The Costs of Pierce's Disease in the California Grape and Wine Industry

Summary Report

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Julian M. Alston

Distinguished Professor Emeritus
Department of Agricultural and Resource Economics
Director, Center for Wine Economics
at the Robert Mondavi Institute for Wine and Food Science
University of California, Davis
Member, Giannini Foundation of Agricultural Economics

and

Devin Serfas

Assistant Professor
RDAR Chair in Applied Agricultural Economics and Risk Management
Department of Resource Economics and Environmental Sociology (REES)
University of Alberta in Edmonton, Alberta

Table of Contents

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1. EXECUTIVE SUMMARY

PD/GWSS still costs more than $100 million per year

Aggregating the costs of vine losses and industry assessments paid by grape growers, compliance costs for nursery owners and citrus growers, and expenditures by government entities, the estimated cost of PD in California is approximately $110 million per year based on 2022 values. This total cost comprises

- $45 million in costs of damage mitigation (including $33 million per year in funded Pierce's Disease activities undertaken by various government agencies and the University of California system, and $12 million per year in compliance costs incurred by the nursery and citrus industries) and
- $65 million per year in costs of lost production and replacement of vines, including $48 million for winegrape vines, incurred by growers.

These figures do not include any of the substantial cost of preventive measures against the spread of GWSSs and BGSSs within vineyards undertaken by growers.

Costs would be much higher without the PDCP

The estimates of costs to growers reported here are conditioned by the presence of the prevention programs that limit the spread of the GWSS.

- If the GWSS were to become distributed throughout California, our estimates suggest average annual costs of PD borne by growers and consumers of winegrapes could increase by $56 million under the most-likely scenarios.
- These potential costs of PD substantially exceed the current costs of the PDCP.

The new estimates of costs of vines lost to PD are somewhat smaller than those reported by Tumber et al. (2014), mainly because the revised estimates of the rates of vine loss to PD are smaller in both the baseline scenario, with current policies in place, and in the hypothetical outbreak scenario, if GWSS were no longer prevented from spreading throughout California.

- These lower rates reflect both changes in perception and changes on the ground, in particular in the management of PD/GWSS and in reduction of its winter habitat in the Napa Valley.
- These changes can be ascribed at least in part to knowledge gained from the PD/GWSS Board's research program.

PD/GWSS Board R&D Program

The PD/GWSS Board has funded more than 300 projects, spending a total of $57 million over the period 2001-02 through 2023-04, worth the equivalent of $72 million in 2024 dollar values. Of that total, about two-thirds was spent for research focused on PD/GWSS. However, in recent years the share for research focused on PD/GWSS has been closer to one-third because spending by the PD/GWSS Board has shifted towards R&D for other pests & diseases such as red blotch virus, leaf-roll virus and mealybugs.

The investment in developing PD-resistant varieties (about one-third of the PD/GWSS Board total research investment) has yielded new varieties of winegrapes that are reported to be highly resistant to PD and to produce good quality wine, but they have not yet been adopted significantly by growers in California. Why is it so?

- The fact that they are hybrids with unfamiliar names, may be a barrier to adoption for some growers.
- A more serious barrier to adoption may be concerns over whether vineyards planted to these varieties could serve as a source of inoculum for vine-to-vine transmission of *Xf* to vineyards planted to nonresistant varieties.

A "back-of-the-envelope" calculation indicates that only a small fraction of California's most PD-susceptible vineyards (on the order of 1 or 2 percent) would need to be planted to PD-resistant varieties to generate annual benefits equivalent to the annual costs of the PD/GWSS Board research program directed specifically to PD/GWSS.

2. INTRODUCTION

Pierce's disease (PD), caused by a strain of the bacterium *Xylella fastidiosa (Xf),* imposes significant annual costs on the California grape and wine industry through losses of vines and through public and private producer efforts to mitigate the damage. *Xf* is spread by a variety of leafhopper insects, called sharpshooters. For many years, when the only insect vectors for the disease were native sharpshooters, PD was a chronic but relatively manageable problem.[1] Major concerns about PD grew after a devastating outbreak in southern California in the late 1990s, spread by a new non-native vector, the glassy-winged sharpshooter (*Homalodisca vitripennis*, GWSS).[2] Extensive programs were created to manage PD/GWSS in southern California, and to prevent the spread of the GWSS into other areas.

The largest and most influential PD-related program in California is the Pierce's Disease Control Program (PDCP). It is a partnership that includes the California Department of Food and Agriculture (CDFA), county agricultural commissioners, the USDA, the University of California and California State Universities, other state and local agencies, industry, and agricultural organizations throughout California. The program aims to slow or stop the spread of GWSS while other short- and long-term solutions to PD are developed. Importantly, the CDFA collaborated with nursery and grape industry members to establish the Nursery Stock Approved Treatment Protocol (NSATP), applied to shipments of nursery stock from infested areas to non-infested areas in California. In addition, research programs were initiated by the University of California, the US Department of Agriculture (USDA) and the California Department of Food and Agriculture (CDFA), which established the PD/GWSS Board in 2001.

Since the inception of these programs in the late 1990s and early 2000s, tens of millions of dollars of public and private funds have been spent each year to prevent the spread of the

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[1] Several sharpshooters are native to California. Among these, the blue-green sharpshooter (*Graphocephala atropunctata*, BGSS), which has been present in the Napa Valley for more than 100 years poses the greatest threat to California vineyards. The BGSSs migrate out of riparian areas in the spring and into vineyards where they can vector PD. They do not fly far from where they hatch.

[2] The GWSS was inadvertently introduced to southern California in the early 1990s. The GWSS has a strong preference for citrus groves as a host; however specific hosts can vary significantly to include woody ornamentals (shrubs and trees), and annual and perennial herbaceous plants. The GWSS also can fly a quarter mile or more without stopping, making it a highly mobile threat. In southern California and the San Joaquin Valley, the GWSS has at least two generations per year.

GWSS and PD and mitigate its effects. In what follows we briefly describe the details of the public expenditures, as well as costs incurred by industry in compliance with the PDCP—which we describe as mitigation costs—for the period 1999–2023. Next, we present estimates of the costs to growers resulting from losses of vines to PD, both under the present regime, with the PDCP in place, and in a hypothetical "outbreak scenario" as might arise if the PDCP were to end. Finally, we present a brief synopsis of findings regarding the PD/GWSS R&D program.

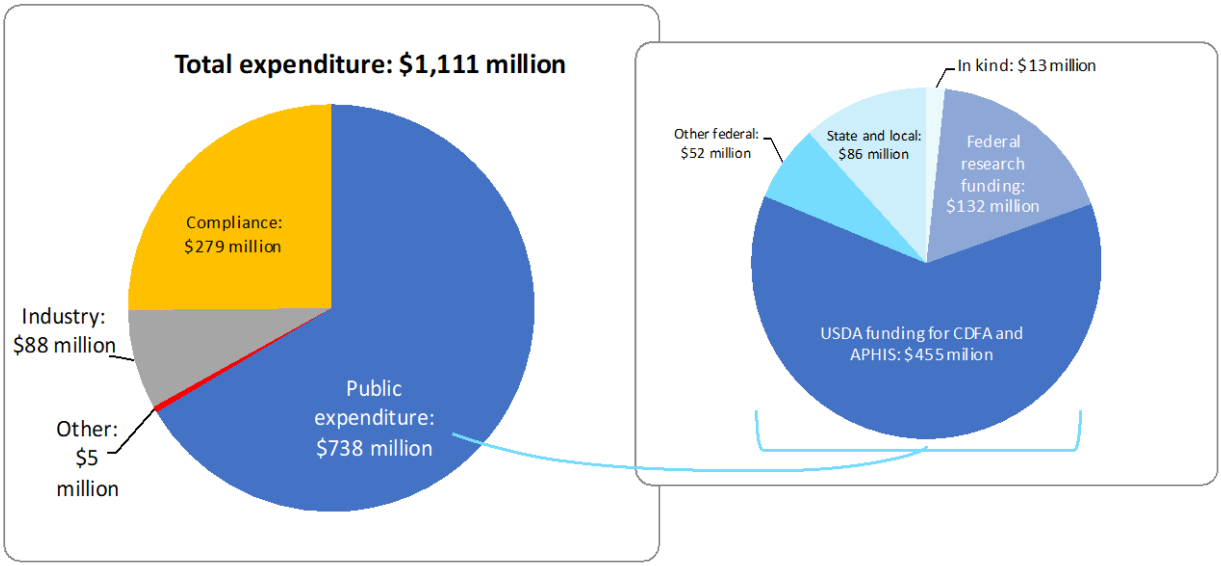
3. PUBLIC AND PRIVATE MITIGATION COSTS ASSOCIATED WITH THE PIERCE'S DISEASE CONTROL PROGRAM

Substantial costs are incurred by both government agencies and the private sector in activities they undertake, under the PDCP, to prevent the spread of GWSS and mitigate the potential damage from PD. Over the period 1999–2023 these costs added up to an estimated $1,111 million, which, after accounting for inflation, is equivalent to $1,567 million in current (2024) dollar values. Figure 1 shows shares of funding over the period 1999–2023. The public expenditure ($738 million, two-thirds of the total) was predominantly sourced from the federal government ($639 million).[3] The private costs ($373 million, one-third of the total) were predominantly (a) "compliance costs" ($279 million) incurred by the citrus and nursery industries in complying with the PDCP shipping protocols, and (b) contributions by grape growers ($88 million), mainly through the winegrape assessment used to support PD/GWSS research, mostly through the PD/GWSS Board.[4]

[3] The federal government contributed approximately $639 million, about 87% of the total public funding for PD-related programs; state and local governments have contributed more than $86 million, about 12%.

[4] The Board has invested over $57.7 million since 2001 for research and outreach. Note, over the years an increasing share of the research expenditures has been for pests and diseases other than PD/GWSS.

Figure 1: *Total Pierce's Disease Program Spending and Cost of Compliance, 1999–2023*



Source: Developed by the authors using data from the CDFA (PDCP and PD/GWSS Board), provided by Matt Kaiser (pers. comm.), and Tumber et al. (2014).

Total annual costs and their balance among the main categories have been fairly stable over recent years. The latest year for which we have complete details at hand is FY 2022-23. In FY 2022-23, the federal government spent approximately $26.8 million on PD-related programs. Of this amount, approximately $5.7 million went to USDA Agricultural Research Service (ARS) and NIFA to support PD and GWSS related research, and approximately $21.1 million went to USDA APHIS and CDFA mainly to support the PDCP. State and local governments contributed approximately $3.0 million to the PDCP, which spent its total funding of $18.6 million on containment, survey and detection, rapid response, and outreach. Public agencies also incurred costs of in-kind services (such as the participation by state employees on state and local task forces, and boards) and other contributions.

The PD/GWSS Board uses an annual Statewide Winegrape Assessment (SWA), currently $1.25 per $1,000 of harvested value, to fund PD/GWSS research and related activities. In FY 2022-23, the Board collected $4.6 million using the SWA. The Board advises the California Department of Food and Agriculture on the use of these assessment funds to find solutions to

PD, GWSS, and other designated pests and diseases of winegrapes. These amounts are buttressed with other assessments collected and managed at the county level.

The other main private costs of mitigation are in the form of compliance costs. Many of California's licensed nurseries are located in GWSS-infested areas and those that ship from infested to non-infested areas are required to take certain precautions to avoid the spread of the GWSS. Complying with CDFA-approved shipping protocols can be very expensive for nursery operators. With an estimated cost of $260 per load, this adds up to $8.1 million in FY 2022-23. Citrus growers also incur costs of complying with the PDCP, estimated at $3.3 million per year.

Table 1: *Annual Costs of PD Mitigation with Current Policy*

Funding Source	1999-00 to 2022-23			2022-23	
	Total	Annual Average	Share of Total	Total	Share of Total
	$ millions		*%*	*$ millions*	*%*
Federal Government	639.1	26.6	57.6	26.8	59.6
State and Local Government	86.3	3.6	7.8	1.2	2.7
Industry	87.8	3.7	7.9	4.6	10.2
Direct Funding Total	**813.2**	**33.9**	**73.2**	**32.6**	**72.4**
Compliance Costs	279.4	11.6	25.2	11.7	26.0
In-Kind & Other Contribution	18.0	0.7	1.6	0.7	1.6
Compliance, In-Kind & Other	**297.4**	**12.4**	**26.8**	**12.4**	**27.6**
Grand Total	**1,110.6**	**48.3**	**100.0**	**45.0**	**100.0**

4. COSTS OF VINES LOST TO PIERCE'S DISEASE

California grape growers bear the greatest cost from PD. In a year with "most likely" prevalence of losses to PD, using our updated estimates of rates of PD prevalence and 2022 values for production, we estimate that California's grape growers would lose about $64.9 million (including $47.6 million for winegrape growers) because vines die from PD. This value

does not include costs of preventive measures taken by growers against sharpshooters, including revegetation of riparian areas and pesticide use, or losses from land left idle.

California's winegrape production is regionally diverse, with substantial variation in the cultural methods used, yield per acre, and value per ton, and variation also in the susceptibility of the vineyard to damage from PD and the prevalence of different species of sharpshooters. The greatest losses from PD are in the Napa-Sonoma region where PD, vectored by the BGSS, causes significant chronic losses. In Southern California and the Southern San Joaquin Valley, PD vectored by GWSS also causes significant losses but for now these are contained by the PD Control Program.

To estimate the expected or average annual costs of vines lost to PD, we combined measures of the cost of vines in different locations multiplied by estimates of the rates of loss to PD. The rates of loss to PD used here are informed "guesstimates," that were derived from a combination of data from observations in the field and advice from various experts. We elicited estimates of "low," "high" and "most likely" loss rates to PD both in the "baseline" scenario, with current policies in place, and an "outbreak" scenario as would arise if the PDCP were to end and the GWSS became distributed throughout the state.

Table 2 shows the bearing acreage in 2022 and corresponding costs to growers of wine, raisin and table grapes, by region, over a range of incidence of PD (numbers of vines lost per thousand per year) in the baseline scenario. The estimated annual value of lost vines ranges from $27.8 million (low PD incidence) to $132.9 million (high PD incidence), around a best estimate of $64.9 million (most likely PD incidence). The wide range reflects both the large potential variation from year to year in PD incidence and the considerable uncertainty surrounding our "most likely" rates of PD incidence.

Table 2. *Expected Cost of Vine Losses, by Grape Type and Region, 2022*

Grape Type and Region	Bearing Area	Value of Vines Lost to PD		
		Low PD Pressure	*High PD Pressure*	*Most Likely PD Pressure*
	Thousand Acres		*$ Millions*	
Winegrapes				
Napa-Sonoma	103.3	9.1	55.0	27.5
Coastal	142.6	3.6	14.3	7.2
San Joaquin Valley North	78.5	1.1	7.7	2.2
San Joaquin Valley South	188.7	5.2	20.8	10.4
Southern California	3.0	0.2	0.6	0.3
Northern California	30.1	0.0	0.0	0.0
Winegrapes Subtotal	***546.2***	***19.2***	***98.4***	***47.6***
Raisin Grapes				
San Joaquin Valley South	118.7	4.8	19.0	9.5
Southern California	0.8	0.0	0.1	0.1
Raisin Grapes Subtotal	***119.5***	***4.8***	***19.2***	***9.6***
Table Grapes				
San Joaquin Valley South	100.7	3.6	14.5	7.3
Southern California	5.5	0.2	0.8	0.4
Table Grapes Subtotal	***106.1***	***3.8***	***15.3***	***7.7***
Grand Total	**771.9**	**27.8**	**132.9**	**64.9**

Source: Data on the number of bearing acres were retrieved from Agricultural Commissioner's Office County Crop Reports from each county, available online at https://www.cdfa.ca.gov/exec/county/CountyCropReports.html.

Notes: The values of vines lost to Pierce's Disease for each scenario are calculated using "*loss rates*" based on expert opinion, weighted average prices from the County Crop Reports, and the costs to establish a vineyard and produce winegrapes by establishment and production year from current UC Davis Cost and Return Studies (available at http://coststudies.ucdavis.edu).

The largest share of losses is for winegrapes, followed by table and then raisin grapes. Among the winegrape regions, Napa-Sonoma (Districts 3 and 4) is the hardest hit, losing an estimated $47.6 million per year in the "most likely" case, making up approximately half of the total losses to growers. District 4 (Napa County) has the highest annual losses, at over $27.5

million, because it has a relatively high rate of losses to Pierce's Disease (0.75 percent per year) and the highest average price for grapes in the state, such that the opportunity cost of losses is higher than other areas. The same is true, but to a lesser extent, for District 3 (Sonoma and Marin Counties).

5. THE VALUE OF WINEGRAPE VINES SAVED BY THE PIERCE'S DISEASE CONTROL PROGRAM

In Table 3, we compare the value of vines lost to PD (a) in the baseline scenario, with current policies in place, and (b) in a hypothetical outbreak scenario, with higher rates of loss to PD, especially in the Southern San Joaquin Valley, as would occur if the GWSS were allowed to spread throughout the state. This analysis is just for winegrapes. In the outbreak scenario the "best" estimate of the annual statewide value of winegrape vines lost to PD is $116.9 million (more than twice the "low" estimate of $53.8 million and approaching one-half of the "high estimate" of $240.3 million) including $45.9 million in Napa-Sonoma and $52.0 million in the southern San Joaquin Valley.

Table 3: *High, Low, and Best-Guess Value of Vines Lost under Alternative PD Scenarios*

Region	Baseline: With Current Policies and Technology			Outbreak: Without Current Policies		
	"Low" Baseline PD Loss	"High" Baseline PD Loss	Best Estimate Baseline PD Losses	"Low" Outbreak PD Loss	"High" Outbreak PD Loss	Best Estimate Outbreak PD Losses
	value of vines lost to PD ($ million/year)					
Napa-Sonoma	9.1	55.0	27.5	18.3	91.7	45.9
Coastal	3.6	14.3	7.2	7.2	28.7	14.3
San Joaquin Valley North	1.1	7.7	2.2	2.2	15.3	4.4
San Joaquin Valley South	5.2	20.8	10.4	26.0	104.0	52.0
Southern California	0.2	0.6	0.3	0.2	0.6	0.3
Northern California	0.0	0.0	0.0	0.0	0.0	0.0
State Total Winegrapes	**19.2**	**98.4**	**47.6**	**53.8**	**240.3**	**116.9**

Table 4 includes estimates of the statewide annual costs of vine losses to PD with high, low, and most likely rates of losses to PD under both the baseline of current policy (for both all grapes and just for winegrapes) and in the outbreak scenario if the PDCP were to end (just for winegrapes). The difference in value of vines lost to PD between the outbreak and baseline scenarios—for which the best estimate is $69.3 million—is an indication of the annual value of vines saved by the PDCP. This does not allow for the fact that the savings in costs of the PDCP would begin immediately while it would take some time for the GWSS to spread throughout the state to the extent assumed in the "outbreak" scenario.

Scaling back in proportion (dividing by a factor of 1.23), we obtain a figure of $56.3 million per year as a reasonable approximation of the estimate of the net benefits—i.e., the value of winegrape vines saved by the PDCP—that would be obtained if we were to update the full analysis as undertaken by Alston et al. (2013) using the revised loss rates. Even though it does not include any allowance for potential loss of table or raisin grapevines, this best estimate is on the order of twice the annual operating cost of the PDCP and well exceeds the annual total cost of mitigation (see Table 1).

Table 4: *Annual Costs of Vine Losses to PD with and without Current Policy*

PD Pressure	Expected Annual Cost of Loss of Vines in 2022 Values			
	With Current Policy, Losses of		Without Current Policy, Losses of Winegrape Vines	Value of Winegrape Vines Saved Attributable to Policy
	All Grape Vines	Winegrape Vines		
	(1)	(2)	(3)	(4)
	$ million, nominal			
Low	27.8	19.2	53.8	28.1
Most Likely	64.9	47.6	116.9	56.3
High	132.9	98.4	240.3	115.4

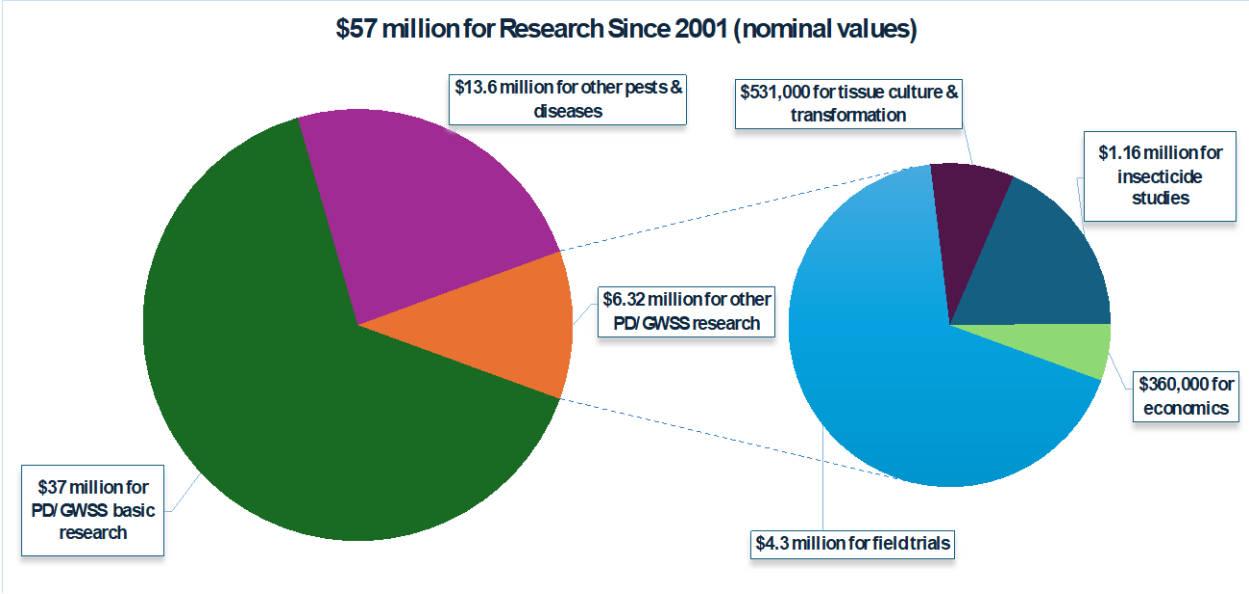
Source: Computed by the authors.

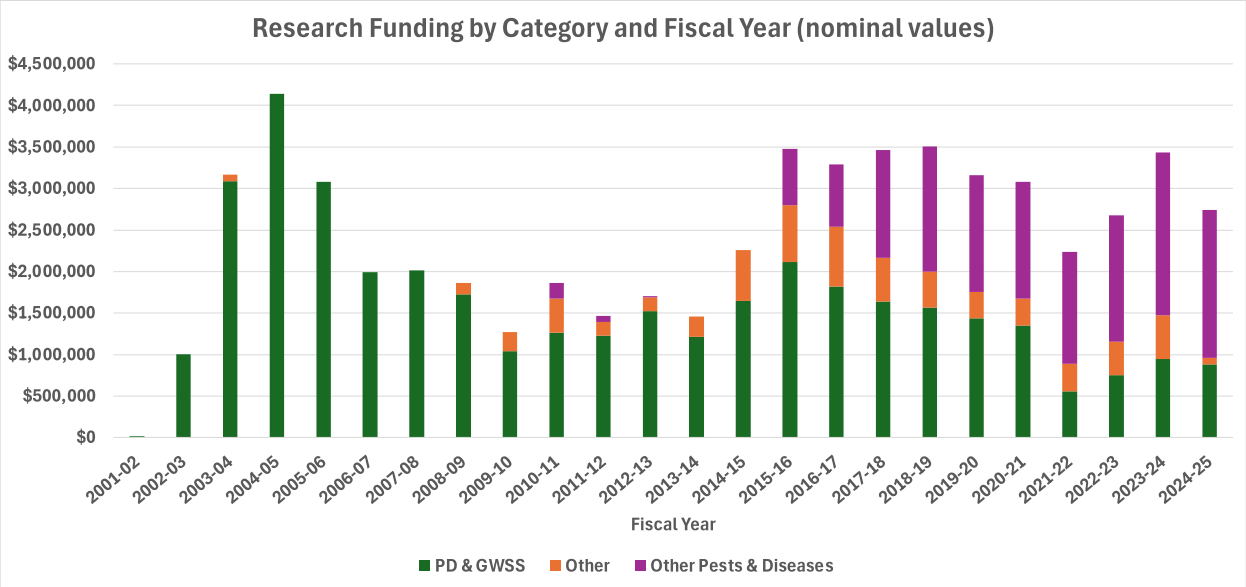
Notes: Values in column (4) are equal to the difference in values between column (3) and column (2) divided by a scaling factor of 1.23 to allow for the difference in timing as described in the text.

6. PD/GWSS BOARD RESEARCH PROGRAM

The PD/GWSS Board has spent a total of $57 million ($72 million in 2024 dollar values) on R&D related to PD/GWSS and other pests and diseases of grapevines. While spending for PD/GWSS took the lion's share of the investment in the first half of this period, spending on R&D for other pests and diseases has been increasingly dominant for the second half. Hence, total funding for the category of PD/GWSS research has declined from more than $4 million per year in the peak years of 2003-04 to 2005-06 to less than half that amount since 2017-18 and less than one-quarter of that amount since 2021-22.

Figure 2. *PD/GWSS Board Research Funding History, 2001-02 – 2024-25*





Source: Created by the authors using data files provided by Matt Kaiser (pers. comm.) on behalf of the PD/GWSSS Board.

Notes: Other Pests & Diseases includes red blotch, leafroll, mealybugs, and more.

Agricultural R&D generally takes a long time to begin to bear fruit, typically at least one or two decades and even longer for perennial crops such as grapevines, but then the benefits can continue for many decades. These long and variable R&D lags make the economic evaluation of investments in R&D difficult, which is easiest for R&D that leads to innovations embodied in inputs used by farmers. It is too soon for most of the projects funded by the PD/GWSS Board to have yielded tangible benefits in the form of new technologies ready to be adopted in vineyards. Evaluation of the benefits of those investments at best can be undertaken in a form of peer review and narrative assessment of the accomplishment in terms of contributions to potentially useful knowledge.

A significant part of the R&D program funded by the PD/GWSS Board was devoted to developing new varieties or rootstocks that would be resistant to PD—$16.7 million, one-third of the total research investment by the PD/GWSS Board over the period, 2001-02 to 2024-25—and those investments have borne fruit. In 2019, UC Davis released five new varieties of wine grapes, bred by Professor Andrew Walker, which were reported to be highly resistant to Pierce's Disease and to produce high quality wine.

Producers in California have not embraced these varieties. One possible reason for slow adoption by growers may be concerns about acceptance by consumers, especially at a time when winegrapes are abundant and PD pressures have been relatively low. Another may be concerns about the possibility that, rather than serving as a buffer the new varieties could serve as a reservoir for *Xf* and a potential source of inoculum that can be spread to adjacent vineyards planted to non-resistant varieties. In other places in the United States, such as Texas and Florida, the advantages of PD-resistance may well outweigh the various perceived disadvantages that have hampered the adoption of the PD-resistant varieties in California so far.

Alston et al. (2014) derived a range of estimates of the benefits from adoption of prospective PD-resistant varieties by combining a range of assumptions about the R&D lag (the number of years before the new varieties would be released: 10, 20, 30, or 40 years) with a range of assumptions about the adoption rate in each main region (40, 60, 80, or 100% of PD-affected area). Extrapolating from those results, with the 10 year R&D lag (which is reasonable, in hindsight) and assuming 10% adoption, the annual average benefits would be equal to $5.7 million per year in the baseline, rising to $12.9 million per year in the outbreak scenario.

Another way to scale this analysis for perspective is to ask: what percentage of the vulnerable vineyard area would have to adopt PD-resistant varieties to generate benefits sufficient to cover the cost of the PD/GWSS Board research expenditure directed toward PD/GWSS specifically, nowadays less than $1 million per year for all aspects, not just resistant varieties? Using the estimates from Alston et al. (2014) for the case of an R&D lag of 10 years, to generate benefits of $1 million per year would require an adoption rate of 1.75% in the status quo scenario and 0.78% in the outbreak scenario.

Whether even this modest rate of adoption may be observed would appear to turn on questions about the potential role for vineyards planted to PD-resistant varieties to serve as a source for vine-to-vine transmission of the disease, rather than as a buffer, and whether something could be done to mitigate that undesired, unintended consequence.

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