The Seedlot Selection Tool (SST): The Story Behind it, Limitations, and Next Steps

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Five years ago, driving to Bachelor for a day of skiing, Brad StClair (USFS, PNW) and I discussed the problems his colleague Glenn Howe (OSU, College of Forestry) was having with the (in) stability of an online website on the Oregon State University server. As a climate change impacts scientist, I wanted to learn about this tool, designed by the two forest geneticists to provide guidance for forest managers, helping them find appropriate seedling stock or helping nursery managers decide where to send their seedlings to ensure good tree growth in the next 50 years, a practice that could be labeled as **assisted migration.**

The issue of assisted migration is controversial. Ecologists like me worry that bringing new individuals to a community might trigger a cascade of problems.

- Will movement of plant materials bring new diseases?
- Might plant materials adapted to other places succumb to diseases and pests present in the "host" community?
- If the "host" community is weathering the climatic changes to which it has been subjected, why interfere with the fragile balance of existing ecosystem interactions and risk increased competition for resources?

These are just a few concerns, but Brad convinced me that the goal of this webtool was mostly to increase awareness of the magnitude of the changes projected by climate models and that assisted migration needed to be carefully planned mostly within a species' current range.

I suggested that Glenn and Brad come to the Conservation Biology Institute (CBI) where I led the Global Change Team (GCT). A team of talented programmers and web developers were putting together powerful web tools to help solve a wide variety of climate change related issues. Talk became action and three web sites emerged from their visits: **seedlotselectiontool.org/sst** (SST), **climaterestorationtool.org/csrt/** (CSRT) focused on sagebrush, and **specieshabitattool.org/spht/** (SPHT) mapping current and expected future ranges of a handful of tree species.

My team had been working with a variety of climate projections at scales varying from 1km nationally to 50km globally. But because of their close relationship with Sally Aitken, the Director of the Center for Forest Conservation Genetics (CFCG), and previous faculty member at OSU before joining the University of British Columbia, Brad and Glenn wanted to use climate projections provided by Tongli Wang, codirector of the CFCG. Tongli's site **ClimateNA** provides climate data at 4km resolution from the past, starting in 1901, as well as for the future in the 2020s (2010-2039), 2050s (2040-69) and 2080s (2070-2100), averaged across 15 climate models from the 5th Assessment Report for the Intergovernmental Panel for Climate Change. There are many ways to downscale the raw results from global climate models and render them more usable at the local level. That subject could be the topic for another newsletter article, and I won't get into it here, simply know that Tongli's method is robust and the data used in the tools have been published and peer reviewed (**https://bit.ly/3qTCxl4**), and they include many variables of importance to forest management.

Skiing at Mt. Bachelor.

Much can be said about the uncertainty of climate projections (and certainly much has been written about it), especially about rainfall (another topic for a future newsletter!). **But observations to date have shown that, if anything, climate models have been conservative.** Changes are occurring faster, especially melting of glaciers and ice caps, than models ever projected. Importantly, all climate models have agreed, for more than 30 years now, that the planet is warming. **In the Pacific Northwest we observed that annual average temperatures have been increasing at 0.2°F per decade since 1895** which matches well **climate projections**.

It is also important to remember that climate models do not predict the exact location or timing of extreme events (a topic for yet another discussion!) despite the fact that these events can exacerbate the effects of chronic warming that has been observed around the world, often driving large mortality events. The world's forests are becoming increasingly more vulnerable to climate variability as extreme events exceed their capacity to withstand them because of the underlying warming trend which causes heat waves to be hotter and the air drier than in the past.

The 2003 European heat wave, the 2010 Russian heat wave, and the hot and dry last two decades in the western US have already caused widespread forest mortality. Insects and disease agents have also responded to the warming and caused deadly outbreaks in stressed forest leading to further forest declines. The 21st century's wake-up call: "climate change is here" was the background driving the creation of the SST. Forests are becoming increasingly more vulnerable to both direct (warming, droughts, heat waves, floods, windthrow) and indirect (pests and diseases, invasives, herbivory, fires) effects of climate change and these interact in unpredictable ways.

What the SST does:

- The SST provides an estimate of the **exposure** at a particular site to the average change projected by climate models
- Lets you visualize places that currently have climates identical or similar to your site today, and see places that currently have the climate that is projected for your site either 30 or 60 years into the future. The latter are the places where you can collect seeds or get seed provenances that are likely to grow into trees well adapted to your site's future conditions.

What the SST does not do:

- The SST does not consider extreme events or the role of refugia on the landscape
- It does not consider the sensitivity of your species of interest and its adaptive capacity.

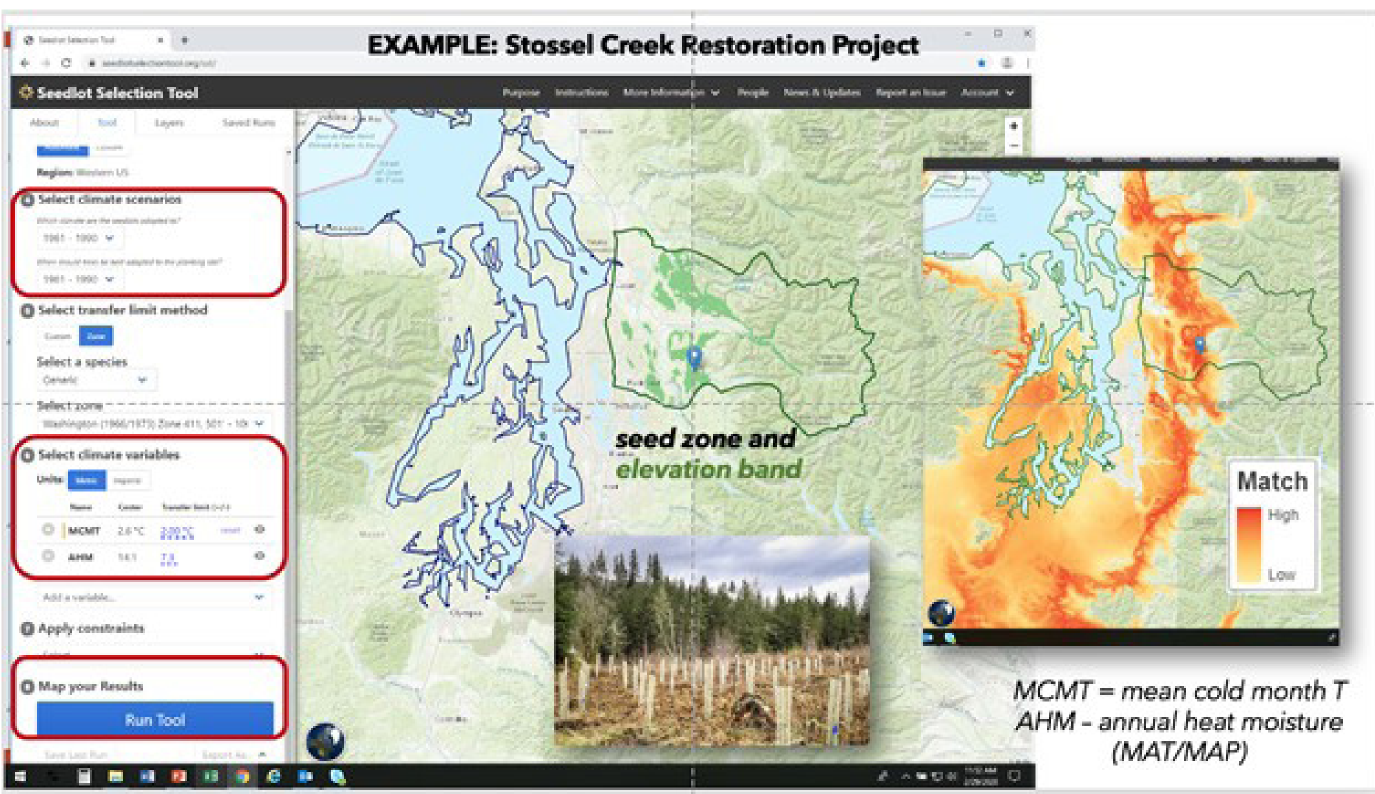


Figure 1. Locations with the same (dark orange) or similar (lighter orange) climatic conditions as the Stossel Creek restoration site (near Carnation, WA) in the 1980s based on mean cold month temperature and annual heat moisture.

Seed sources for future conditions will typically be either in more southern locations or at lower elevation – sites that are warmer and often drier. Conversely if you want to see where the conditions at your site today might be found in the future, you can choose the option "find planting sites" in the SST and visualize the areas where, in the future, the climate will be similar to what it is today at your site. Those sites will usually be further north or at higher elevations.

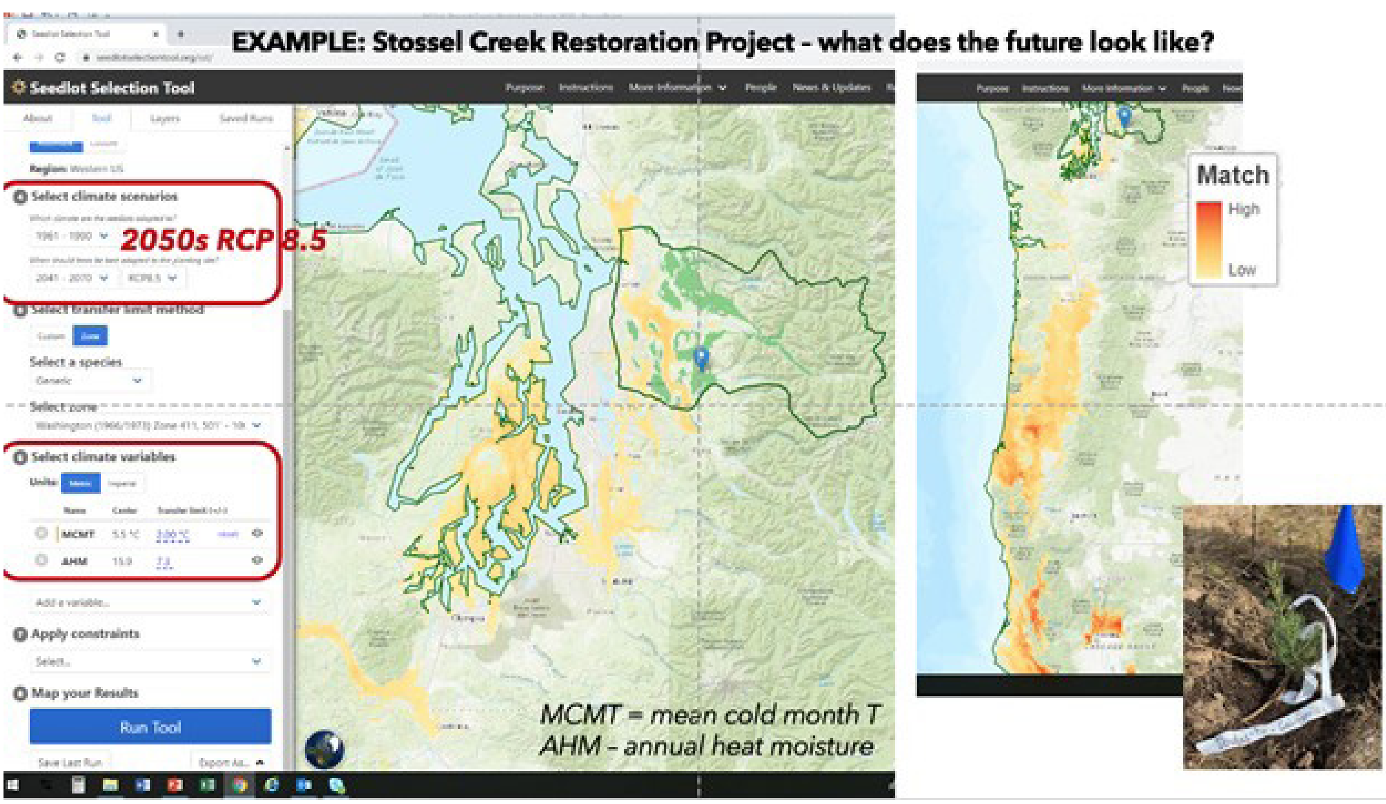
Keep in mind, however, that your site could also be a climate refugium. A site's microclimate might buffer it from regional conditions – a north-facing hillslope in a deep mountain valley, for example. Such climate refugium can be identified by instrumenting a site and collecting weather data that can be compared with records from nearby meteorological stations. If differences exist, they can tell you how much of a buffer you might expect at your site as long as extreme events such as a fire or the introduction of an exotic disease for example do not compromise the integrity of the refugium.

Considering climate velocity, or the rate at which a species must migrate to maintain constant climate conditions and, in this case, evaluating the urgency for you to find seedlings adapted to different climatic conditions, can help determine when some sort of "assisted migration" should occur. Many species will not be able to disperse fast enough to track suitable climates. In the case of trees, it is unlikely their life cycle will enable them to keep up with the changes projected for the rest of this century and the question is: will they survive? While the SST is a great way to map locations with similar climatic conditions it does not indicate the **sensitivity** of the species of interest. To explore this, another web tool was created. The SHT includes simulation results for 7 species of conifers illustrating their current range and their expected shifts in the future using the same climate projections as the SST. It pinpoints areas where tree ranges will either expand or contract, given landscape conditions. These results can help practitioners determine if their site will remain within the expected future range of their species of interest. If not, it might be a good idea to consider planting another species. The influence of increasing atmospheric CO_2 on the trees' water use efficiency might also confer them increased capacity to withstand hot dry air but more observations are needed to confirm that effect.

Finally, a quick word about the adaptive capacity of trees. The level of stress caused by warming depends upon:

1. The magnitude of temperature increase
2. The magnitude of the concurrent evaporative demand
3. The duration of the exposure to heat (days/weeks), the season (warmer winters) or time of day (warmer nights), and the soil water availability (soil properties, groundwater depth)

Figure 2. Locations with the same (dark orange) or similar (lighter orange) climatic conditions that the Stossel Creek restoration site will have in the 2050s based on mean cold month temperature and annual heat moisture.



Few of these characteristics are included in the web tools mentioned above. **Trees are adapted to survive episodic heat waves.** For example, a common response to drought is to close stomata to reduce water loss and the possibility of hydraulic failure (embolism), but heat stress can be much more severe when cooling through transpiration is reduced by stomatal closure. Moreover, stomatal closure can cause carbon starvation when heat waves become recurrent and lead to reduced ability by stressed trees to fight insect infestations and ultimately cause their death.

Another example of adaptive capacity is the timing of budburst that has been studied by PNW researchers documenting adaptation to shorter winters with earlier budburst dates. Further research with common garden experiments are ongoing to determine the tolerance of various species to projected climate conditions and the amount of genetic variation within species with different physiological thresholds.

What is Next:

Our rapidly changing climate is causing increased vulnerability of forests around the world. To quote Brancusi "to see far is one thing, going there is another" and the challenges to be addressed are many.

Because it is a widespread, national and even global problem, collaboration and information sharing will be key to find creative solutions and avoid pitfalls while adapting management practices. Web tools such as those described here help managers but are just one example of how scientists are trying to provide practitioners the tools they need to prepare for the future. Other sites like **climatetoolbox.org** explore applications to other sectors while **drought.gov** provides information on past and current climate trends. Much is available yet the dissemination of applicable knowledge is critical but difficult.

Scientists need to hear from practitioners to learn what they know and what they see so those scientists can improve their models, focus on relevant issues, and deliver complementary information. The 1st North Sound Riparian Conference was a giant step in that direction. Projects like Forest Heath Watch Western Redcedar Dieback **[link to Joey's article]** are another example.

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Questions to the author:

Dominique, if you could hear your dream input from practitioners, what would that look like?

DOMINIQUE: A dream input: detailed, site-scale climate observations. For example, a few years ago we were talking to a small vineyard owner about climate futures and the difficulty of using coarse scale projections to simulate the future of a small place like a vineyard, a field, a forest stand. That person had installed solar panels on his roof and downloaded all the climatic info for his place. It was a dream. You could see fluctuations in daytime temps, night-time temps. He had a precip gauge so also had rainfall amounts. Suddenly we had a baseline. In a few years, we'll be able to see if there are trends in the data. Rather than rely on interpolated climate data from met stations miles away from the property we can look at what really happens at his place.

What questions would you like practitioners to weigh in on?

DOMINIQUE: The question practitioners should always ask is: **how are model projections relevant to my place?** What have I observed? Practitioners should take notes, keep track of budbreak or their favorite flowers blooming dates to keep track of climate variations at their place. Models do the best they can but models are based on a lot of data. Without reliable relevant data models are weak. Climate models are run at coarse scale but if you have your own baseline you can compare with the simulated regional trend and customize the forecast to your site.

Also a dream question is: **May I have your email address?** Practitioners should feel they can email or call scientists any time they have a question. Reporters focus on the sensational, and sometimes they get it wrong. If a question arises, the public should always feel comfortable asking an expert. Asking a scientist does not mean he or she will know the answer but he or she will likely be able to refer you to someone else who will. Scientists can and do change the focus of their research when they hear questions and realize what is really important for practitioners.

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