An Exploratory Analysis of the Phylloxera Crisis of the 1800's and the Implications on the Current Virginia Wine Industry

A Research Paper submitted to the Department of Engineering and Society

Presented to the Faculty of the School of Engineering and Applied Science
University of Virginia • Charlottesville, Virginia

In Partial Fulfillment of the Requirements for the Degree
Bachelor of Science, School of Engineering

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Spring, 2020

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Phylloxera's Lasting Impact on Our Global Economy:

In the mid 1880s, the French wine economy completely collapsed. Hundreds of farmers faced the same problem: "severe root damage, yield loss and eventual vine death" (Lund, 2017, pg.2). Scientists were mystified by the vine's decay, but quickly discovered a bug called phylloxera "feeding on the structural roots of the *Vitis vinifera*", the European vine (Lund, 2017, pg.2),. However, the American vines had "adapted to resist the depredations of the bug because the two had coevolved" (Gale, 2011, pg. 66). British entomologist Charles V. Riley realized the connection between the two vines and figured out the "ultimate solution for phylloxera was grafting" the European vine to the resistant American vine (Carton, 2008, pg. 144). This American vine produced an inferior quality grape than the European vine, with records dating back to Virginia in 1700s that the grapes smelled and tasted like "wet fur" (Lukacs, 1996). With grafting, Virginia was able to produce higher quality wine, and create a robust wine industry. By using actor network theory, this paper draws connections between key actors, and explores the relationships that were created in order to fight the phylloxera. This network will help to understand the current day wine industry, and the impact phylloxera had on Virginia.

Research Question and Methods:

How did scientific analysis play a role in solving the phylloxera infestation of the wine industry during the mid 1800s, and what is its lasting effect on the Virginia Wine industry?

In order to answer the research question, this paper builds a network of key actors to determine how scientists solved the phylloxera infestation that destroyed the French wine industry. The data to build the network is collected using the University of Virginia database of scholarly articles, historical cases, online books, and primary documents. In order to find data about scientists in the 1800s, key words such as “entomologists,” “viticulture,” “great wine blight,” and “grape phylloxera” are used. To find documents about phylloxera key terms such as “phylloxera,” “Vitis Vinifera,” and “Vitis Spp” are used. Lastly to explore the current Virginia wine economy key words such as “East Coast,” “Virginia Wine,” “colonies,” and “Thomas Jefferson” are used. The majority of the documents used to explore the relationships created in order to fight the phylloxera and create the modern wine economy in Virginia, were autobiographic novels, scholarly research papers, historical cases and journal publications. Within the paper itself the data is organized by historical timeline, going from the phylloxera lifecycle, the great wine blight and phylloxera’s impact on Virginia.

Phylloxera Throughout History:

For the first settlers in Virginia, during the 1600s, the hope for wealth was tied to the potential of the new land they had stolen. England specifically hoped that the colonies would produce silk, wine, and olive oil, which the English had to purchase in cash from their rivals, Spain and France, (Pinney, 1989, pg. 13). Many of the new settlers had seen native American grapes growing in the wild, and expected America to soon produce high quality wine that the British could trade with other nations. They quickly realized that the natural grape did not produce the same quality wine as the European grapes (Holloway, 1997).

The next solution to the problem of “rank” tasting wine was to try and grow the higher quality European grapes in Virginia (Lukacs, 1996). However, the farmers struggled against the harsh winters, mold, and a pest native to eastern United States called phylloxera. Settlers realized that “Virginia was not easily going to become a source of abundant wine” (Pinney, n.d., pg 23). This problem persisted all over North America and into the 1800s, with phylloxera the cause of the failure to produce European grapevine in the United States (Sorensen, Smith, Smith, & Carton, 2008, pg 136). The phylloxera feed on the structural roots of the European grapevine which “provide entry to soil-borne fungi and bacteria, resulting in progressively more severe root damage, yield loss and eventual vine death” (Lund, 2017, pg.2).

Not only did phylloxera affect the production of wine in North America, but in the 1800s the pest invaded the vineyards of France. At the time grapes were the second most produced food in France, only after wheat. The phylloxera slowly infected the vineyards, with slow growth and sickly yellow leaves, appearing in the second year of infestation (Pinney, n.d., pg 29). When dug up, the vine shows “gnarled roots already decaying”; but the phylloxera has already moved to the next living plant (Pinney, n.d., pg 29). The pest proved catastrophic to the French wine industry and “between 1863 and 1890 the phylloxera destroyed 40% of French vineyards” (Banerjee, Duflo, Postel-Vinay, & Watts, 2010, pg 714). One study found that due to the lack of income and poor nutrition, the children born in affected regions of France were 0.5 to 0.9 centimeters shorter than their peers (Banerjee, Duflo, Postel-Vinay, & Watts, 2010, pg 727).

The solution for the French wine plight would not come until a British born, American based entomologist by the name of Charles V. Riley realized the American phylloxera and French phylloxera were the same insect. He also proposed the best solution to the crisis was to graft the European vines to the native American grape roots due to their resistance to the insect (Pinney, n.d., pg 29). This solution saved the French and American wine industries, and allowed states like Virginia to create robust wine economies.

Actor Network Theory and Phylloxera:

This paper uses Actor Network Theory to visualize the connections between the human actors (Riley, the farmers and French scientists) and non-human actors (the phylloxera). Actor Network Theory (ANT) "aims at describing the very nature of societies" by forming smaller sets of associations of human and non-human actors (Lator, 1996, pg. 369). The relationships and interactions between these actors are then mapped by "threads" to create a network. These networks are altered by the addition of new actors, and their effect can be seen on how the network changes in response. There is no component of size of in ANT, simply the network is just "longer or more intensely connected" (Lator, 1996 pg. 371). ANT was originally created within the field of Science Technology and Society (STS) studies, but has moved out in recent years into other fields such sociology, and geography (Müller, 2015, pg. 30). The major contributors to this framework are Bruno Latour, Michel Callon and John Law.

One criticism of ANT is that it struggles to understand the sociotechnical elements of the networks (Cressman, 2018, pg. 10). Specifically, it fails to "acknowledge unequal power relationships" (Müller, 2015, pg. 30). Therefore, this analysis might struggle to incorporate the complex social environment and biases of the French wine industry during the 1800s. Secondly, it ignores the differences between human and non-human actors in which humans have intentions with their actions and pursue their own interests, while things do not (Müller, 2015, pg. 31). Lastly, ANT discards social context if it cannot be formed into an association, so anything outside the network is not accounted for but could still shape the interactions between actors. Therefore, in this particular analysis it might prove difficult to limit and control the number actors.

ANT will be used for this analysis because it allows for non-human actors to have a strong impact on the network. This research paper will see Charles V. Riley changed how wine was produced after the phylloxera crisis in the 1800s. Even though the network has valid criticism, its strengths in being able to map relationships will prove worthwhile.

Understanding Phylloxera's Network and Historical Impact:

Illustrated in Figure 1 is the network of actors that answers the research question of how scientific analysis solved the phylloxera infestation of the wine industry. In particular the network focuses on the key actors, such as the grapevines, the French vineyards, French scientists, Charles V. Riley, and Virginia. However, some actors within the network were black boxed in order to keep within the scope of research paper this size. Through communication in letters between Charles V. Riley and French scientists were able to identify that the phylloxera in France was the same as the Phylloxera that plagued the eastern United States. Charles V. Riley was then able to study the life cycle of the phylloxera in order to understand how it attacked the European grapevine. Riley was also able to find which American grapevines are resistant to grape phylloxera, in order to optimize the grafting of the two grapevines to save the wine industry. His lasting research on grafting and the phylloxera enabled the Virginia wine industry to grow and produce high quality wine.

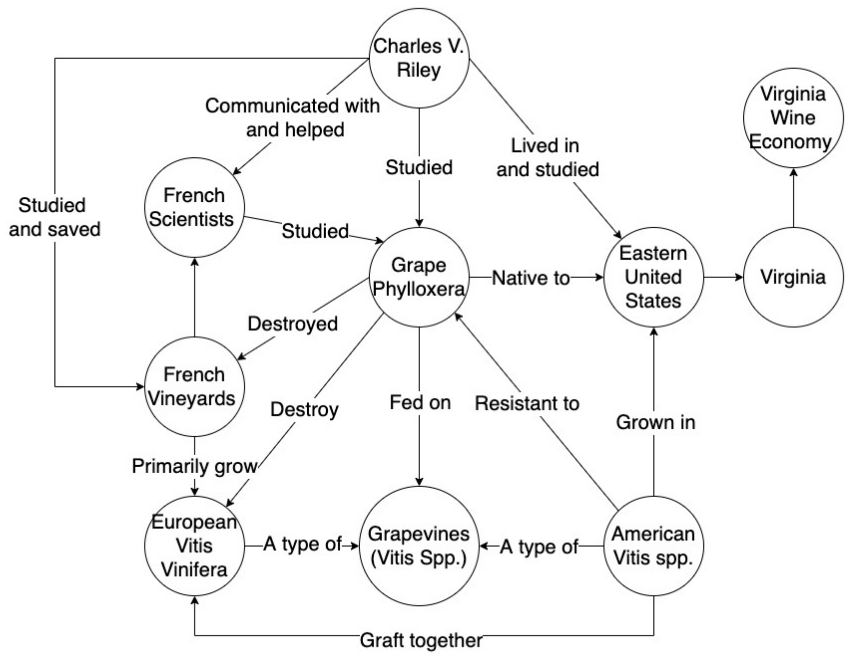

Figure 1: Phylloxera Actor Network (Olson, 2020)

In the research paper "Use of DNA Markers for Grape Phylloxera Population and Evolutionary Genetics: From RAPDs and SSRs and Beyond" authors Javier Tello and Astrid Forneck describe in detail the relationship between different grape varieties the phylloxera (Tello & Forneck, 2019, pg. 1). This paper, along with other evidence, builds the network by solidifying the relationships between the actors phylloxera, and American and European grapevine varieties. The phylloxera, which is an insect that is "native to the eastern North America" and feed on different grape varieties (Tello & Forneck, 2019, pg. 1). The phylloxera have a very complicated life cycle due to their "sexual and asexual reproductive stages" allowing the insect to have genetically complex populations and an ability to adapt based on environment (Tello & Forneck, 2019, pg. 1). These complex populations are able to feed either on the roots or the leaves of the grapevine to survive. When the phylloxera feeds on young or mature structure roots, galls are produced underground which eventually deform and crack, providing an entry way to the soil borne fungi and bacteria, leading to the death of the vine (Lund et al., 2017, pg. 2). Alternatively, when the phylloxera feed on the leaves of the grapevines, galls also form, however they are less damaging to vine health. Therefore, the ability to sexually and asexually reproduce allows the phylloxera to interact differently with various populations of grapevine variety, as seen in the network (Figure 1).

Specifically, with co-evolution the American Vitis grapevines developed "different adaptations mechanism to reduce the damage potentially caused by grape phylloxera, including full resistance, partial resistance, or tolerance" (Tello & Forneck, 2019, pg. 2). One mechanism is that the North American Vitis species allow the phylloxera to "feed on the young root tips and leaves, but prevent destructive feeding on the structural roots" (Lund et al., 2017, pg. 2). However, the same cannot be said about the European grapevine. No co-evolution happened and therefore the *Vitis Vinifera* "structural roots are highly susceptible" (Lund et al., 2017, pg. 2) to the damaged caused by phylloxera. When the phylloxera were introduced to France in 1866, it led to the "rapid destruction of vineyards and the collapse of a wine based agricultural economy" (Lund et al., 2017, pg. 2).

It took 30 years for the French wine economy to recover from the phylloxera. In 1866, there was the first record of phylloxera in France, a vineyard mysteriously withered and died (Pinney, 1989, pg 136). As the insect spread through France, more and more vineyards died as the phylloxera ate the structural roots of the European grapevine. Quickly French scientists began to study phylloxera, labeling it under another name, *P. vastatrix* (Sorensen et al., 2008, pg 136). Charles V. Riley, a British born, American based entomologist in Missouri, was very curious about the devastation happening in France. In 1868 in St. Louis, Riley read the reports about *P. vastatrix,* and other descriptions of the insect, and agreed with other scientists that the insect in America and in France were strikingly similar. The only question was, why did galls form on the roots of the European grapevine, while galls formed on the American grapevine leaves (W. C. Sorensen et al., 2019, pg. 85). In 1870, French scientists “demonstrated that leaf gall phylloxera would rapidly infest the roots of European vines” (Sorensen et al., 2008, pg 137). The experiment with the formation of leaf or root galls confirmed that the phylloxera had traveled from North America to France. Which lead to more scientific exploration about North American and French grapevine varieties in order to explain the difference in the galls. Riley served as a “leading expert on phylloxera, and was able to establish the identity of the North American insect with the unknown creature” (Pinney, 1989, pg 393).

After identitfying that the two insects were actyally one and the same, the scientists set out to understand why native grapes in North America were resistant to the phylloxera, and the French grapevines were not. Riley studied the lifecycle of phylloxera as well as the North American grapevines. While studying the new work of Charles Darwin, Riley concluded that the North American grapevine, through natural selection, had grown resistant to the phylloxera, causing the insects to only fed on the leaves (Sorensen et al., 2008, pg 140). The discovery of the resistant North American grapevine then lead to the explanation of “why attempts to cultivate the European Vitisi vinifera in eathern North Americ has inveriably failed” (Sorensen et al., 2008, pg 141). Through studying the phylloxera, Riley was able to produce a list of resistant North American grape variarites, and “suggested the idea of grafting vinifera to native American rootstocks” (Pinney, 1989, pg 393). Through more experiementation it was determined that the French farmers were able to either plant North American grapevines or the more expensive option of grafting the Euorpean and North American grapevines together. Over the course of several years, it was discovered that grafting the grapevines together, was the optimal solution. Grafting allows the grapes to keep the high quality of the French grapevine, while retaining the resistance of the North American grape. These two scientific explanations, the phylloxera identification, and the information about the North American grapevine resistance, lead to the end of the phylloxera crisis.

The last part of the network is the relationship between the state of Virginia and phylloxera. Virginia always tried to cultivate wine from Thomas Jefferson trying to plant European grape at Monticello in 1770 (Holloway, 1997) to the first settlers that discovered the grapevine native to America produced wine that “tended to smell and taste rank- something like wet fur” (Lukacs, 1996). The early grape growers were unable to cultivate the European grape variety because of the “onslaughts of mildew, rot, flying insects, bacterial infection and extremes of weather” (Pinney, n.d.). As techniques were perfected and with the invention of pesticides, the American farmers realized that the European grapes were not growing due phylloxera. The method created by Riley and other French scientists built in the nineteenth century is still “standard practice today” (Pinney, n.d.). A recent publication from the Virginia Tech University about different strategies to grow grapevines in Virginia states that “all vinifera grapes grown in Virginia should be grafted to a pest resistant root-stock” (Wolf, T. et al. 2009, pg. 3). The authors indicate the reason for this is to provide tolerance of the phylloxera on the roots of the grape (Wolf, T. et al. 2009, pg. 3). This connects the scientific efforts of Riley and other French scientist to Virginia of the 1800s as well as today’s wine industry of Virginia. Virginia is now home to 312 wineries, with wine tourism a driving factor in the Virginia economy, and has experienced 39% growth from 2010 to 2017 (Mariani, 2019) (Reed, 2017). Without the scientific exploration and solution to the phylloxera crisis, Virginia would not have been able to produce the high-quality European wine that is being produced today.

Some limitations of this analysis are in the size and scope of the research topic. The phylloxera spread not only to France but to other wine regions around the world. For this research paper and network, not all of those actors could be included. Another limitation is that Actor Network Theory struggles to understand the sociotechnical elements of the networks (Cressman, 2018, pg. 10). This analysis struggles to incorporate the complex social environment and biases of the French wine industry during the 1800s. Specifically, the criticism Riley and other French scientists faced when trying to use evolution and Darwinism to explain phylloxera life cycles. Additionally, the network was unable to include the biases of American wine and the resistance to adapt grafting or planting American grapevines in France.

This research should be continued to understand phylloxera and it's implication on the wine industry as the phylloxera continues to evolve due to changes in "climate change and novel vineyard management practice" (Tello & Forneck, 2019, pg. 5). The technique for fighting phylloxera is the same now as it was 100 years ago, with most of the hybrids being the same. (Tello & Forneck, 2019, pg. 1). The implications on society have to be further researched in case the phylloxera adapts again and is able to start feeding on the structural roots of grapevines.

Conclusion:

Riley and French scientists played a vital role in understanding the phylloxera and their damage on North American and European grape varieties. These explorations helped shape the current wine industry we see today, especially in Virginia. Without these actors and this network, the French wine industry might have been destroyed. Through the use of Actor Network Theory, the complex relationships between vital players was uncovered, and the significance of scientific reasoning are seen.

Works Cited:

Banerjee, A., Duflo, E., Postel-Vinay, G., & Watts, T. (2010). Long-run health impacts of income shocks: wine and phylloxera in nineteenth-century france. *Review of Economics and Statistics*, *92*(4), 714–728. https://doi.org/10.1162/REST_a_00024

Cressman, D. (2018). Actor-network theory. *The Blackwell Encyclopedia of Sociology* (pp. 1–2). https://doi.org/10.1002/9781405165518.wbeosa009.pub2

Gale, G. D., Jr. (2011). Dying on the vine: how phylloxera transformed wine. Retrieved from http://ebookcentral.proquest.com/lib/uva/detail.action?docID=692424

Lator, B. (1996). On actor-network theory: A few clarifications. *Sozjale Welt,* 47(4), 369-381. Retrieved January 31, 2020, from www.jstor.org/stable/40878163

Lukacs, P. (1996, December). The rise of american wine. *1996*, *47*(8). Retrieved from https://www.americanheritage.com/rise-american-wine

Lund, K. T., Riaz, S., & Walker, M. A. (2017). Population structure, diversity and reproductive mode of the grape phylloxera (daktulosphaira vitifoliae) across its native range. *PLOS ONE*, *12*(1), 1–21. https://doi.org/10.1371/journal.pone.0170678

Mariani, J. (2019). The state of the state of virginia's wines. Retrieved September 27, 2019, from Forbes website: https://www.forbes.com/sites/johnmariani/2019/04/17/the-state-of-the-state-of-virginias-wines/

Müller, M. (2015). Assemblages and actor-networks: rethinking socio-material power, politics and space: assemblages and actor-networks. *Geography Compass*, *9*(1), 27–41. https://doi.org/10.1111/gec3.12192

Olson, S. (2020). Figure 1 phylloxera actor network. *Unpublished manuscript,* University of Virginia.

Pinney, T. (n.d.). A history of wine in america. Retrieved from https://publishing.cdlib.org/ucpressebooks/view?docId=ft967nb63q&chunk.id=d0e364&toc.depth=1&toc.id=d0e93&brand=eschol;query=Wiederkehr

Reed, S. (2017, January 19). Virginia wine industry contributes nearly $1.4B annually. Retrieved September 27, 2019, from Ashburn, VA Patch website: https://patch.com/virginia/ashburn/virginia-wine-industry-contributes-nearly-1-4b-annually

Tello, J., & Forneck, A. (2019). Use of DNA markers for grape phylloxera population and evolutionary genetics: from RAPDs to SSRs and beyond. *Insects*, *10*(10), 317. https://doi.org/10.3390/insects10100317

Sorensen, C. W., Smith, E. H., Smith, J., & Carton, Y. (2008). Charles v. riley, france, and phylloxera. *American Entomologist*, *54*(3), 134–149. https://doi.org/10.1093/ae/54.3.134

Sorensen, W. C., Smith, E. H., Smith, J. R., & Weber, D. C. (2019). Charles valentine riley: founder of modern entomology. University of Alabama Press. http://ebookcentral.proquest.com/lib/uva/detail.action?docID=5808040

Wolf, T., Dami, I., Zoecklein, B., & Warren, M. K. (2009). Commercial grape varieties for virginia. *Communications and Marketing, College of Agriculture and Life Science, Virginia Polytechincal Institute and State University*, 1–48.