# Planting Our Future Forests:
## Species and Seed Source Considerations


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*USDA Forest Service, Pacific Northwest Research Station, Corvallis, Oregon*


for the greatest good

***Climate Adaptation Strategies for Pacific Northwest Forests***
***Northwest Natural Resource Group, November 6, 2019***

# Reforestation decisions

1. Natural regeneration or planting?
   - Can I get sufficient stocking of the desired species in a reasonable time frame?
   - Can I improve productivity using select planting stock?
   - Will trees be adapted?
     - Local species and seed sources have been the default choice
     - But perhaps should consider other seed sources and species
2. Choice of species?
3. Choice of seed source?
   - What species and seed sources are available?
   - Will trees be adapted?

***Planting will become more important in the future because of climate change!***

for the greatest good

# Plants are adapted to local climates

***Every species, every population, every individual plant has a range of climates in which it can best survive, grow and reproduce***

***Because of natural selection at a location, we can assume that plants are adapted to their local climate***

# But climates are changing, which affects adaptation


Species
Considerations

# Environmental Niche Modelling

*Modelling to predict the distribution of species in geographic space based on their known distribution in environmental space (their realized ecological niche)*

- *Also called climatic niche modelling, species distribution modelling, predictive habitat distribution modelling, and climate envelope modelling.*
- *A correlative process*
- *Criticism that it does not always reflect actual species distribution.*
- *Actual distribution may depend on a number of other factors including dispersal ability, evolutionary history, biotic interactions.*

***Error rates:***
***Predict present, but absent 5.4%***
***Predict absent, but present 0.5%***

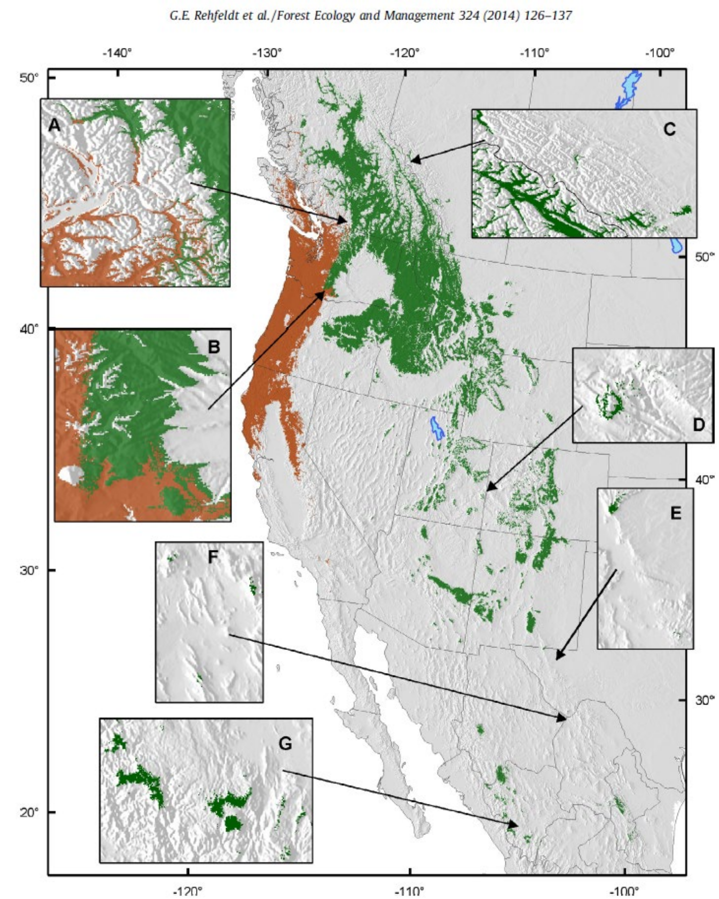
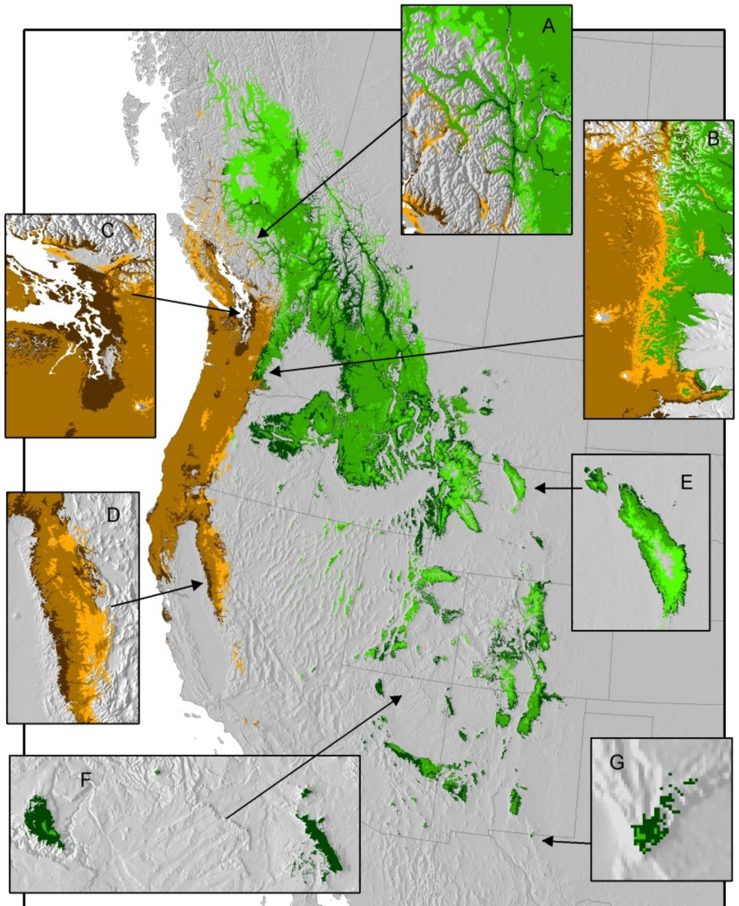



*Fig. 3: Mapped prediction for climate niche for Psuedotsuga menziesii var menziesii (brown) and var. glauca (green)*

*Rehfeldt et al. 2014. Comparative genetic responses to climate for varieties of Pinus ponderosa and Pseudotsuga menziesii: Realized climate niches. Forest Ecology and Management 324: 126-137*

# Predicted climatic niches by 2060 for *Pseudotsuga menziesii* varieties



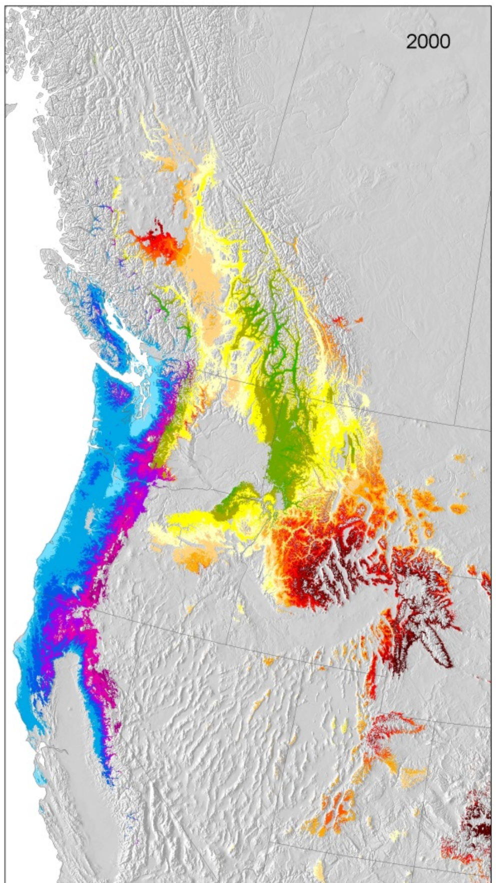

| | Habitat lost (dark color) | Remains suitable (middle color) | Habitat gained (light color) |
|---|---|---|---|
| var. menziesii (browns) | 18% | 82% | 18% |
| var. glauca (greens) | 35% | 65% | 32% |

- *Habitat is lost at the trailing edge (lower elevations and further south)*
- *Gained at the leading edge (higher elevations and further north)*

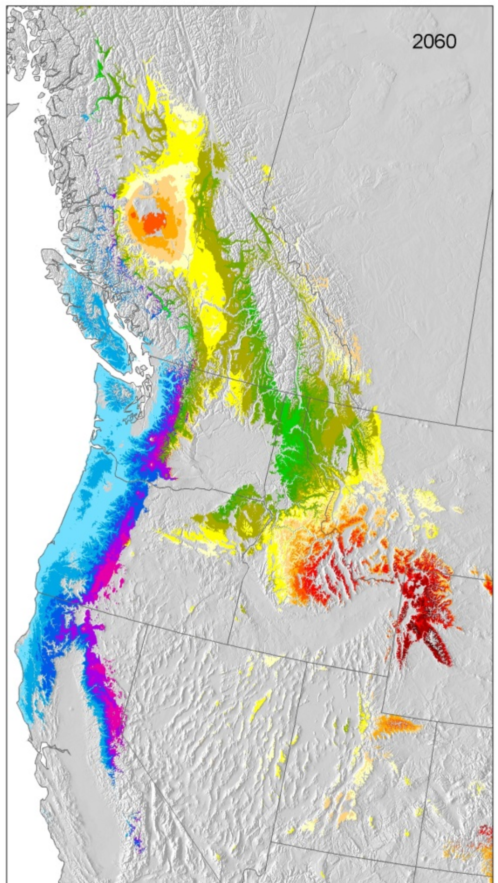
*Rehfeldt et al. 2014. Comparative genetic responses to climate for varieties of Pinus ponderosa and Pseudotsuga menziesii: Realized climate niches. Forest Ecology and Management 324: 126-137*

# Populations variation: Clines in growth potential within current and future (2060) climatic niches

*Year 2000*



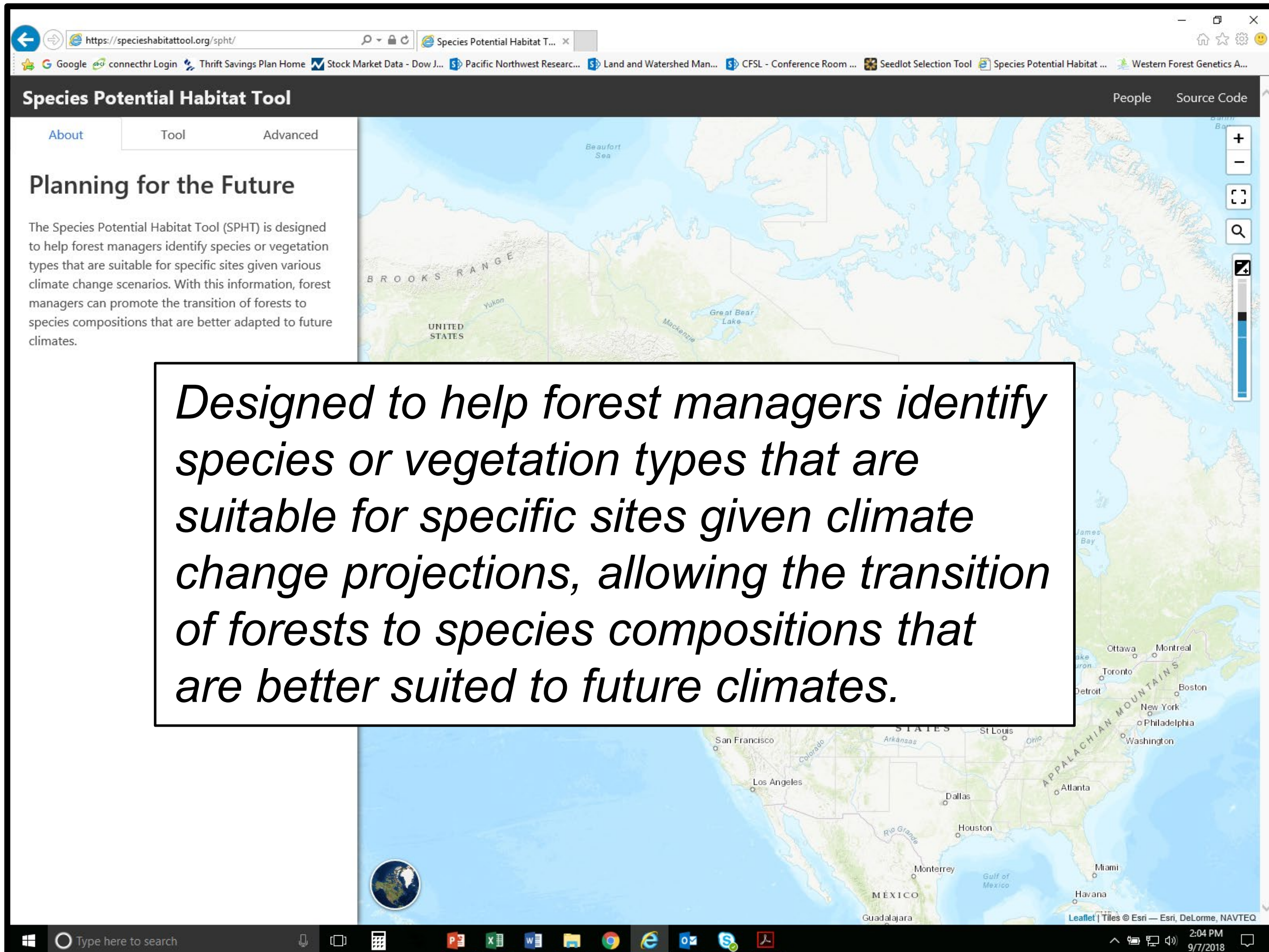

*Year 2060*




| | Remaining suitable from today | Current climatype suitable through 2060 |
|---|---|---|
| var. menziesii (light blue = high growth magenta = low | 82% | 58% |
| var. glauca Dark green = high Dark red = low | 68% | 1% |

*Rehfeldt et al. 2014. Comparative genetic responses to climate for varieties of Pinus ponderosa and Pseudotsuga menziesii: Clines in growth potential. Forest Ecology and Management 324: 138-146.*

# Species Potential Habitat Tool




*Designed to help forest managers identify species or vegetation types that are suitable for specific sites given climate change projections, allowing the transition of forests to species compositions that are better suited to future climates.*

*Features:*

- *Can zoom into areas of interest*
- *Can look at different time periods and RCPs*
- *Integrated with the Seedlot Selection Tool (can be used as a constraint)*
- *Can export as a GIS file*

***https://specieshabitattool.org/spht/***

# Species Potential Habitat Tool

About | Tool | Advanced

## 1 Select Species

Select

## 2 Select Species Distribution Record

1961 - 1990

## 3 Select Modeling Conditions ⓘ

*Select a future time range and a model*

| | RCP 4.5 | RCP 8.5 |
|---|---|---|
| 2011 - 2040 | ☐ | ☐ |
| 2041 - 2070 | ☐ | ☐ |
| 2071 - 2100 | ☐ | ☐ |

## 4 Download ⓘ

*Download results to a pdf*

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# Species Potential Habitat Tool

About | Tool | Advanced

**1 Select Species**

Select
Lodgepole pine
Douglas-fir
Sitka spruce
Ponderosa pine
Engelmann spruce

**2** ...ibution Record

**3 Select Modeling Conditions**

*Select a future time range and a model*

| | RCP 4.5 | RCP 8.5 |
|---|---|---|
| 2011 - 2040 | ☐ | ☐ |
| 2041 - 2070 | ☐ | ☐ |
| 2071 - 2100 | ☐ | ☐ |

**4 Download**

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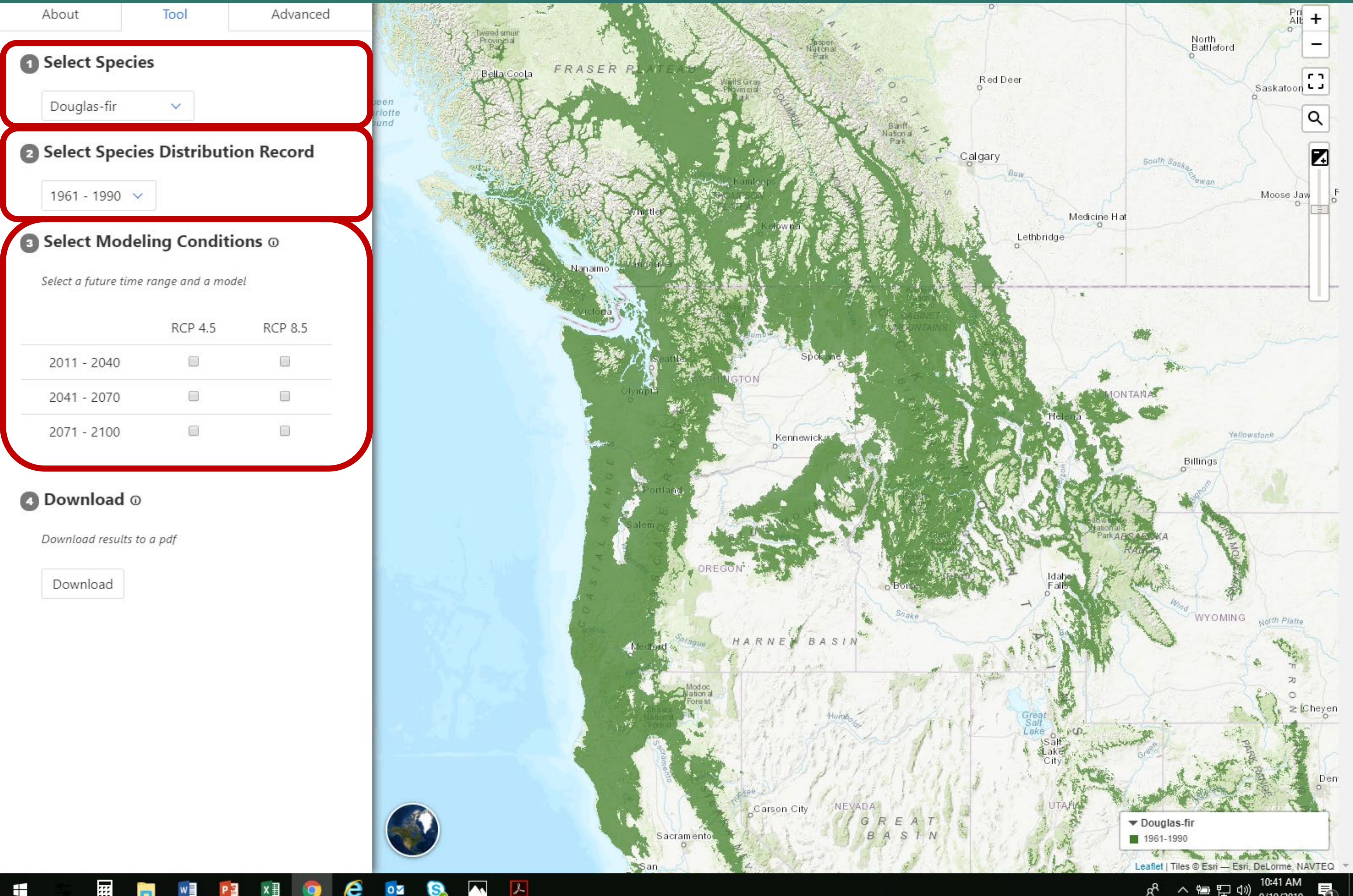
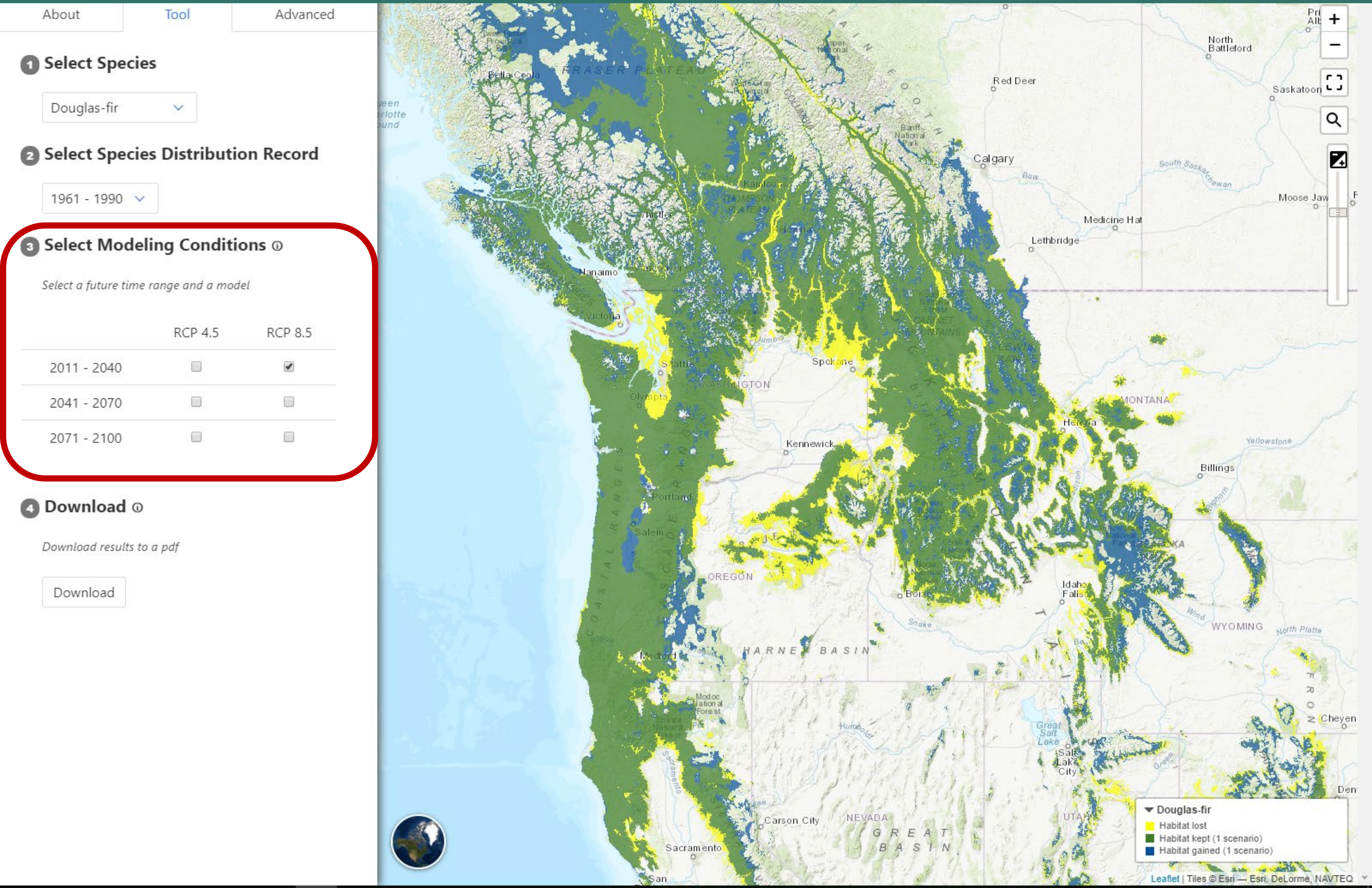
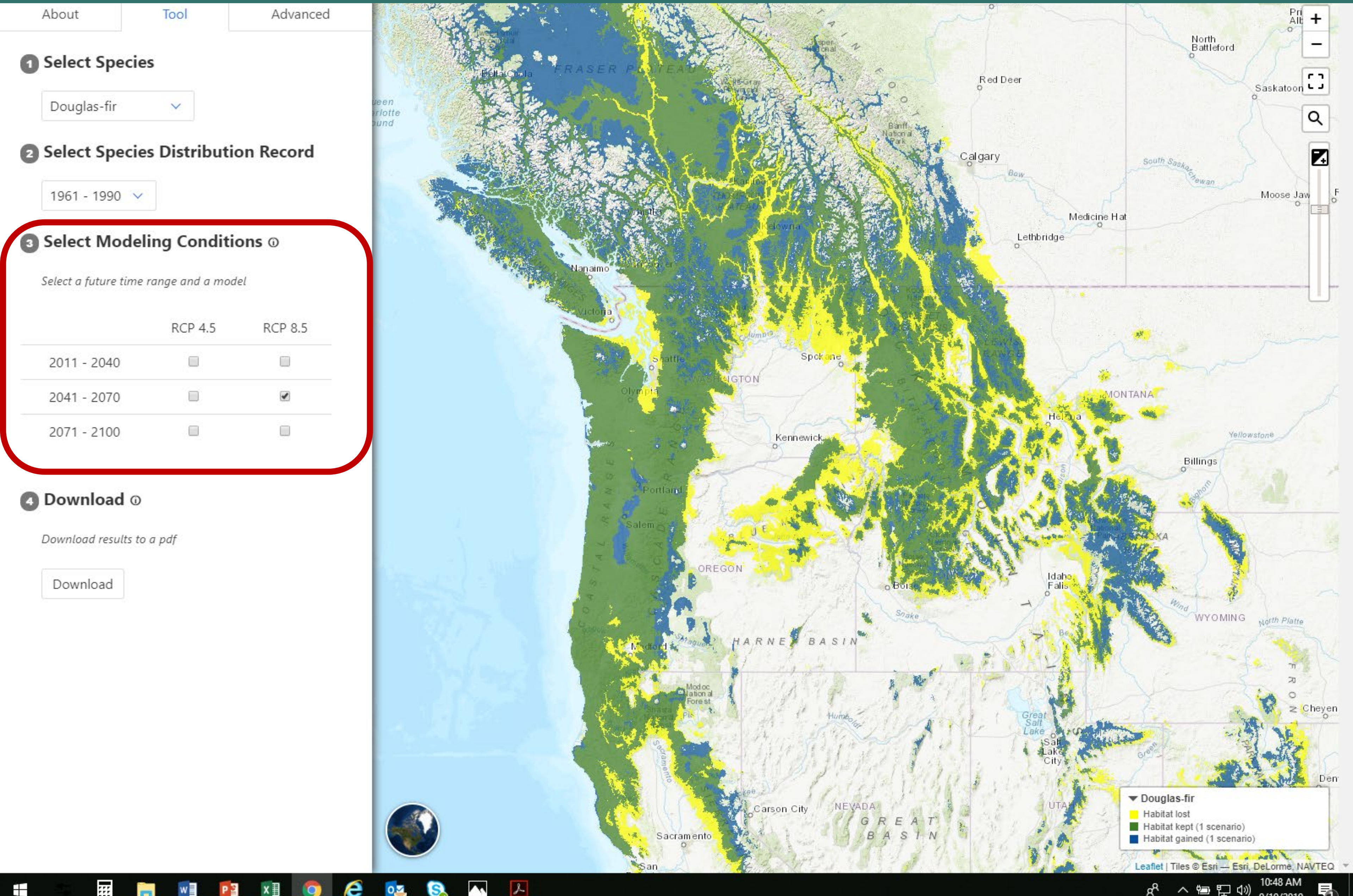
# Douglas-fir historic distribution



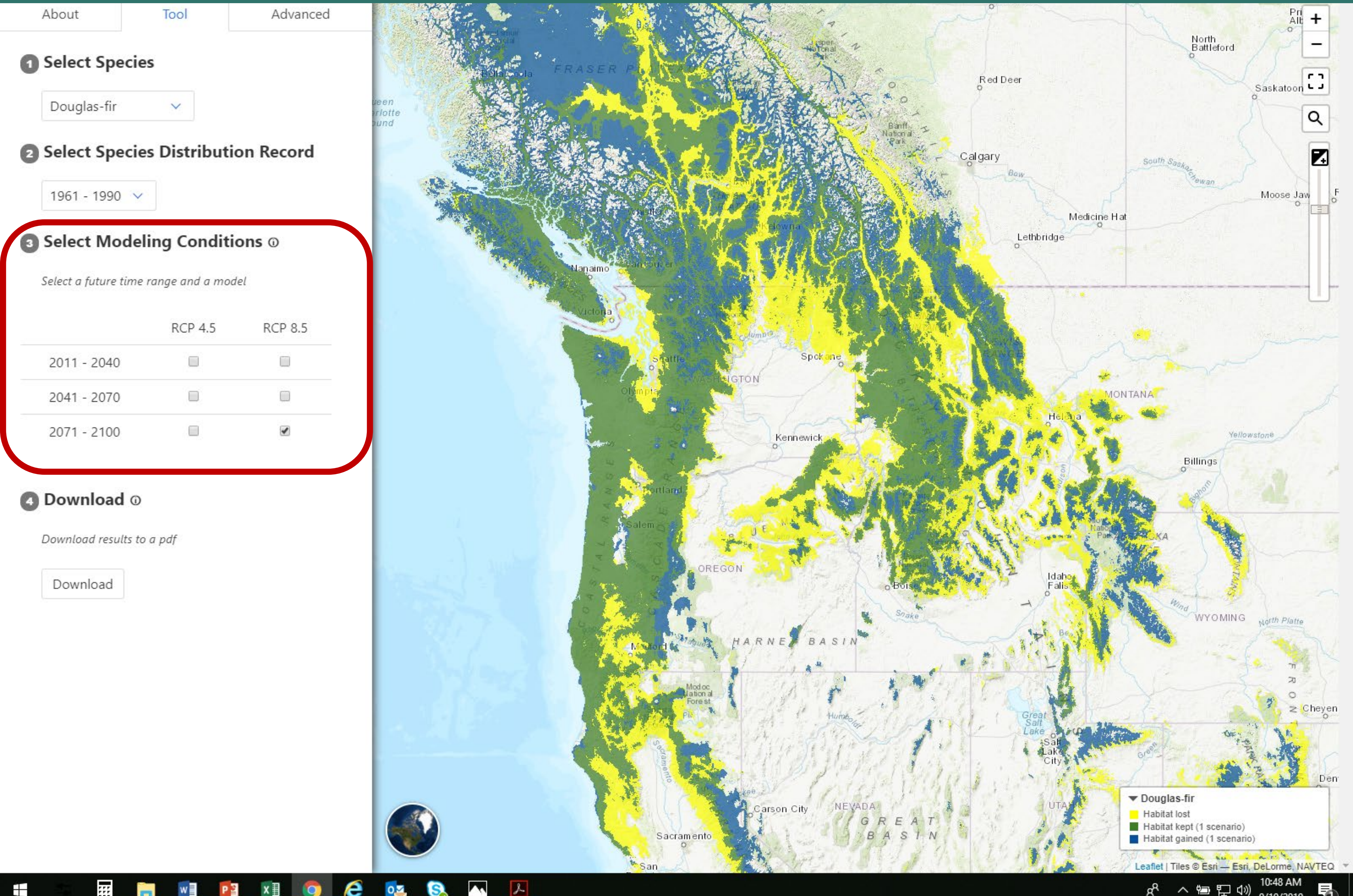
# Douglas-fir 2011–2040 RCP 8.5 projected distribution



# Douglas-fir 2041–2070 RCP 8.5 projected distribution



# Douglas-fir 2071–2100 RCP 8.5 projected distribution



# Douglas-fir – can overlap projections

About | Tool | Advanced

**1 Select Species**

Douglas-fir

**2 Select Species Distribution Record**

1961 - 1990

**3 Select Modeling Conditions**

*Select a future time range and a model*

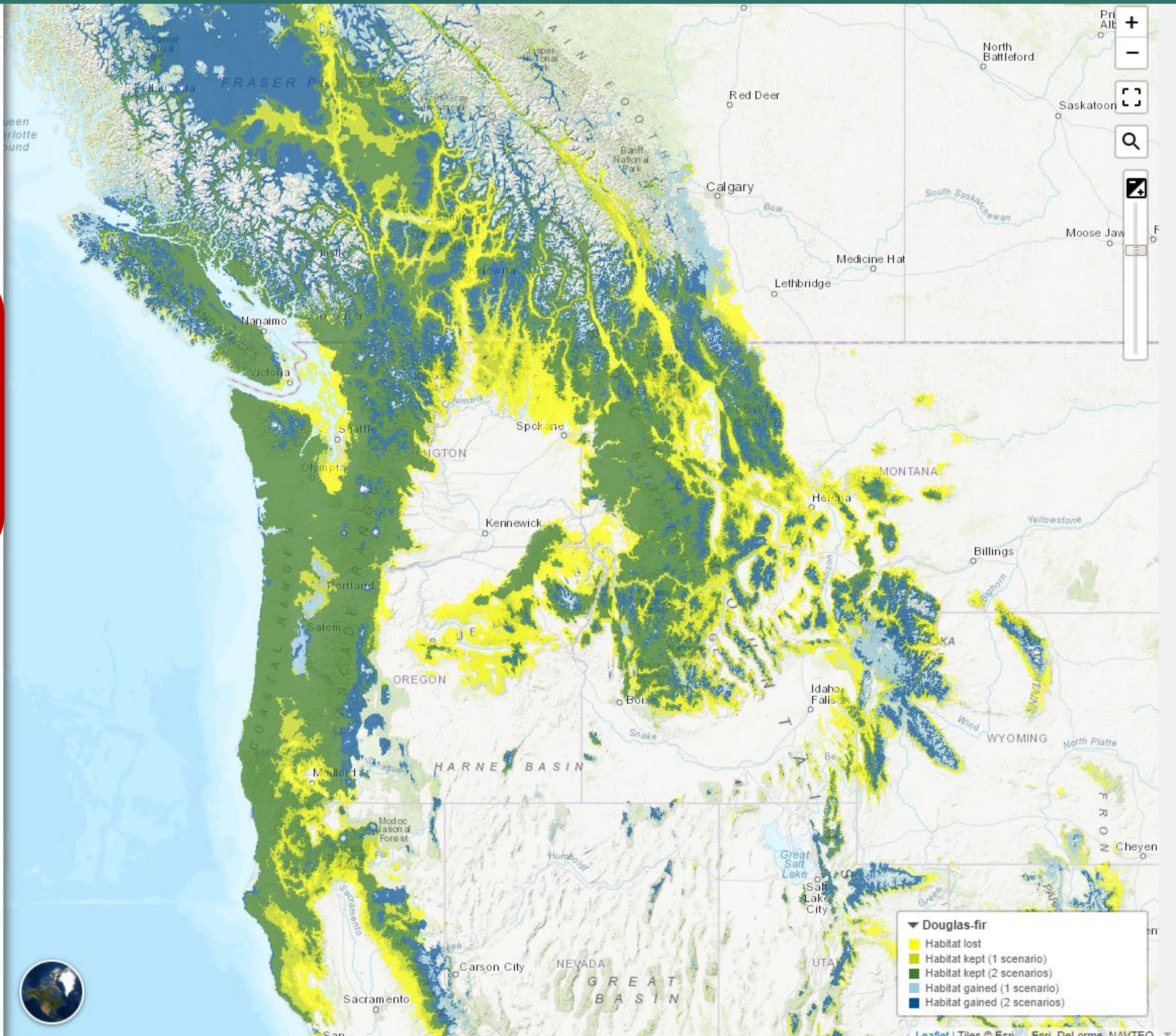
| | RCP 4.5 | RCP 8.5 |
|---|---|---|
| 2011 - 2040 | ☐ | ☐ |
| 2041 - 2070 | ☐ | ☐ |
| 2071 - 2100 | ☑ | ☑ |

**4 Download**

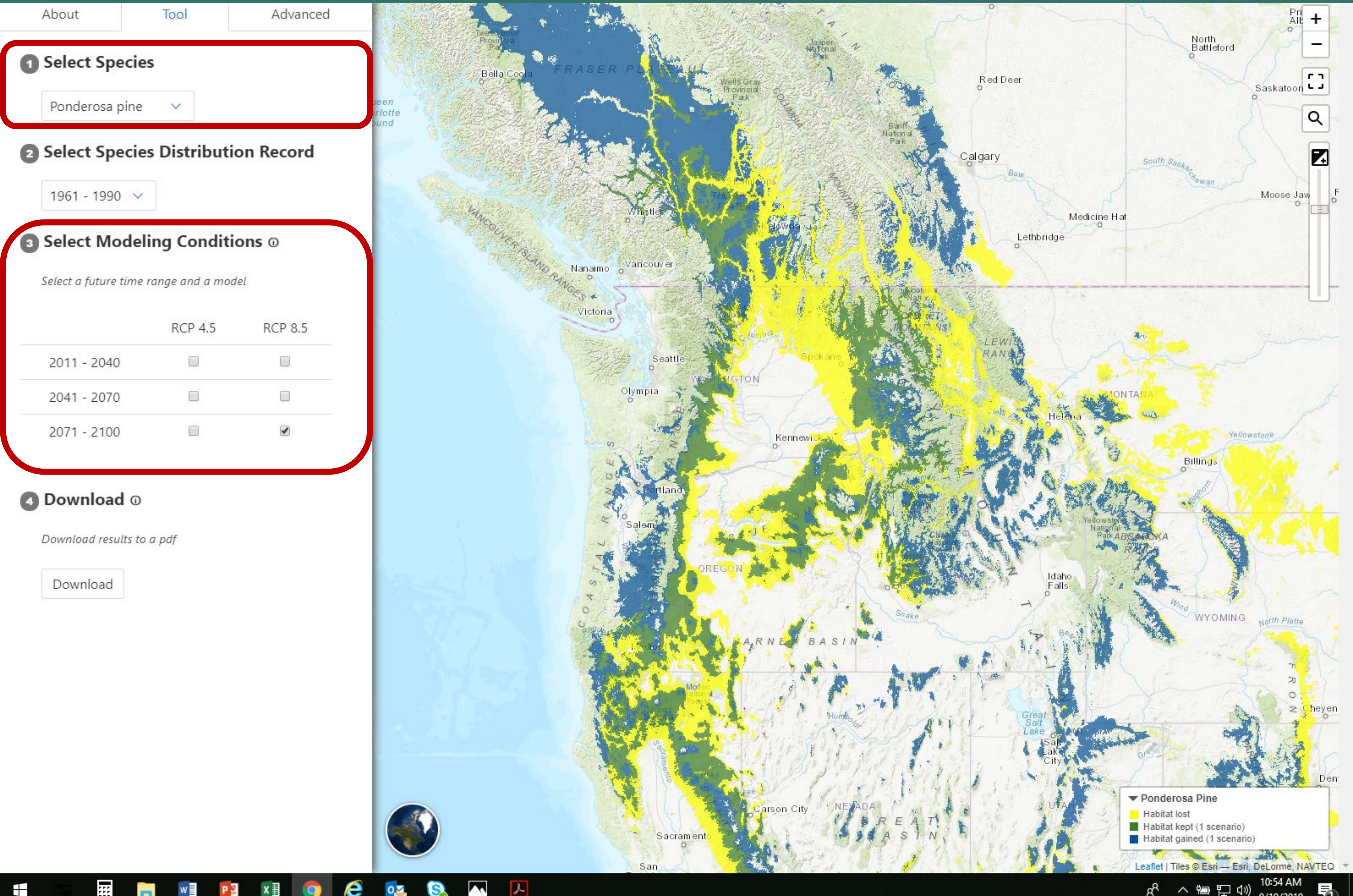
*Download results to a pdf*

Download

https://specieshabitattool.org/spht/#



# Ponderosa Pine 2071–2100 RCP 8.5 projected distribution

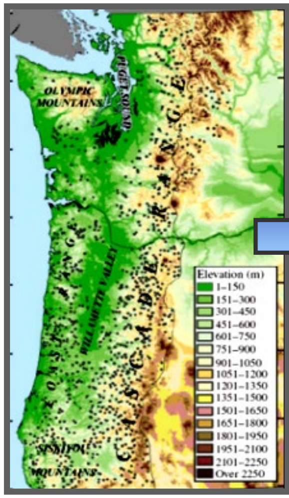



Seed Source
Considerations

# 1. Genetic variation across the landscape tracks climatic gradients = evidence for adaptation

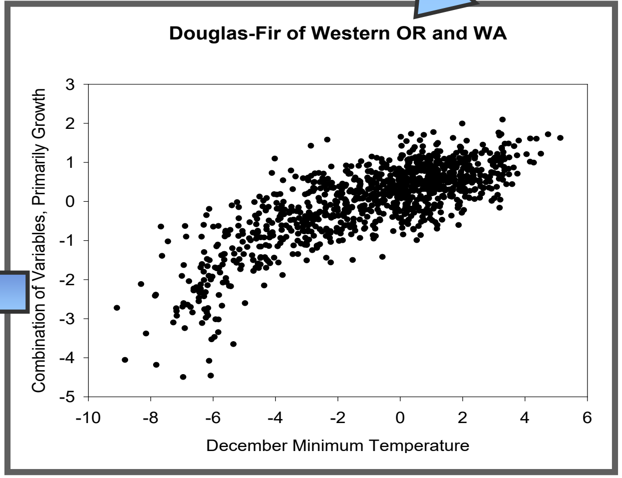
## Douglas-Fir Genecology Study

Collect seed from many trees



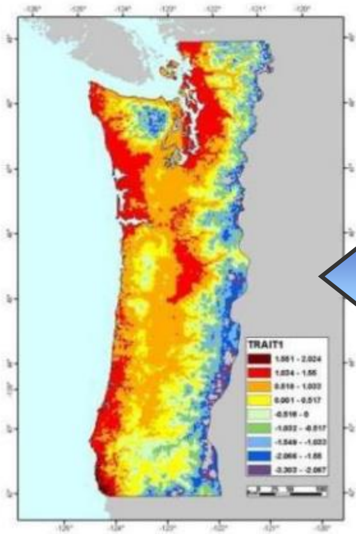

Grow families in a common environment

Measure many adaptive traits



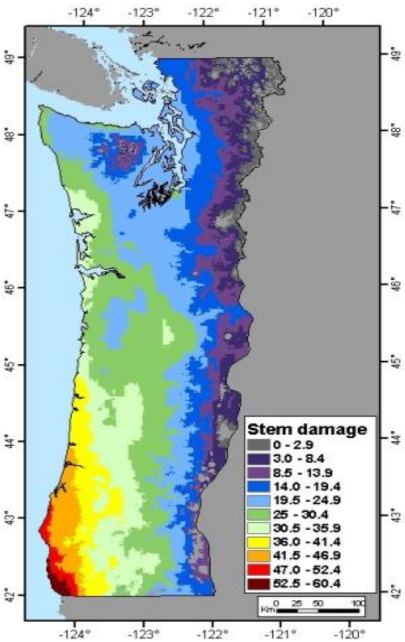

Traits vs source environment

GIS



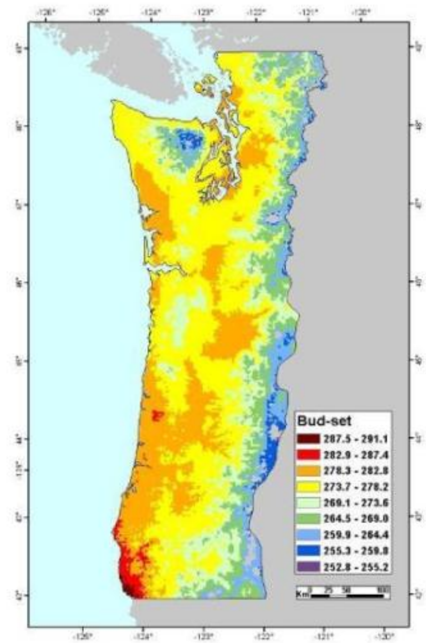

**St.Clair et al. 2005. Genecology of Douglas-fir in western Oregon and Washington. Annals of Botany 96: 1199-1214.**

Fall cold damage



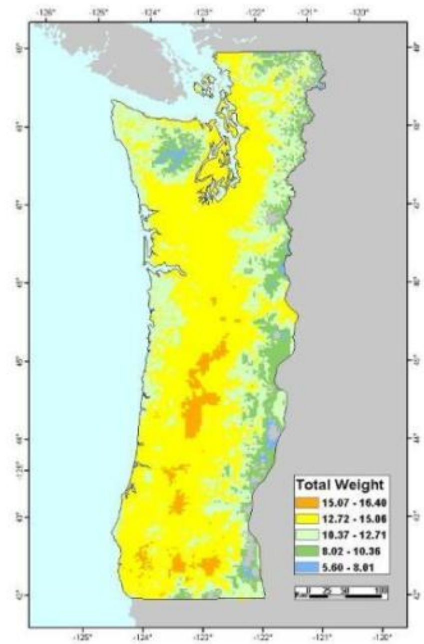

r = 0.79
Qst = 0.68

Bud-set



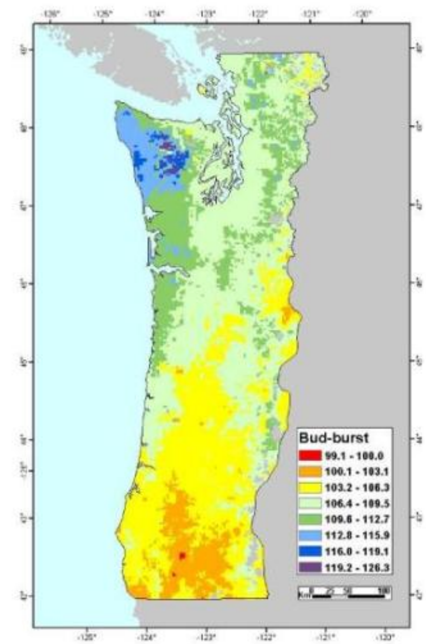

r = 0.76
Qst = 0.29

Biomass




r = 0.52
Qst = 0.13

Bud-burst




r = 0.60
Qst = 0.21

1. Populations differ
2. Traits are correlated with source environments
3. Relationships make sense

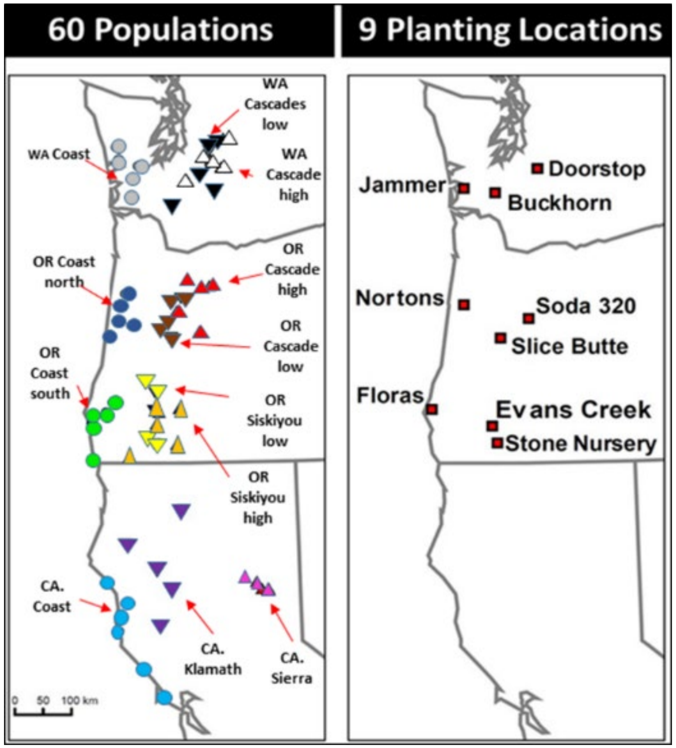
Different traits show different patterns and scales of adaptation

# Sitka spruce planted in Vancouver , BC


*Picture from Sally Aitken*
*http://blogs.ubc.ca/aitkenlab/author/cmahony/*

# 2. *Field tests indicate that forest trees are often adapted to local climates*

## Douglas-Fir Seed Source Movement Trial



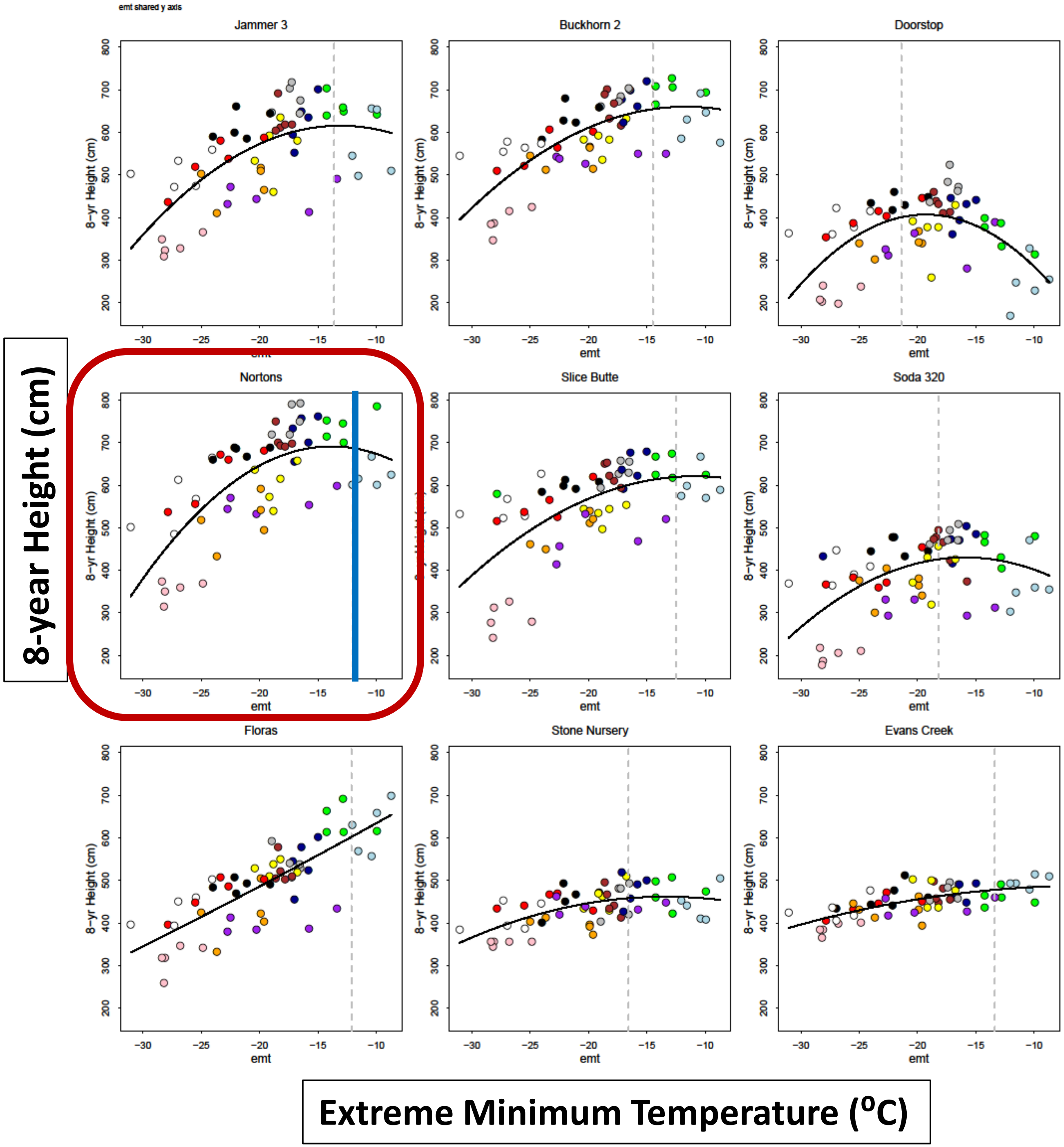

**Doorstop (WA high elevation)**:
Coldest, wettest site
Mean cold temp = 34° F
Mean warm temp = 59° F
Annual precip = 72 in

**Buckhorn (WA low elevation)**:
Intermediate site
Mean cold temp = 39° F
Mean warm temp = 64° F
Annual precip = 59 in

**Stone (OR low elevation)**:
Warmest, driest site
Mean cold temp = 39° F
Mean warm temp = 72° F
Annual precip = 20 in

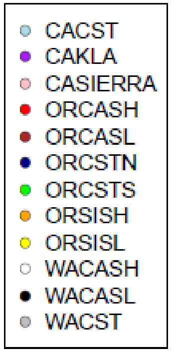
***<u>Can address:</u>***

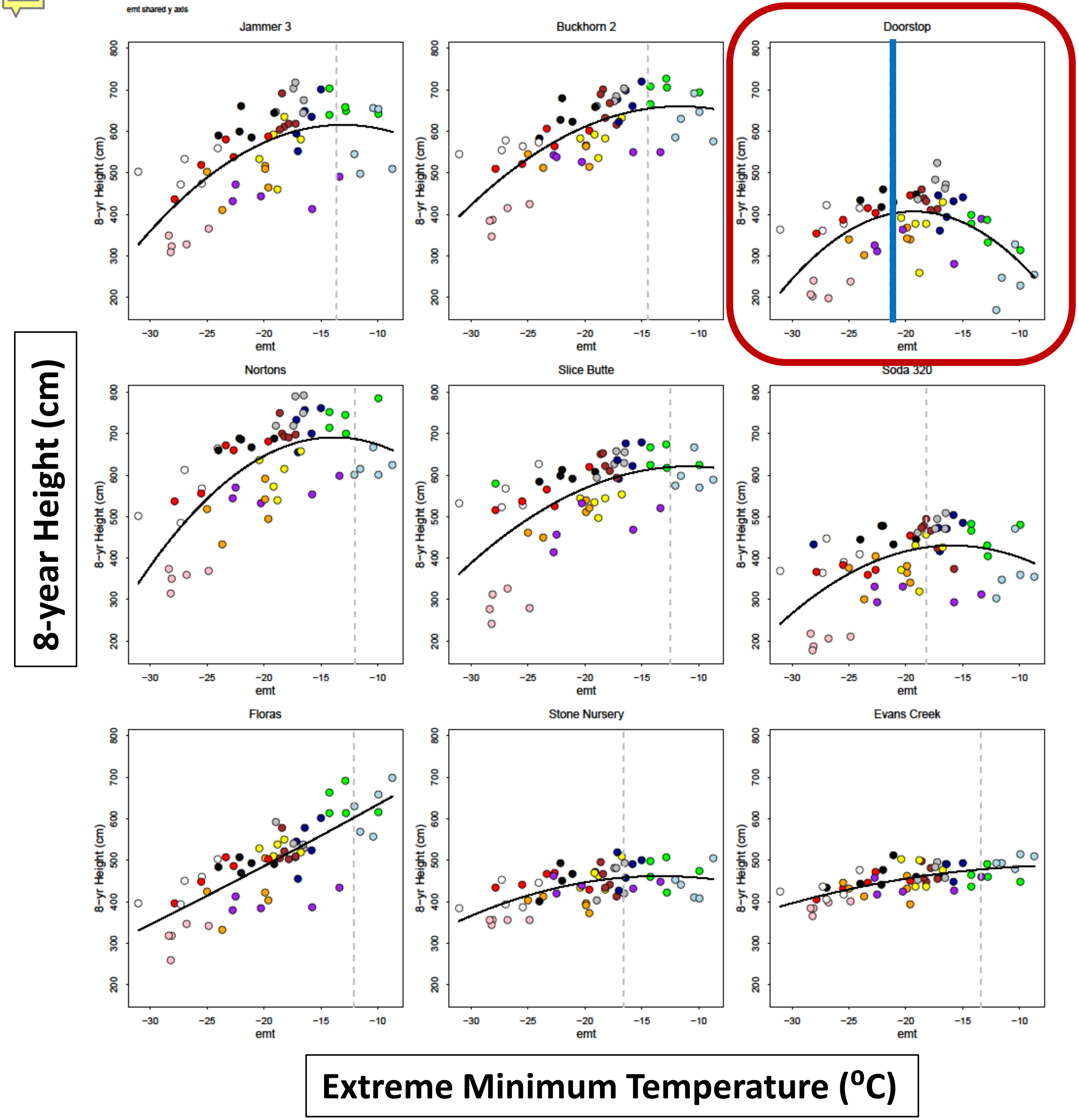
1. ***Which climate variables are driving adaptation.***
2. ***Are local populations best?***
3. ***How local is local? = transfer limits***




**Populations are locally adapted:**
at all sites, sources from climates similar to the test site are among the tallest

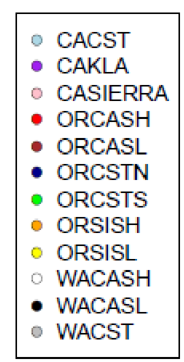
**Nortons Test Site:**
Warm, coastal site
EMT = -12 °C






**Populations are locally adapted:**
at all sites, sources from climates similar to the test site are among the tallest

**Doorstop Test Site:**
Cold, montane site
EMT = -21 $^{o}$C



# 3. Species show different patterns and degrees of adaptation

*Distance needed to detect genetic differences in Northern Rockies (Rehfeldt 1994)*

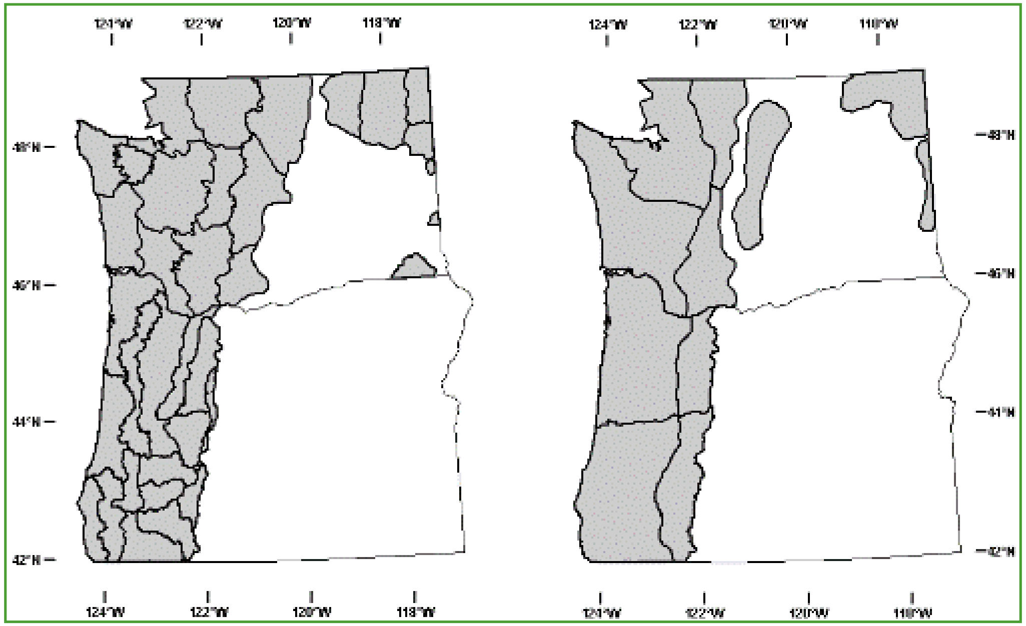
| Species | Elev. (m) | Frost-free days | Evolutionary mode |
|---|---|---|---|
| Douglas-fir | 200 | 18 | Specialist |
| Lodgepole pine | 220 | 20 | Specialist |
| Engelmann spruce | 370 | 33 | Intermediate |
| Ponderosa pine | 420 | 38 | Intermediate |
| Western larch | 450 | 40 | Intermediate |
| Western redcedar | 600 | 54 | Generalist |
| Western white pine | none | 90 | Generalist |

# 4. Seed zones and seed transfer guidelines have been developed to ensure adaptation

- Based primarily on collective knowledge of climate and vegetation types
- Includes 500 ft elevation bands within zones
- Later revised in OR and WA to account for species-specific patterns of adaptation



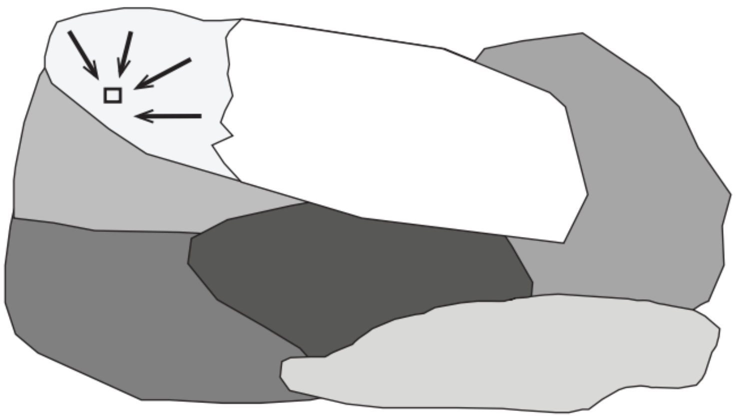
Revised seed zones



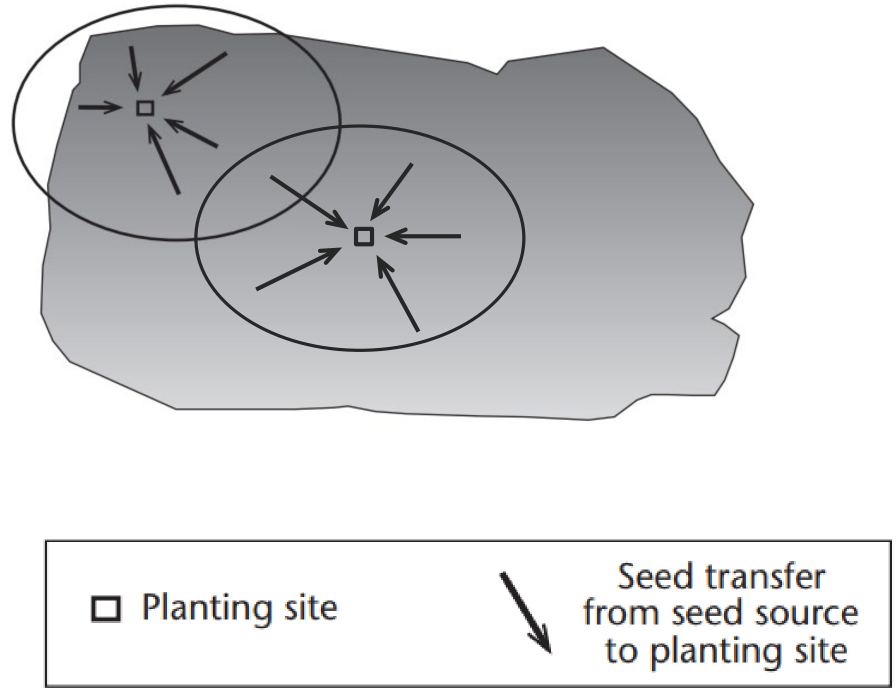
Douglas-fir; *Specialist* Western redcedar; *Generalist*

# Seed Transfer Systems

Fixed zone



Focal point = seed movement guidelines




*Modified from: O'Neill et al. (2017) A proposed climate-based seed transfer system for British Columbia. Prov. B.C., Victoria, B.C. Tech. Rep. 099.*

# 5. Climates are changing and local populations may no longer be adapted.

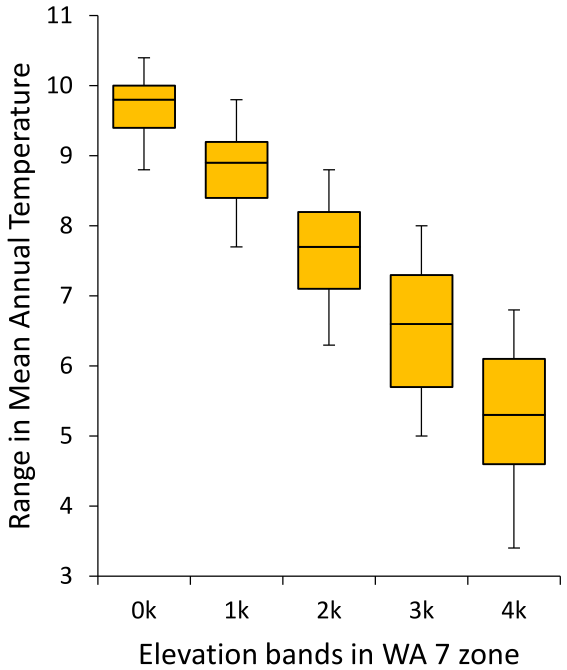
Three questions:

1. Are native populations adapted to current and future climates?
2. If not, how far do we have to go to find populations adapted to a planting site (assisted migration)?
3. How far should we move a population to ensure that it continues to exist?

Depends on:

1. Which climate factors are most important for adaptation?
2. How far climatically one can move populations before growth and survival are unacceptable?

# Transfer distances based on seed zones



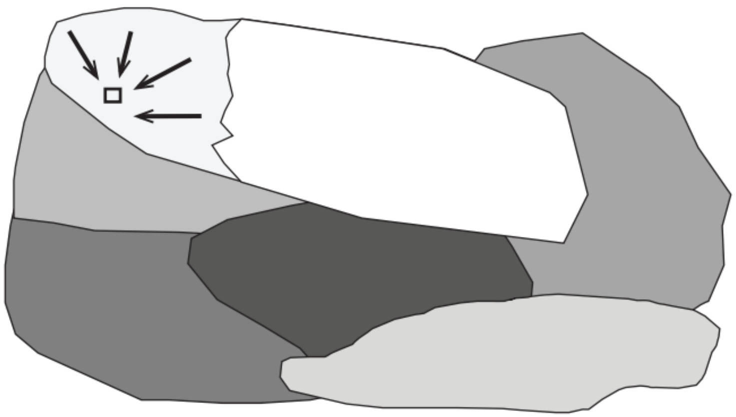

Douglas-fir Seed Zones


Transfer distances in °C mean annual temperature

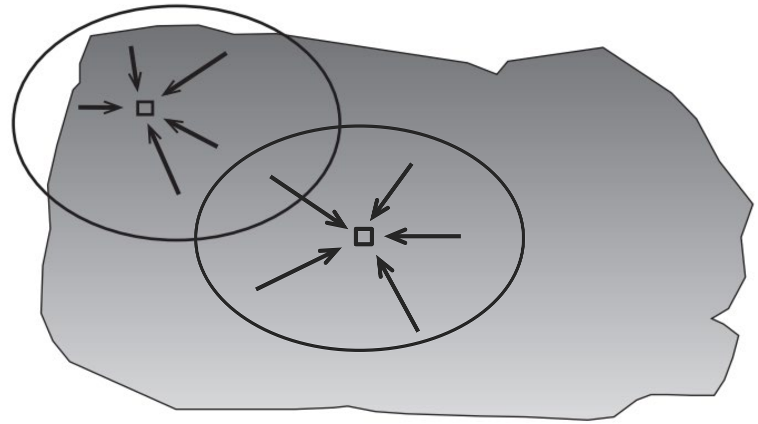
| | 25th – 75th | 5th – 95th | Maximum |
|---|---|---|---|
| Zone WA 7 3000-4000’ | 1.5 | 3.4 | 4.2 |
| Average all zones | 1.0 | 2.2 | 3.2 |
| Greatest all zones (WA 10) | 3.6 | 6.3 | 8.2 |

# Seed Transfer Systems

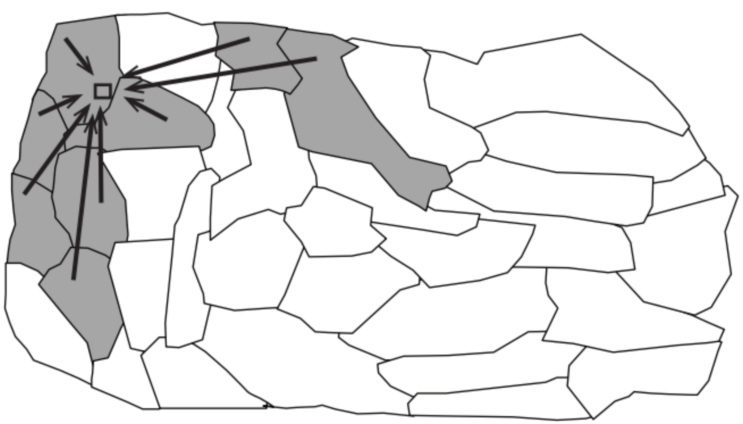
Fixed zone

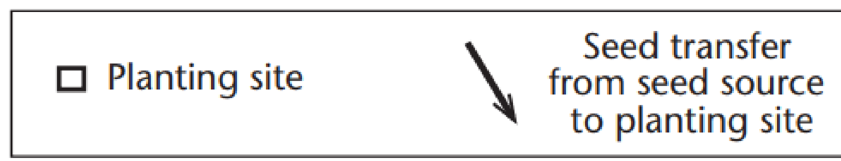


Focal point = seed movement guidelines



Focal zone






*Modified from: O'Neill et al. (2017) A proposed climate-based seed transfer system for British Columbia. Prov. B.C., Victoria, B.C. Tech. Rep. 099.*


***Three questions:***

1. ***Are native populations adapted to current and future climates?***
2. ***If not, how far do we have to go to find populations adapted to a planting site (assisted migration)?***
3. ***How far should we move a population to ensure that it continues to exist?***

# Can address two objectives:

***Given a <u>planting site</u>***

***<u>Which seedlot</u> is well adapted today…or in the future?***

***Find***

***Given a <u>seedlot</u>***

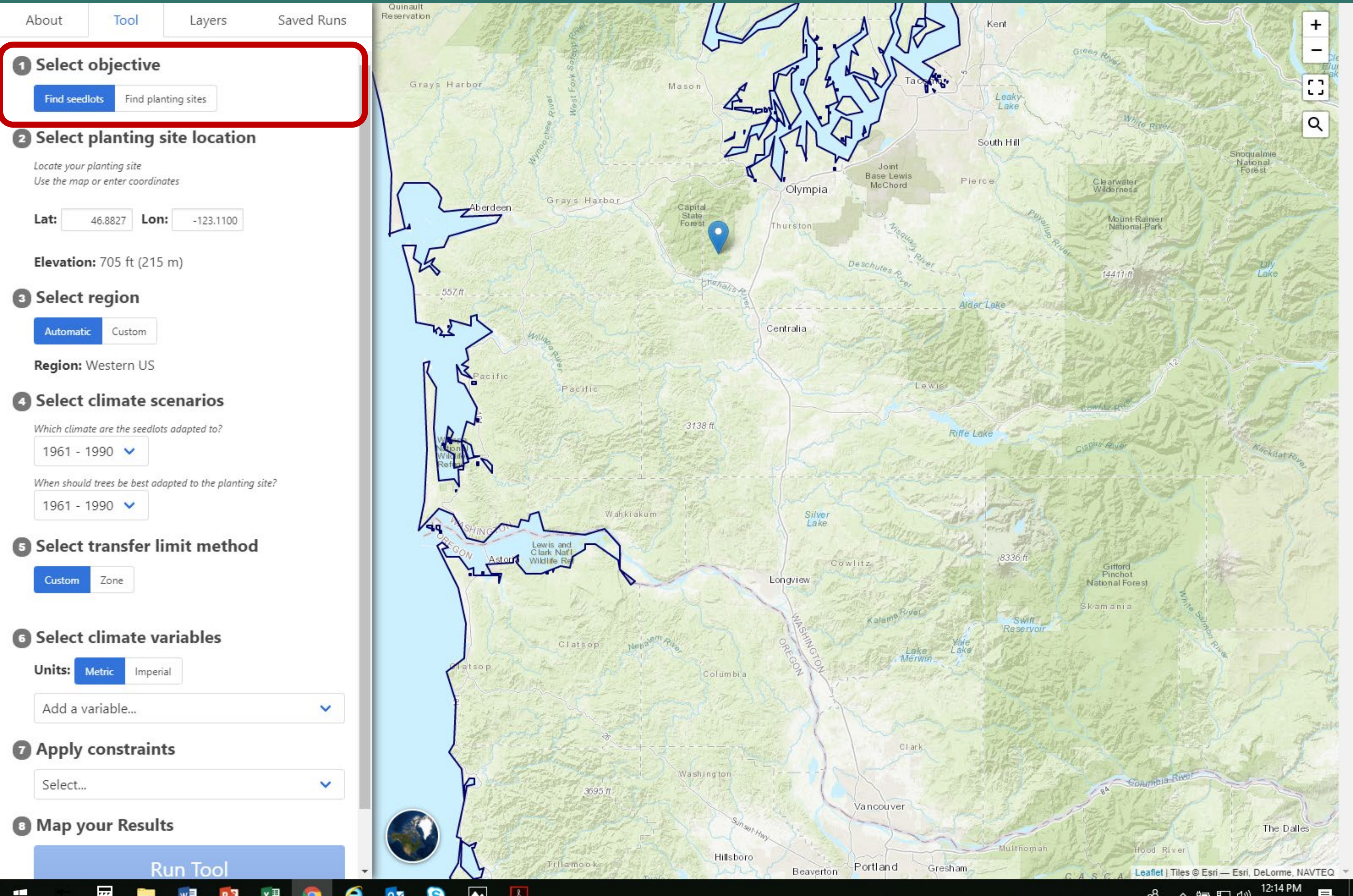
***<u>Where</u> is it well adapted today…or in the future?***

***Find***

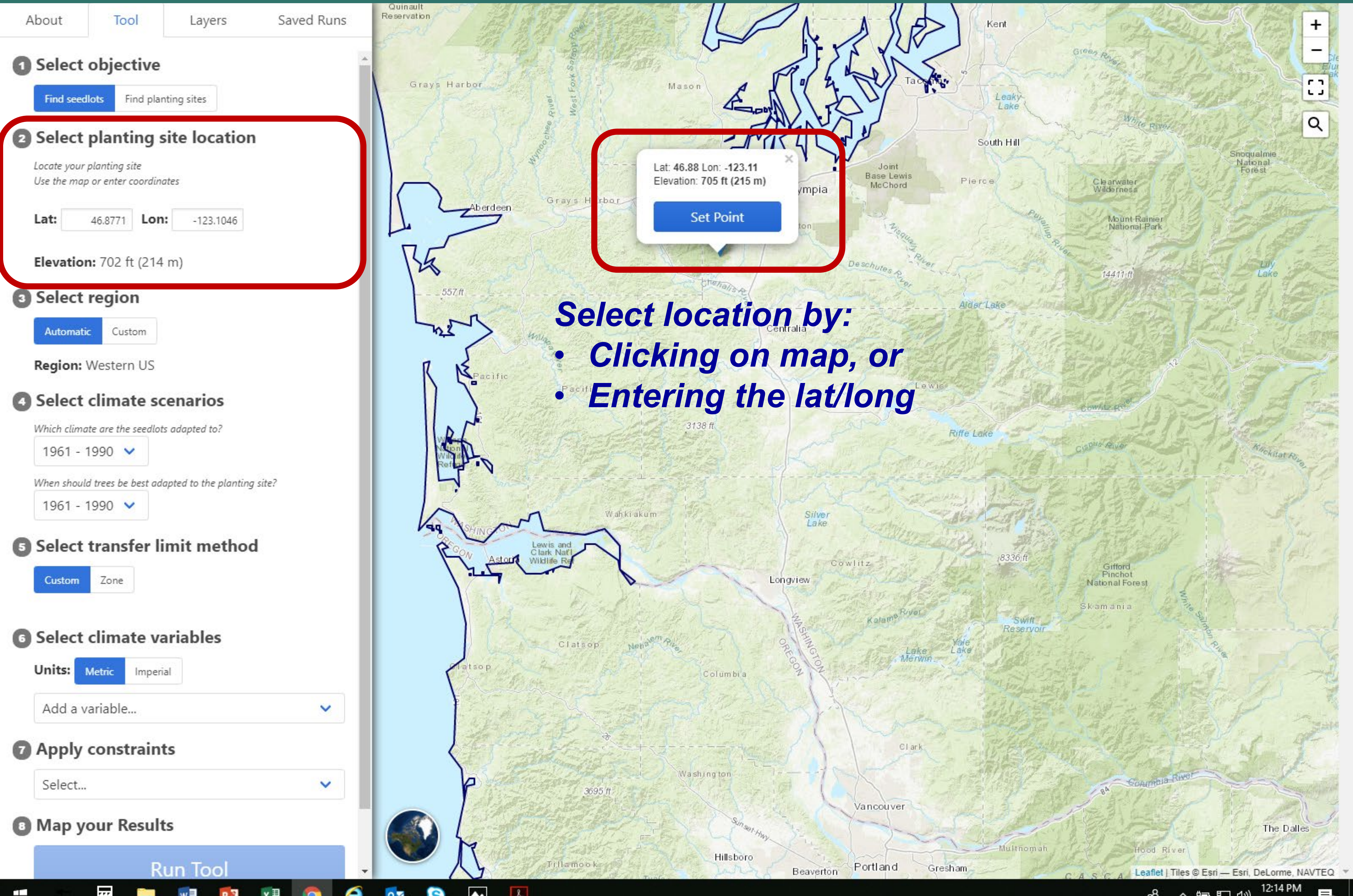
# Seedlot Selection Tool is a powerful tool for:

- Matching seedlots to planting sites
- Characterizing past, current, and future climates at a site
- Illustrating the potential concerns about climate change
- Seed planning given climate change concerns
- Gene conservation given climate change concerns

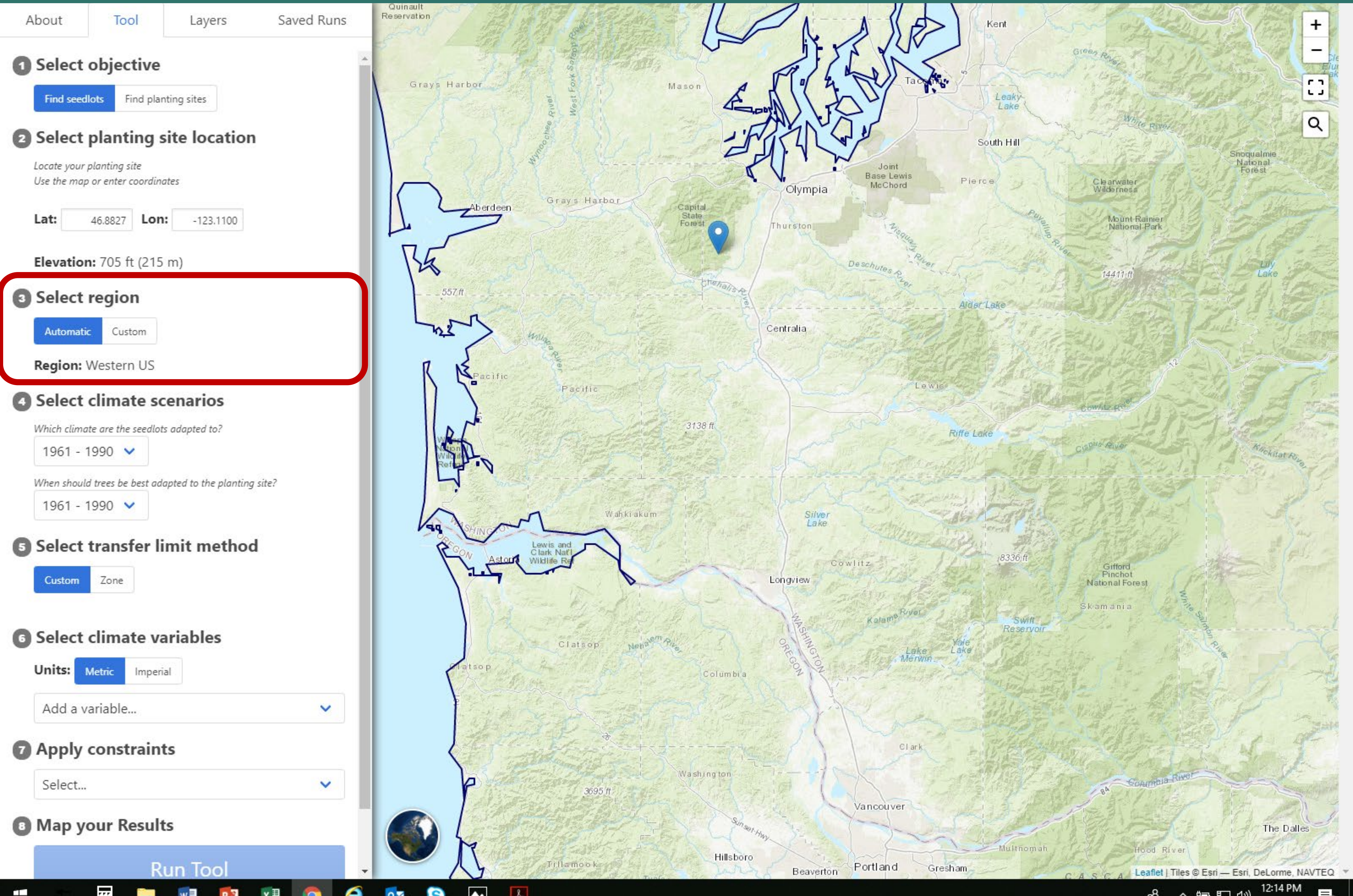
# Seedlot Selection Tool Example



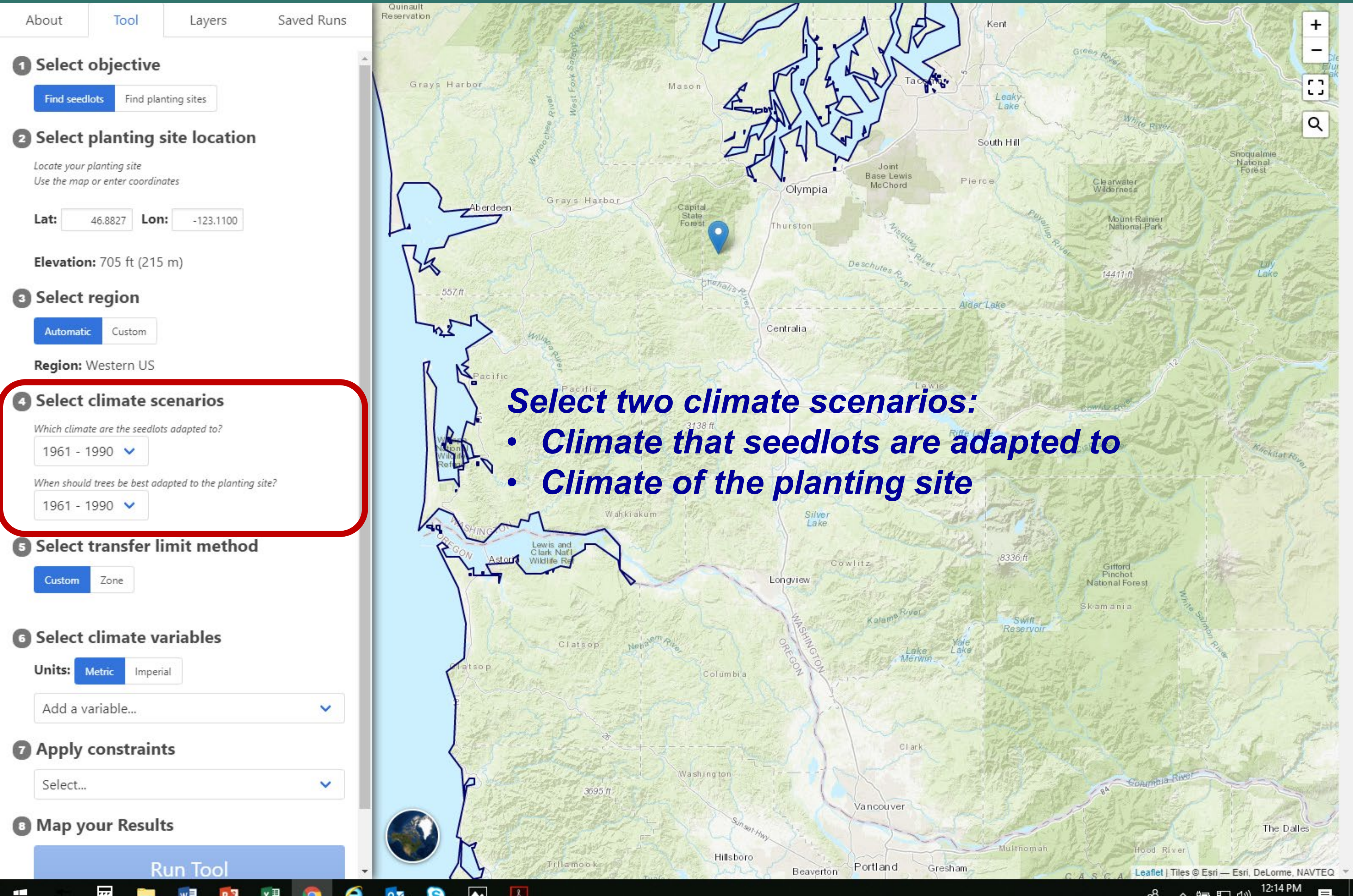
# Select location of planting site



# Select region (use automatic)



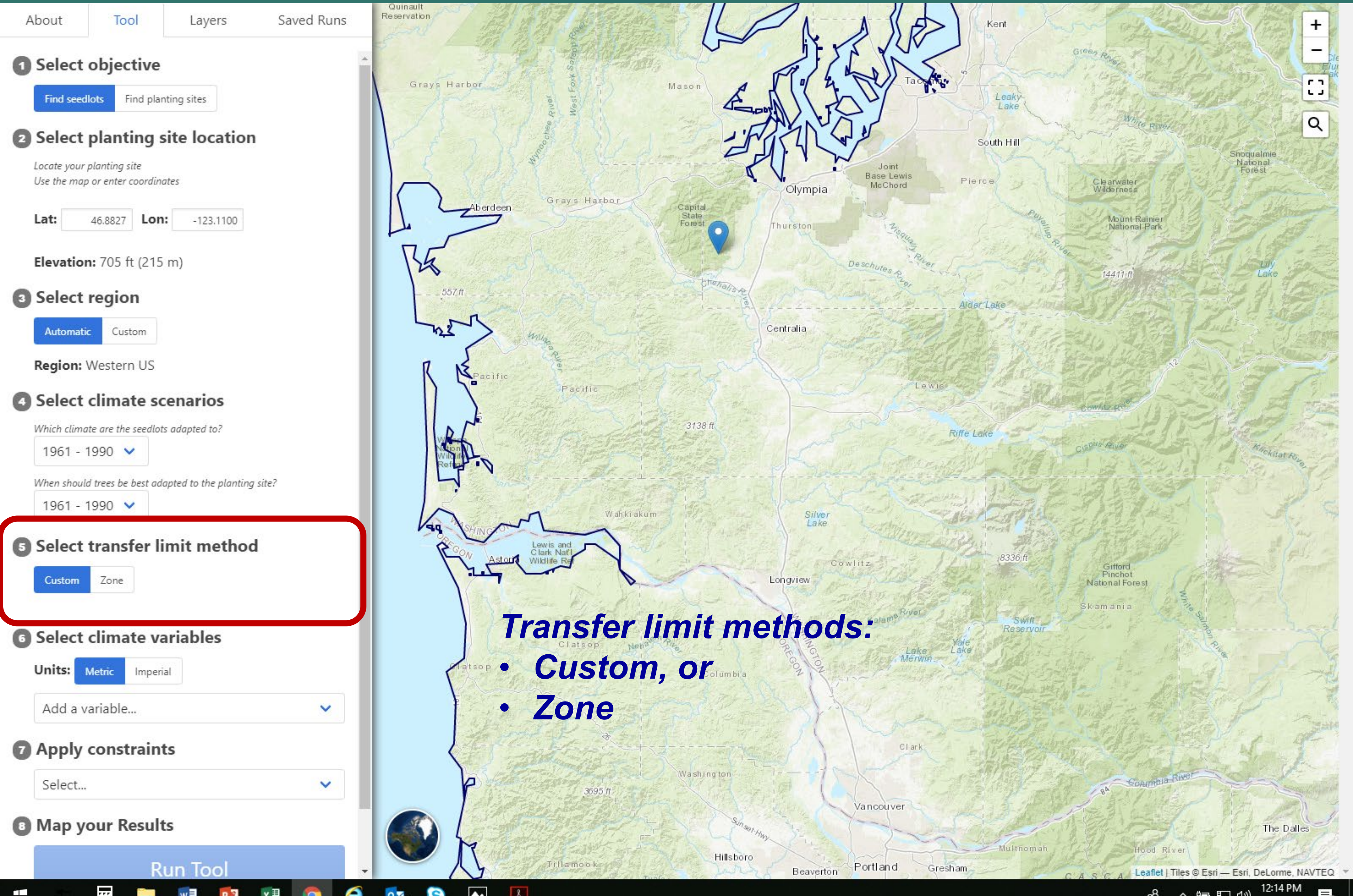
# Select climate scenarios




***Select two climate scenarios:***

- ***Climate that seedlots are adapted to***
- ***Climate of the planting site***

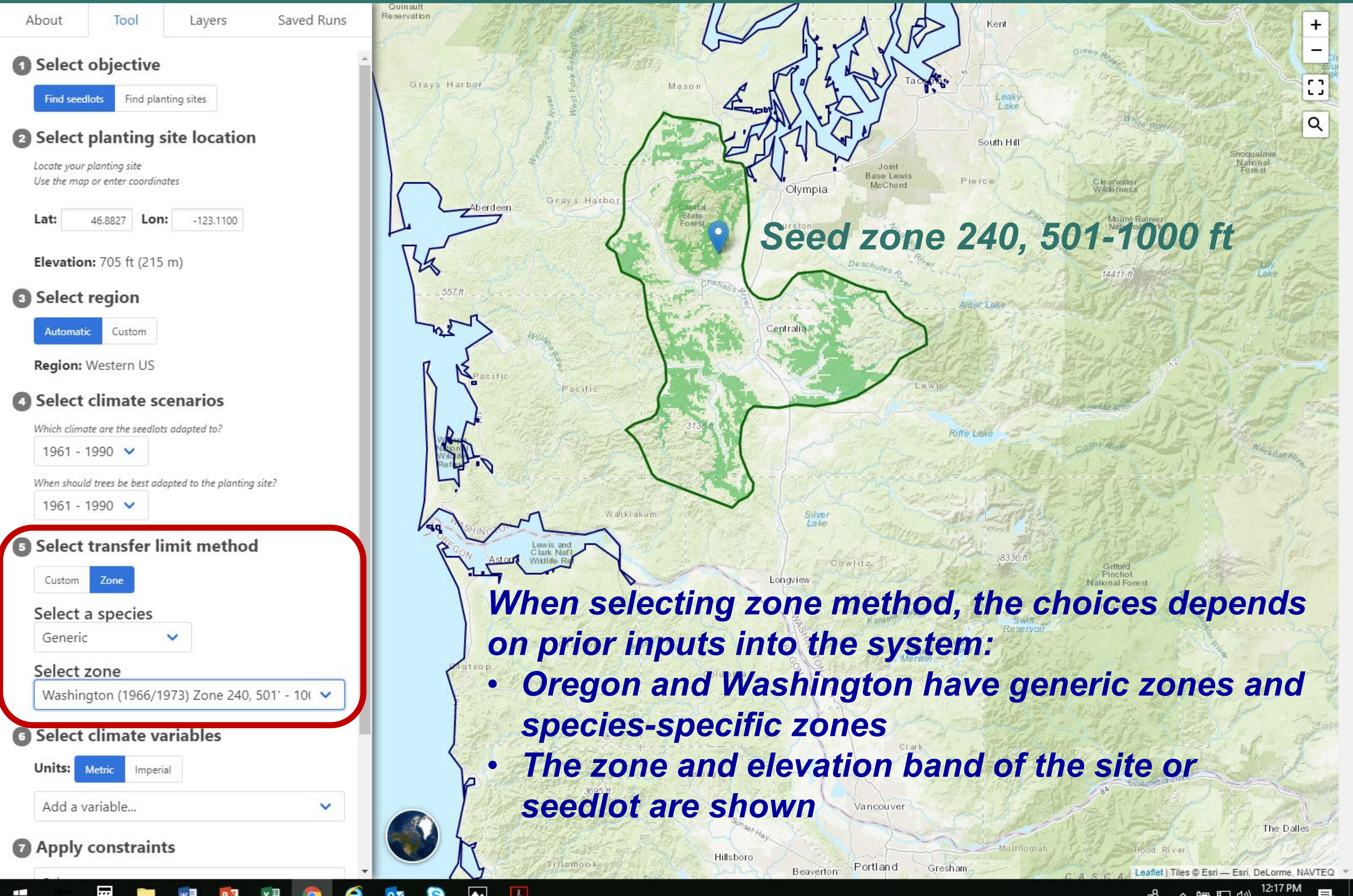
# Select transfer limit method




**Transfer limit methods:**

- **Custom, or**
- **Zone**

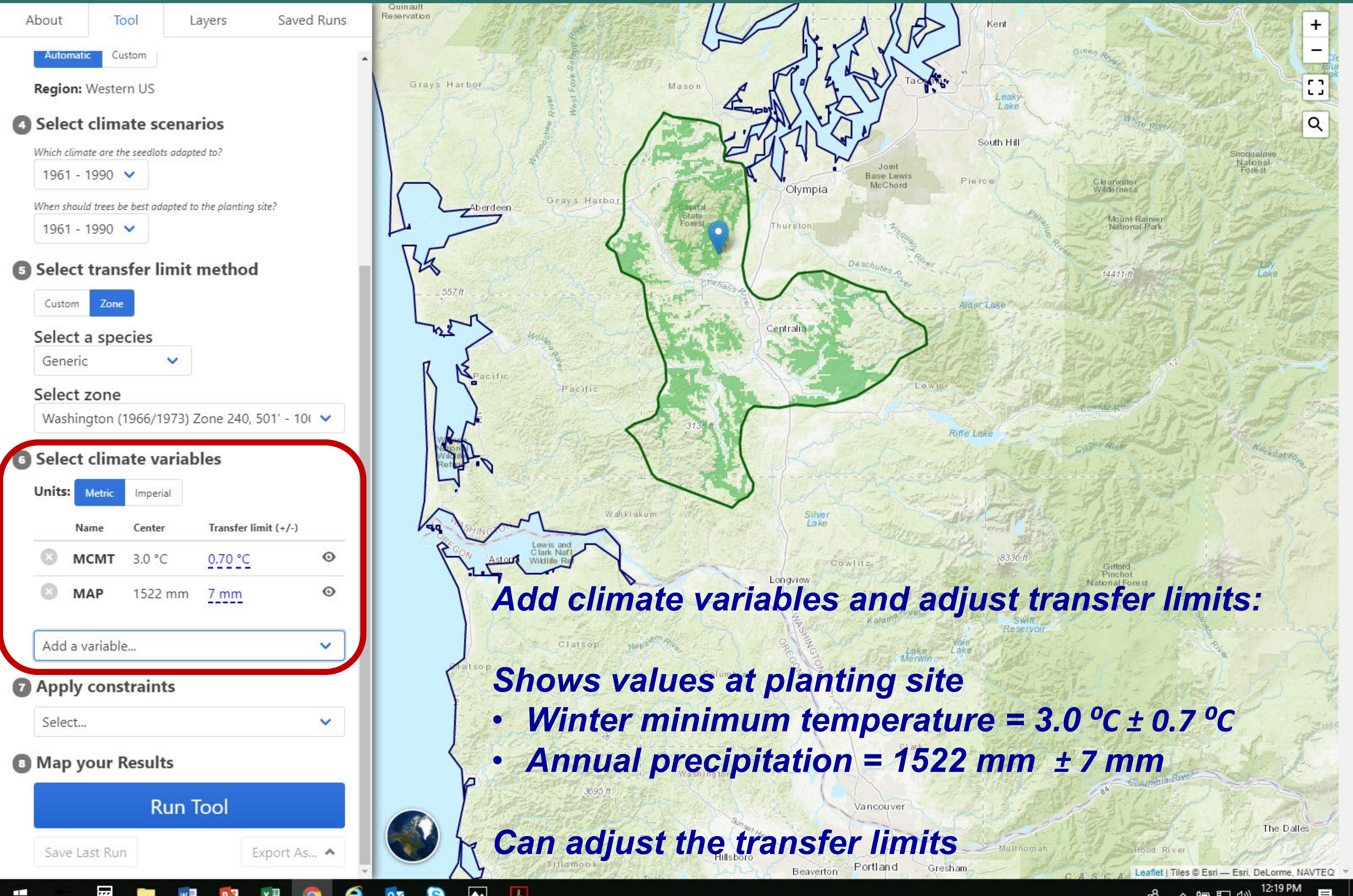
# Using the seed zone method




***When selecting zone method, the choices depends on prior inputs into the system:***

- ***Oregon and Washington have generic zones and species-specific zones***
- ***The zone and elevation band of the site or seedlot are shown***

# Select climate variables



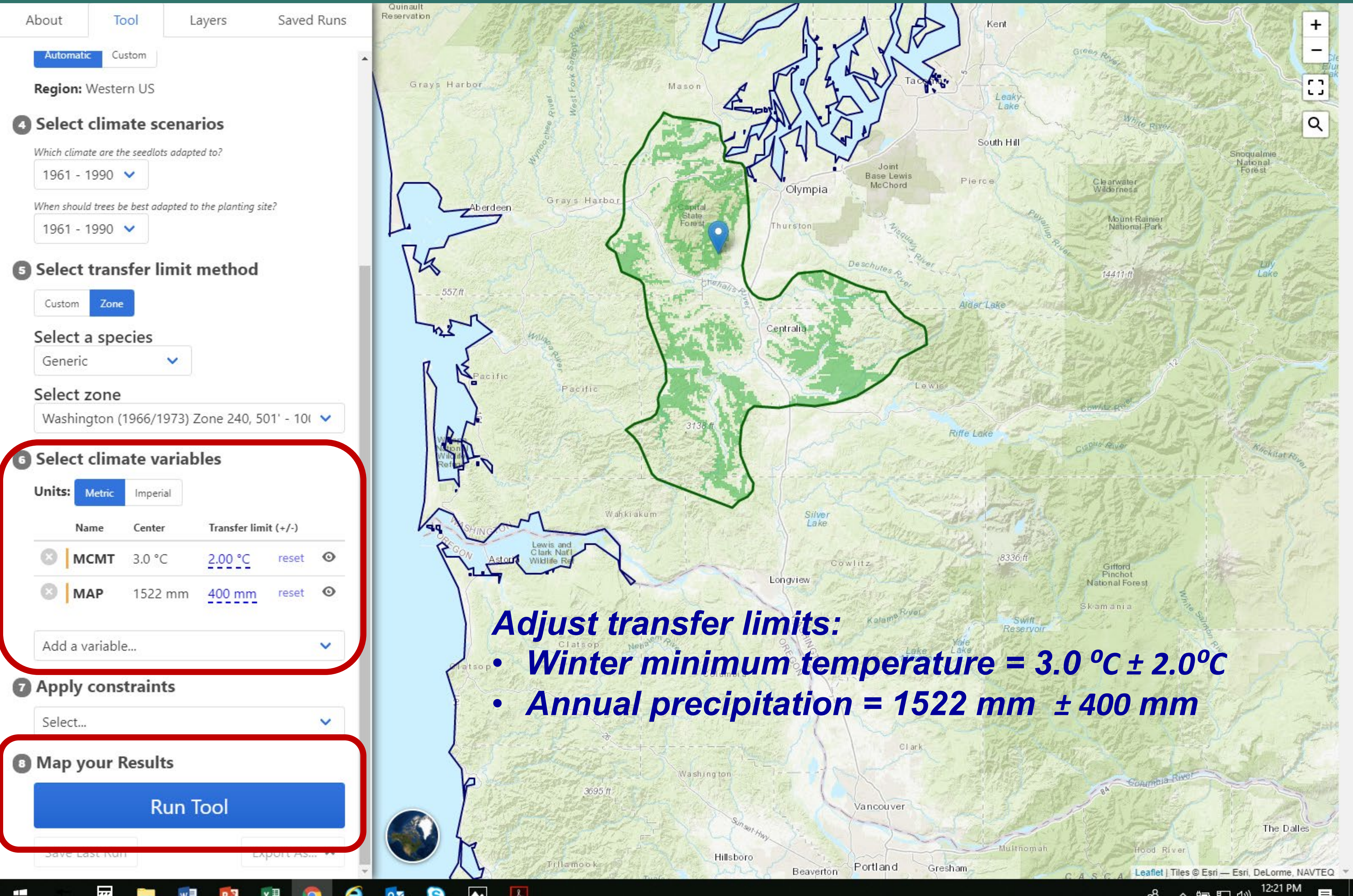

***Add climate variables and adjust transfer limits:***

***Shows values at planting site***

- ***Winter minimum temperature = 3.0 $^oC$ ± 0.7 $^oC$***
- ***Annual precipitation = 1522 mm ± 7 mm***

***Can adjust the transfer limits***

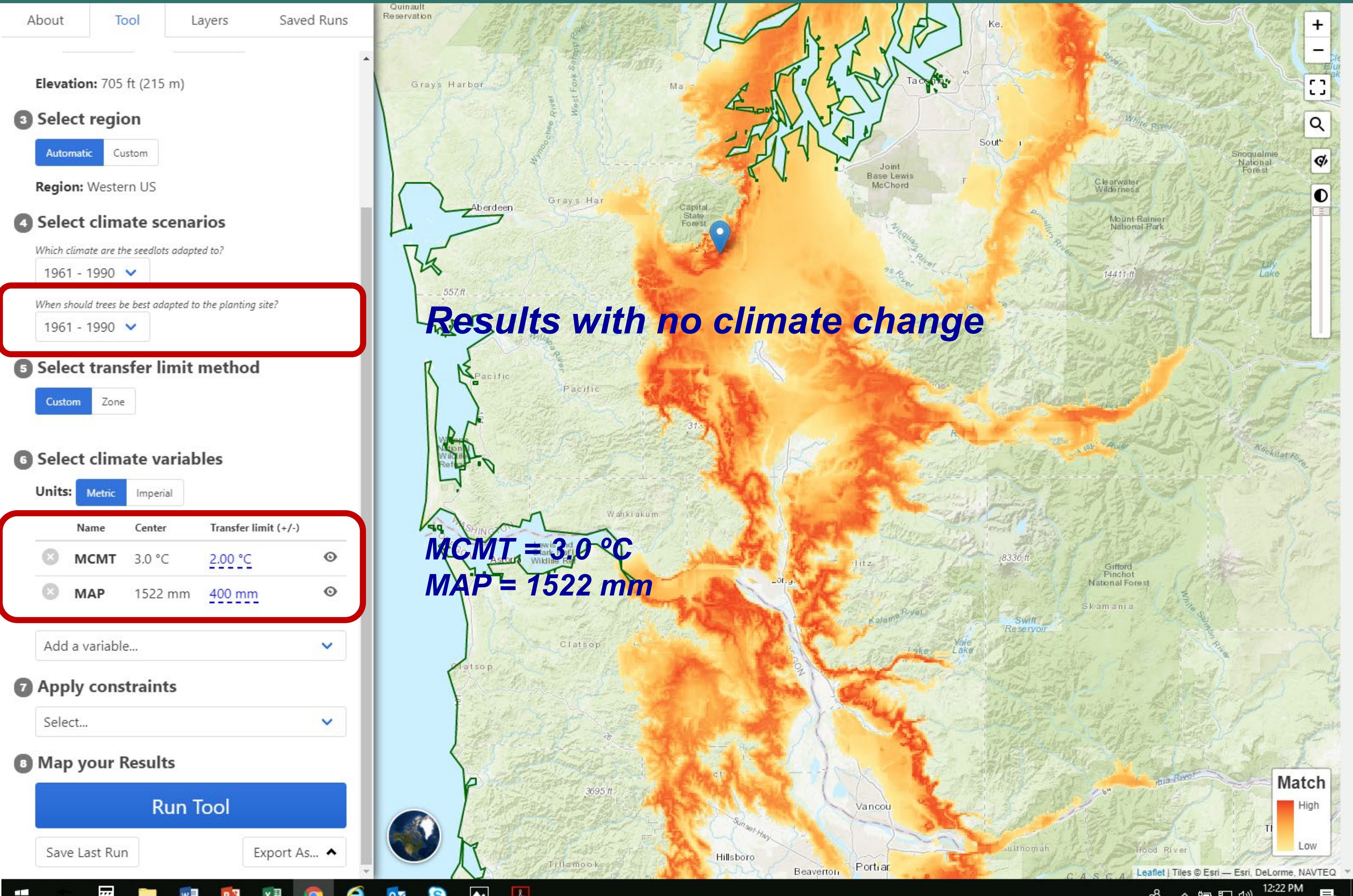
# Adjust transfer limits



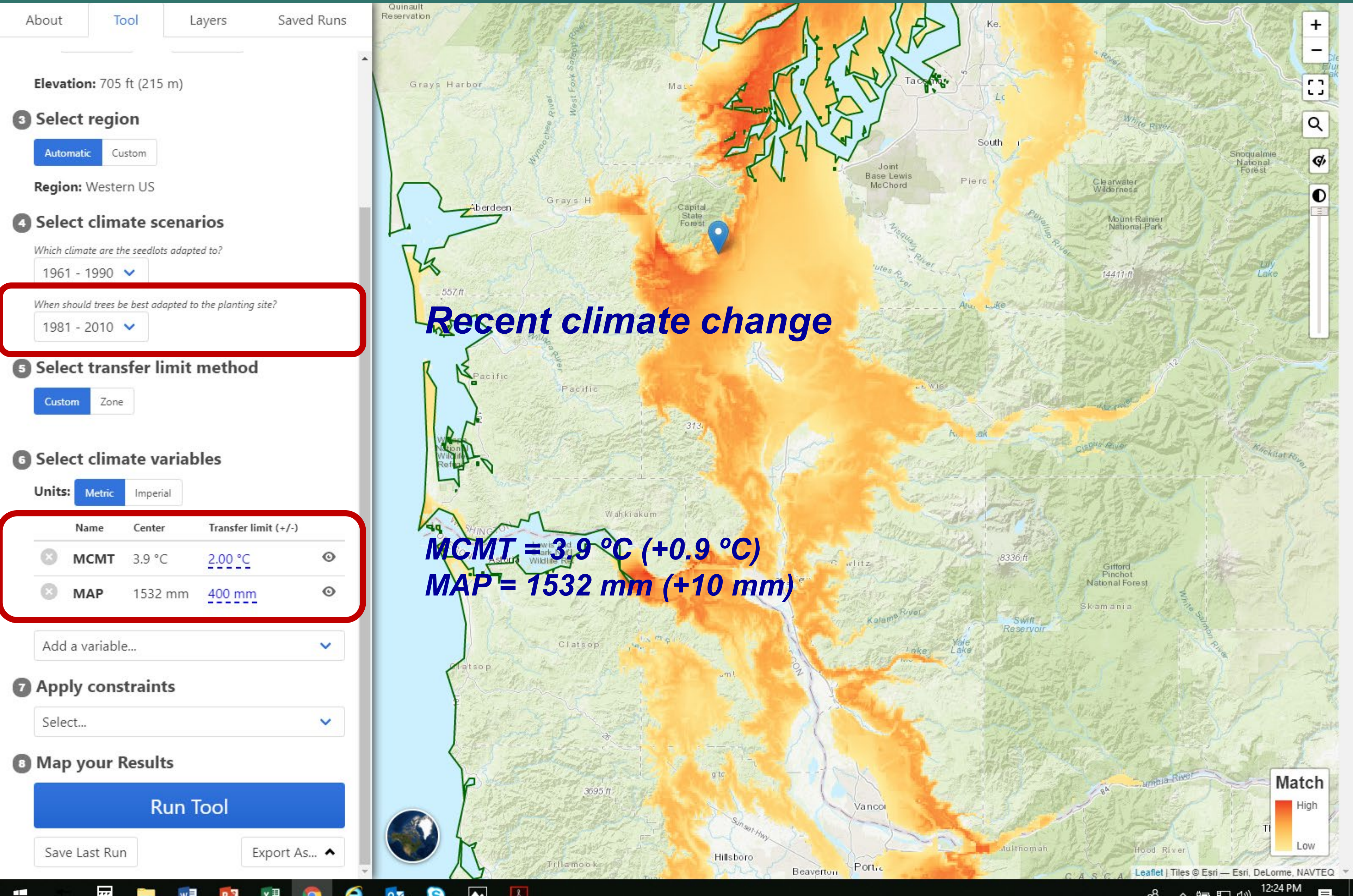

***Adjust transfer limits:***

- ***Winter minimum temperature = 3.0 $^{o}$C ± 2.0$^{o}$C***
- ***Annual precipitation = 1522 mm ± 400 mm***

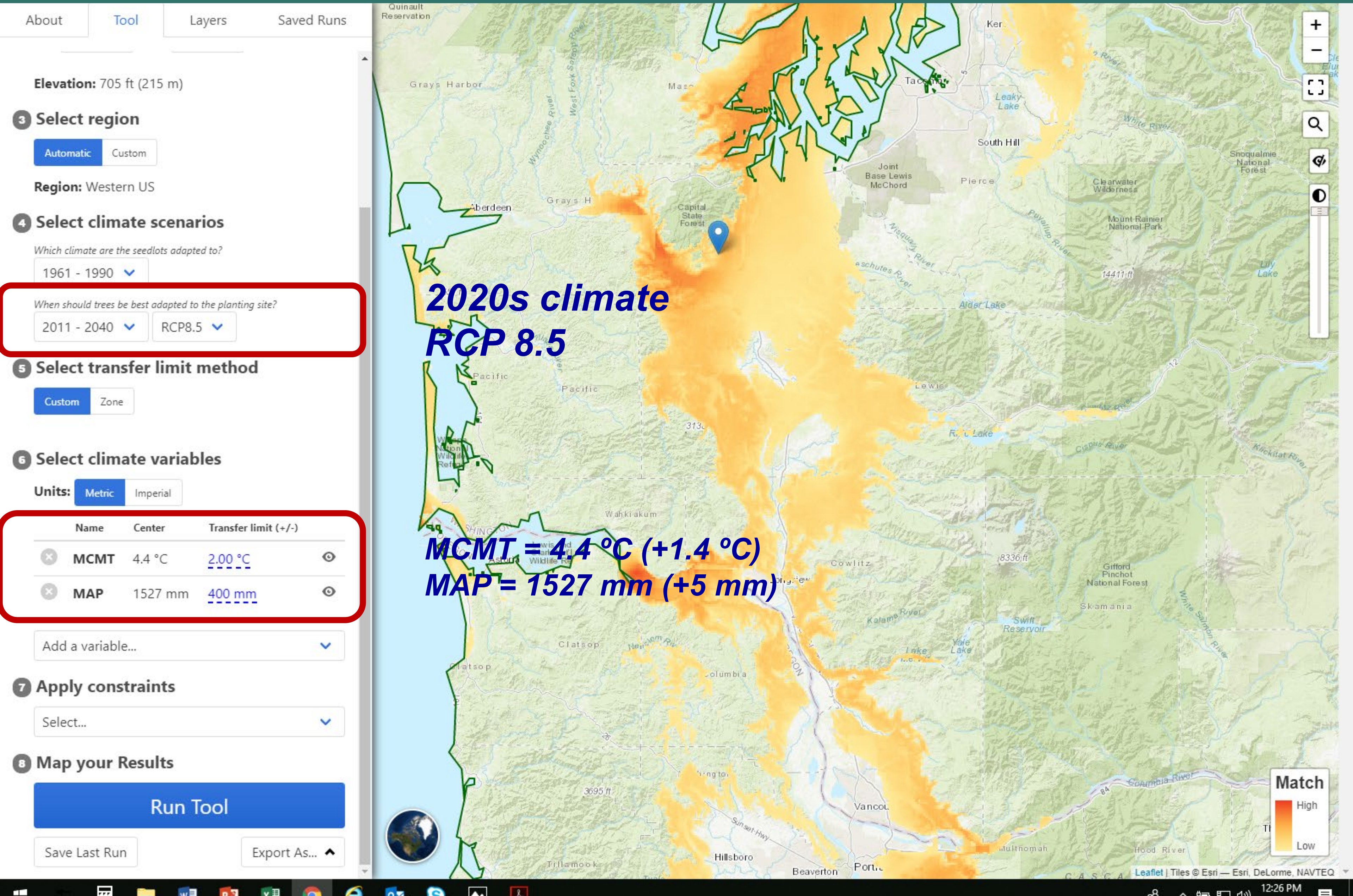
# Seedlots for planting site - Ignoring climate change



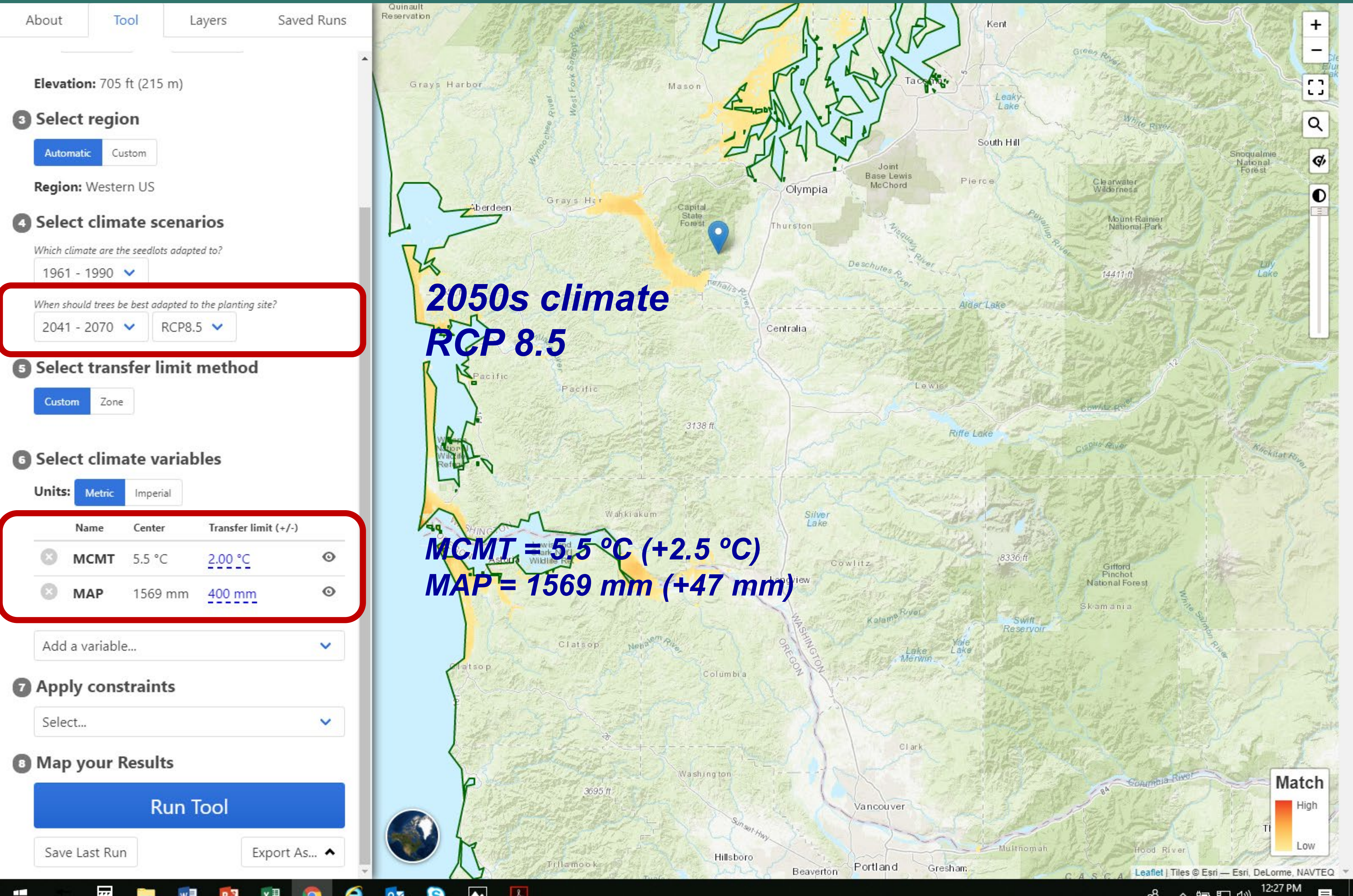
# Seedlots for planting site – Recent climate



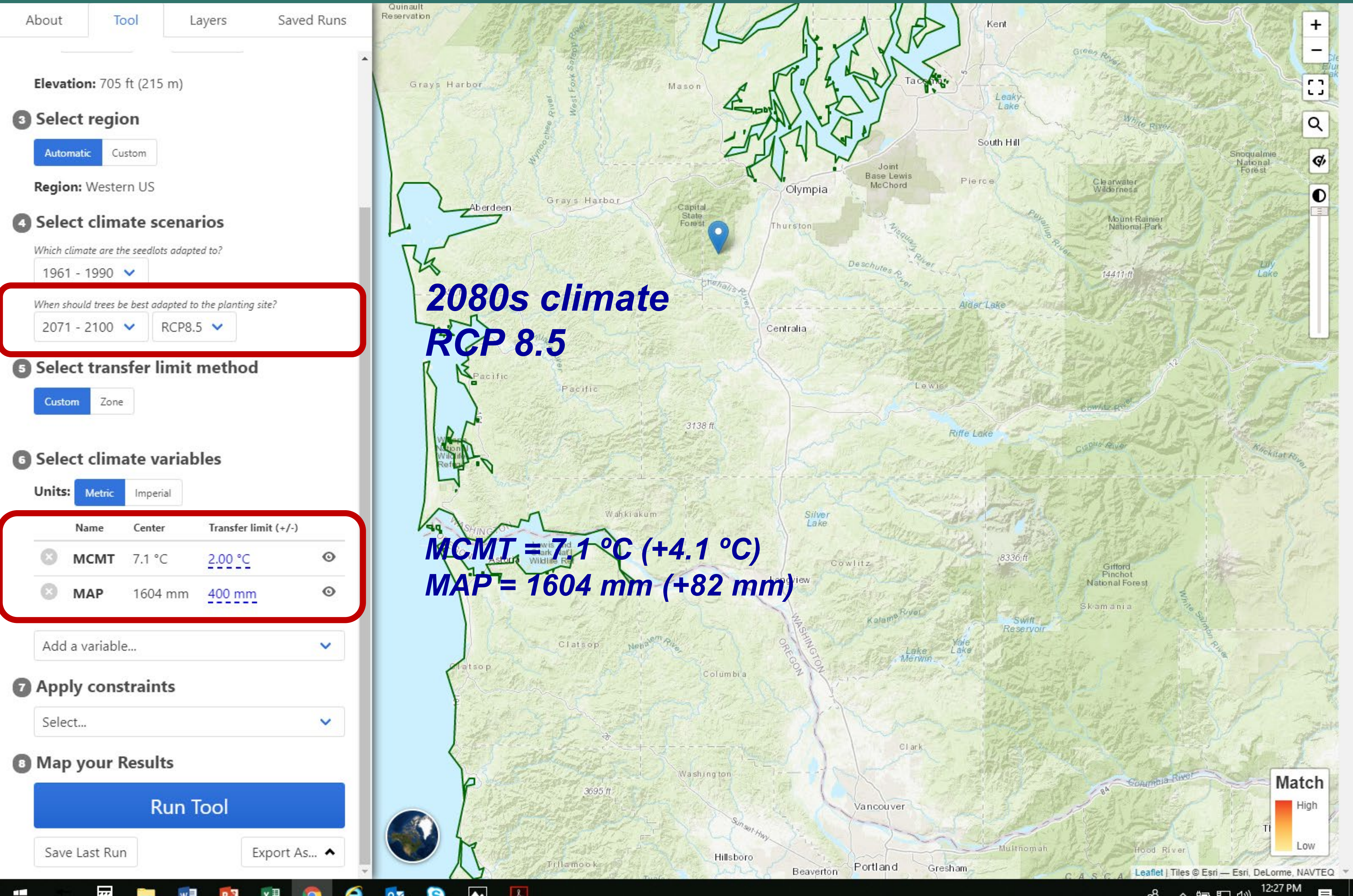
# Seedlots for planting site – 2020s climate



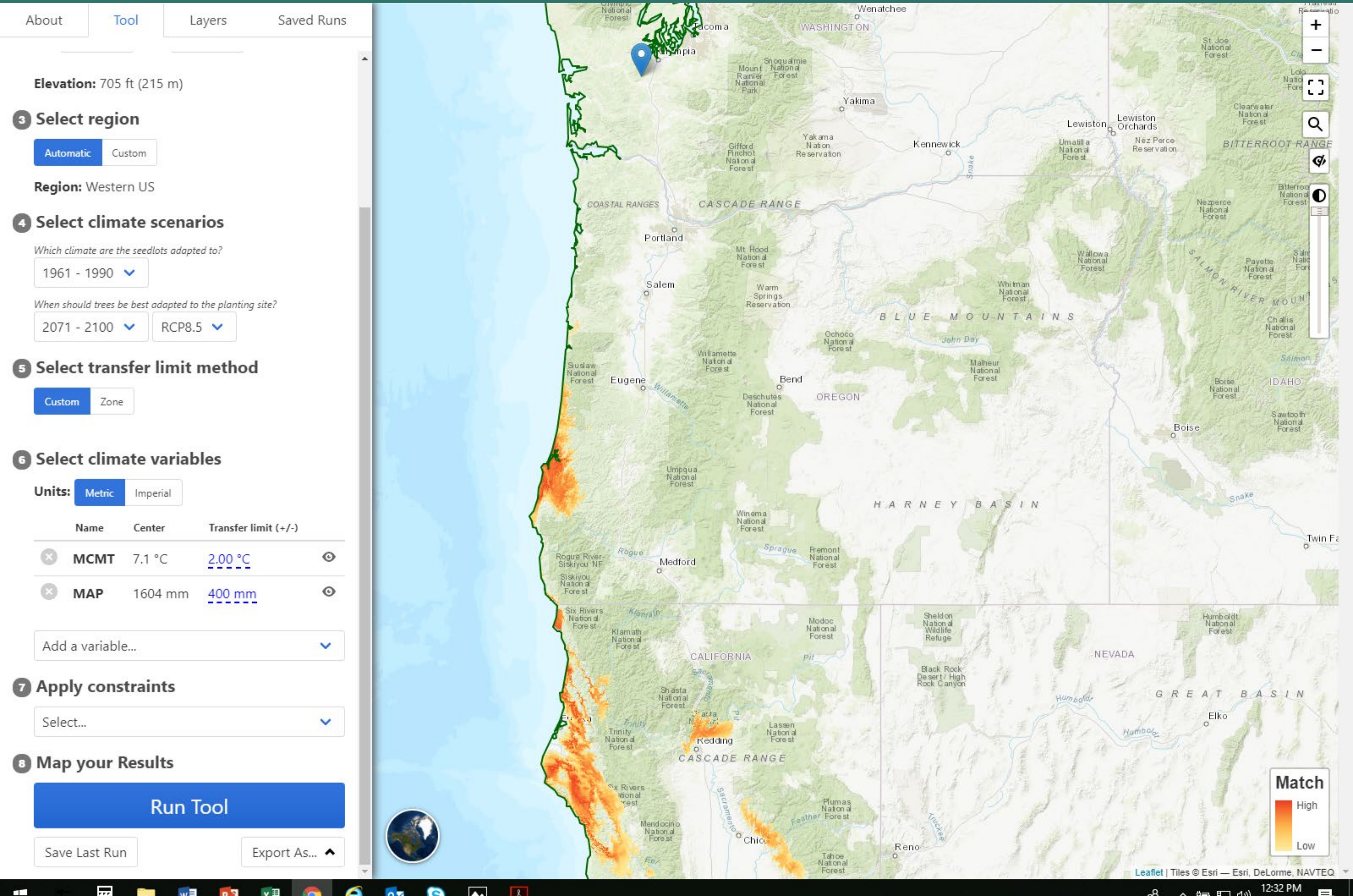
# Seedlots for planting site – 2050s climate



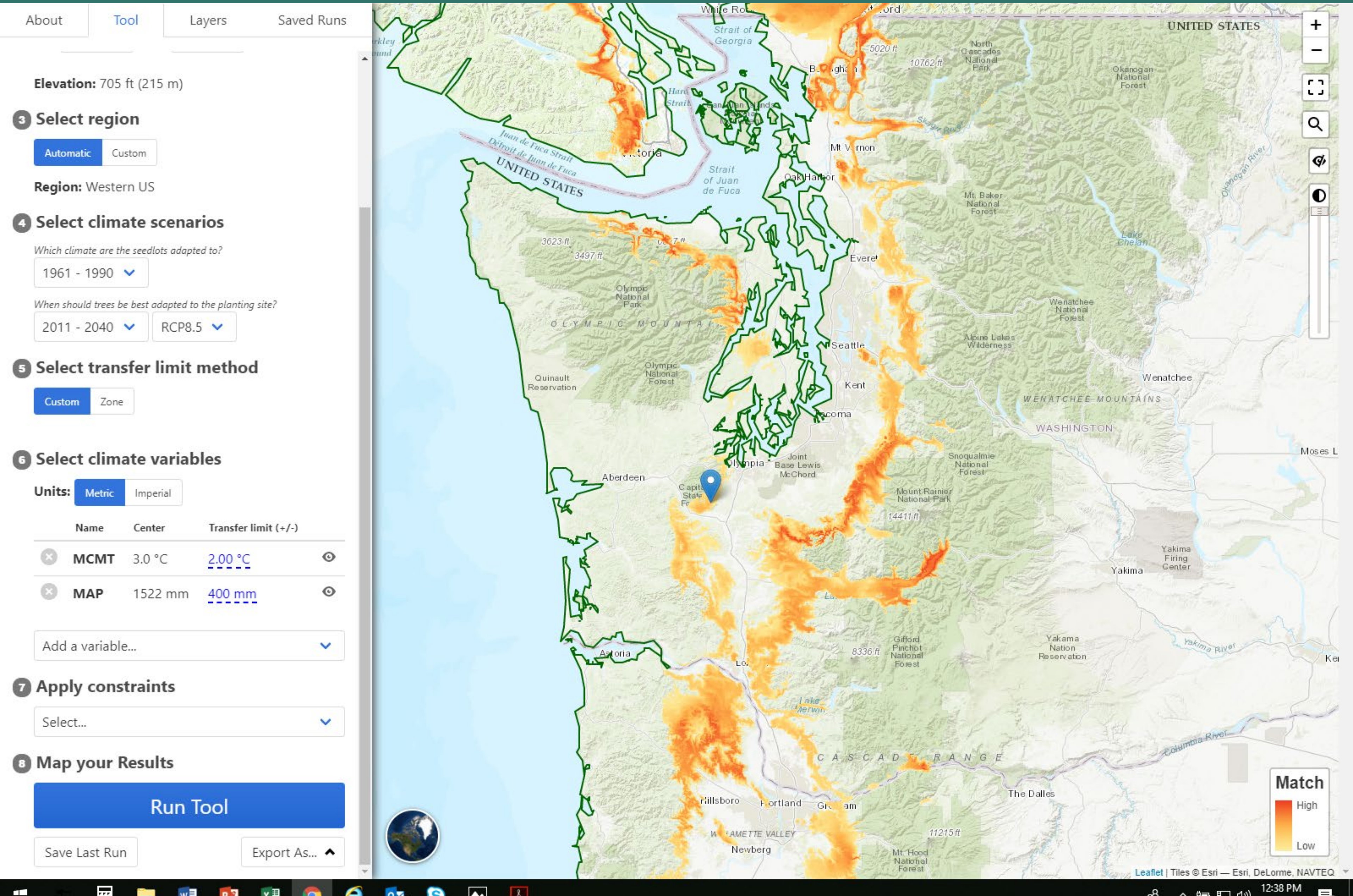
# Seedlots for planting site – 2080s climate



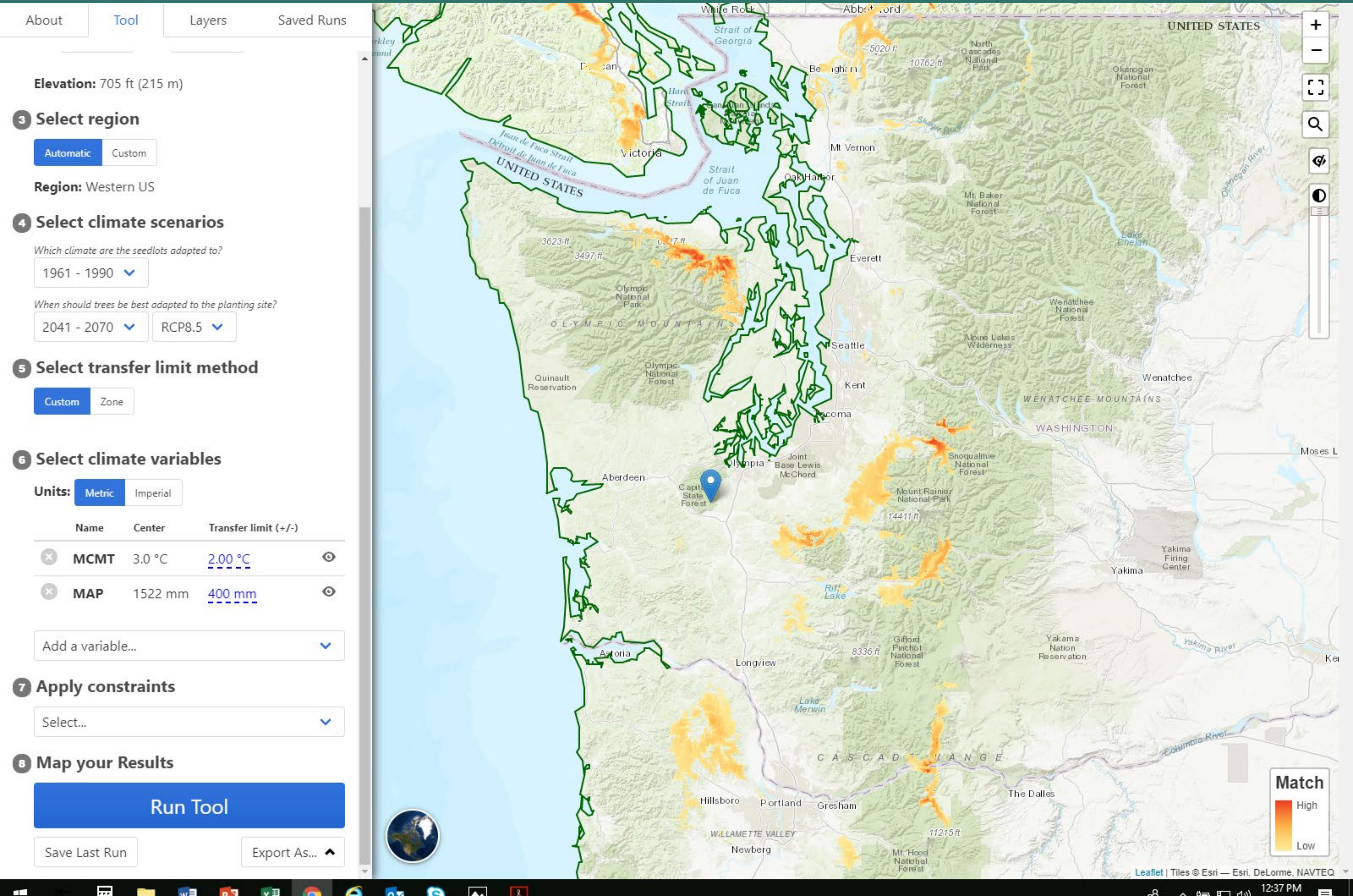
# Seedlots for planting site – 2080s climate



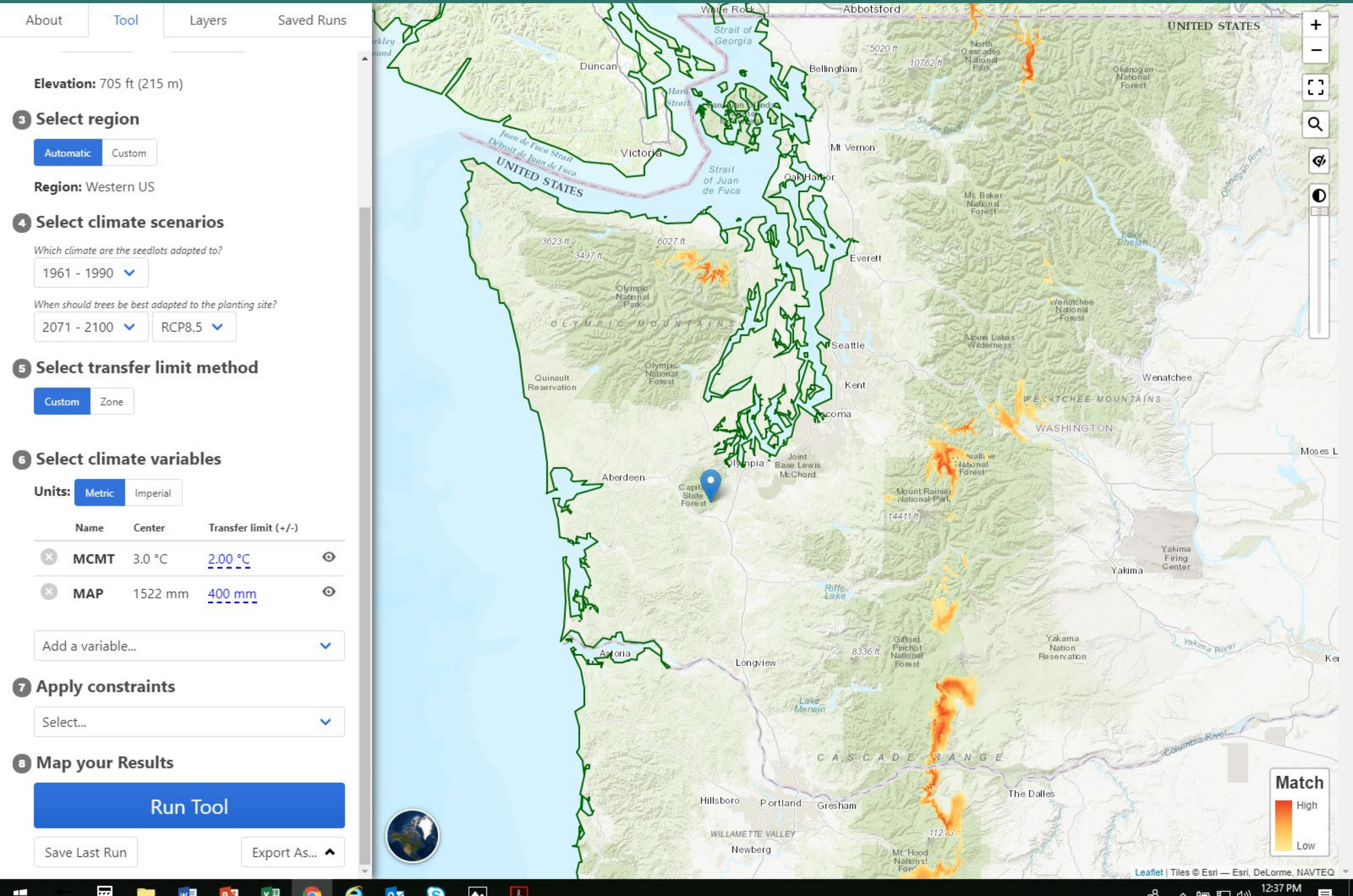
# Planting sites for a seedlot – 2020s climate



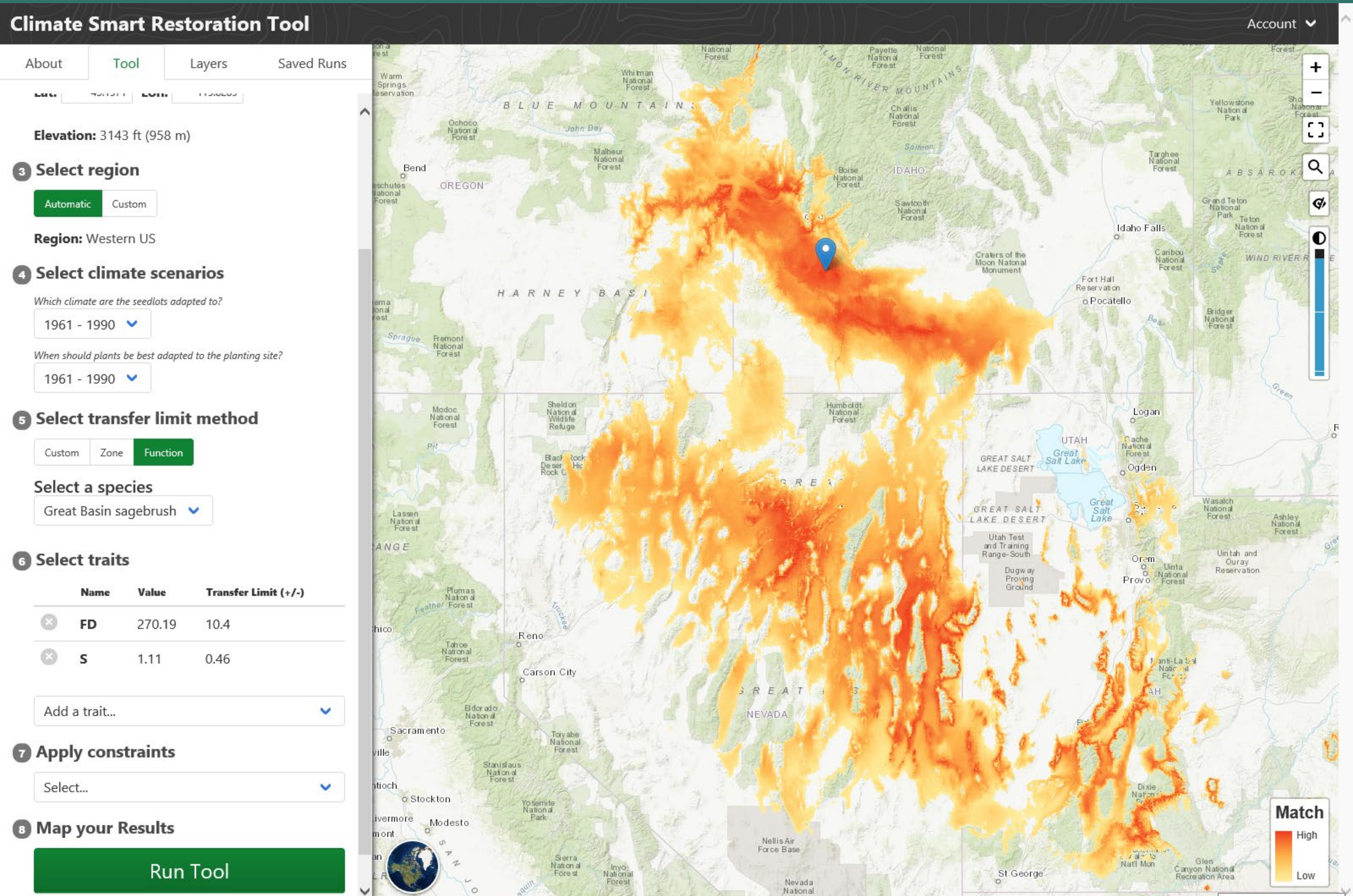
# Planting sites for a seedlot – 2050s climate



# Planting sites for a seedlot – 2080s climate



# Climate Smart Restoration Tool
# Wyoming big sagebrush seedlots for planting sites



# Conclusions: Addressing climate change risk

- Climates are warming and are expected to continue to warm, more so in the north than in the south.
- In the short-term (currently, next decade or so), local populations are adapted to the local climate (within range of current transfer guidelines).
- In the long-term (by mid- to late-century), local populations are at a high risk of maladaptation to projected climates (and species at the warm edge of range).
- Adapted populations (i.e., from similar climates as present) may be found at lower elevations or further south.
- Need to balance adaptation to the present conditions with adaptation to future conditions – a moving target.
  - Match to the climate of the next decade or two.
    - Stand establishment is highly critical phase
    - Aim too far out and likely to see frost damage in the near term
- Use mixtures to account for uncertainty and climate change over the life of a stand.
- Start planning for future seed needs for warming climates.
- Consider gene conservation activities to conserve genetic diversity.

# People and Funding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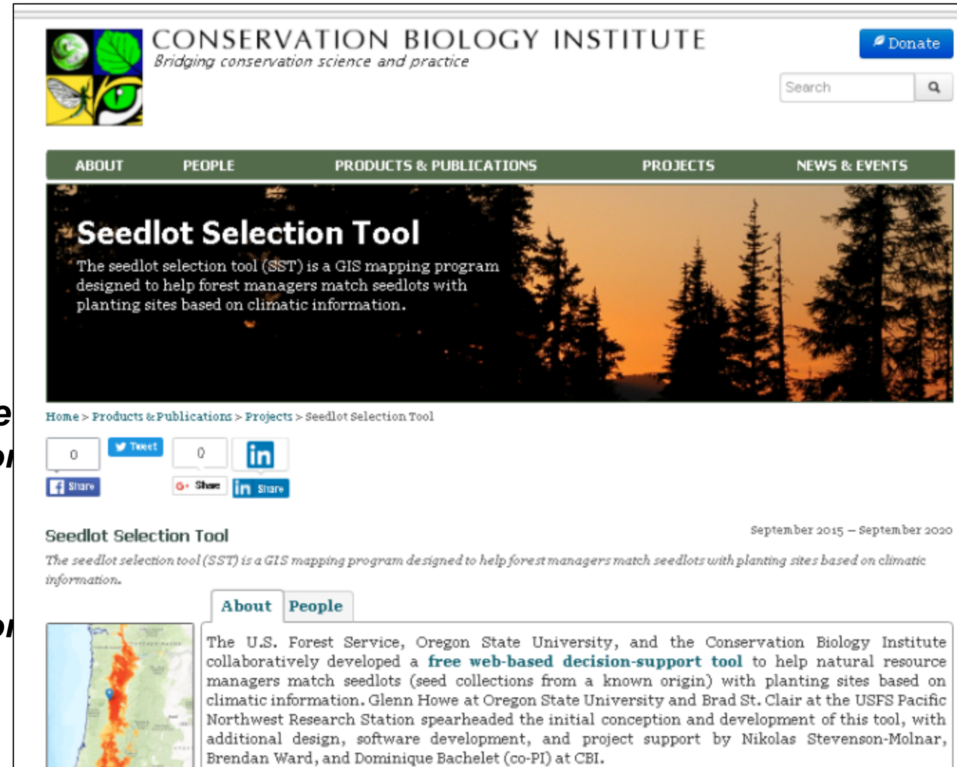


***consbio.org/products/webinars/climate-smart-seedlot-selection-tool***

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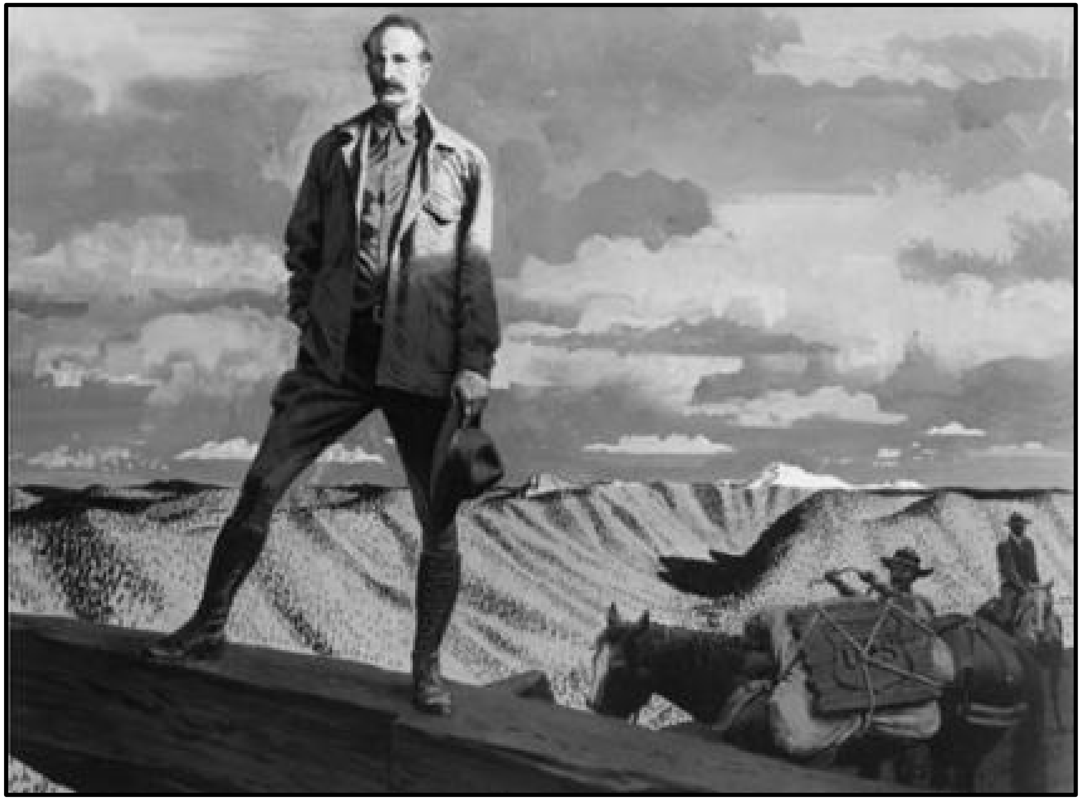

“The vast possibilities of our great future will become realities only if we make ourselves responsible for that future”

- Gifford Pinchot


Questions?