TRANSFER OF FOREST GENETIC RESOURCES IN LIGHT OF CLIMATE CHANGES

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About myself

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Bosnia and Herzegovina, Europe

Previous research

Seed science

Nursery

Aforestation

Reaforestation

My project

Transfer of forest genetic recourses in light of climate changes – assisted migration

OBJECTIVES

- Impact of climate changes on forests in Oregon

- Comparison between Oregon and Bosnia & Herzegovina:

- Forest management
- Forest species and associations
- Species migration
- Seedlings production and quality standards
- Long-term provenance tests
- Short-term seedlings tests

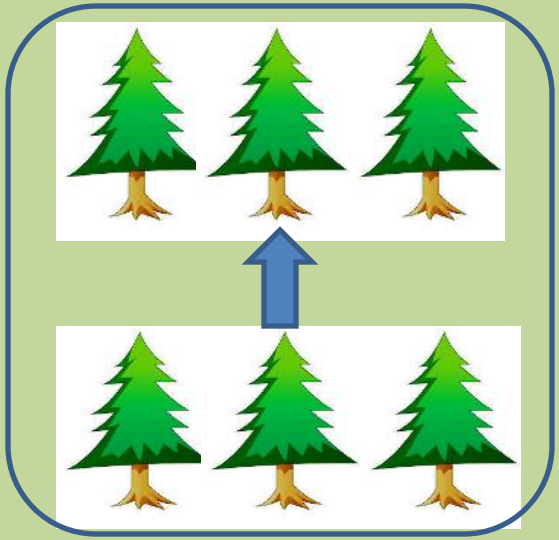
- Methods and techniques for dealing with climate changes
- New technologies
- Possible solutions, recommendations, etc.
- Long term collaboration

DEFINITIONS

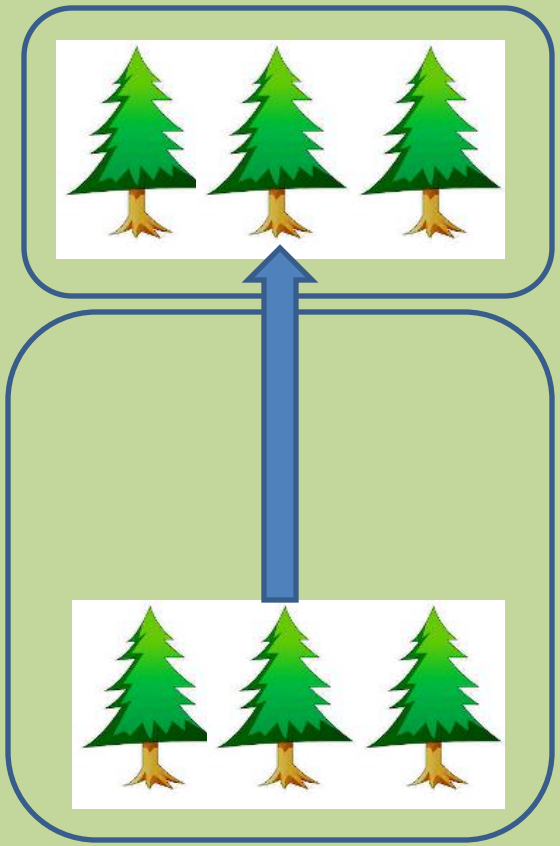
Term	Definition
Assisted migration	1. Human-aided translocation of species to areas where climate is projected to become suitable to reduce the risk of extinction due climate change (*Mueller and Hellmann 2008*) 2. The purposeful movement of species to facilitate or mimic natural range expansion as a direct management response to climate change (*Vitt et al. 2010*)
Assisted colonization	1. The translocation of species to favorable habitat beyond their native range to protect them from human-induced threats such as climate change (*Ricchardi and Simberloff, 2009*) 2. Translocation of a species beyond its natural range to protect it from human-induced threats (*Seddon, 2010*)
Managed relocation	1. An intervention technique aimed at reducing negative effects of climate change on defined biological units such as populations, species and ecosystems. It involves the intentional movement of biological units from current areas of occupancy to locations where the probability of future persistence is predicted to be higher. The underlying motivation id to reduce the threat of diminished ecosystem service or extinction from climate change (*Richardson et al. 2009*) 2. A conservation strategy involving the translocation of species to novel ecosystems in anticipation of range shifts forced by climate change

DEFINITIONS

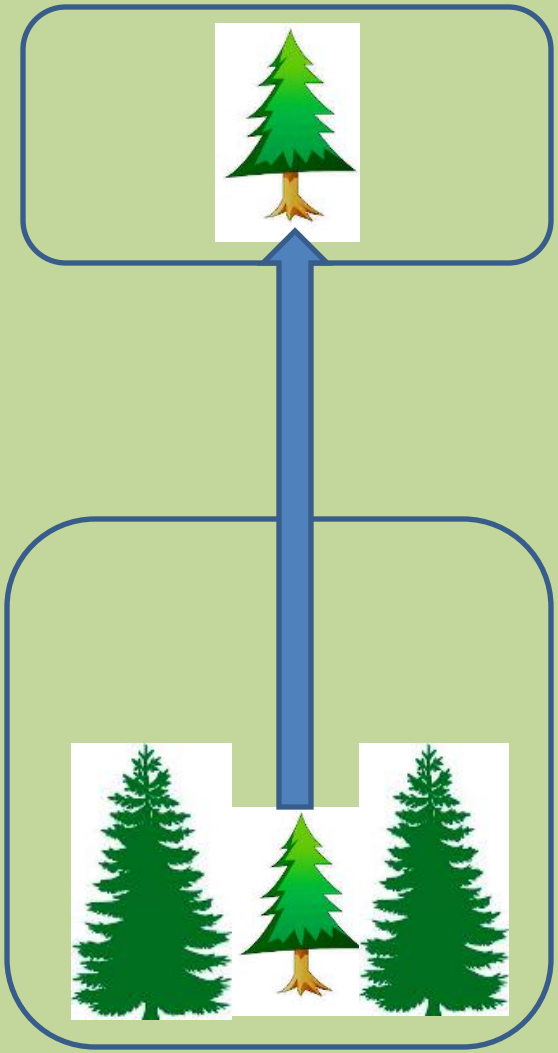
Assisted Population Migration



Assisted Range Expansion



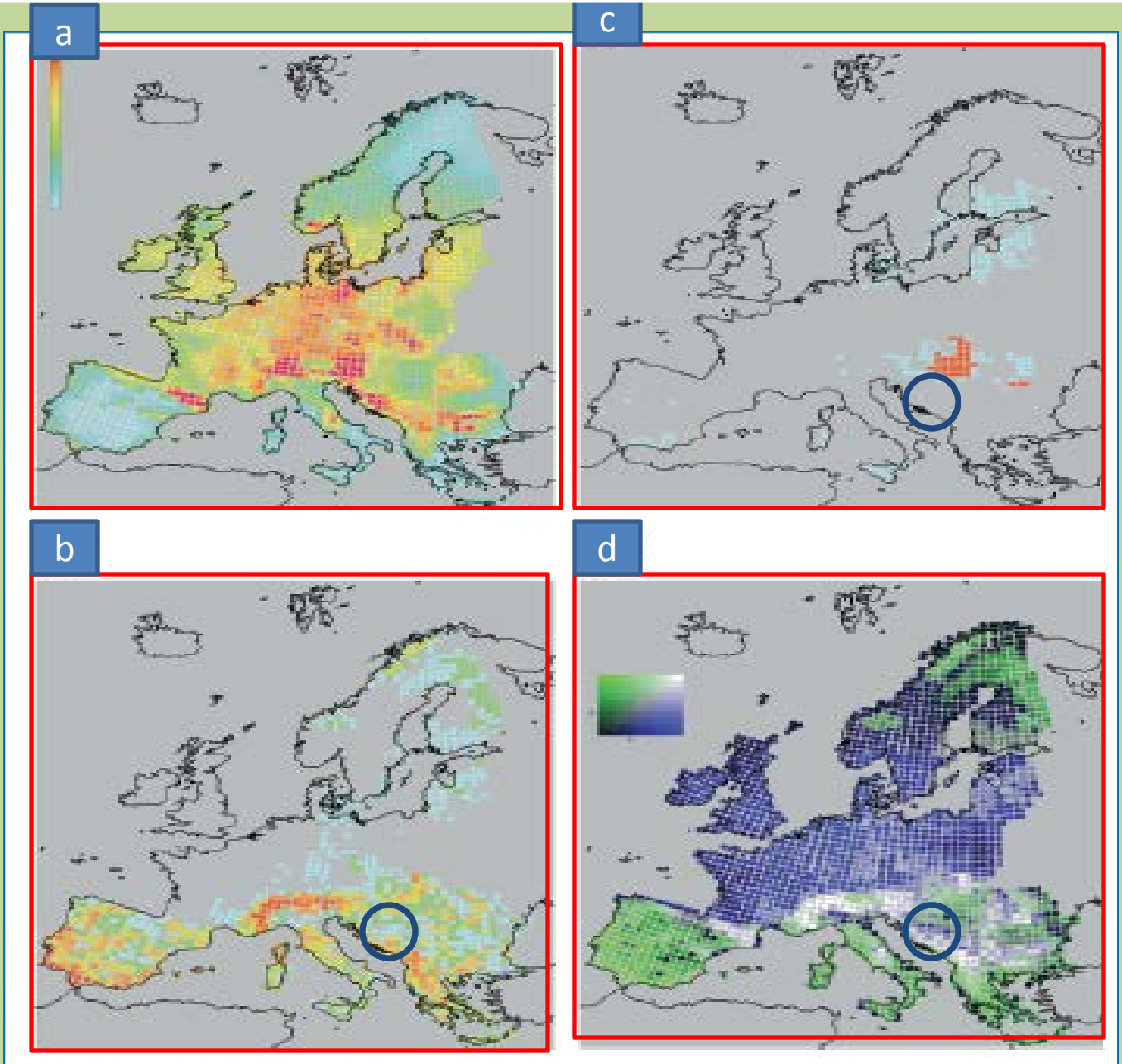
Assisted Species Migration



INTRODUCTION

Diversity

Climate change impact

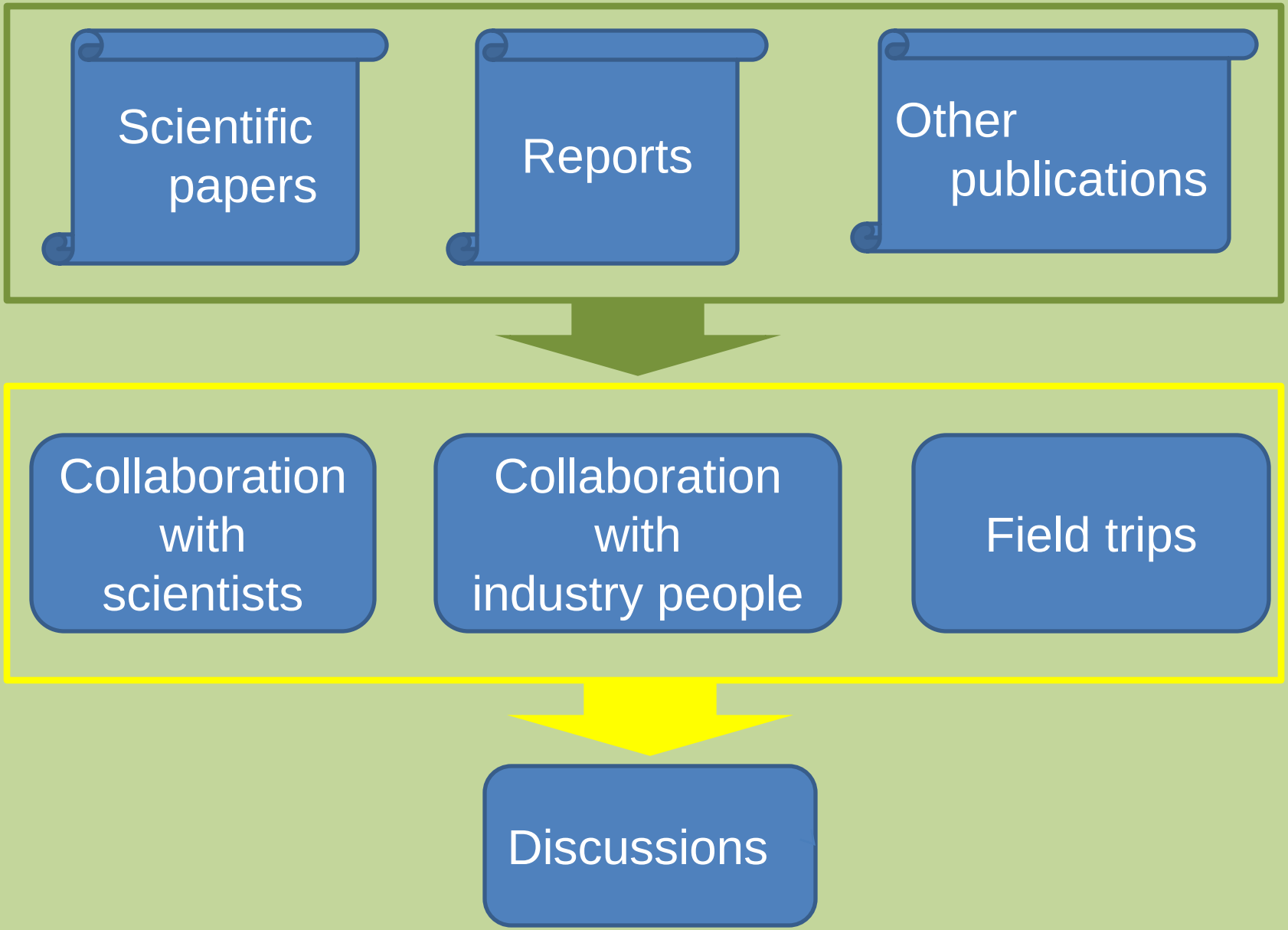


Araujo et al. 2004.

Non overlapping diversity

Richness in the future

METHOD OF RESEARCH



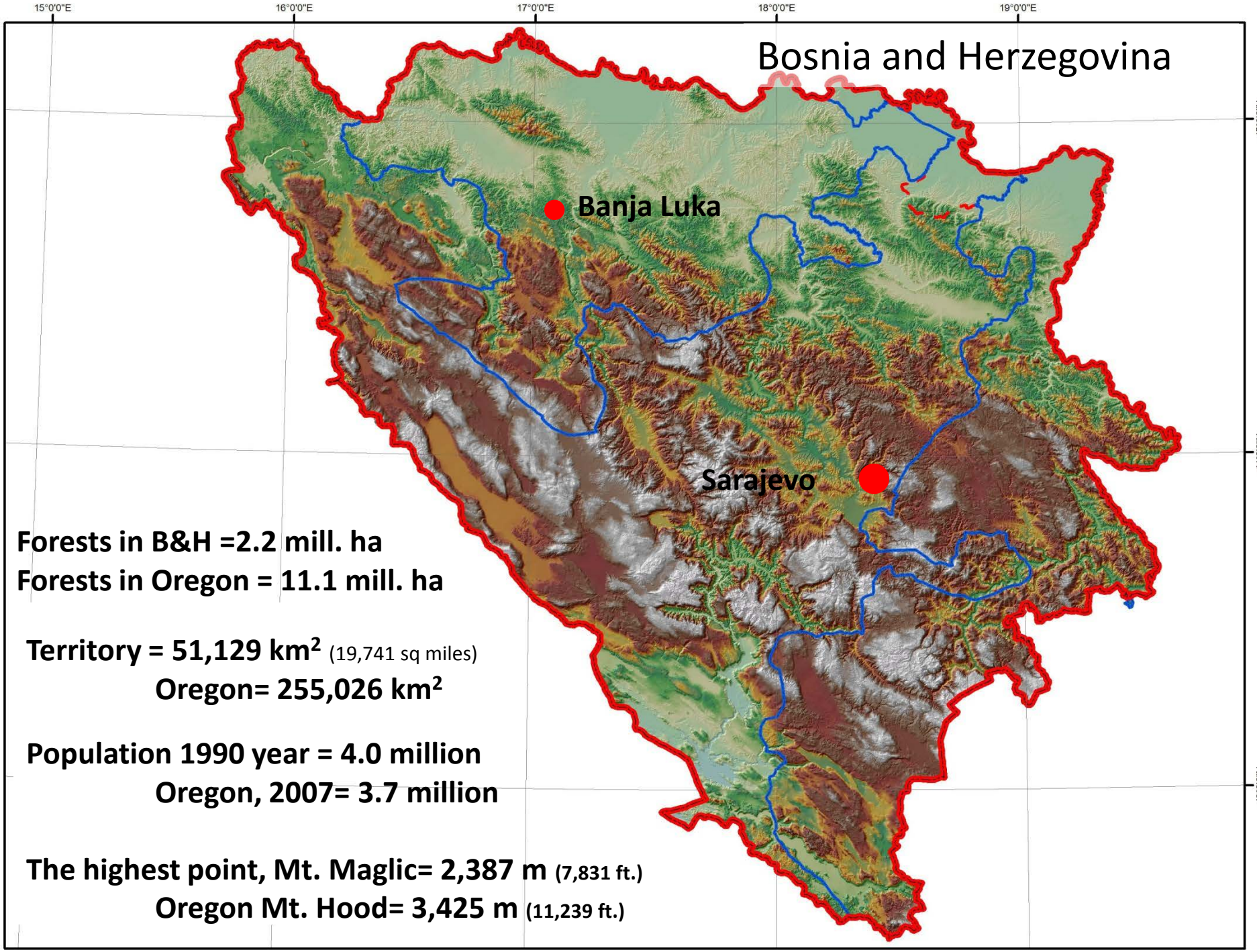
WHERE IS BOSNIA?

-19.174 square miles

-4.000.000 inhabitants

-Two entities:

1. Federation of Bosnia and Herzegovina
2. Republic of Srpska



Forests in B&H =2.2 mill. ha
Forests in Oregon = 11.1 mill. ha

Territory = 51,129 km^2 (19,741 sq miles)
Oregon= 255,026 km^2

Population 1990 year = 4.0 million
Oregon, 2007= 3.7 million

The highest point, Mt. Maglic= 2,387 m (7,831 ft.)
Oregon Mt. Hood= 3,425 m (11,239 ft.)

FOREST BIODIVERSITY

More than 100 tree species
More than 150 shrub species

The most important species are:
-Norway spruce (*Picea abies*)
-Europe beach (*Fagus silvatica*)
-European Silver fir (*Abies alba*)
-Austrian pine (*Pinus nigra*)
-Scotch pine (*Pinus silvestris*)
-Sessile Oak (*Quercus petraea*)

Great number wild fruit trees
Castane sativa, *Corylus avellana, Juglans regia, Malus silvestris*, *Prunus avium, Pyrus communis*, *Sorbus aucuparia*, *Sorbus domestica, Sorbus torminalis*, *Rubus sp*. *Vaccinuium myrtillus*, etc.

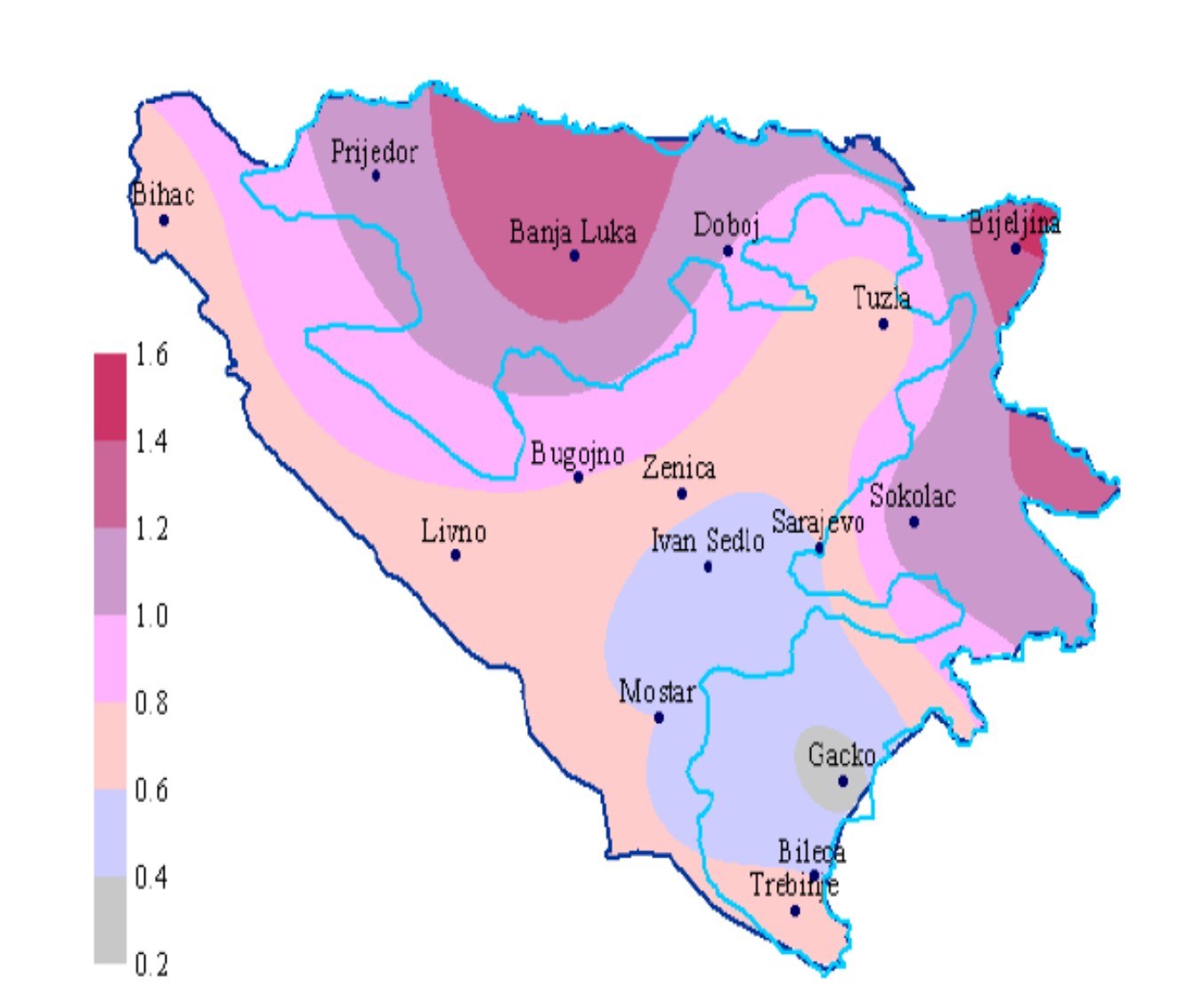
Great number noble broadleaves
-different species of genus *Acer*
-different species of genus *Fraxinus*
-different species of genus *Sorbus*, etc.

Great number of endemic trees:
-**Serbian spruce (*Picea omorika*)**

STRUCTURE OF FORESTS IN B&H

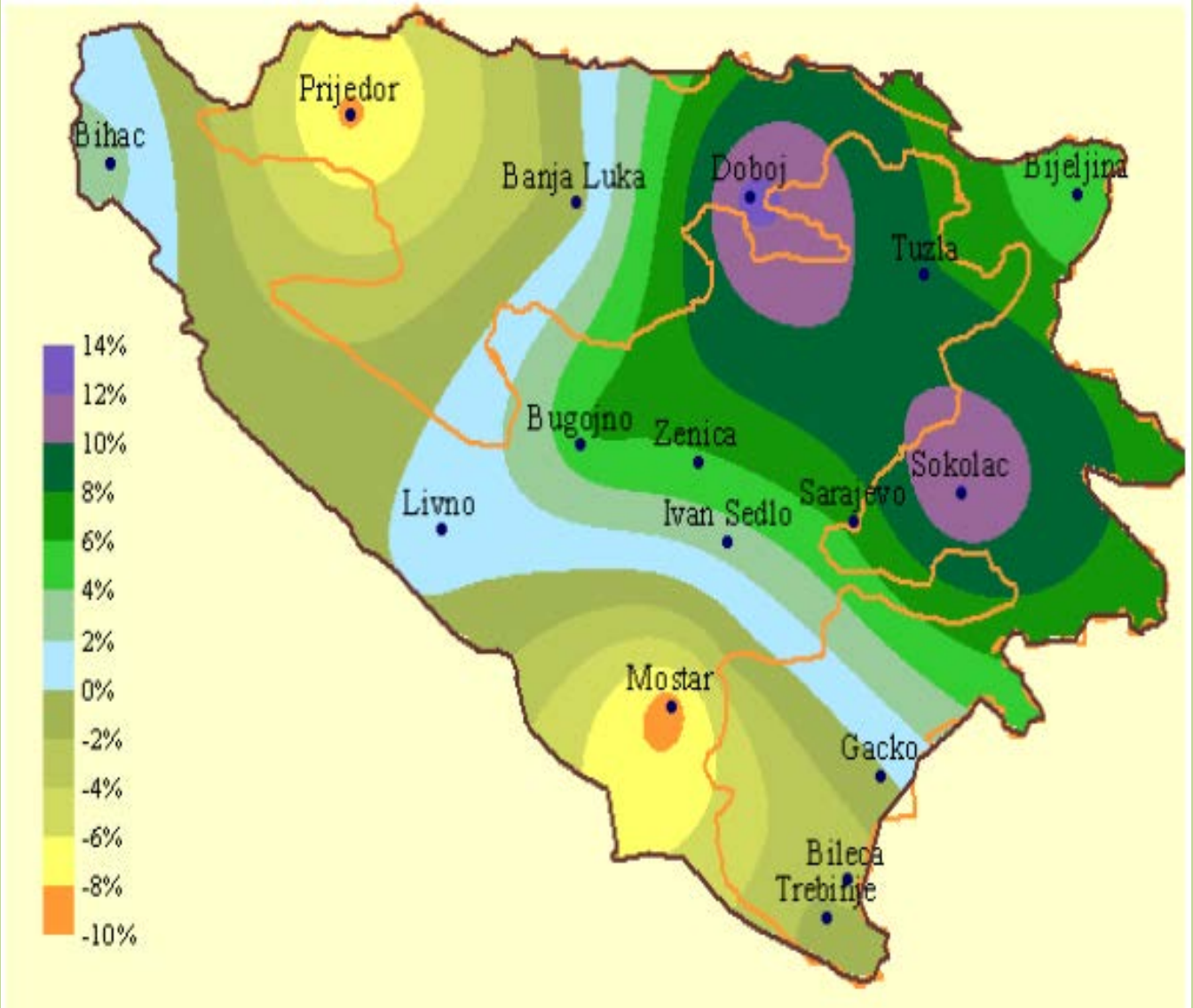
Source: NEAP, March, 2003.	R. Srpska		Federation B&H		BiH	
	[ha]	%	[ha]	%	[ha]	%
	State forests					
High valuable forests	553,763	46	645,081	43	1,198,844	44
Degraded and coppice forests	259,034	21	260,403	17	519,437	19
Bare area (Karst)	166,919	14	301,132	20	468,051	17
Total	979,716	81	1,206,616	80	2,186,332	81
Private forest						
Area	229,874	19	293,563	20	523,437	19
Total (state and private forests)						
Area	1,209,590	100	1,500,179	100	2,709,769	53/100

BOSNIA AND HERZEGOVINA AND CLIMATE CHANGES



Increase in average annual temperature in the last decade (1999-2008) compared to the reference period (1961-1990) in B&H expressed in ^{o}C

BOSNIA AND HERZEGOVINA AND CLIMATE CHANGES



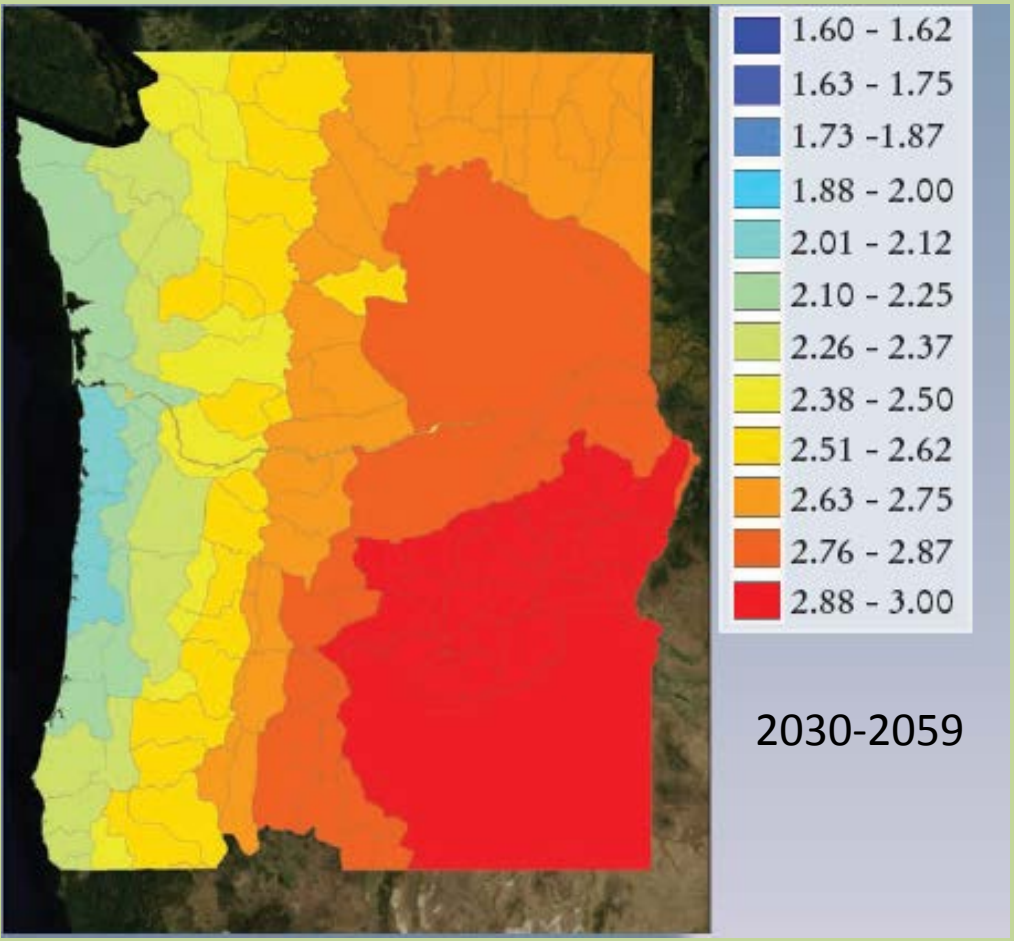
Spatial distribution of annual surplus/deficit of rainfall in the last decade (1999-2008) compared to the reference period (1961-1990) of B&H

BOSNIA AND HERZEGOVINA AND CLIMATE CHANGES

High mountainous zones in B&H those are the most sensitive to the effects of global climate change

Climate changes VS new, resistant species & new technology and planting method

OREGON AND CLIMATE CHANGES



Climate change projections for the Pacific Northwest include year-round warming and potentially increased winter precipitation and decreased summer precipitation (*Mote and Salathé* 2009)

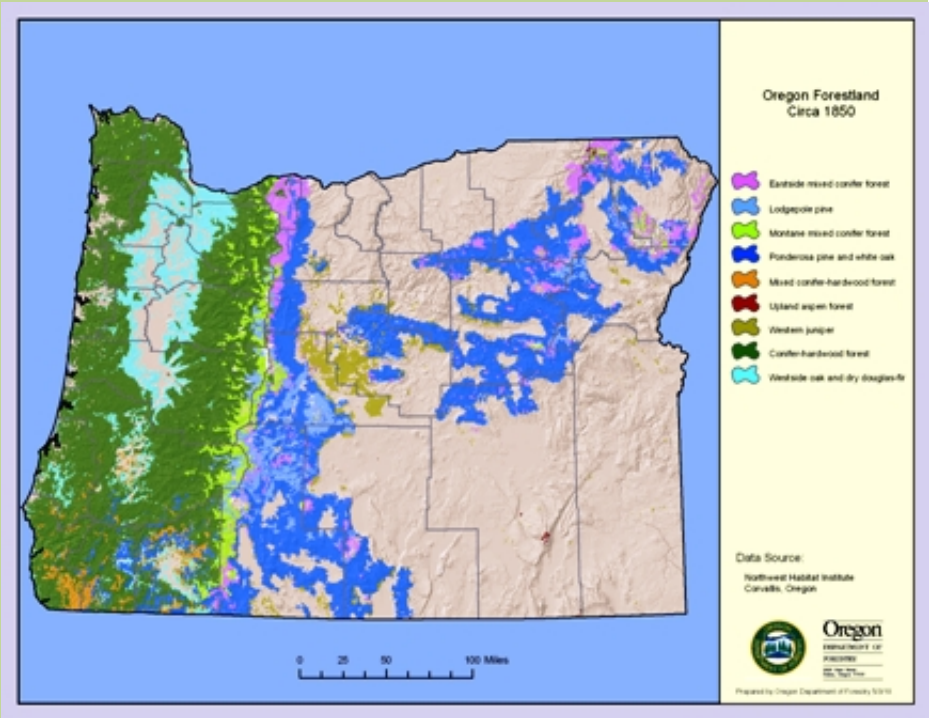
Increase CO2 concentration (Chimura 2011)

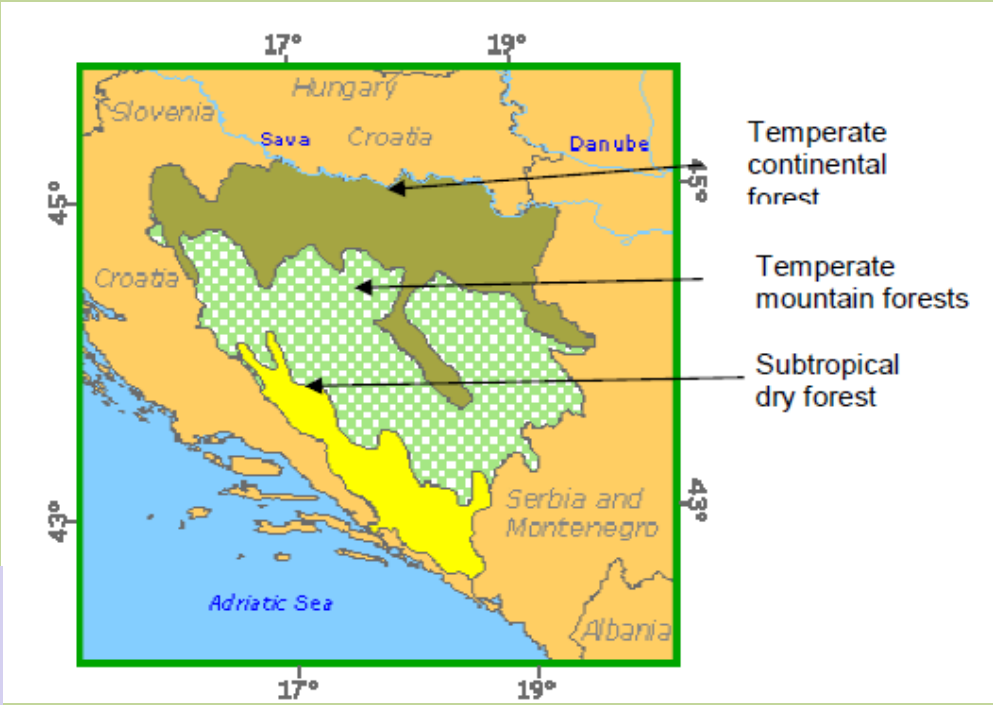
Genetic Resource Management and Climate Change: Genetic Options for Adapting National Forests to Climate Change

Vicky Erickson, Carol Aubry, Paul Berrang, Tom Blush, Andy Bower, Barb Crane, Tom DeSpain, David Gwaze, Jim Hamlin, Matt Horning, Randy Johnson, Mary Mahalovich, Monty Maldonado, Richard Sniezko, Brad St. Clair. 2012. Washington, DC: USDA Forest Service, Forest Management.

OREGON VS B&H – SIMILARITIES AND DIFFERENCES

FORESTS	
SIMILARITES	**DIFFERENCES**
Species diversity	Forests management
Forests zones	Proportion of species
Elevation bands	Species distribution





CLIMATE	
SIMILARITIES	**DIFFERENCES**
Diversity of climate	Spatial distribution
Climate changes	Ocean influence
Warm summers and cold winters	Relief

BOSNIA AND HERZEGOVINA AND CLIMATE CHANGES

Key Sector	*Vulnerability*	*Primary adaptation measures*	*Secondary adaptation measures*
FORESTRY	-Loss of biodiversity due to climate change	- Conduct a detailed mapping of forests - Afforestation of bare - Establishment of plantation forests for the needs of industry and energy - Increased protection of forests against pests and plant diseases	-Higher level of care for forest protection - Improve the forest

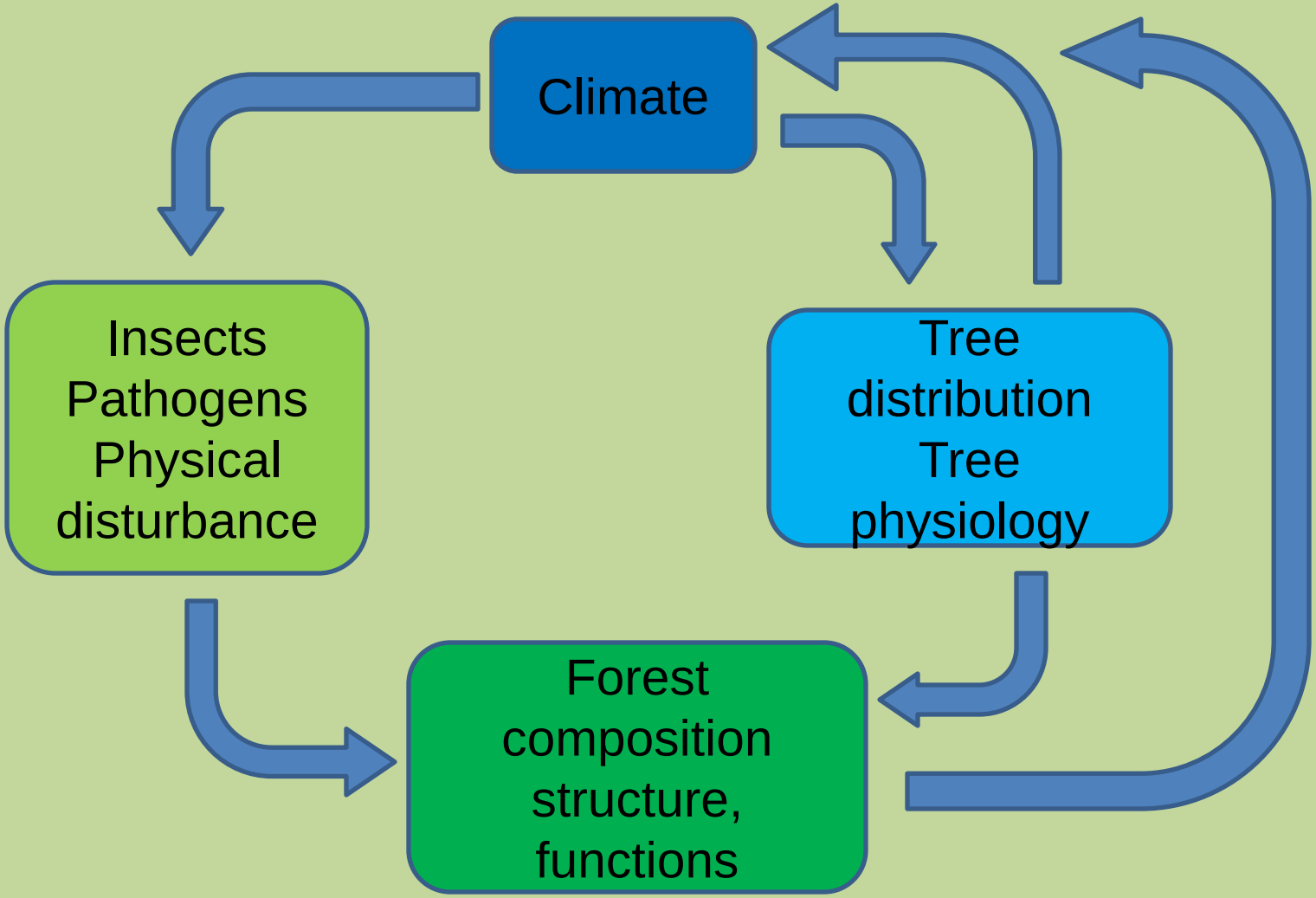
NO PLAN HOW TO DO IT!

SPECIES AND POPULATIONS MOST VULNERABLE TO CLIMATE CHANGES

- Rare species
- Species with long generation intervals e.g. long-lived species
- Genetic specialists
- Species with limited phenotyphic plasticity
- Species or populations with low genetic variation:
  - -Small populations
  - -Species influenced by past genetic bottlenecks
  - -Inbreeding species
- Species or populations with low dispersal and colonization potential (fragmented, disjunct population)
- Population at the trailing edge of climate change
- Population with “nowhere to go” (lack of nearby suitable habitat)
- Population threatened by habitat loss, fire, disease or insects

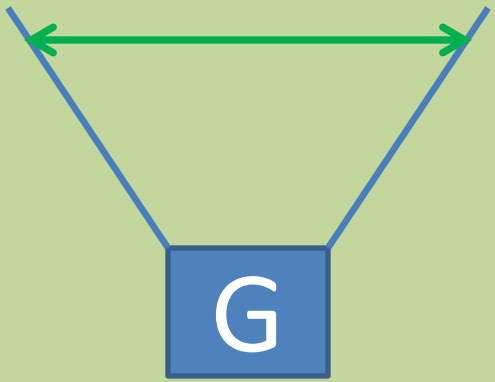
Source:St. Clair and Howe, 2011

HOW DOES IT WORK?



WHAT WE CAN DO?

Phenotypic plasticity

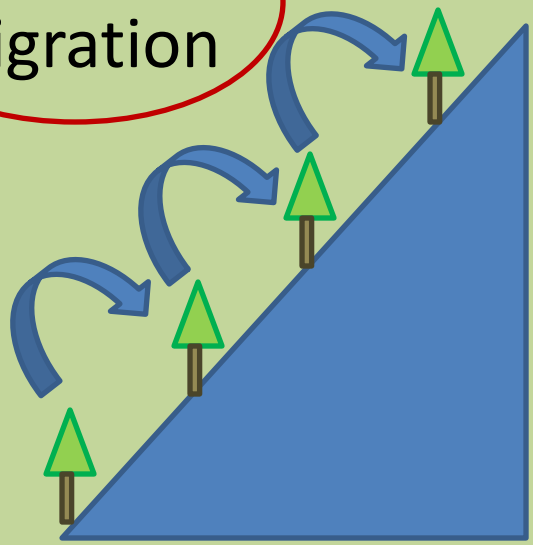


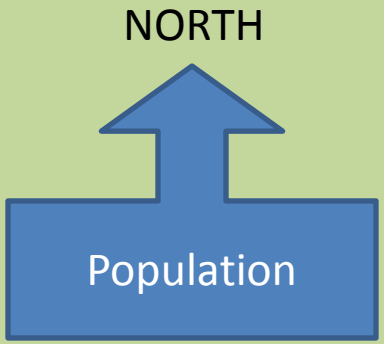
Conservation

- Arboretums
- Seed orchards
- Provenance tests, etc.

- Seed collection
- Tissue collection
- Gene banks

Assisted migration





WHY TO EMPLOY AM?

- Genetic variation - at the level of species, populations, individuals and genes - is an important part of biological diversity
- Term forest genetic resources refers to the actual or potential value of the hereditary variation contained in forest trees and shrubs
- Genetic variation of forest trees is today being eroded at an increasing pace, mainly due to climate changes

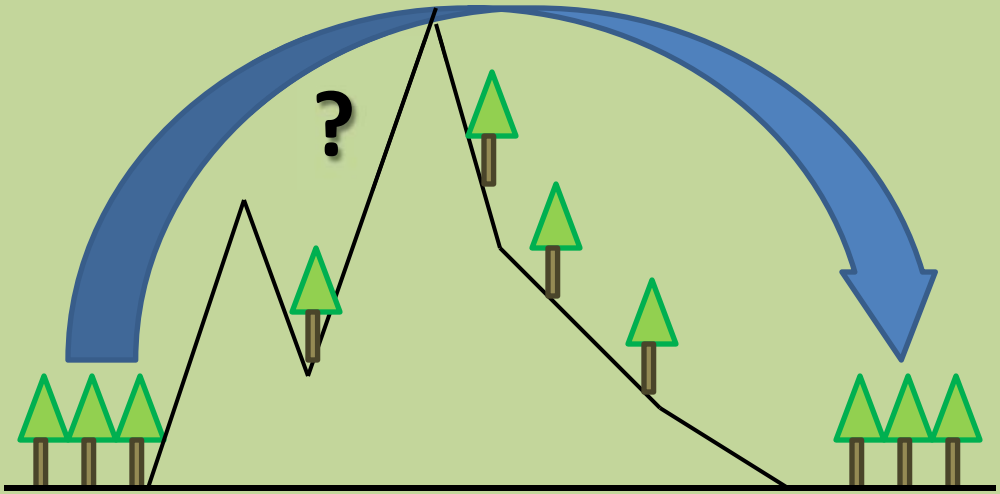
- Climate changes:

1. Temperature rising (IPCC, 2007)
2. Precipitations redistribution over the year (IPCC, 2007)
3. CO_2 increase (IPCC, 2007)

- Actual migration rate estimates: less than 100 m per year (*Aitken et al. 2008*).
- Need: 250-600 m and 200-275 km to the north or 12 generations (1200-1500 years) (*St Clair and Howe, 2007*)

WHY TO EMPLOY AM?

1. Conservation of rare genotypes
2. Shifting grounds trees only 100m annually (seed and pollen)
3. Risk for species to become invasive: around 1% (*Williamson and Fitter*, 1996)
4. Environmental specialists
5. Stability in the wood production
6. Lack of connectivity among population
7. Different time of pollination
8. Mimic long term natural migration



RESEARCHS

SHORT-TERM

- Vulnerability assessment
- Seed investigation
- Seedlings investigation
- Short - term investigations in provenances test, progeny trail plots and seed orchards (phenology research)
- Phenological variables include the timing of budbreak, flowering, leaf abscission, bud set, and the onset of cold hardiness

LONG-TERM TESTS

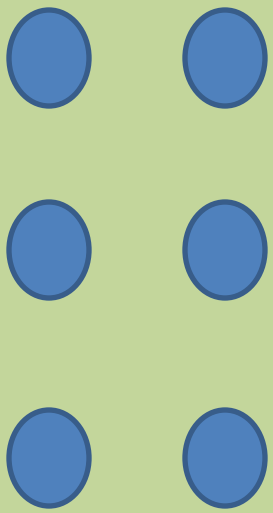
- Progeny tests
- Provenance tests
- Seed orchards
- Old growth forests

HOW TO ASSESS VULNERABILITY?

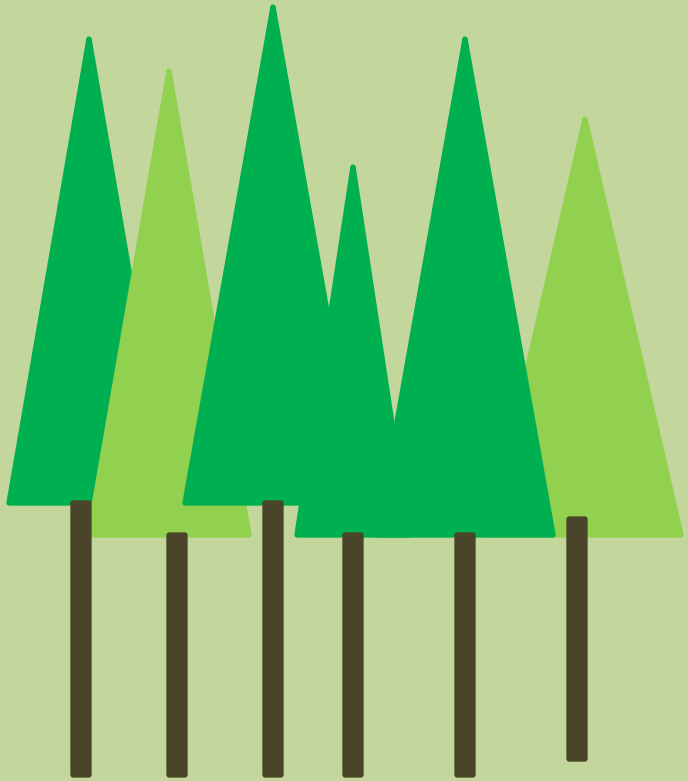
According to Potter and Crane 2010

Distribution

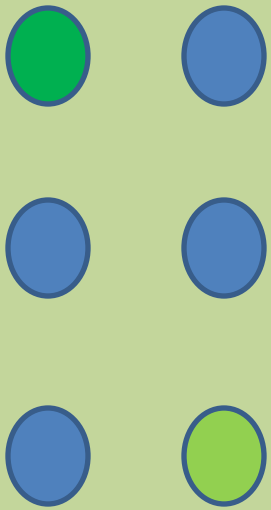
1. Frequency of occurrence



2. Proportion of canopy trees

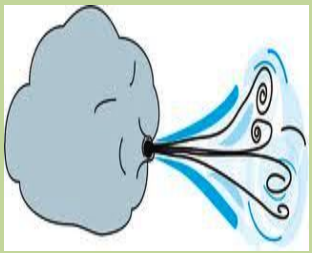


3. Distribution within study area



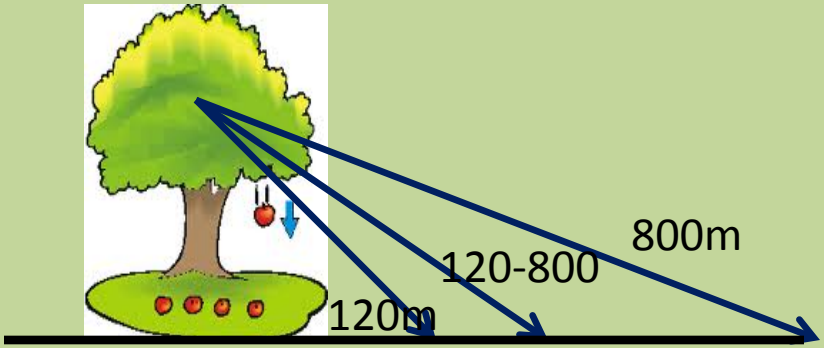
Reproductive capacity

1. Seed dispersal vector



2. Fecundity

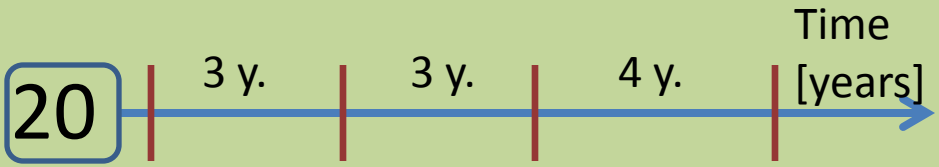
3. Seed dispersal capacity



5. Dioecy

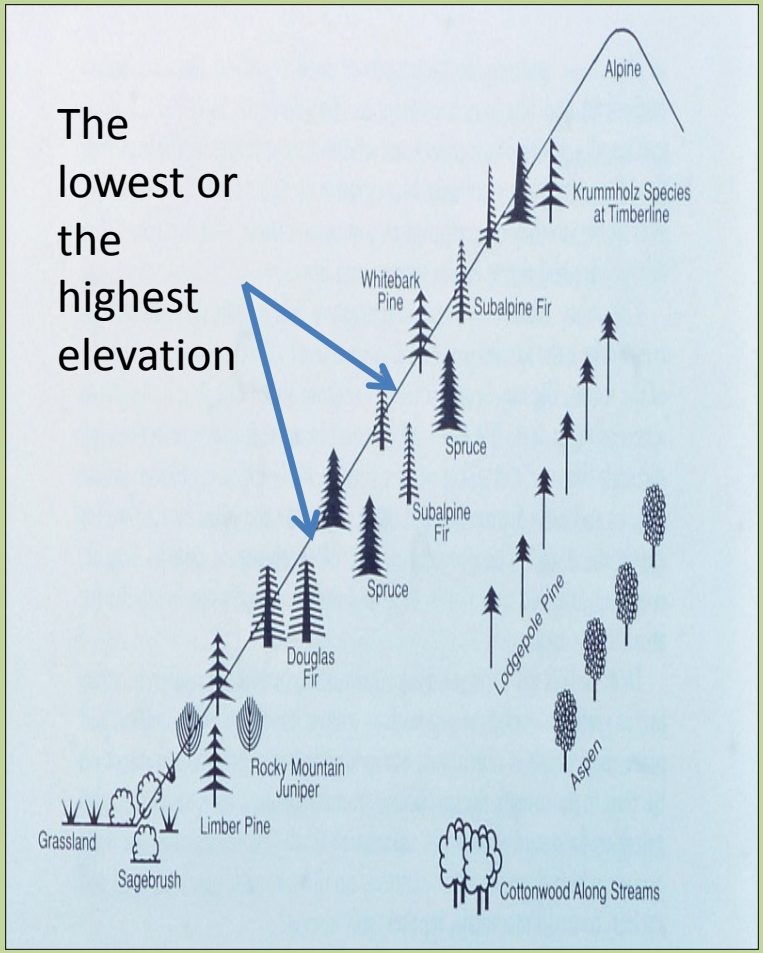
Breeding system:
- Monoecious
- Dioecious

4. Minimum seed – bearing age



Habitat affinity

1. Mean elevation



2. Successional stage

- Successional stage(s) in which species achieves its greatest canopy presence

3. Habitat specifity

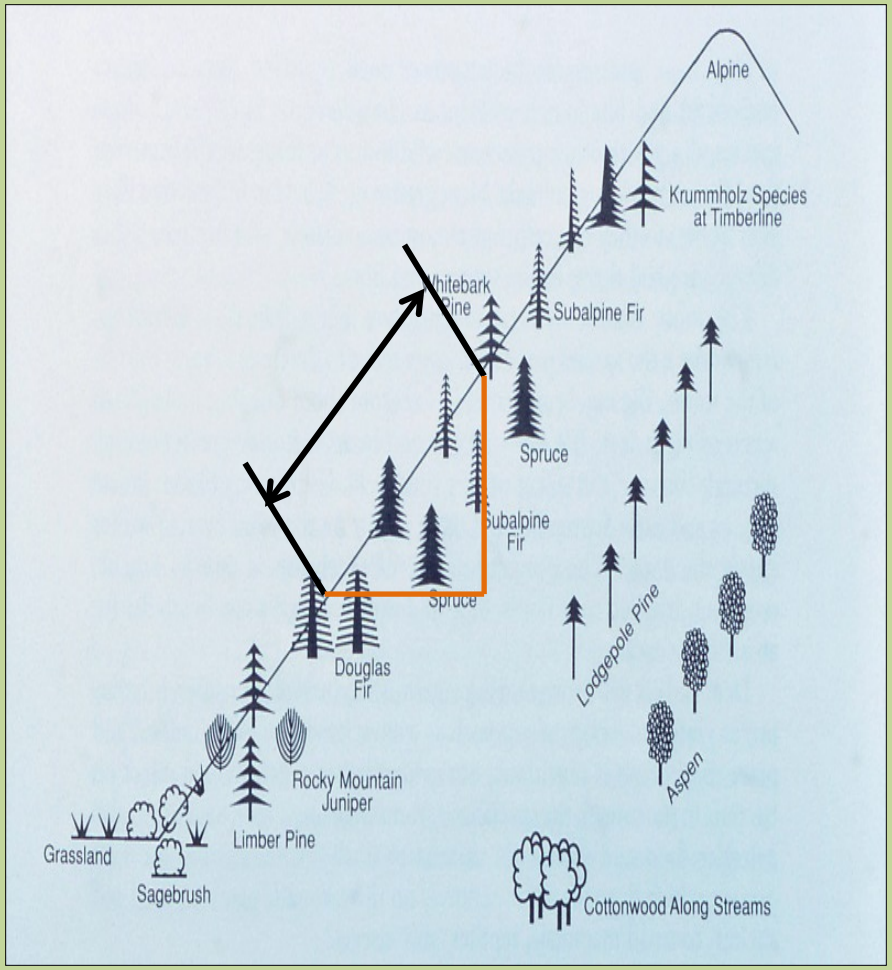
- Habitat specificity relative to all other tree species within the subregion

4. Drought tolerance

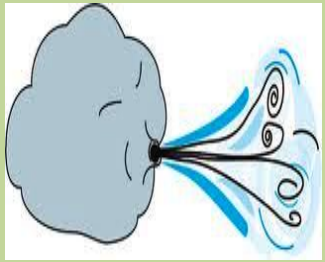
- Drought tollerance relative to all other tree species within the subregion

Adaptive genetic variation

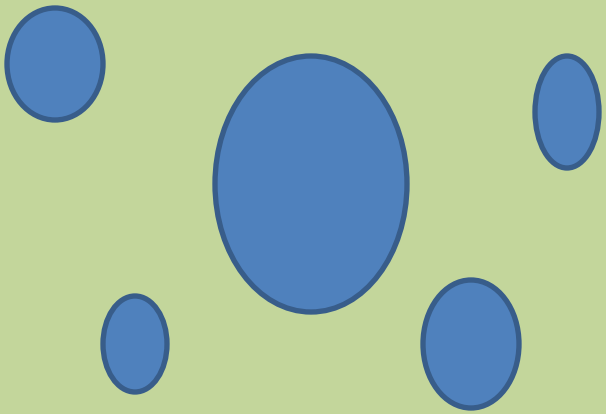
1. Elevation band width of seed zone



2. Pollen dispersal vector

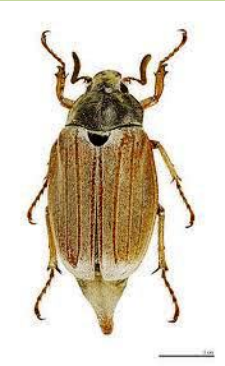


3. Disjunct populations



Major insect and disease threats

1. Threat



2. Severity

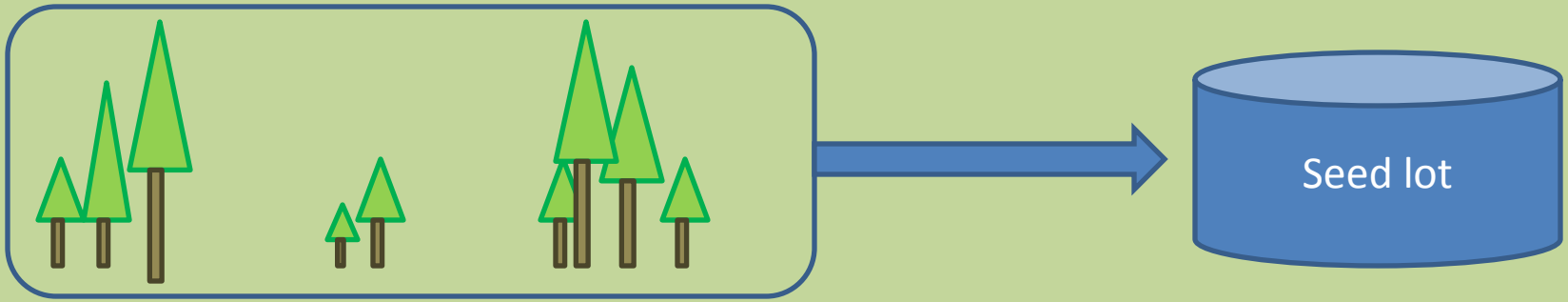
A rating of the present impact of insect or disease threats

3. Immediacy

- Potential to reach region of interest
- Present in the region
- Present in the region and climate change appears to be a contributing factor in increases in distribution and impact

SEED COLLECTING

- Collect from a minimum of 50 maternal plants to capture 95% of the genetic diversity
- Collect no more than 10–20% available seed on any given day, to ensure that collection efforts do not impact vital rates of the target populations
- Collect across any obvious environmental gradients
- Collect both from within the center of population density AND from the periphery to ensure the greatest genetic diversity and to ensure collection from individuals that may perform better in marginal portions of the habitat
- Search out and collect even the smallest plants, because they may contain quantitative trait variation that would pre-adapt them to an alternate site
- Collect at peak seed maturity, recognizing that some phenotypes (and sires) will be excluded, or collect on multiple days



SEED COLLECTING

- Collect from within the entire inflorescence, recognizing that proximal patterns of maternal plant development as well as patterns of embryo development
- Collect voucher specimens
- Standard collection protocols that include collectors name, locality information (particularly GPS coordinates), property ownership, terms of the collecting permit if it limits the use of the seeds, etc.
- Information on the habitat that might be critical for habitat matching
- Additional information on the status of the target population should include an estimate of population size, percentage of reproductive plants, and the number of plants from which the seeds were collected, which is particularly important when the seeds are not separated by maternal line…

Part of the seed collection protocols presented here are a synthesis of those developed for the Millennium Seed Bank; Brown and Briggs, 1991; Vitt and Havens, 2004; Guerrant et al., 2004.

SEEDLINGS

1. Genetic quality of seedlings

- Origin from the specific populations or seed mixture

2. Morphological characteristics of seedlings

- Developed root system
- Optimal ratio between root system and above-ground part of seedling
- Height
- Root collar
- Appearance of seedlings, etc.

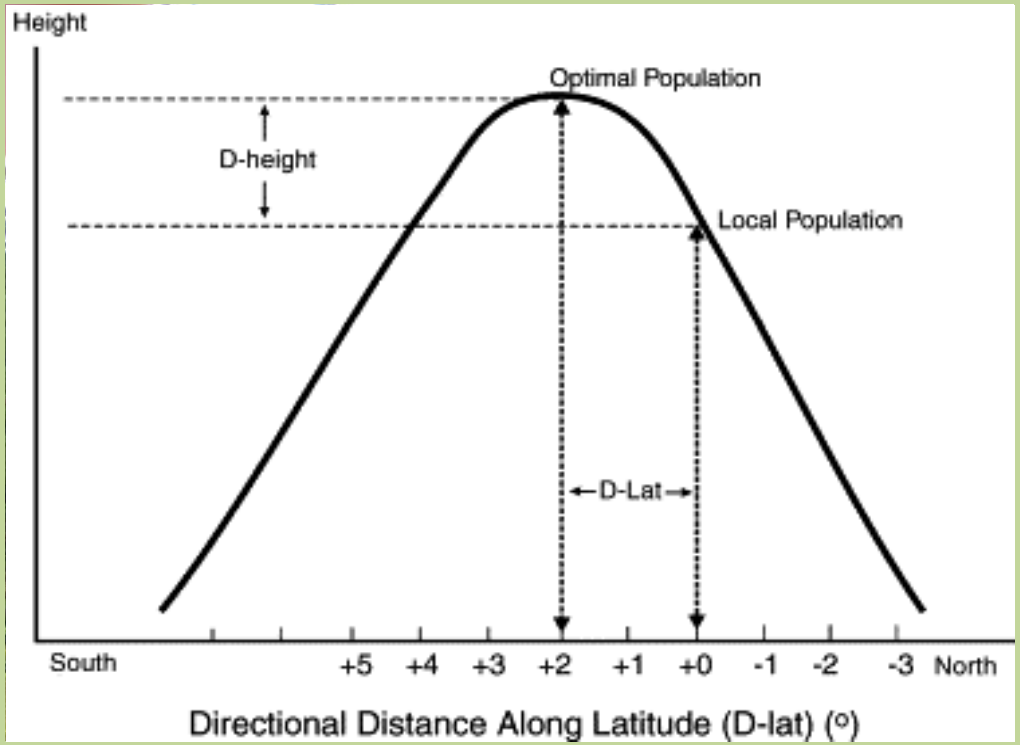
SEEDLINGS

3. **Physiological characteristics of seedlings**

- Seedlings capability to resist to drought stress
- Seedlings capability to resist to frosts
- Seedlings capability to resist to pollution

LONG TERM TESTS

1. Progeny tests
2. Provenance tests
3. Seed orchard



-Survival

-Height

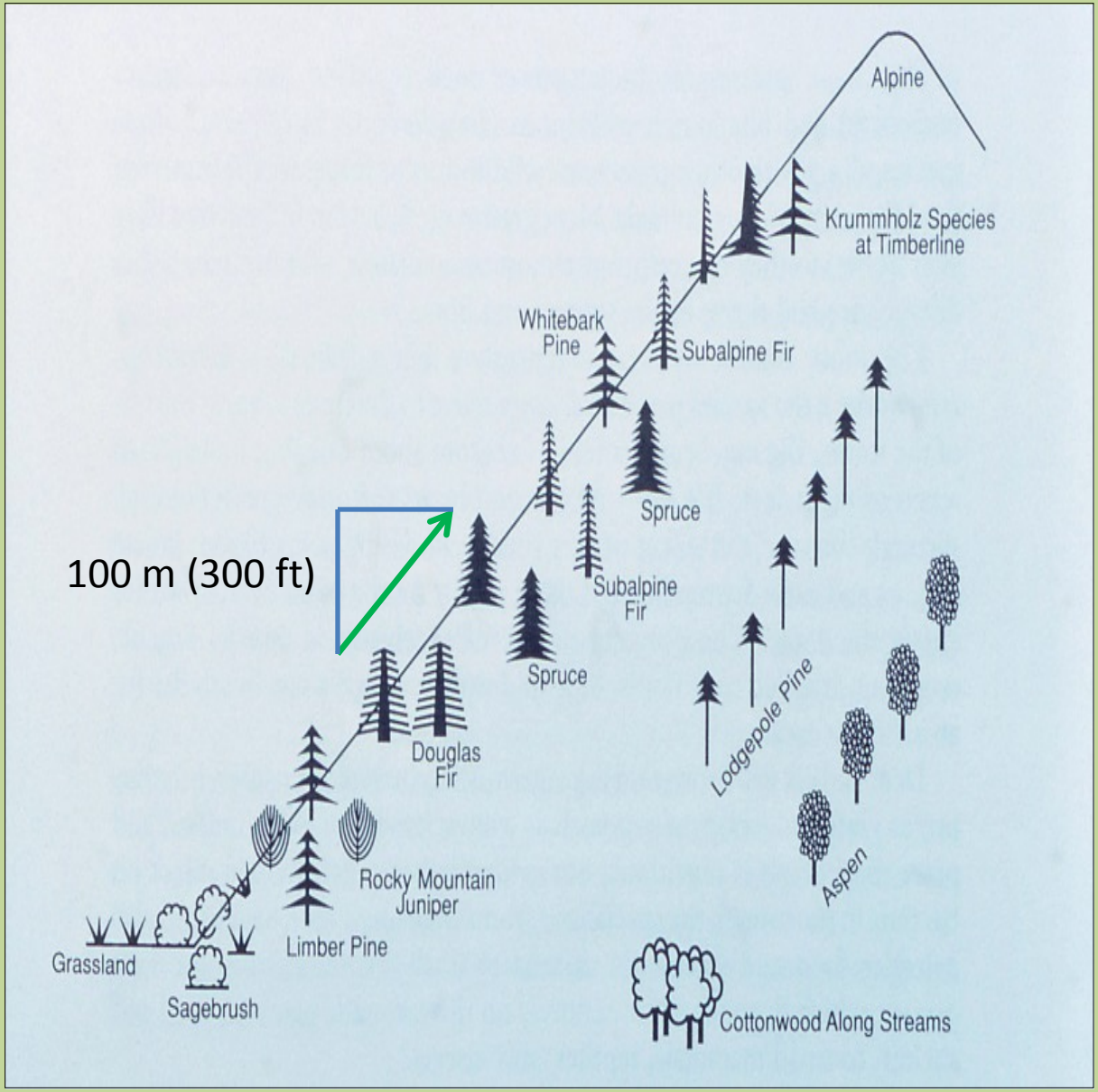
-DBH

-Volume

-Increment

-Vegetative and reproductive phenology

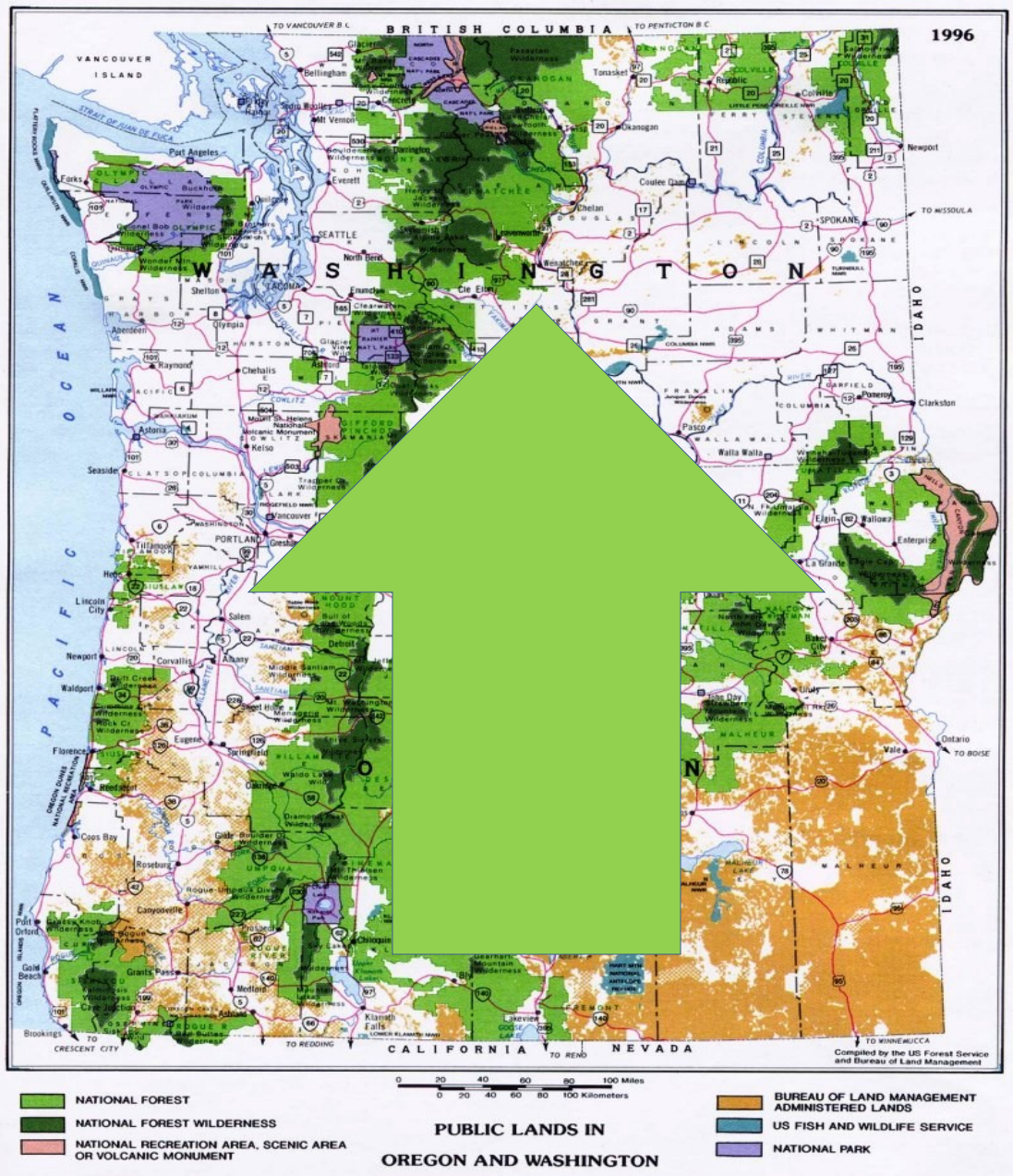
LONG TERM TESTS



FIRST OPTION

- 100 m – 0.56°C
- Forest genetic recourses move upward for 100m or more
- Risks: frosts

LONG TERM TESTS

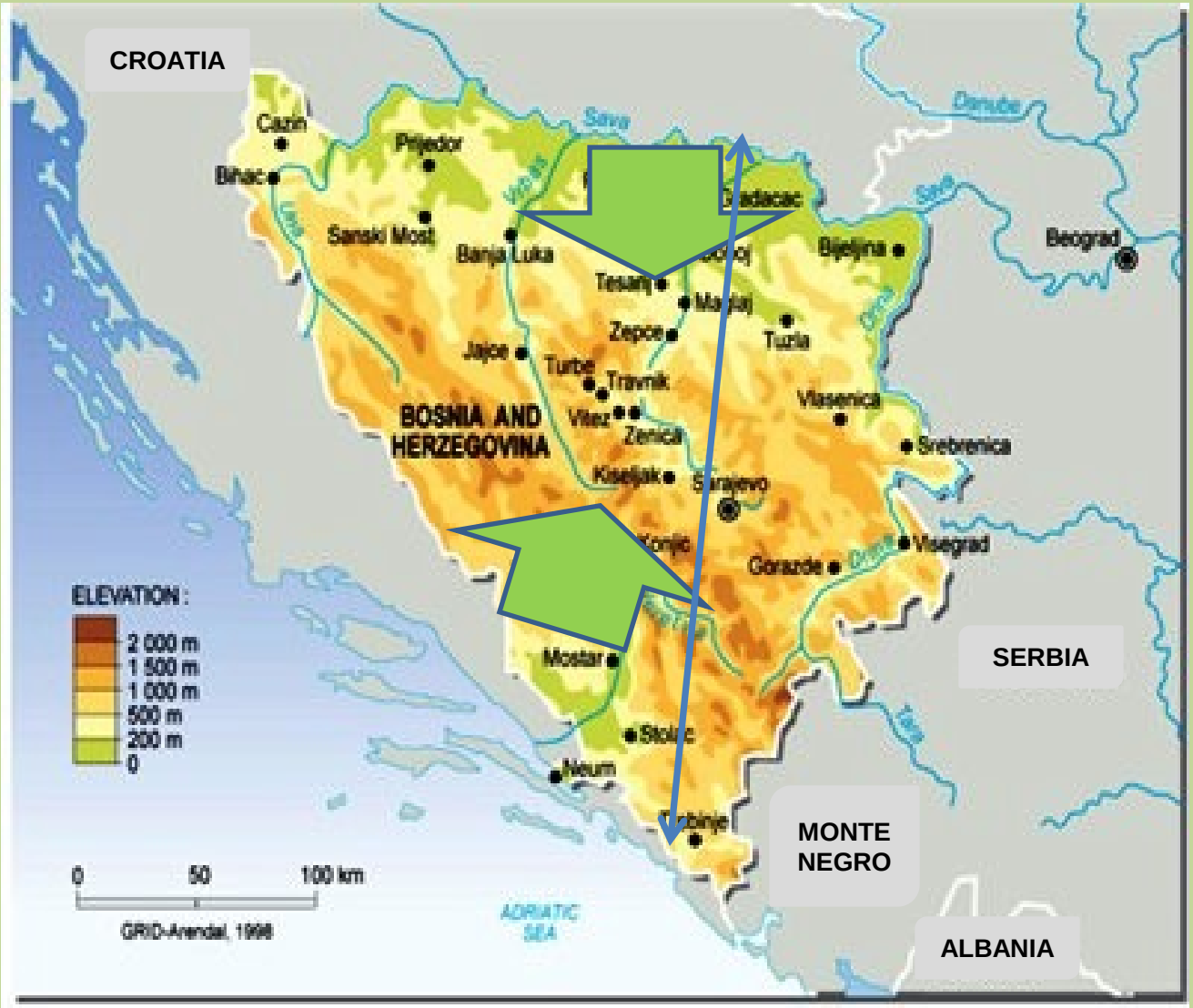


THE SECOND OPTION

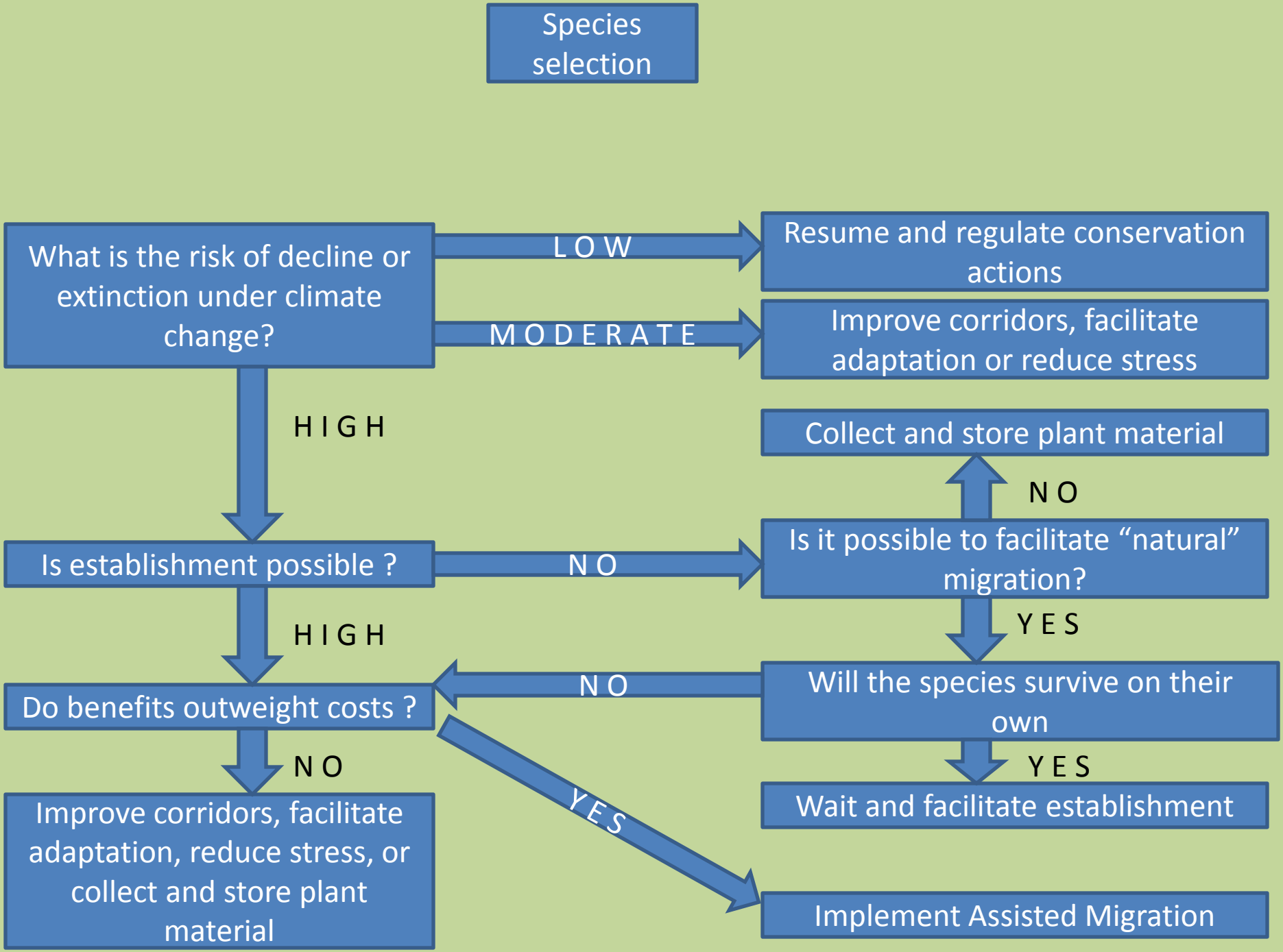
- **Move forests genetic recourses to the north for 200 km (656168 ft)** (*Beaulieu and Rainville 2005, O'Neill et al. 2008, Pedlar et al. 2012, Gray and Hamann, 2013*)
- **Risks: frosts**

Source: http://www.brookingsbrokers.com/Brookings_Oregon_Maps/page_1328128.html

LONG TERM TESTS

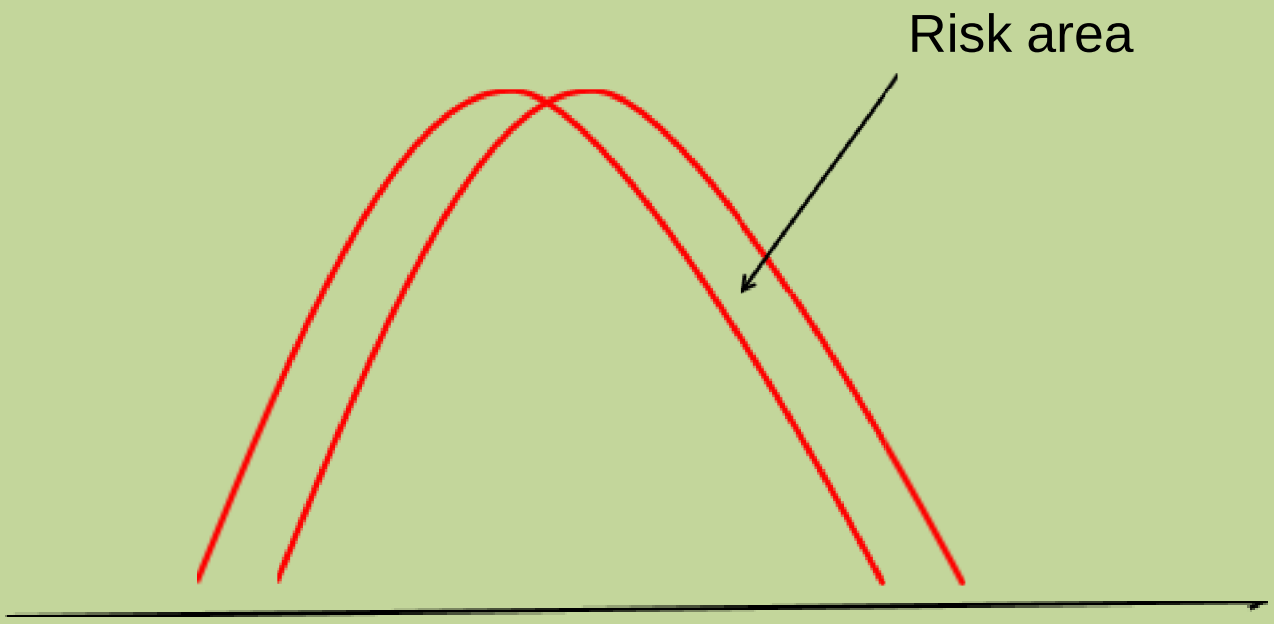


http://www.grida.no/graphicslib/detail/topographic-map-of-bosnia-and-herzegovina_98ae


Species selection
What is the risk of decline or extinction under climate change?
L O W
Resume and regulate conservation actions
M O D E R A T E
Improve corridors, facilitate adaptation or reduce stress
H I G H
Collect and store plant material
N O
Is establishment possible ?
N O
Is it possible to facilitate "natural" migration?
H I G H
Y E S
Do benefits outweight costs ?
N O
Will the species survive on their own
N O
Y E S
Wait and facilitate establishment
Y E S
Improve corridors, facilitate adaptation, reduce stress, or collect and store plant material
Implement Assisted Migration

WHY NOT TO EMPLOYE AM?

1. Invasion risks and impacts
2. Irreversibility
3. Genetic impact (genetic pollution)
4. Bias toward species we deem important
5. Legitimization of unauthorized AM.



FUTURE PLANS FOR PNW

The specific objectives of this project are to:

• Assess the relative vulnerability of forest trees of the Pacific Northwest to potential impacts of projected climate change.

• Recommend actions that will:

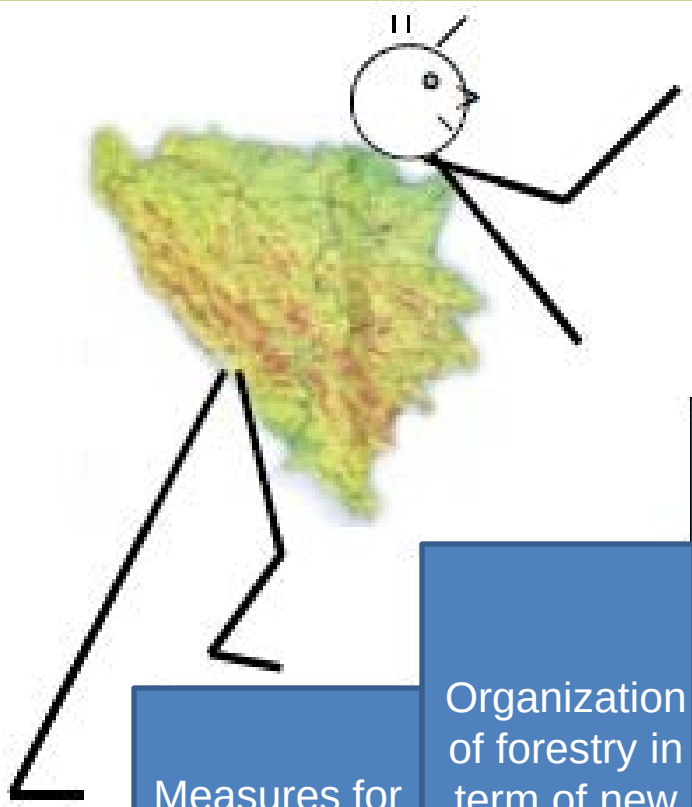
o improve understanding of changes taking place among tree species,

o maintain and increase forest biodiversity and increase resiliency, and

o prepare for an uncertain future.

• Collaborate in the implementation of these actions with the other land management agencies of Washington and Oregon.

FUTURE PLANS FOR B&H



Assessment of vulnerability

Measures for adaptation of development and protection

Organization of forestry in term of new environme-ntal conditions

Organization of the state (capacity building)

Acting

Policy, Goals, Strategies, Programs, Actions

Cooperation Partnership

CONCLUSIONS

➢Climate changes are present in Oregon and they are similar to climate changes in B&H

➢We are dealing with same problems:

1. Loss of diversity
2. Trees range shifting
3. Lack of participation in summer
4. Drought, etc…

➢ Possible solutions:

1. Assisted migration
2. To do nothing

RESEARCH NEEDED BEFORE ANY ACTION

Some of recommendation for AM – just 20 years down the road

THANK YOU FOR YOUR ATTENTION