and not enforcement should be the operating philosophy. The deterrent effect that might be produced by an effective information and education campaign, particularly in passenger contraband, has a relatively high potential for risk reduction. The record of successes and failures is discussed in Section 71.

81.6 Encourage Private Efforts. Protection is a joint public-private endeavor. Carriers, for example, already participate actively in a variety of ways, as discussed in Section 72.2. This participation and cooperation should be encouraged, taking the view that protection is a shared responsibility. Specific suggestions for private cooperation are included in the Source Inspection System outlined in Section 82.1.

81.7 Establish Risk Standards. Explicit standards as to how much risk will be tolerated need to be established by responsible officials. We tolerate a substantial flow of migrants now, as pointed out in Section 24. However, there has been no official recognition that this tolerance exists, and further, no explicit judgment concerning its acceptability as a risk.

81.8 Provide Evaluation. An evaluation of present efforts is not possible at this time. As discussed in Section 73, there are techniques available, but these require measures of program costs to be related to the effectiveness of risk reduction. Furthermore, none of these methods can be used in evaluation, until a standard of risk toleration is established. To properly assess the effectiveness of a quarantine and inspection program, it will be necessary to maintain an intensive detection or survey capability. This activity could be targeted to locations and special environments at critical seasons; e.g., the use of blacklight traps at airports. Recent experience with detection lag-times; e.g., cereal leaf beetle, suggest that a more intensive effort might pay off. In addition, such an effort might reveal small colonizations which die out from natural factors. Such information would tell us what pests are coming through the barriers, and may permit a continuing reassessment of quarantine and inspection actions.

In the case of exotic forest pathogens, it would not be surprising if some of these had already colonized. Yet, the low level of domestic surveillance allows them to go undetected until a substantial buildup has occurred. This is also true of many crop plant pathogens due to their exponential manner of increase; by the time they are detected, they are widely distributed.

Assessing the value of baggage inspection activities as a means of protection is an important activity. Although the Task Force was unable to locate any assessment studies performed by other nations, we expect that foreign officials must be concerned about efficiency and the quality of program performance, just as we are in the U.S. Given the difficulties of performing evaluations and the limited experience in this area, we recommend a pooling of talents and ideas.

Program manipulation, which is so essential to assessment, might be politically and administratively more feasible in other countries of the world, to the mutual benefit of all.

82 STRATEGIES

Program strategy for the immediate future should be to find all possible means to bring about an international pest control system, and to revise program actions in line with the principles stated in the previous section.

82.1 Develop a Source Inspection System. The purpose of a source inspection system is to provide incentives for exporters and foreign countries to ship us pest-free commodities, and to establish sanctions if they do not. It is based on the principle that those who make inspection and treatment necessary, either by inadequate pest control at origin, or by importing contaminated materials, should pay the costs of inspection and treatment, rather than the general taxpayer in the country of destination.

At present, the U.S. Department of Agriculture, through APHIS, routinely inspects materials shipped into the U.S. The procedures used are of uncertain value, and the methodology cannot be objectively evaluated. Of greater import, the present procedures cannot find contamination until the vector reaches our shores. The Agricultural Source Inspection and Surveillance Technique (ASIST), herein described, transfers most of the inspection and associated activities to the country in which the material originates.

ASIST has additional obvious advantages. (1) Inspection could be performed while shipments are being assembled. This is especially important with the increased use of containerization. (2) The cost of inspection and treatment is borne by the commercial interests concerned. (3) The procedures provide less governmental interference with commerce. The disadvantage is the transfer of control from those who are interested in keeping our agriculture free of foreign pests to those interested in selling foreign products here, a conflict of attitude.

For ASIST to succeed there must be strong cooperation from the shipper and his government. The incentive for this is the provision for more rapid access to our markets, and the penalty is the denial or slowing of access to our markets.

Implicit in ASIST is a qualitative change in the work to be performed by APHIS inspectors. There is a deemphasis of routine haphazard inspection and the monitoring of fumigations. There is a corresponding emphasis on the use of sound scientific, managerial and statistical procedures. However, it would be a mistake to minimize the effort required to implement such a system. A myriad of problems not touched here and probably not envisioned will have to be investigated and solved. ASIST is not a panacea, and will need to be implemented on a case-by-case basis.

Here is a description of the six steps of ASIST which are illustrated in Figure 8-1:

Step 1. Establishment of Standards. A viable inspection or control system is impossible without standards. The lack of measurable standards is a constant criticism of present procedures. For materials that must be treated as a condition of entry, the treatment must be explicitly established. For materials that are to be inspected as a condition of entry, the permissible infestation levels and required degree of assurance must be agreed upon. Also, licensing, certification procedures, and responsible agents will need to be established.

Step 2: Source Processing of Material. While specific procedures will vary according to country, product, season, potential pest, etc., common actions will be inspection and fumigation. The source processing allows inspection before packing or assembly. This can often be economically accomplished. This could be especially advantageous for containerized shipments. As another example, packing material could be fumigated or inspected before use.

Step 3: Normal Procedures Performed in the U.S. Usually the only procedure performed by USDA personnel would be the verification of the certificate accompanying the shipment. A rigid, low level sampling scheme will also be implemented. The methodology implemented will be determined by both scientific and statistical considerations. Not every shipment will be inspected. Only a very small portion of any shipment will be examined. The inspection is instituted as a quality control measure on the overall system. Information gained about a particular shipment is ancillary. A shipment found infested obviously should not be allowed to continue to its destination without treatment. However, an individual negative finding would not necessarily be sufficient to infer that the system fails to supply adequate protection or in statistical terms, that the system is "out of control."

Step 4: Procedures for Country with Preliminary Entrance into System. All materials will be thoroughly inspected or routinely treated at the owner's expense. It would be preferable for this to be performed by private contractors, licensed and regulated by USDA.

Step 5: Disposition of Material. Normally, the imported material would be shipped directly to its final destination without further processing. In those rare cases in which the low level inspection (Step 3) or high level inspection (Step 4) finds an infestation, the material would be treated before being sent to the destination or destroyed or returned. These procedures would be at the shipper's option and expense.

Step 6: Evaluation of System. The major element in the evaluation procedure is the findings of the low level inspections of Step 3. Note that the word "inspections" is plural. Decisions are to be made upon the evidence accumulated at an applicable period of time, year, shipping season, total record, etc. The entity being evaluated is the system and not the individual shipment. Other elements in the evaluation include existence of irregularities in certification and change in pest risk.

FIGURE 8-1

AGRICULTURAL SOURCE INSPECTION AND SURVEILLANCE TECHNIQUES (ASIST)

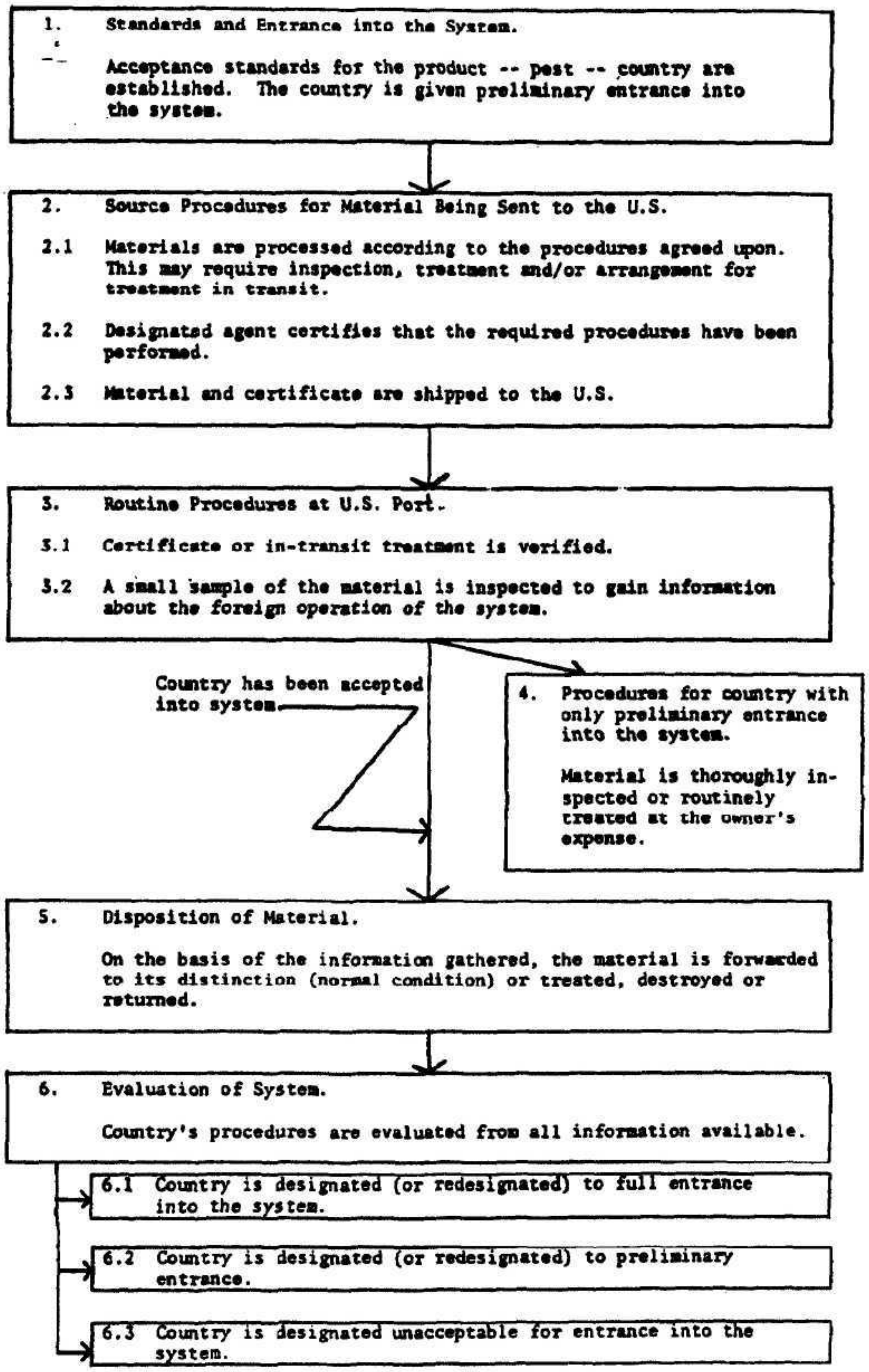

TABLE 8-2

NUMBER OF RECOMMENDED ACTIONS* TO MINIMIZE THE RISK OF ENTRY OF THE 100 MOST IMPORTANT EXOTIC PESTS AND DISEASES

		Class of Commodity or Vector									
Rank	Recommended Strategies	Misc. Living Plants	Soil	Deciduous Nursery Stock	Logs (with bark)	Evergreen Nursery Stock	Aircraft	Stored Products	Other (Inc. logs w/o bark)	Total	%
1	Exclude (deny entry or destroy if presented)	19	26	7	12	4		5	11	84	51
2	Inspect and treat if pest is found	4		6		6		3	6	25	15
3	Inspect and destroy if pest is found	3		6	1	12		1	2	25	15
4	Treat (without inspection)			5		1			3	9	6
5	Require post-entry quarantine	5								5	3
6	Inspect and deny entry if pest is found					1			1	2	1
7	Require controlled processing								1	1	.1
8	Limit entry to specified locale**									0	0
9	Inspect, and change action of future shipments									0	0
10	Other						9		4	13	8
	TOTAL	31	26	24	13	24	9	9	28	164	100

* A total of 164 separate actions are recommended against the 100 species on the basis of the 8 classes of commodities or vectors listed in the heading.

** Although this seems like a reasonable strategy, the Task Force was unwilling to consider this as an appropriate action for <u>any</u> of the 100 important species that were reviewed in detail.

The decisions made as a result of this evaluation may be any of the three indicated. It would be expected that 6.3, removal from the system, would be rare. The change in status or retention of status indicated by the other two options could occur frequently.

The workability of such a system depends heavily on the wording of regulations, the way in which procedures are carried out, and the cooperation of foreign governments and shippers. The use of fines as well as confiscation of forbidden products may be necessary. In some cases an importer may be willing to incur treatment costs in the country of origin in order to avoid the usually higher treatment costs at a U.S. port of entry. If contamination of commodities occurs in transit, it may be necessary to hold the carrier liable.

In July 1972, the U.S. Senate ratified and the President signed the International Plant Protection Convention, joining 31 other countries who have ratified the Convention, and the 62 countries who are either signatory or adhering members. Each contracting government agrees, to the best of its ability, to make provision for (1) A competent official plant protection organization, (2) distribution of information regarding pests and diseases of plants, (3) research and investigation in the field of plant protection, and (4) the issuance of plant protection (phytosanitary) certificates only under conditions that make such certificates dependable documents. The Convention recognizes that the spread of plant pests and diseases throughout the world with plants and plant products has been primarily due to inadequate control of such pests in the country of origin. Such control is a surer safeguard against spread than regulations requiring certification or disinfestation.

The Convention appears to hold promise, since it provides a basis for governments to consider the ASIST approach. However, no U.S. actions for implementing the Convention appear to exist. After years of lagging behind, it is time for the U.S. to take positive actions in the directions agreed upon.

If ASIST meets with favor both here and among our trading partners, it will mean a change in the procedures for issuing export certificates. That is, in addition to monitoring foreign systems for reducing infestation rates of traded goods to tolerable levels, AQI will have to do the same for the system used by our exporters. Fortunately, the techniques for doing this appear to be identical.

82.2 Revise Program Strategies. Recognizing that the development of ASIST will require an extended period of time, the Task Force also reviewed existing program strategies and concluded that they should be revised in line with the principles stated in Section 81. For example, concentration on the high risk species means that exclusion is the dominant strategy, as the following discussion illustrates.

Ten separate strategies were identified. Then each of the 100 most important exotic pests were discussed in detail, based on the Pest Briefs described in Section 41. As a result, one or a combination of appropriate strategies was agreed upon for each pest. Unfortunately, it was not possible to quantify the effectiveness of all the feasible strategies that might be employed to reduce the likelihood of entry and establishment.

Table 8-2 shows the distribution, by major commodity or vector, of the 164 separate quarantine actions that are recommended to minimize the risk of entry of the 100 most important exotic pests and diseases. It is significant that 51 percent of the total number of recommended actions fall within the exclusion strategy. That is, complete denial of entry or destruction of the commodity if it is presented for entry, is the action advocated. More than two-thirds of all actions are accounted for by (1) Exclude (deny entry or destroy if presented) and (2) inspect and destroy if pest is found.

It is also significant to note that in the 26 instances where the pest is found in soil, exclusion is recommended in every case. Soil is simply too dangerous a material to allow its entry under any circumstances. There is a similar reaction to the importation of logs. In only one of the 13 cases where logs are a likely vector of the pest is inspection even permitted. In all other cases it is recommended that logs not be imported. There is a mixed reaction to nursery stock that is free of soil, but exclusion is still recommended in 11 out of 48 cases. There were nine instances among the 100 major pests where it was believed that hitchhiking aboard aircraft could be a significant pathway. In these cases treatment of the aircraft and/or airfields is recommended.

In summary, this analysis shows that emphasis ought to be on exclusion, and that all other conceivable actions play a minor role in an effective quarantine program.

82.3 Monitor Customs Baggage Seizures. Seeds, nuts, green plants, fruits, vegetables, meat and other agricultural materials in passenger baggage can be identified by anyone. A college graduate biologist employed by USDA is not needed to identify such materials. The only purpose of employing such skills is to permit a judgment about admissability, based on relative risk. The knowledge required to establish an exception and permit entry is of a very high order, and since there is a significant possibility of an error, why take the risk? It should be made clear that the taxpayer is buying a convenience for the traveler through this arrangement. He is not buying increased protection. In fact, this arrangement may weaken the protective screen. There is no reason why, if a traveler wishes to bring in such materials, he should not have them properly cleared through the customary channels. For especially valuable plants, a biologist could be available upon summons from the cargo areas.

Customs should simply confiscate all such materials found in baggage, while advising the traveler of his right to treatment at cost if he insists ~~on~~ entry. Such confiscations would increase deterrence, and lower the risk still further.

Some of the dangerous insects may gain entry through baggage as strays, but there ~~is~~ no practical means of preventing this.

USDA has a continuing interest in the Customs confiscation actions and should monitor that system for verification. Kennedy Airport is a prime location for this, since it receives 40.5% of all foreign visitor arrivals, and 48% of U.S. overseas travelers depart from Kennedy. Most of these U.S. citizens are assumed to return through this port of embarkation. Therefore, nearly one-half of all overseas passenger traffic enters through Kennedy. This provides a ready focus for continuing efforts to monitor pest risk and to assess Customs performance.

In summary, we should switch from the employment of USDA inspectors to make contraband exceptions in passenger baggage, on the call of Customs, to monitoring the seizure of all contraband by Customs.

82.4 Eliminate Border Inspection of Passenger Vehicles. There is no evidence, from the biological point of view, of significant numbers of pest organisms that are present in Mexico which are not already present in the U.S., that are a major threat. (Only two species appear on the list of the 100 most dangerous, as shown in Table 4-9.) Yet 15-20 percent of APHIS inspection manpower is tied up on the Mexican border, with a great deal of it engaged in primary inspection to meet the responsibilities of other agencies, such as Customs and Immigration. While this may appear to be an efficient use of manpower from the overall Federal point of view, it is not cost-effective in achieving agricultural protection objectives.

In terms of protection, the Mexican border inspection of passenger vehicles is relatively low priority, and except for certain cargo and live animal inspection, should be discontinued. As in airline baggage inspection, Customs should confiscate contraband when found, and USDA should simply monitor that system.

82.5 Regulate Germ Plasm Traffic. The movement of germ plasm around the world for breeding and other worthy scientific purposes is accelerating, and has become a significant international threat. Since the classic case of the Gypsy Moth introduction for silkworm breeding, there has been a number of other dramatic incidents. As discussed in Section 22.3, regulatory attention is needed, and it is important that the scientific professions participate in the design of regulations and procedures that facilitate compliance, and provide chastisement for those who do not cooperate.

82.6 Develop Pan-American Quarantine. A North American/Central American Commission should be established to explore a cooperative program to keep South American pests from entering. It might build on the cooperative experience with animal diseases. The program might include cooperative inspection of vehicles entering Panama from South America.

83 OPERATIONS

The recommendations appearing hereunder should be acted on whether ASIST is adopted or not.

83.1 Review and Streamline Regulations. A formalized and regular arrangement for discussion of key problems with the industry (a consultative committee) should be established. This group should review and advise USDA on the establishment of new regulations, maintain continuing review of existing regulations, including recall as necessary. Such a group, including State officials[1], would permit dialogue between regulators and the regulated and encourage the government to consider the impact of regulations on the industry.

The possibilities for bribery should be borne in mind. The creation of regulatory situations wherein the power to have significant impacts on industry operations is in the hands of regulatory officials and not subject to review leads to the temptation for bribery.

No hint of bribery among U.S. officials has come to the attention of the Task Force. However, we have been advised that bribery is a regular part of the regulatory situation in a number of foreign countries. Bribery is also an acknowledged way of doing business in a number of instances in the United States, e.g., the recent revelations of the way bribery operates in the New York City construction industry. In that situation a body of regulations exists which makes it impossible to do business within the regulations. As a result, regulatory officials must be bribed in order to carry on business.

To prevent this sort of situation, we believe that a complete review of quarantine regulations should be undertaken, that includes explicit judgments about scientific integrity as well as administrative feasibility from the point of view of the airlines, shippers, and the general public. This should be done periodically, with a group selected for this purpose. Quarantines should be reviewed, and revised or revoked as necessary. As noted in Section 63.3, the record of two revocations in 30 years looks peculiar. There could be others that should be revoked.

83.2 Establish Uniform Inspection Procedures. APHIS has no established procedures for inspection. As a consequence, there is a wide variation in inspection practices at the different ports, and a failure to make generally available the experience and scientific knowledge that could

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1. For additional comments on the necessity for cooperative review of quarantine regulations, see Jones, Halwin L. 1972, "A Critique of the Status of Plant Regulatory and Quarantine Activities in the United States."

contribute to an effective performance by each individual inspector. Detailed inspection procedures should be prepared and included in a manual to serve as an operating prescription for carrying out the intent of the quarantine in a consistent and effective manner at all locations.

83.3 Employ Statistical Sampling. Sampling, in one form or another, has been applied in agricultural quarantine and control programs for over fifty years. The rationale for doing so is clear. There is neither sufficient funding nor trained manpower to inspect all pest hosts or even a large proportion of them. And yet, important and often costly decisions are made each day.

As discussed in Section 67 the costs and benefits in sampling are complex and are not well understood. Furthermore, unless samplings are based on a statistical design the results may be misleading or even totally erroneous. Statistical sampling procedures need to be designed and skillfully applied through standardized procedures developed for the wide variety of practical conditions that are faced by APHIS inspectors on a daily basis.

83.4 Use the New Detection and Control Devices. Developing technology offers two principal areas which may be significant to AQI operations, as discussed in Section 66. In the area of detection, the bioluminescent and mass spectrometer "sniffers" offer a potential for greatly increased effectiveness of baggage inspection. It appears that the bioluminescent system holds the greatest promise. Economic utilization of these devices is influenced by their use by the Bureau of Customs. This in turn depends upon the device's ability to detect narcotics. AQI should maintain close communication with Customs to assure that agricultural needs are met if and when such devices are put into use.

Although major developmental work on the irradiation of agricultural commodities to preserve them and to achieve disinfestation is underway, its success is problematical. But if irradiation becomes widely used it would significantly alter AQI quarantines and operations. The most immediate prospect for consideration will likely be shipments of irradiated papaya from Hawaii to the mainland. AQI should be prepared to alter its quarantines and inspection activities as irradiation becomes practicable.

83.5 Test Pathway Survival. Very little research has been done on the environmental conditions associated with the various pathways of entry. A small amount of investigation might pay off handsomely. For example, one of the recognized pathways for the introduction of foreign animal diseases into the United States is the international mail. Small lots of processed or cured meats are frequently included in gift packages sent to residents in this country by relatives living in countries where animal diseases that do not occur in the U.S. are known to be endemic.

The quarantine program designed to intercept these products employs inspectors at all international post offices to examine selected packages for contraband. The volume of packages received daily makes it virtually impossible to obtain 100% inspection; therefore, the program is essentially a screening process. Thousands of pounds of prohibited meat are intercepted annually; however, with package inspection being much less than 100% it must be assumed that some unknown percentage of potentially infectious meat is getting through the quarantine barrier.

At this point in our examination of this pathway it must be emphasized that we assume that the product was produced using meat from an infected animal; that there is sufficient virus or bacterial contamination of the product to cause infection and that the virus or bacteria can survive the hostile environment of the mail. Furthermore, we must assume that part of the infectious product will be discarded by the recipient in this country into the garbage, that it will be fed uncooked to susceptible swine in violation of current State laws.

Published research data will support a conclusion that the virus of Foot-and-Mouth Disease and African Swine Fever will survive in cured meat for a period of time commensurate with a reasonable mailing time from a foreign country to the United States. Studies to provide firm data to support the validity of our assumptions are needed. A relatively simple study would be to feed the meat confiscated by the inspectors to susceptible swine held in absolute containment. The results of such a feeding experiment would support or refute the assumptions made for at least the first half of the pathway.