Notes on Geomorphology and STZ

steppe

The effects of climate on plants is mediated both directly and indirectly by landforms, and directly by soils, across a range of spatial scales (Giaccone et al. 2019, Moesland et al 2013, Swanson et al. 1988). Landforms directly influence climate to produce micro-climates such as cold pools (e.g. in valleys) and micro-rain shadows (e.g. by mountains and ridges), resulting in variation in evapotranspiration and soil moisture availability gradients in even (Pastore et al. 2022, Minder et al. 2008). Topographic slope and aspect control the amount of incipient solar radiation altering both soil temperatures and soil moisture, affecting both soil moisture and soil microbial composition and activity (Dearborn and Danby 2017). Topographic features have also been shown to influence the amount of soil water availability, at various depths and across time, by altering the amount of overland, and subsurface, water flow leading to areas with either elevated or reduced amounts of water (McAuliffe 1994, Wondzell et al. 1996, Qui et al. 2001). Soil water content has been shown to be influenced by the amount of coarse fragments in soil (Katra et al. 2008), as well as soil textural (English et al. 2005, Fernandez-Illescas et al. 2001, Singh et al. 1998), and chemical properties (e.g. carbonates, and soil organic carbon) (Duniway et al. 2010, Rawls et al. 2003). Collectively, these factors can lead to an apparent decoupling between the resolution of climate variables generated by spatial modelling and interpolation approaches, and the responses of plant populations (Potter et al. 2013, Lenoir et al. 2016). However this apparent discord in scale may be ameliorated by a proactive approach many steps of which are already utilized by STZ developers.

Section 1.

The direct effects of topography on climate are a well known phenomena and a variety of approaches for downscaling gridded climate data from moderate resolutions (e.g. ~800m, ~1km) to fine resolutions (e.g. 30m) have been developed (Potter et al. 2013, Wang et al. 2016). Essentially these models ... They can be used by analysts to develop high resolution gridded surfaces which can be used to help explain Indeed, this approach is already implemented by a majority of researchers (e.g. Johnson et al. 2017, St. Clair et al. 2013, Shyrock et al. 2017). However, Given recent advances in computational power, predicting fit eSTZ models onto similarly high resolution surfaces is now an achievable task for most research groups. However, while these tools are more effective for modelling the variability in localized climate, they do not address the localized effects of geomorphology on precipitation which has reached the soil surface.

Inclusion of landform characteristics, such as topographic position, and topographic wetness indices, aspect and slope are achievable with data products such as (Geomorphon 90,), or may be rapidly calculated using a variety of GIS... Given recent advances in remote sensing, in particular LiDAR, these products - especially the latter have great accuracy, and as covariates may help explain responses between populations; for example many populations from more arid portions of ranges may actually be located in refugial areas (e.g. northern facing toe's of slope) where they are buffered from the realized micro climate. High resolution soils data are available for a variety of physical and chemical components, as well as soil moisture, however in our experience these data are less accurate than the aforementioned topographic data sets due to a lack of equatable remote sensing approaches (Hengl et al. 2017, Vergopolan et al. 2021).
Gibson et al. 2019 used soil covariates from the SSURGO data base and found variables which moderate soil water content, such as soil organic carbon and percent clay, and were able to decrease variance in models relating common garden results to source populations. However, within their region of analysis the climate only models suggested three zones, and the the climate + soil models generated eight zones with four of them collectively constituting less than 5%, relative to XX pSTZ (*REED GET THIS NUMBER*) treating the same area (Bower et al. 2014). While utilization of these covariates may increase predictive abilities they may also create more seed zones than are practical, and their incorporation may require post processing steps

where STZs with very small total geographic coverage are removed from downstream applications, e.g. by reassignment to their nearest neighbors.

Note that, aside from 'extreme' or harsh soils such as mine tailings and serpentine, evidence for adaption of plant populations to individual soils appears to be seldom documented in the literature (Macel et al. 2007, Ellis & Ågren 2024, O'Dell & Rajakaruna), indicating that most populations for most species appear suitable for restoration sites.

Finally, maternal effects may manifest in common gardens . . . . These may be captured and better controlled for by incorporation of these variables under certain modelling frameworks (ASK FRANCIS!).

Section 2.

Restoration practitioners, when presented with multiple seed source options for a restoration and which have similar climate similarity to the site, have expressed interest in matching seeds using additional criteria. In scenarios where a practitioner has reason to believe that a population from a soil with more similar textural properties is desired spatially modelled products such as SoilGrids can be used to determine the similarity between major textural components. Under certain scenarios, the use of Ecological Site Descriptions (ESD's) will articulate the relationship between climate, geomorphology, and the response of vegetation to sites. The use of ESD's will not only lead to a match between geomorphology, but also foster the selection of seed lots where the focal species has been in a similar vegetation context to it's desired outcome, i.e. the population will have been exposed to other species likely to recruit at the site, or to be seeded. However, the development of ESD's across Western North America has been a long process, and the status of their mapping is variable, and to date no gridded surfaces for them exist. A solution has been the development of Ecological Site Groups (ESG's), these data sets combine local expertise with geospatial modelling approaches and have been developed for at least one large geographic expanse. While this product does not offer the same resolution as ESD's, they provide a solution which reflect the interactions between climate and geomorphology, and may be used at least temporarily to express these relationships.