Winegrape ideas from reading the literature

**Misc**

Winegrape vines take 4-5 years to reach reproductive maturity, and can renmain economically productive for 50-60 years (common knowledge? See Bindi et al 1996). So planting varieties that will be able to adapt to predicted climate in teh future is important. Not much scope for quick turnarround of varieties, need planning in advance.

Historically, winegrape grwers have adaptively made changes to viticultural partices in light of climate change (Ashenfelter and Storchmann, 2016 – economic).

vanLeeuwen and Destrac-Irvine 2017 – a good general overview of how viticulture can adapt to climate change, mostly by getting vines to veraise later

vines will verase 16-24 days earlier by teh end of teh centtury in comparison to now Duchêne et al 2010 (for GW and RI in france). Also bigest changes predicted in teh first half of teh century.

Ferguson et al 2014 – estimated day of bud-burst, initial hardiness and maximum hardiness were all positively correlated. More hardy varieties in winter then tend to budburst earlier in the spring.

If I have enough data, I would like to look at the variation due to root stock and clone. What capacity is there for retaining a variety but still adaptive planting?

The ideal window for harvesting grapes in the northern hemisfer is 10th September to 10th October. Because of climate change some wines like Merlot and Sav blanc wont be so high quality in Bordeaux because their picking dates earlier than 10th September. Van Leeuwen et al 2019. How do we adapt to this?

1. plant later ripening varieties (but European regulations and market demand)

2. Plant later ripening clones

3. Change rootstock. Data is scarce though.

4. Increase Trunk height so vines dont get as warm in the summer (how does this affect their winter hardiness?). vanLeeuwen and Destrac-Irvine 2017 and vanLeeuwen etal 2019 talk about a special golblet growing shape that helps, but you cant mecanically harvest.

5. Reduce leaf area to fruit weight ratio. Fewer leaves mean less sugar accumilation in teh berries during verasion. More applicable for white wine than red

6. Late pruning in winter delays budburst in spring by a few days. Still quite experimental though.

Could any of the viticultural practices employed to encourage later ripening also affect the vines ability to maintain winter hardiness? Perhaps a problem for places like the okanagan where summer temperatures are already high

Increased droubt likely because warmer and more evapotransporation. This can have positive or negative effects on wine quality, depending a lot on how extream the conditional already were. Van Leeuwen et al 2019.

How much clonal variation is there in winegrape winter hardiness? There is quite a bit for sugar accumilation dynamics (van Leeumen et al2019 fig 8) and sugar accumilation plays an important role in hardiness

what about clones? Chosing the right clone is a powerful tool to deal with drought stress (V), so maybe for winter hardiness too?

Blueberriy varieties that were more cold hardy also tended to require more chilling (Arora et al 2004)

Is there a relationship between maximum winter hardiness and ideal growing temperatures? See Ashenfelter et al 2016 for a plot of variety optimal temp for growing.

There is some capacity for breeding more appropriate varieties, but it willl only help so much. Duchêne

et al 2010 found that crossing varieties was insufficient to breed varieties in Alsace that woudl reproduce wine charicteristics into the 2nd half of thh 21st century. Mayeb better to switch varieties altogether? Also this paper explains nicely teh problem of optimum ripening temperatures shifting later in teh sason but verasion dates shifing earier due to warmer temperatures

changes in the duration of periods between flwoering and veraion in Reisling in Alsace (Duchene and Schneider) no clear change for budburst-flowering. Also dry summers may cause problems.

Hannah et al 2013 – looked at projections of where will be suitable for winegrapes considering climate change. They predict that the area suitable will change a lot, and this will probably cause conflicts with biodiverity/ecological conservation.

**Climate Modelling**

I could frame a question around predicting species’/varaiety’s niches? Thsi might be more ecological? About how difficult it is based on a one or a few climate variables. Focus on suposed increases in where wine can be grown in teh north because winter temperatures are getting higher, but what about teh influence of increasing heatwaves, drought and false springs? Also how does considering within species variation change the answer? But what if better adapted varieties cant reach new areas? Also how much can we infer about changes in summer heat/drought from changes in winter temperatures? Do places generally increase winter and summer temperatures teh same amount? Does something weird happen in spring? Might there be more extreme fluctuations in climate? Are microclimatic differences consistent across seasons?

Are more cold tolerant species more or less sensitive to heat/drought? Maybe some tradeoff? This will matter when considering new areas to grow grapes.

What about the potential affects of lack of chilling in warmer winegrape regions? See Luedeling et al 2009 about this problem in trees

Could vineyards use micro climates within regions to find the perfect balance of warmer winters without too hot summers? Maybe a slope aspect or something? I could take a look at this by seeing if there are any small scale climate patterns in which areas will be most suitable. I.e. mostly a particular facing slope or something.

Fraga et al 2016 – overview of projected changes in climate (and other stuff) and how this will change viticulture in Europe. More yield in France. Can gro grapes in UK. Spain will have lower yield. Changes in phenophases. Also strong regional heterogeneity.

How should i deal with climate modeling uncerainty? Deser et al 2012.

weather stations local but outside the vinyard dont give perfect results – they can overestimate or underestimate max and min daily temperatures (Antivilo et al 2017)

Blanco-Ward et al 2017 analysied climate change and portugese winegrapes. They focused on the number of summer days with Tmax >25degrees C, the number of very hot stressful days with Tmax > 35, CSDI-cool spel duration index, WSDI – warm spell suration index, R10 – number of days with heavy precipitation (daily > 10mm), CED – maximum consecutive wet days >1mm.

Blanco-Ward et al 2017,s modelling suggests significant advancing verasion (22days) without noticable chang ein variance. Also more days that are too hot, and greater variation in this.

Small spatial extents can have very different climates (Courault and Ruget, 2001)

the heat requirements of different phenological stages were independent accross varieties (Duchêne et al 2010). So a variety that only needs a littel warming in teh spring to burst bud may need a lot of warming to flower or veraison? Does thsi mean selecting the optimum variety will be more compicated? Are there varieties that are equally cold hardy in winter but have quite different requirements for summer warmth to verase?

Winkler Index – bioclimactic index to classify winegrowing regions based on the thermal requirements of winegrapes. Calculated from the sum (between April and October) of the daily average temperature exceeding 10 degrees c. How well does this index describe the climactic variabilty within the valley in Washington or the Okenagan valley?

In the Mediteranian basin, spring and summer are predicted to warm more than autumn and winter (Ferrise et al, 2016). Is that teh case in my datasests too? Does this mean that enouph warming in winter to decrease frost damage will mean too much increase in temperatures in summer so a bad quality crop? Also temperatures increases are patchy. Also entire grapevine growth cycle shortened between 6-10 days on average. This is a problem because shorter time to grow means less yeild of grapes.

Need to consider the effect of higher CO2 alongside warming conditions.

Winegrape hardiness is closely linked to daily maximum and mean temperatures, rather than minimum temperatures (Hubackova 1996).

**False Springs**

Could I get at which varieties are going to be less vulnerable to false springs?

How much of a problem will false springs be? Will they be more of a problem for areas that are only just getting warm enough for planting? Will this cause problems if you need to plant a very hardy vine but then it is more susceptible to false springs? \***\**need more research on false spring modelling*\***\*

Most damage to crops occurs during spring frosts or autumn heat waves (Charrier et al). SO this is where my model need s to be most accurate?

Phenology - Do I see evidence that more cold hardy varieties budburst earlier? (see Ferguson et al 2014). If so these varieties may be MORE cold vulnerable in spring than less hardy varieties

How will earlier budburst dates interact with potentially more common false springs or late winter frosts (tardive frosts)? See Sgubin et al 2018 for more info on this. How regionally variable is this?

**Trait Plasticity**

Does the same vine reach the same hardiness each year, conditional on temperature? Does the same variety or clone? How plastic is cold hardiness?

What about how variable varieties are between sites? If I take teh same varieties, and look at how they differ relatively at different sites, will some varieties differ more? I.e. be more plastic? Or are acc/deacc rates unchanging?

**How does winter hardiness correlate with other important things?**

What would i expect it to correlate with? What is an important thing?

\* heat and/or drought tolerance. Will new areas really become available because of warmer winter temperatures, or will these areas become to extreem during teh summer?

\* Wine quality/verasion timing/phenology

\* yield

\* where does cold hardiness fit into syndromes?

\*what trade-offs are there physiologically in becoming and maintaing cold hardiness?

Ferguson et al 2014 – more variation in Hc max than Hc initial between varieties. Doesn't that suggest that some varieties must get hardier quicker? How does that work physiologically, and what are the costs of this? Does microclimate affect the rate of change of hardiness in relation to temperature? Or will Riesling always get (for example) 1 degree more cold tolerant for a unit of chilling wheras Merlot only 0.5 degrees of cold tolerance? If rate does change, would I expect more variation for a hardier grape? If the rate is invariable I would expect less between site variation (if micro climates are taken into consideration).

**Modelling**

Processed based modelling – can I think of a simpler one that would still work?

Should I focus on maximum hardiness or the rate of deac/acc? (related to potential risk of False Springs vs very cold periods midwinter). Charier et al mentioned that it has been observed that maximum hardiness achieved in winter is not dependent on environment (need to take another look at this).

The Feguson 2011 model was not good at predicting late winter/spring hardiness. It tended to overestimate hardiness a lot because the model didnt understand the physiological changes taking place as vines get ready for budburst. The 2014 Ferguson model estimated hardiness based on phenological stage for the spring temperatures, and that seemed to work better. They said that LTE values derived from the lab were not correct for buds that were not dormant – something to do with water chemistry I think?

Maybe have a model that has two different rate periods, one before spring bud physiological changes move to budburst, and one after this point. But how would i estimate this pivot date?

Maybe i could include a logistic component to my regression (like Fegusson et al 2011) to stop harciness increasing linearly when it’s really cold?

Lenz et al 2016 - in trees, budburst happened a certain number of days after the last time temperatures went below the freezing tolerance of new leaves.

Could I just include a model estimating chilling requirement and budburst (i.e. Caffera and Eccel 2010) and include that as teh dates when i expect rates of change of hardiness to change?

Caffarra and Eccel 2010 – model chardonay phenology using three submodels (budburst, flowering and verasion). Model suggests phenotypic plasticity because mountain vines didnt react the same as all the non-mountain vines

Cortazar-Atauri et al 2009 modelled budburst for varieties in France, and found models considering dormancy outperformed those not considering dormancy

maybe i should have two slopes year year, one for accimation period and one for deaclimation period? I woudl need to choose the switch from end to ectodormancy though, i guess. And still need to account for non-linear relationship at extreme values

Could I just use a break point model to get a slope for autumn and a slope for spring? Bet breakpoint to midwinter or to change to ectodormancy?

Maybe I could have a transformation so that teh relationship is not linear? Vines acheive winter hardiness using supercooling of intracellular water (see Kovaleski et al 2018 intro), and the maximum hardiness possible with this mechanism is 40 degrees C. (Biggs, 1953 in Kovaleski et al 2018 ). Maybe I could use this number in teh non linear transformation?

Maybe uses a logistic regression? Kovaleski et al 2018 used a logistic regression to get deaclimation rate. Can it be used for non binary data?

Kovaleski et al 2018 found that different varieties of winegrape had different rates of deacclimation

**Physiology/ mechanisms**

Energy is necessary to drive acclimation and sugars play an essential role in freezing tolerance, the

resiliency of photosynthesis under stress conditions and how photosynthates are utilized (growth vs acclimation) also need to be better understood (Gusta and Wisniewskib 2012). Could there be a growth cost to being more cold hardy? Do more cold hardy vines produce smaller yeilds?

Proteins work in concert with sugars to establish cold tollerance. If plants havent got enouph sugars (carbohydrates) from the growing season then they cant be cold hardy ( Gusta and Wisniewskib 2012).

There is a model based on carbohydrate amounts in cells that models cold hardiness in Walnut trees

What are teh physiological differences between a more and a less cold hardy vine variety?

Lots of references in Lenz et al 2016 about how budbreake is closely related to loss of winter hardiness. Expect more cold tolerant leaves to mean earlier budbreak because the risk of frost is lower. Is that why ,ore cold hardy vines budbreak earlier? Or do they budbreak earlier for other reasons? Are the leaves of more generally cold hardy varieties more cold hardy too?

Lenz et al 2016 – suggest freezing resistance is rather fixed trait in trees. Freezing resistance was very similar amoung distinct populations of teh same species. SO its easier to adjust leaf-out date than how cold hardy your leaves are.

Phenological response to temperature seems to be quite plastic based on elevation. For example budburst should change based on climate conditions (see Caffarra and Eceel 2020). So should hardiness be plastic also? - Yes. But should the rate of acc/deacc also be plastic? Maybe this relates to the physiological mechanisms underpinning winter hardiness?