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**EVERYTHING YOU KNOW
ABOUT WINE IS WRONG**

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Everything You Know About Wine is Wrong
*--and why that matters for conservation of wildlife
and the environmental sustainability of the industry*

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ABSTRACT

Everything you know about wine is right -- for now. But by mid-century, global changes will have upended conventional wisdom in the wine industry: climate change, shifting global demand, new vinification techniques, and marketing innovations will transform the industry. Climate change will expand the areas now suitable for grape growing into northern latitudes and higher altitudes, while also changing the climates, and thus suitability, of current growing regions. More advanced and intensive manipulations during the vinification process will facilitate winemaking in new areas and allow adaptation in old ones. The desire for European-style wine by China's middle class will skyrocket, fueling global demand that will fund the adaptation needed in both viti- and viticultural sides of winemaking.

This transformation has profound implications for the environmental footprint of the industry and conservation, both in traditional wine regions and in emerging wine-producing areas. The large expansions of vine impinge upon areas of high habitat importance for iconic wildlife, and adaptation to warming and heat stress may mean more water use in current growing regions. Solutions – like those proposed in the Yellowstone to Yukon program and China's Eco-Compensation program—must balance the needs of the wine industry with those of wildlife, and will therefore require extensive and collaborative land use planning.

KEYWORDS

Climate change adaptation, conservation, vinification, China, European wine regions

Everything you know about wine is wrong
*--and why that matters for conservation of wildlife
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Everything you know about wine is right -- for now. But by mid-century, it will be wrong, and here's why. Climate change, shifting global demand, consumer preferences, new vinification techniques, and marketing will transform the industry and upend conventional wisdom. This transformation has profound implications for the environmental footprint of the industry and conservation, both in traditional wine regions and in emerging wine-producing areas.

Things that would ring true to a well-informed wine consumer right now might include:

- Most wine is produced in Mediterranean climates;
- European wine regions are a successful marketing tool;
- China isn't a big consumer of European-style wine;
- Extensive chemical manipulation during vinification is not common in fine wines.

By 2050, each of these statements will be wrong, and the stakes couldn't be higher – for wine, for the environment, and for the environmental footprint of wine production. Let's look at each of these themes in turn.

Mediterranean Wine

Wine has deep Mediterranean roots. While many types of wine are made from a variety of sources (e.g., palms), European-style wine is made from grapes, *Vitis vinifera*, and was already established as a domesticated crop by the late Neolithic (~3500 BCE) in Egypt, Greece, and other regions bordering the Mediterranean Sea (McGovern, 2003).

Mediterranean climate regions are areas with winter rainfall and summer temperatures

above 10° C (Klausmeyer and Shaw, 2009). Outside of Europe, Mediterranean climates are found in California, Australia, Chile, and South Africa. These regions are among the foremost wine producing regions outside of Europe (*State of Viticulture Worldmarket Report*, 2014).

Climate change will change all that. Large areas suitable for vineyards will open up in Northern Europe and Western North America as climate changes (Hannah et al 2013a). These newly suitable areas will outnumber Mediterranean climates in terms of the raw acreage suitable for growing wine grapes. Areas as far north as Montana and British Columbia, including large parts of what is known as the ‘Yellowstone to Yukon’ conservation area, will be suitable for wine grape growing by mid-century.

This isn’t all new –much wine is currently produced in areas that are not Mediterranean climate regions. Famous wine producing regions such as Bordeaux and Burgundy are actually north of the Mediterranean climate belt in Europe (Klausmeyer and Shaw 2009). All wine producing regions of Germany are non-Mediterranean and have long represented the far northern boundary of grape-growing suitability (Ashenfelter & Storchmann, 2010).

Climate change will tip the balance of suitability heavily towards these non-Mediterranean regions. Vineyards are already being established in the Okanagan Valley of British Columbia, in England, and in Tasmania. These non-Mediterranean vineyard areas will continue to expand. Actual vineyard establishment will be driven by market demand as well as climatic suitability; but if demand is strong, suitability projections suggest that more wine will be produced in non-Mediterranean regions than in Mediterranean climates by the middle of this century –less than 40 years from now (Hannah et al., 2013; *State of Viticulture Worldmarket Report*, 2014).

What will happen in current growing regions is less clear. Most wine suitability models suggest that conditions will deteriorate in current wine producing regions due to rising temperatures and water stress (the ratio of demand to available supplies) (Hannah et al

2013a). One of the key models used to predict suitability is based on growing degree days (GDD). GDD can be used to calculate time of grape ripening based on cumulative local temperatures—and thereby to categorize climates based on their suitability for different varieties (i.e. early-ripening grapes, light-bodied wines, full-bodied wines, lower quality table wines, and finally, bulk or fortified wines) (Diffenbaugh, White, Jones, & Ashfaq, 2011). Using unconstrained GDD in projections results in major declines of wine suitability in all current Mediterranean climate regions (Hannah et al., 2013), moving them toward the bulk wine category (Diffenbaugh et al., 2011).

However, the biological effect of temperature on grape ripening may begin to tail off at higher temperatures (Van Leeuwen et al 2013). One way to simulate this effect is to cap GDD above a certain temperature. This, of course, negates the effects of further global warming, since warming above the cap temperature is simply ignored (Hall and Jones 2010). If capped GDD is used, much smaller declines in wine suitability are calculated for Mediterranean climate regions. The truth is probably somewhere in-between, with temperature effects attenuating, but not completely ceasing, at higher temperatures.

Climate change researchers prefer to use uncapped GDD, because it demonstrates the effects of global warming (Hannah et al 2013b). Many wine researchers favor the use of capped GDD (van Leeuwen et al 2013), which captures, but probably over-estimates the attenuation of warming effects. No studies are available that compare capped and uncapped GDD to a true temperature response curve for wine grape ripening. In sum, suitability for wine grape growing will be declining in Mediterranean climate regions at the same time that it is going up dramatically in non-Mediterranean regions, but we don't know exactly how much.

The prevalence of traditional cultivation practices like dry farming could also help mitigate some Mediterranean regions' vulnerability to climate change. Dry-farming eschews supplemental irrigation. In order to sustain grapevines throughout the dry season, growers carefully manage the soil's accumulated moisture via minimal tilling and widely spaced vines with deep root systems (Arnold & Williams, 1999; "Dry Farming,"

2015). Dry-farmed vines rely on grapes' sensitive chemical signaling system, which allows vines to respond quickly to soil drying and/or high evaporation demands by closing their stomata to minimize water loss (Chaves et al., 2010). Anecdotal evidence from a small number of dry-farmed vineyards in California suggests that they are surviving with no (or extremely minimal) irrigation even through the state's four-year drought (Barth, 2014; Haas, 2015; Pierson, 2014; Venton, 2015; Walker, 2007). This successful production under hot and dry conditions suggests that grapes' protective mechanisms, stimulated by dry farming practices, can buffer them against extreme weather. In Mediterranean regions, where droughts are likely to be exacerbated by climate change (Berg & Hall, 2015; Diffenbaugh, Swain, & Touma, 2015), dry farming could allow winemakers to produce high quality grapes even under water restrictions – at least in the near term. Traditionally, European winemakers have believed that irrigation dilutes flavor and eliminates terroir from emerging (Mackay, 2010; Matthews, 2015); as a result, a significant proportion of vineyards in Europe remain dry farmed, which could offer them a competitive advantage under a changing climate as compared to widely irrigated areas like California or Australia (“Dry Farming,” 2015).

Whatever the outcome of the GDD debate on the climate status quo in current growing regions, and however irrigation norms impact regions' ability to adapt to initial temperature changes, there indisputably will be more suitability for wine grape growing in non-Mediterranean climates than in Mediterranean climates in just a few decades (Hannah et al., 2013). So if you think a random bottle of European-style wine plucked from the global production pool is most likely to be from a Mediterranean climate region, you are right, right now – but will likely be wrong by 2050, or sooner.

Wine Regions

Wine regions in Europe are the product of centuries of viti- and vinicultural tradition. At the same time, they are also an effective marketing tool. However, because they equate grape varieties with regions (e.g. Burgundy with Pinot Noir and Chardonnay), they are a marketing tool whose days may be numbered in the face of climate change and changing markets.

The modern formal wine regions in France are not as old as one might think. They date from a little over 100 years ago. French vineyards were struck by aphids (*Phylloxera vastatrix*) beginning in about 1875 (Meloni & Swinnen, 2014). French wine production crashed, falling 70% over the next 20 years. The phylloxera epidemic was a boon to Algeria, then a French territory, which became the world's leading wine exporter. Subsequently, French production rebounded when resistant rootstocks from America tamed the Phylloxera. Formal wine regions were created in the early 1900's and further formalized in the 1930's to help protect the recovering French vineyards and to exclude cheap Algerian imports (Meloni & Swinnen, 2014). A half a century later, production in Algeria was almost non-existent. The French wine regions have persisted even though wine produced in most other parts of the world is marketed by varietal. The regions distinguish French wines and promote them based on *terroir*, unique associations of flavors and place (Matthews, 2015).

France's formative role in global wine culture gave it considerable sway when the EU developed the European Common Wine Policy in the 1960s. EU rules, intended to protect existing growers and limit production of cheaper bulk wine, mirror French policy. Planting rights (i.e. the permission to plant vines for the production of any category of wine) in particular geographic areas are sparingly allocated, and the types of grape varieties used, maximum yield per hectare, and specific wine-making methods are all rigidly specified (Meloni & Swinnen, 2012).

As climate changes, however, vineyards may need to shift to more heat tolerant grape varieties. At that point, the association of variety with place becomes dysfunctional as a marketing tool. Vineyards may find it increasingly difficult and expensive to cultivate current varieties as temperatures rise. For instance, Pinot Noir has a relatively low upper temperature tolerance and may become more expensive to produce in Burgundy than other, more heat tolerant varieties (GV Jones, 2012; Gregory V Jones, 2003). In such a setting, it would reduce production expenses to switch to and market a different varietal.

The association of place (Burgundy) with varietal (Pinot Noir) becomes a marketing burden on the vintner, rather than an asset.

With an expanding number of EU member states, tension between incumbent growers and new producers has grown, provoking heated debate over liberalization of wine policy. In 2007, as part of a larger overhaul of its wine regulations, the EU proposed abolishing planting rights by 2013. The major wine producing states, led by France and Germany, immediately protested – delaying any changes until at least 2015 (Meloni & Swinnen, 2012). In the new EU rules published in April 2015, the European Commission appears to have come to a compromise: starting in 2016, the planting rights system will be replaced by planting authorizations, which will still be managed at a national level but will allow for an annual expansion of 1% of total vine area (COGEA, 2014; “European Commission Publishes New Vine Planting Rules,” 2015, “The EU System of Planting Rights: Main Rules and Effectiveness,” 2012). This allowance for limited growth appears to come in part as a response to an external study predicting growing demand for exports and the recognition that the status quo has left Europe ill-equipped to achieve increased penetration abroad (COGEA, 2014).

Traditional wine regions’ resistance to change makes sense: the planting rights-based regulations have long created a system favoring their high-end wines. These regions’ decisions now, however, could have long-term implications for their ability to adapt in the face of climate change. In fact, given their current marginal climate, German vineyards’ grape growing days (GDD) and therefore, their overall suitability is likely to increase, with a 1° C increase in temperature predicted to increase prices by about 20 percent (Ashenfelter & Storchmann, 2010). A more flexible system allowing all Europeans to expand production would only be to their benefit.

China

China is big. But as a whole, its population isn't big on European style wines. Grain-based alcoholic drinks (e.g., beer or rice wine) are more popular with meals (Cochrane et al 2003). The consumption of grape wine for any reason remains modest compared to consumption of other alcoholic beverages in China.

But beneath this mass indifference to European style wines lies an undercurrent of interest with vast portent for global demand (Thorpe, 2009). Among imports to China, European wines show the highest growth rate. Upper class Chinese now demonstrate an intense and growing interest in European style wine (COGEA, 2014). Chinese bidders are driving up the cost of high-value bottles of wine at auction in Europe, and becoming active players in purchasing vineyards in Europe and elsewhere (Espinasse, 2012; Reyburn, 2013). Numerous studies suggest that, for Chinese, country-of-origin is more important than any other factor in purchasing fine wine (Balestrini & Gamble, 2006; Lee, Huang, Rozelle, & Sumner, 2012): two thirds of imports come from the EU and more than half of those from France (*State of Viticulture Worldmarket Report*, 2014). The importance of *mianzi*, or maintaining face, in Chinese culture all but mandates that, if wine is served for guests or on important occasions, it be French red wine (Liu & Murphy, 2007; Somogyi, Li, Johnson, Bruwer, & Bastian, 2011; Yu, Sun, Goodman, Chen, & Ma, 2009). Indeed, Chinese consumers are often unaware of the existence of white wine or believe it to be less healthful (Liu & Murphy, 2007).

Chinese elites are demanding more fine wine. But they're not the only ones pushing this trend: Chinese government policies since the 1980s have encouraged popular interest in wine. The government sees advantages in swaying its population away from traditional grain-based liquors, like baijiu; Beijing has progressively increased consumption taxes on high alcohol spirits with that intention (Jenster & Cheng, 2008). Market analyses report increased consumption of wine by women. Particularly with the growing numbers of females in the workforce, where business drinking is the norm among colleagues, the lower alcohol content of wine could create a friendlier atmosphere for women trying to

establish themselves (Pingali, 2011). In addition, increased wine consumption could address food security issues: the more the government can guide the populace toward fruit-based liquors, the more rice and grain can be reserved for human consumption (Brown & Halwell, 1998; Jenster & Cheng, 2008).

In addition, China is the fastest growing producer of European style wines in the world. It is already one of the five largest wine producing countries and produces 15% of the world's wine grapes (*State of Viticulture Worldmarket Report*, 2014). In 2013, Chinese wine producers, a highly concentrated cadre, had enough clout to convince the government to launch anti-dumping and anti-subsidy probes on wines from the EU (Lin, 2013). The move was widely seen as a response to an EU decision to impose high tariffs on imports of Chinese solar cells, but the Chinese won the skirmish in that it elevated visibility of Chinese wine production and secured them promises of technological assistance from European winemakers ("European Commission - PRESS RELEASES," 2015). This is not a wash for the Europeans: the European Commission has identified one of the keys to expanded exports in China as "better informed and more experienced consumers" (COGEA, 2014). Enhanced education of Chinese consumers and experience in winemaking in China could foster an eager and informed market --exactly what Europe will need to tap China's thirst.

As this interest in European style wine makes its way from the upper classes to the growing middle class in China, a huge surge in global demand is likely to follow. The middle class in China numbered about 230 million in 2014 (Theil 2014). By 2022, that number is likely to be 630 million, three-quarters of urban Chinese households and forty-five percent of the total population (Barton, 2013). If this largely urban future middle class consumed wine at even half the rate of the American middle class (23%) (Gallup 2012), it could represent nearly 75 million wine consumers within the next decade.

If you currently think China doesn't matter much in global wine markets, think again.

Chemistry in vinification

Vinification is moving from art towards science. Complex manipulations are now allowing premium wine to be produced from grapes grown under less-than-optimal conditions – both at the cooler and warmer ends of the temperature spectrum. Increasing suitability for wine grape growing in Northern Europe or the Yellowstone to Yukon region of North America may not be optimal for several decades, but it will be improving, and vinification can help bridge the gap until optimal conditions arrive. For instance, although these cooler climates often produce higher acid grapes, experimentation with different winemaking procedures has identified techniques that force increased precipitation of tartaric acid, producing a more balanced wine (Baiano et al., 2012).

Wine from Montana doesn't sound so wild, when you consider the results of a blind wine tasting now known as "the Judgement of Princeton" (Ashenfelter 2012). The test pitted New Jersey wines (yes, New Jersey wines!) against French wines, judged by a panel of French and American wine experts. The format was modeled on "The Judgement of Paris," the taste-off that helped launch California wines into prominence in the 1970s. In the Judgement of Princeton, the scores for the New Jersey wines were statistically indistinguishable from the French wines (Ward 2012). This doesn't mean that New Jersey wines are as good as French wines. What it does mean is that if experts can't reliably tell them apart, consumers probably can't either. This result wasn't because New Jersey is great wine making country, but rather because vintners have learned to make use of a combination of vinification and what the land has to offer to make good wines.

While extensive manipulation of the grapes is accepted in the production of bulk wines, especially those grown in suboptimal regions, any discussion of viticultural modification becomes considerably more tense when applied to fine wine from traditional growing regions. Most elite winemakers agree that a wine's potential for quality is determined by the grapes, and that while a winemaker can accentuate and further develop those flavors, the grapes make the difference between a great wine – and everything else (Nicholas,

2015). These ideal grapes express terroir, the qualities of the environment and the soil they grew in, and are therefore unique to a particular vineyard. To suggest that adjustments in the winery could significantly improve or alter a wine thereby challenges a central dogma of winemaking (Matthews 2015). Researchers are beginning to test this belief, however: a recent assessment examined the impact of both natural characteristics of each vineyard (i.e. facets of terroir) and technological choices made during wine production on quality ratings across Haut-Médoc, home to some of the most highly prized wines in the world. The conclusion? Technologies definitively impact wine quality and price, whereas natural endowments do not seem to matter – or at the very least, are not reflected in critics’ assessments of the wines (Gergaud 2008).

While tradition creates a strong preference for minimizing manipulation of the fruit, winery interviews in Napa revealed widespread acceptance of techniques to adjust sugar and acid levels (Nicholas & Durham, 2012). Vinicultural adaptations to heat stress are increasingly common, even as they remain controversial among many purists (Nicholas & Durham, 2012). Too much heat exposure can leach the grapes of acid and result in very high alcohol wines. Acidification and de-alcoholization of wines via reverse osmosis provide easy, inexpensive, and rapid responses to making wine in warmer years, but in the long run, these techniques’ capacity to provide adaptation to ever larger changes in temperature is limited (Nicholas & Durham, 2012).

Simultaneously, scientists seek to understand the basis for the more complex components of wine—the aroma and flavor compounds—which decrease in grapes at increased temperatures (Nicholas & Durham, 2012; Nicholas, 2015). New techniques and methods in the winery are being studied for their potential to accentuate these aromas through vinification (Cai et al., 2014; Liang, Chen, Reeves, & Han, 2013; Loira et al., 2013). As global warming increases, it will be interesting to see whether the science necessary to preserve the nuances enjoyed in fine wines can keep up – and whether fine winemakers will adopt it without feeling that it compromises their wines’ integrity. A question: at what point will winemakers choose to switch to more heat-adaptive varieties rather than rely on vinicultural manipulations to their already established grapes?

With advanced vinification, wine from anywhere – even Montana – could be palatable to consumers and competitive in the global market. This result swings the doors wide open to wines from all sorts of places – and lots of new places will become suitable for wine due to climate change. In a growing global market over the coming decades, more-- and more scientific-- manipulations of the grapes will likely become more common during the winemaking process.

The Future of Wine

One way to read these developments is that there will be major shifts in patterns of wine production and consumption this century. This future for wine predicts much more wine produced in the Northern Hemisphere, much more wine consumed in China, and increased environmental pressure in both newly suitable areas and traditional growing regions.

The expansion to newly suitable areas is well underway – that part of the future of wine seems assured. Vintners exist in British Columbia and Montana, not far from Yellowstone National Park and in the area conservationists call the Yellowstone to Yukon (Y2Y) conservation areas. Some of these vintners are buying their grapes from vineyards to the south, but others are fully operational vineyard-to-bottle wine estates. Horticultural scientists are actively studying which varieties are best adapted for these new areas (Reynolds, Cliff, Wardle, & King, 2004; Shellie, 2007). Land in Tasmania is being purchased for vineyard installation by large beverage corporations, and the state government has prioritized the wine sector for development (Smith 2013). Winemaking is expanding in the UK and gaining footholds in northern continental Europe. These expansions are constrained by soil, economics, and in some cases, water. Even with these limitations, they are already occurring on a large enough scale in these regions that it seems very probable that, with continued improvement of climatic suitability, vast areas will be in vine in the coming decades.

Given the increased climactic suitability, vineyards will also appear in parts of the tropics that currently produce little or no wine. These regions are mostly tropical mountains in the Andes and the rift mountains of Africa (Hannah et al., 2013). Rising global prices will mean that wine production with intensive vinification will be profitable in these areas, even if the wine produced is mostly in the bulk category and intended for local consumption.

Growth of both wine consumption and production in China seems highly likely as well. Government officials in Sichuan, which harbors the country's best wine suitability, are promoting the region as a destination for installation of European-style wine vineyards (Chen 2013). As affluence and the middle class continue to grow in China, interest in European-style wine should blossom.

The rise of consumption in China will create market conditions that soften the economic impact of declines in suitability in traditional growing regions. Robust demand will mean rising prices globally, and profits will help pay for vineyard adaptation measures against rising temperatures. Drought-resistant rootstocks, re-trellising and other measures to reduce the impacts of climate change all cost money. But if prices rise, these measures will be affordable. Mediterranean climate regions can then continue to be major wine producers, even if conditions aren't what they once were.

Viticultural choices—farming and planting methods like irrigation, evaporative cooling, increased shading, or other alterations of the vineyards' microclimates—could make all the difference (Nicholas & Durham, 2012). A study on adaptive potential in the western US wine industry suggests that if these methods could be used together to increase the severe heat tolerance from 15 to 30 days during the growing season, losses of premium wine acreage could be reduced. By examining projected temperature change on a county level, combined with the sensitivity of the grape varieties grown there, this research suggests vineyards could quantify just how much and what kinds of adaptation measures are necessary for their specific geographic locale (Diffenbaugh et al., 2011). Particularly

given the potentially steep trajectory of temperature changes, this could give winegrowers the crucial time needed to adapt, rather than waste time and money tinkering with trial and error (Nicholas & Durham, 2012). Of course, some of Europe's ability to adapt depends on its own willingness to adopt new technologies and varieties that will ease winemakers' transitions. France and Germany's aversion to policy change leaves their fate an open question.

Implications for Conservation and Eco-friendly Wine

Ongoing climate change clearly represents a major challenge to the status quo in wine: it will compel changes in where and how grapes are grown and ultimately, how wine is crafted. But these are not simply economic changes. How the wine world proceeds will also have significant impacts on nature, conservation, and the environmental footprint of the industry. The large expansions of vine impinge upon areas of high habitat importance for iconic wildlife. Adaptation to warming and heat stress may mean more water use in current (especially Mediterranean) growing regions (Fischer, Tubiello, van Velthuizen, & Wiberg, 2007). Tropical montane vineyards will be competing for space with the most biologically rich and unique ecosystems on the planet (Meyers et al 2000). How the industry handles these challenges will go a long way to determining the future environmental footprint of winemaking and consumer and public perception of the environmental friendliness of the industry.

Iconic wildlife in the path of coming wine expansion includes giant pandas, grizzly bears, mountain lions, Andean bears, and macaws. The regions of greatest concern are the southern part of the Yellowstone to Yukon (Y2Y) conservation area in North America and panda habitat in the mountains of China.

Pandas haven't had much to worry about from wine until recently, but they have been impacted heavily by all other sorts of agricultural development. The giant panda once ranged over most of China but is now confined to small mountaintops in Sichuan and

other central provinces. These montane areas harbor the best land for wine grapes in China, today overlapping and in a warming future, possibly eclipsing panda reserves and habitat. Panda reserves themselves won't be developed for vineyards, but surrounding forest areas can be. Under forest tenure reform currently unfolding, nearly 20% of the remaining non-protected forest fragments in panda habitat could be converted to agriculture. Wine grapes are one of the leading candidate crops (Yang et al 2013),

On the other side of the world, wine grape suitability will be expanding due to climate change in parts of Montana, Idaho and British Columbia, on lands that are important in the Yellowstone to Yukon (Y2Y) conservation effort. Y2Y is an effort to link parks, government lands, and private land in ways that give bears (black and grizzly), mountain lions, elk and other large mammals the access to habitats that they need to survive (Pearce 2008). All of these species cover large areas, moving from summer to winter pasture (elk and other ungulates) or foraging for food in the summer to prepare for winter (bears). Vineyards going into these areas would mostly replace ranchlands. Compared to ranchland, vineyards create a much greater barrier to the movement of large animals: they replace native vegetation and may have to be fenced to prevent wildlife predation on grapes. Expansion of the wine industry in this region therefore presents a challenge to the goals of Y2Y and the survival of wide-ranging species in the area.

In current Mediterranean growing regions, rising temperatures will cause heat stress that may result in elevated demand for water for purposes of both irrigation and adaptation strategies like evaporative cooling (Diffenbaugh et al., 2011; Hannah et al., 2013). Most of these Mediterranean regions are already under high water stress. The increased water demand from vineyards could lead to social conflict, or, if increased withdrawals come at the expense of stream water levels, result in damage to local ecosystems. A high proportion of fish and freshwater fauna are endangered in Mediterranean systems, so increased vineyard water use for cooling or irrigation may have impacts on highly sensitive systems.

14 Percent Solutions

Lions and pandas and bears – oh my! Is this really the future of wine? Do we have to choose between a nice red and the world's great wildlife habitats?

Fortunately, there are solutions available, especially opportunities for the industry and conservationists to work together to find solutions in advance of the coming changes. Many of these solutions require planning of land use, so multiple vineyards must be engaged in action. This contrasts with earlier environmental issues tackled by the industry, which focused on pesticide use, carbon footprints, and sustainability practices – all of which were under control of individual vineyards. The new challenges mandate group action, which will require more conversation and increased information sharing.

In China, the solution comes in the form of a government Eco-Compensation Program (Yang et al 2013). This program operates with farmers participating in the new forest tenure reform. It buys back development rights for forests that provide key ecosystem services, such as flood or landslide protection. This program could be extended to panda habitat that might be lost to vineyard development under the tenure reforms (Yang et al 2013). The area involved is tiny relative to the total area suitable for wine grapes in central China but is a significant amount (10-15%) of remaining giant panda habitat. Thus, impact on the development of China's wine industry would be negligible, while impact on survival prospects for the highly endangered panda would be substantial. The Eco-Compensation Program is a \$100 billion effort, so the necessary level of resources could actually be directed to help wine and pandas coexist.

In North America, the solution in the Yellowstone to Yukon region is more complex, but the Y2Y effort itself is a strong foundation. The participants in the Y2Y program include government agencies, private landholders, and conservation groups. They work together to plan land acquisitions in areas critical to wildlife and to harmonize planning between national parks, multiple-use forestlands, and private land holdings. The wine industry in the region is nascent, so it is not yet a significant player in Y2Y. But that will change as

climatic suitability for wine improves. Y2Y will need to identify developers seeking land for vine in the region and engage them before they become established. Members of the wine industry need to be made aware of the Y2Y effort and seek advice when planning land acquisitions. This can help concentrate vineyard development in existing agricultural lands and create mutually accepted areas in which movements of large animals can be prioritized.

Northern Europe can benefit from similar collaborative planning efforts. Although much of the region is already used for agriculture, some forest areas and wildlife habitats might be replaced with vine in the absence of advance planning. Formerly local or national conservation efforts may need to expand in scope to adequately plan for broad-scale expansion in the Northern European wine industry.

Mediterranean climate regions already have collaborative planning efforts underway, prototypes that wine-growing regions could use as models. In South Africa, the Biodiversity and Wine initiative is a joint effort of multiple vineyards and multiple conservation groups, working to define vineyard expansion avenues that preserve the rich local plant diversity, notably proteas, a genus of South African flowering plant (Biodiversity and Wine Initiative 2012). As climate changes and wine suitability moves upslope into remaining natural habitats, this planning collaboration will pay off again. The initiative has even resulted in an environmentally-themed marketing campaign, “Diversity is in our Nature”. In Chile, the Biodiversity, Wine, and Climate Change program aims has similar collaborative planning goals, with climate change adaptation explicitly included as a goal (Viers 2013).

These collaborative industry-conservation initiatives are the next wave of environmental consciousness within the wine community. The first wave of environmental awareness focused on issues that can be controlled at the level of individual vineyards, such as pesticide use, greenhouse gas emissions, and green best practices. The industry is justifiably proud of the progress that has been made in all of these areas.

As climate change impacts manifest themselves, changing the very terroir of each vineyard, the industry will face a two-fold environmental challenge: it will have to address land use change and expansion and its implications for wildlife, as well as increased water demand. Dauntingly, these are not changes controlled by any one vineyard but rather cumulative impacts of the actions of several, or several hundred, operators. Reducing negative impacts requires collaboration between vineyards, as well as between the wine industry and conservation groups—presenting both a new challenge and a second opportunity for the wine industry to be a pioneer in environmental solutions.

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