Protecting against Invasive Species:

A Risk-Based Approach to Live Plant Inspection

Targeting importers with higher records of infestation can reduce the introduction of invasive species through the international trade of live plants.

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The importation of live plants to the United States has been expanding at a substantial rate, fueled by domestic demand for house and landscaping plants and low offshore production costs. In fact, since the mid-1970s, the dollar value of imported plants for cultivation has grown at an average rate of 68 percent per decade. However, these imported plants have long represented a primary pathway for the unintentional introduction of invasive pests and pathogens, which can "hitchhike" on imported goods with sometimes costly consequences. For example, the citrus long-horned beetle (*Anoplophora chinensis*) and white pine blister rust (*Cronartium ribicola*), both native to Asia, were introduced to the United States on live plants and have prompted expensive control campaigns. The citrus long-horned beetle attacks and kills a wide range of hardwood trees, including maple, oak, willow and poplar, as well as crop trees such as apple and citrus, and hence was the subject of a major—and fortunately successful—eradication campaign. White pine blister rust, meanwhile, continues to be the subject of major control efforts as it devastates ecologically and economically important white pine trees.

Inspecting imported goods is one way to reduce the introduction of invasive pests and pathogens and ensure the protection of domestic agriculture and natural resources. However, federal resources for inspecting live plant shipments have not grown at the same rate as imports. In 2011, the US Department of Agriculture's Animal and Plant Health Inspection Service (APHIS)—which is tasked with minimizing the "entry, establishment, and spread of exotic plant pests, diseases, pathogens, and noxious weeds"—proposed moving from a more uniform method of inspecting shipments of imported live plants to a risk-based approach that concentrates effort on imports with more problematic inspection histories. Although the basic idea of risk-based inspections is simple—target riskier imports more intensively—designing the actual system is complicated by the involvement of thousands of offshore producers, each likely to adapt its behavior to any change in the border inspection strategy.

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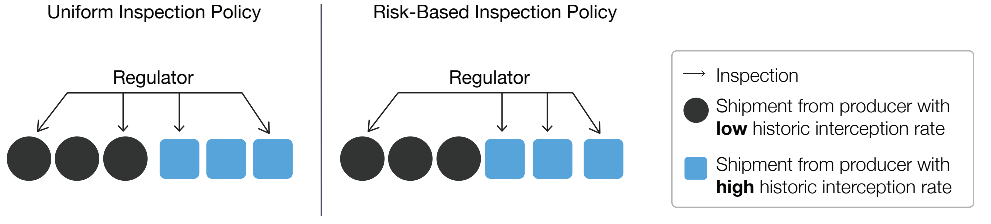
In new research, we evaluate how to effectively design such an inspection program and find that relative to a uniform inspection policy, a risk-based inspection approach can cut the expected rate of infested shipments entering the United States by one-fifth—simply by reallocating existing resources.

Uniform versus Risk-Based Inspection of Live Plant Imports

As part of its mission, APHIS inspects shipments of imported plant material at ports of entry across the country. This involves examining individual plants within a shipment for signs of pests or pest damage. Inspected shipments that are found to be infested—which we refer to as "intercepted" shipments—may be either treated, destroyed, or returned, imposing a cost on the producer and preventing pest entry into the United

Figure 1. Uniform versus Risk-Based Inspection Procedures



States. When shipments are not intercepted, they continue on to their intended destinations.

APHIS differentiates shipments of live plants according to their type (that is, plant genus) and country of origin, and we refer to these unique combinations as "producers" of shipments.

Historically, APHIS has taken an essentially uniform approach, inspecting shipments from all producers at similar levels. In contrast, under a risk-based inspection policy, we consider a program in which producers are divided into medium- and high-risk groups based on their historic interception rates—a record characterizing previous inspection performance (Figure 1). Producers with a high historic interception rate are assigned to the high group and receive more frequent inspections than producers in the medium-risk group. Because historic interception rates are updated based on outcomes from recent inspections, producers move from the medium to high group and vice versa.

History of the Risk-Based Inspection Approach

Our analysis of risk-based inspection of live plant imports builds on a history of economic analysis. A model of a risk-based inspection policy was first applied to air pollution control problems by RFF's Winston Harrington in 1988. In Harrington's model, firms make the decision to "comply" or "violate" an emissions standard, and the regulator sets a policy in order to achieve a target compliance rate with the lowest number of inspections. Firms are divided into high- and low-compliance groups, each with an assigned inspection frequency and fine for noncompliance. Firms with worse compliance records are subject to some combination of more intense inspection, greater penalties for violations, or tougher standards. However, firms can move between groups based on outcomes of recent inspections and an assumed set of transition rules.

Harrington found that a direct benefit of this type of targeted inspection policy is that incentives for cleaner activity are steered toward the dirtiest entities. An additional indirect incentive—known as "enforcement leverage"—is generated from the threat of moving into the high-inspection/high-penalty group or the prospect of escaping into the low-inspection/low-penalty group.

A Risk-Based Approach to Plant Inspection

A substantial policy design challenge is the allocation of inspection resources over a diverse set of imports to prevent entry of plant pests and pathogens. Conceptually, it is clear that a risk-based method for determining inspection intensity should provide gains when risks across shipments are not uniform. But several important questions arise: If shipments are to be categorized into groups based on historic risk, how should thresholds to distinguish group membership be established and how should inspection intensity differ between groups? How should these parameters be set to ensure that available inspection resources are not overburdened? What monitoring structure generates the greatest incentive for offshore producers to engage in sufficient phytosanitary efforts? Finally, given that changing inspection policies is costly, what level of improvement in reducing pest and pathogen entry can be expected from a shift to risk-based sampling—in other words, do the costs outweigh the benefits?

We created a risk-based inspection model to answer these questions. In the model, the regulator announces a cutoff that determines how producers will be treated—those with interception rates above the cutoff are placed in the high-risk group with the remainder falling in the medium-risk group. The regulator also announces how inspection frequencies will differ between groups. Producers respond by choosing their level of effort to reduce infestations with the goal of minimizing their expected losses. These potential losses come from the costs of phytosanitary efforts, delays associated with shipment inspections, penalties for intercepted shipments, and the potential for a complete ban from the market if interception rates are extreme. So although phytosanitary efforts are costly, they reduce the anticipated level of all other losses.

A Cost-Effective Approach

Using our calibrated model of shipment inspections and producer responses, we find that producers indeed apply greater phytosanitary effort under a risk-based inspection policy than under a uniform inspection policy, regardless of whether they are in the medium- or high-risk group.

Although producers in the medium-risk group are inspected less frequently under a risk-based policy than under a policy with uniform inspection, they nonetheless have a stronger incentive to provide cleaner shipments to avoid being transferred into the high-risk inspection group. Producers in the high-risk group have the incentive to increase their phytosanitary efforts, both to reduce costs associated with interceptions and to facilitate transition to the medium-risk group, which receives less frequent inspections. Additionally, producers just above the interception rate cutoff also increase their phytosanitary efforts to escape into the medium-risk group. This enforcement leverage—combined with the higher inspection frequency in the high-risk group—leads to reductions in the expected rate of infested shipments entering the United States.

To achieve the goal of minimizing the number of infested shipments entering the country given available inspection resources, just over half of the shipments (from the riskiest producers) fall into the high-risk, high-inspection group, and all of these shipments are inspected. In contrast, the remaining producers are placed in the medium-risk group, in which each shipment has just a 28 percent chance of being inspected. As noted, producers move between these groups as their interception history is updated over time.

We estimate that relative to uniform inspections, the optimal risk-based policy cuts the expected accepted infested shipment rate by one-fifth. This improvement is substantial, given that it simply involves reallocation of current inspection efforts. These gains are achieved by targeting shipments from producers with the worst interception records more intensively and incentivizing producers to clean up their shipments. Although the focus on inspection highlights the role of border interceptions in preventing pest introductions, in reality, reductions of accepted infested shipments resulting from inspection come mainly from incentivizing producers to clean up shipments at the source, and only secondarily from interceptions at the border. ●

FURTHER READING

Springborn, Michael R., Amanda R. Lindsay, and Rebecca S. Epanchin-Niell. Forthcoming. Harnessing Enforcement Leverage at the Border to Minimize Biological Risk from International Live Species Trade. *Journal of Economic Behavior & Organization*.