The Economics of Invasive Species

Prepared for the
Oregon Invasive Species Council

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Contents

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Summary

- The prevention, eradication, and control of invasive species is an economic and policy issue and has less to do with biology and ecology than many people involved in managing natural resources realize.*
- Invasive species were introduced into the United States as a result of trade, commerce, and the fulfillment of cultural needs. Decisions about agricultural production, conversion of land from forest to fields to towns, the growth of trade and tourism, and the choice of introduced species for food production, garden ornamentals, and for hunting and fishing are among the fundamental economic drivers of the invasive species problem.
- Economics provides us with many of the tools we need to understand the drivers of the invasive species problem and inform managers and policymakers about the costs of invasive species and the costs and benefits of different prevention, eradication, and control measures.
- Studies have been carried out to estimate the economic effects of invasive species and their management on natural resources. These have been particularly focused on forest or agricultural production losses and control costs, but the economic impacts on ecosystem functioning and human health have been less well studied at both state and national levels. Examples of estimates of the annual cost of invasive species in the U.S. and Oregon (in 2008 dollars) are shown in the chart below.
- Although these studies provide policymakers with important information with which to make decisions, inconsistency in study methodologies limits the usability and comparability of these studies in making policy decisions.
- A much wider role for economics is needed that goes beyond financial analyses of agricultural or timber production losses and control costs and embraces measures of the impact of invasive species on total economic value and the consequences of the loss or impairment of ecosystem services for the economic well-being of Oregon.
- Early detection and rapid response (EDRR) and prevention are among the most cost-efficient and -effective ways of reducing the costs of invasive species. Education is a primary process driving EDRR and prevention. Enhanced education of the public, government agencies, industry, and nongovernmental organizations is needed to strengthen all links in the invasive species management chain.

U.S. general estimate	Total direct- and indirect-use impacts	$143 *billion*/year
Noxious weeds (21 species in Oregon)	Production losses, fire damage, control costs	$125 million/year
Sudden oak death (Oregon)	Nursery production and forest losses if established Control costs of current outbreak	$81–310 million/year $7 million/year
Invasive plants (Portland, Oregon)	Complete removal and native species revegetation on 40% of public lands (over a five-year period)	$31 million/year
Zebra mussels	Projected control costs to 13 hydropower facilities	$25.5 million/year

* *"Until prevention speaks the language of economics as well as ecology, it will consistently take a back seat to transportation and trade."*—Jason Van Driesche and Roy Van Driesch. 2001. *Guilty Until Proven Innocent: Conservation Biology in Practice*. Winter 2001/Vol. 2 No. 1 http://www.hear.org/articles/cip_winter2001v2n1_guilty.pdf

Introduction

Approximately 50,000[1] non-indigenous species (NIS) have been introduced into the country as a result of human commerce, trade, and movement. Some have been introduced intentionally, such as those used as livestock, pets, food crops, and ornamental plants. Other species have been introduced unintentionally, such as the zebra mussel, which hitchhikes in the ballast water of oceangoing ships.

Once introduced, many NIS fail to thrive in their new environment. Other species thrive and have positive or at least no adverse effects on the ecosystem into which they are introduced. Indeed, NIS comprise more than 98% of the U.S. food system generating a value of over $893 billion per year.[1] However, some NIS become "invasive species" (IS), which, according to the Convention on Biological Diversity[2] (CBD), are "alien species whose introduction and spread threaten ecosystems, habitats, or species with socio-cultural, economic and/or environmental harm and/or harm to human health." According to the CBD, invasive species are one of the leading causes of the loss of natural biodiversity.

The means or routes by which species are introduced into new ecosystems are "pathways" or "vectors." Examples of these vectors are the intentional release of species (such as brook trout introduced into Cascade lakes to augment fishing opportunities); organisms that arrive lodged in the bodies of their hosts, such as livestock or fresh fruit and vegetable produce; species that arrive in packing material; and unintentionally introduced species such as the zebra mussel, which are transported in the ballast water of oceangoing ships. What all these pathways have in common is that they are the direct result of the global and regional trade, transport of goods and people, and the cultural needs associated with people. With increasingly open national economies and a large increase in the volume of global trade in the past 50 years, the numbers of IS in the U.S. are rising.

While the global transport of goods and people is the primary vector for the introduction of IS, and ecological factors such as a lack of controlling natural enemies and a lack of effective predators explain their propagation in new ecosystems, the factors that allow them to become established and thrive in new environments is also readily explained by economics. Property rights, trade rules, and prices affect people's decisions on land use, the use of certain species in consumption and production, and the global and regional movement of goods and people.[3] While global trade is the main vector for biological invasions, regional trade (such as between the U.S., Mexico, and Canada, or between states in the U.S.) exacerbates these effects.

Biological invasions are a classic "Econ 101" example of a negative externality arising from people's economic decisions. Negative externalities are simply the uncompensated third-party costs arising from a particular decision or action. The risks of biological invasions are endogenous (internally caused) in that they are affected by how countries value goods and services that can become vectors for invasive species, how they protect themselves from IS, and how they react to them after they occur.[4] In these respects, IS management is more of an economic and management problem than a biological or ecological one. Indeed, economic studies are increasingly being used to justify measures against IS.

> *Economics is much more than just a method for calculating costs. It is a framework for understanding the complex causal interactions between human behavior and natural processes, and for finding institutional and behavioral solutions to seemingly intractable environmental problems.*[5]

Missing is a broad body of knowledge about the social and economic consequences of nonnative species invasions. Since the loss of amenities caused by invasive species in natural systems is often incremental, few people realize the impacts invasive species already present impose on our economic and recreational use of the natural world.[6]

Invasive species management is also a "weakest link" public good. It is nonexclusive, meaning incentives exist to take a "free ride" on the efforts of others and shoulder less than a fair share of the costs of control. Also, the collective benefits of IS management are orders of magnitude above what they are to the individuals or regions receiving them, further reducing the incentive for individual action. IS management is only as effective as the weakest link in the chain. For example, five ports on the west coast may have best-practice biosecurity measures in place, but a sixth port may put in place the minimum biosecurity practices required by law. This "weakest link" can result in IS introductions into the region despite the very best efforts of the other five ports.

Invasive Species Management and Economics

A common management goal for IS, such as that outlined by Bio-Security New Zealand,[7] is "the exclusion, eradication, or effective management of risks posed by weeds, pests, and diseases to the economy, environment, and human health." Economics can be used to help meet this goal by providing

- before-the-fact evaluation, prioritization, and selection of prevention, eradication, and control measures;
- after-the-fact evaluation of measures to assess their efficiency and effectiveness;
- impact assessments such as an evaluation of the costs of damage from IS, and the costs of measures employed to prevent, control, or manage the damage; and
- an understanding of the relationship between human behavior and the prevention, eradication, and control of invasive species.

Exclusion and early detection are the most cost-effective methods of controlling and preventing IS (see figure 2, page 11). In one study, early detection, control, and eradication yielded a cost-to-benefit ratio of 17:1 (OTA 1993). Another study yielded a ratio of 34:1 (ODA 2000)—meaning a potential savings of $34 for every $1 invested in early-detection programs.[8]

The goal of Oregon's invasive species action plan[9] is to "facilitate early-detection efforts to keep invasive species out of the state, find invasions before they establish permanent footholds and do whatever it takes to eradicate incipient populations of undesirable species." This focus on early detection and rapid response has paid dividends and is likely to continue to do so. The costs of controlling any IS rise rapidly as the species gains a stronger foothold in the ecosystem. After the establishment phase, eradication may no longer be a possibility, and damage mitigation and control may be the only feasible policy responses.

Case I: eBay and Gypsy Moths in Oregon

Gypsy moths (*Lymantria dispar*) are one of North America's most devastating pests. When they reach high population densities, they can cause extensive defoliation of trees and shrubs. They were originally introduced into the eastern U.S. in 1869 as part of research for the silk-producing industry; they subsequently escaped, and widespread eradication efforts were made beginning as early as 1890. Millions of acres in the eastern U.S. have been defoliated by these creatures.

Gypsy moths were largely confined to the eastern U.S., but in 1983, three gypsy moths were discovered near the town of Lowell, Oregon. An extensive trapping program was implemented, and more than 1,900 were caught in the area in 1984. The Oregon Department of Agriculture (ODA) implemented aerial spraying of a biological insecticide in 1985, in an effort to eradicate the moth. Nearly a quarter-million acres were treated, and spraying continued in 1986. In 1987, extensive trapping revealed no gypsy moths in the area, and the pest was deemed eradicated. Since that time, ODA has continued monitoring for the moths, deploying over 18,000 traps statewide. Although a few have been caught every year, and limited spraying continues to be carried out, the species has been effectively controlled.

Interestingly, in 2006, 66 moths were caught in Oregon, most of them in Bend, in the central part of the state. Further investigation found that this new infestation arrived from Connecticut in a 1967 Chevy purchased through the Internet auction site eBay. This illustrates the difficult task that faces policymakers trying to control invasive species. Control of an IS does not end with its eradication. Constant monitoring is required, which has become a routine, albeit challenging, task for state agencies dealing with the problem.

Oregon Department of Agriculture www.oregon.gov/ODA/PLANT/plant_ann_rep06_ippm_part2.shtml

Economic Impacts of Invasive Species

Ecosystems provide humans with goods and services, each of which can be assigned (often arbitrarily) a value. Many studies have been carried out that highlight the detrimental effect of IS on natural ecosystems—and therefore, on their value. Use values (such as the value of food production or the value of recreation activities in natural areas) can be measured, and they form the basis for the vast majority of studies. Non-use values (such as existence value, i.e., the value of knowing that a natural ecosystems exists; or bequest value, i.e., the value of leaving a natural and functional ecosystem to future generations) go beyond financial analyses and are therefore more difficult to quantify. A loss of these values does, however, impose a loss of wellbeing to individuals and society and should be taken into account when making policy decisions. The concept of total economic value and examples of ecosystem services are shown in figure 1 and table 1.

Subsidies to producers and the inclusion of IS control costs in the calculation of economic growth (and hence, total economic wellbeing) may distort the accounting of true costs in dealing with invasive species. However, attempts have been made to quantify these impacts at both state and national levels.

To date, there have been two major nationwide studies of the costs of impacts from invasive species.

- ✍ The first, from the office of technology assessment,[10] found that costs associated with 79 harmful species over an 85-year time period amounted to over $139 billion.
- ✍ A more recent study[1] estimated the costs associated with a much wider group of IS to be in the region of $143 billion per year. Both of these estimates were based on direct- and indirect-use values (such as damage and costs of control) but did not take into account non-use values.

There were significant differences in the way the two studies were conducted, but what they both illustrate is the difficulty in quantifying the impacts of IS at a national level. These studies also suggest that the overall magnitude of annual economic effects exceeds the federally defined threshold of $100 million per year for "major" economic impacts.

There have been many studies on the impacts of individual invasive species in localized settings (table 2). Most of these studies attempt to value existing invasions and disregard the value of preventing future invasions, which might be the most effective policy tool available. They also focus on the loss of provisioning services, and the corresponding direct-use economic impacts, which are reflected in business or financial data. Only a few take into account non-use impacts of invasive species. This might be due to the difficulty of preparing estimates of these non-use values and the controversy over the available methods (such as contingent valuation) used to quantify these effects. Economic analyses are hindered by the lack of uniformity in methodologies used, by uncertainty about what constitutes an adverse ecological impact, and by the difficulties in predicting the nature and magnitude of impacts. Using a "standard" methodology for what impacts to include in the assessment, what measurement methods to employ, and what discount rates and multipliers to use will greatly improve the usability and comparability of these results in making policy decisions.

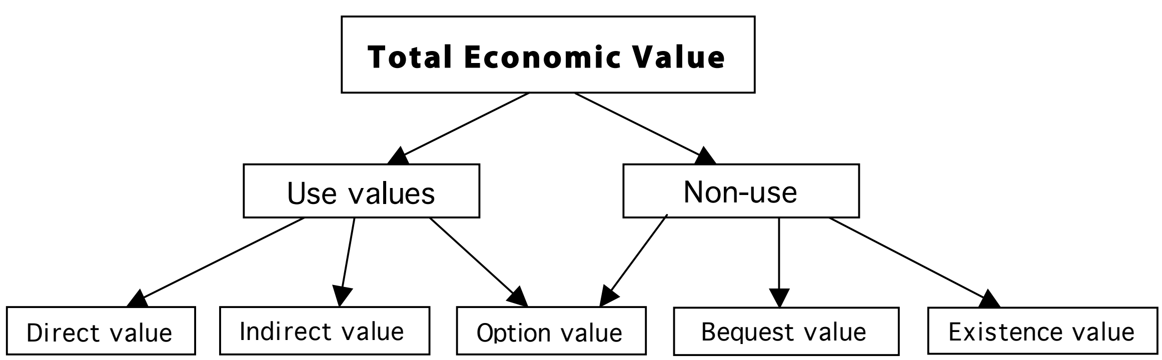

Figure 1.—Components of Total Economic Value. Modified from Born, W., F. Rauschmayer, and I. Brauer. 2005. "Economic evaluation of biological invasions—a survey." *Ecological Economics* 55, pp. 321–336.

Table 1.—Examples of various ecosystem services, and types of values provided.

Service	Examples	Type of value provided
Provisioning	Food production	Direct-use value
	Ingredients for pharmaceutical and industrial manufacturing	Direct-use value, option value (use value)
Regulating	Climate regulation	Indirect-use value
	Carbon sequestration	Indirect-use value
	Waste decomposition	Indirect-use value
	Nutrient dispersal and cycling	Indirect-use value
	Population dynamics	Indirect-use value through food chain and food web interactions
Supporting	Habitat for endangered species	Existence value
Cultural	Intellectual and spiritual inspiration	Non-use value
	Recreation	Direct-use value, non-use value
	Scientific discovery	Direct-use value, option value
Preserving	Genetic diversity for future options, insurance	Option value, bequest value, existence value

Case II: Benefits of Biological Control of Tansy Ragwort in Oregon

Tansy ragwort (*Senecio jacobaea*) was introduced into the U.S. from Europe for its medicinal qualities. It has become widely distributed throughout Oregon and other western states, achieving high densities on valuable pastures. The plant produces pyrrolizidine alkaloids, which are toxic to cattle and other livestock and cause millions of dollars in losses from livestock deaths per year, along with reducing pastureland productivity.

The state of Oregon designates the tansy ragwort as "noxious" and has implemented a biological control program for it, involving the release of cinnabar moths and ragwort flea beetles, which effectively attack the seeds, leaves, and roots of the tansy ragwort. The biological control program provides an estimated annual benefit of $6.24 million, with a minimum benefit-to-cost ratio of 13:1. The annual benefit includes $4.62 million in reduced livestock deaths, $1.59 million in increased productivity of pastures, and $1.06 million in reduced herbicide use.

Radtke, H. and S. Davis. 2000. "Economic analysis of containment programs, damages, and production losses from noxious weeds in Oregon." Report prepared for Oregon Department of Agriculture, plant division, noxious weed control program.

Table 2.—Economic impacts of selected invasive species.

Species	Description of economic impact	Annual cost (adjusted to 2008 $)
U.S. general estimate	Total direct- and indirect-use impacts	$143 *billion*
Weeds (U.S.)	Control costs, production losses	$30.6 *billion*
Invasive fish species (U.S.)	Depletion of natural stocks, other effects	$6.03 *billion*
Zebra mussels (U.S.)	Damage to infrastructure, control costs	$1.12 *billion*
Fire ants (Texas)	Damage to livestock, public health	$335 million
Aquatic weeds (U.S.)	Losses, damages, control costs	$122 million
Purple loosestrife (U.S.)	Control costs, forage losses	$50 million
Introduced rats (U.S.)	Consumption of stored grains, other materials	$21.2 million
Sudden oak death (Oregon)	Loss of market due to quarantines Control cost for outbreak throughout southern Oregon forests Disease control and nursery production loss Control cost of current forest outbreak	$229 million $100 million $81 million $7 million
Invasive plants (Portland, Oregon)	Complete removal and native species revegetation on 40% of public lands (cost per year, over a five-year period)	$31 million
Zebra mussels (Oregon) (projected)	Projected control costs to 13 hydropower facilities	$25.5 million

Case III: Potential Cost of Zebra Mussels to Hydropower Facilities on the Columbia River


U.S. Geological Survey

The zebra mussel *(Dreissena polymorpha)* was introduced into the Great Lakes via ballast water discharged by ships arriving from Europe. Zebra mussels form large, dense populations that may reduce available food and oxygen for native species and completely choke out native mussel and clam species. They colonize and clog water-intake pipes, filtration equipment, and power generating facilities, costing over $1 billion per year.[1]

Zebra mussels—and quagga mussels *(Dreissena bugenis)*, a closely related and even more broadly adapted species—have since spread into most of the aquatic ecosystems in the eastern U.S. and are expected to invade most freshwater ecosystems in the country. Because these species have gained strong footholds over such a wide geographic area, eradication may be impossible. They have not yet been detected in Oregon, but infestations have established in California, Nevada, Arizona, Colorado, and Utah. State agencies are on high alert and have been studying the potential impacts of these species. One study estimates the potential costs for cleaning and maintaining the turbines of 13 hydropower facilities on the Columbia River to be in the region of $25.5 million annually—not including lost revenues from interruptions in power generation. The costs to clean and maintain fish screens, ladders, hatcheries, and locks are even greater.

Zebra and quagga mussels are mostly likely to enter a region through infested watercraft. The cost of establishing boat inspection and decontamination stations at state border entry points is estimated at $2.85 million (source: Oregon State Marine Board).

Phillips, S. 2005. "Potential economic impacts of zebra mussels on the hydropower facilities in the Columbia River Basin." Report prepared for the Bonneville Power Administration, February 2005.

Case IV: Plan for Eradication of Invasive Plants in Portland, Oregon

In November 2005, the City of Portland held a town hall on invasive species. The meeting established the need for a long-term strategy for managing invasive plants. As a follow-up to this meeting, the city council passed Resolution 36360, which requires the city to develop a 3-year work plan and 10-year goals to reduce noxious weeds.

In response to resolution 36360, the city has estimated the cost of the complete eradication of invasive plants that cover an estimated 12,000+ acres of vegetated land within city limits. This is approximately 40% of all vegetated public land in the city.

The estimated cost of invasive plant removal and revegetation with native plants is some $12,000 per acre over a five-year period. Over the five years, the city would spend more than $150 million on invasive plant control and revegetation. Also necessary is an ongoing maintenance program, at slightly lower cost, to maintain invasive species-free conditions in our natural areas.

Based on these cost estimates, complete eradication of invasive plants is not feasible at this time. Thus, the city of Portland has established management priorities* and set goals for a 10-year program to remove invasive plants from 40% of city-managed lands.

*E.g., requiring removal of invasives during development and redevelopment; outdoor maintenance; technical assistance to landowners; outreach and education; media and publication; and updating inventories, plant lists, regulations, and coordination.

City of Portland. 2008. City of Portland Invasive Plant Strategy In Response to Resolution 36360. http://www.portlandonline.com/bes/index.cfm?c=47815

Case V: Controlling Sudden Oak Death in Southwest Oregon

Phytophthora ramorum, the cause of sudden oak death (SOD), is a recently introduced invasive pathogen that kills oaks and wild rhododendron and damages many other plants in western forests and horticultural nurseries. It is a threat to similar forests around the world and is subject to state, national, and international quarantines. If allowed to spread unchecked in Oregon, it would seriously impact southwest Oregon forests, and the resulting quarantine regulations would disrupt the domestic and international trade of many forest and agricultural products.

The potential loss to the nursery industry and forests from SOD is estimated to be between $81 million and $310 million per year (for direct control, management, and regulatory compliance costs plus loss of markets). The annual timber harvest value of the four southwest Oregon counties (Josephine, Coos, Curry, and Douglas) is $1.68 billion per year (based on 2006 data). This would be severely impacted by quarantine regulations.

Since the first finding of SOD in Oregon in 2001, eradication of the disease by cutting and burning host plants has eliminated SOD from some treatment areas, but it continues to appear in new locations in and near the regulated area in Curry County. In 2006 and 2007 the disease expanded considerably. As a result of this expansion, Oregon's Curry County quarantine area was increased to 162 square miles in early 2008.

The current management program of early detection and eradication has cost approximately $1.8 million per year. The cost of compete eradication is estimated to be a minimum of $7 million per year for a period of three to five years. This cost has to be set against potential losses of at least $100 million per year should SOD continue to spread uncontrolled in southwest Oregon.

Kanaskie, A., E. Hansen, E. Goheen, and N. Osterbauer. 2008. "Sudden Oak Death Eradication in Oregon Forests: The Final Phase." Oregon Department of Forestry, Oregon State University, U.S. Forest Service, and OSU Oregon Department of Agriculture, 5-27-2008.

Conclusion

Integration of economics with invasive species management can provide policymakers at all levels with useful information for making important decisions about prevention, eradication, and control. Effective IS management will be realized when

- ✍ we have much greater awareness of the local, national, and international roles that economic forces play in driving the IS crisis.
- ✍ we embrace a much wider role for economics that goes far beyond financial analyses in the search for solutions to the IS challenge. The use of a standard or common approach to performing economic analyses will improve the usability and comparability of the results within states and nationally.
- ✍ a greater level of coordination between local, state, national, and international agencies is achieved. In this respect, a comprehensive biosecurity framework is the only way to avoid, remedy, and mitigate the economic and ecological risks posed by IS.
- ✍ a higher level of education of the public, government agencies, industry, and nongovernmental organizations is achieved, thereby strengthening all links in the IS management chain.

Oregon's focus on early detection and rapid response is an integral part of a comprehensive biosecurity framework. However, if resource managers are inattentive to the underlying economic drivers of trade, commerce, movement of people, and cultural demand for many NIS, the IS problem will continue. Ever-greater resources will be required to control newly established IS and significant losses to the economic well-being of the state of Oregon and the nation. Improved knowledge and greater appreciation of the economics of exclusion, early detection, and control will expand the tools we need to address the IS problem at all levels of management.

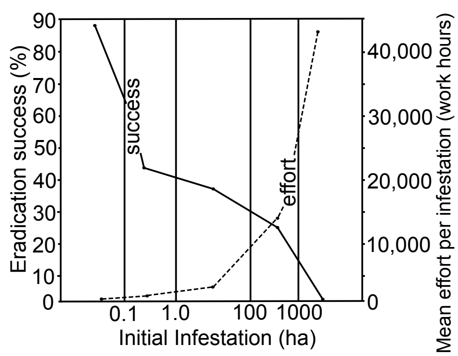

Figure 2.—Successful eradication (%) decreases and effort (work hours) increases with degree of infestation. Early detection and response are critical for cost-effective eradication of invasive species. (Based on data for eradication of 18 noxious weed species and 53 independent infestations in California.)[11]

Notes

1 Pimentel, D., R. Zuniga, and D. Morrison. 2005. "Update on the environmental and economic costs associated with alien-invasive species in the United States." *Ecological Economics* 52, pp. 273–288.

2 Online at www.cbd.int/

3 Lovell, S., S. Stone, and L. Fernandez. 2006. "The economic impacts of aquatic invasive species: A review of the literature." *Agricultural and Resource Economics Review* 35(1), pp. 195–208.

4 Jensen, R. "Economic policy for invasive species." Online at www.nd.edu/~rjensen1/workingpapers/InvasiveSpecies.pdf

5 Perrings, C., M. Williamson, E. Barbier, D. Deflino, S. Dalmazzone, J. Shogren, P. Simmons, and A. Watkinson. 2002. "Biological invasion risks and the public good: an economic perspective." *Conservation Ecology* 6(1):1.

6 Van Driesche, Jason and R. V. Driesche. 2000. *Nature Out of Place: Biological Invasions in the Global Age*. Washington, D.C.: Island Press.

7 Online at www.biosecurity.govt.nz/

8 Oregon Department of Agriculture. 2000. "Economic analysis of containment programs, damages, and production losses from noxious weeds in Oregon." www.oregon.gov/ODA/PLANT/docs/pdf/weed_body_a.pdf

9 Online at www.oregon.gov/OISC/docs/pdf/oisc_plan6_05.pdf

10 OTA. 1993. "Harmful non-indigenous species in the United States." OTA F-565, Washington, D.C.: U.S. Congress Office of Technology Assessment, U.S. Government Printing Office.

11 Rejmánek, M. and M. J. Pitcairn. 2002. "When is eradication of exotic pest plants a realistic goal?" In C. R. Veitch and M. N. Clout (eds.), *Turning the Tide: The Eradication of Invasive Species*, pp. 249–253. Gland, Switzerland: International Union for the Conservation of Nature and Natural Resources.

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