Can a model transferability framework improve ecosystem service estimates? A case study of soil carbon sequestration in Tillamook Bay, OR, USA

Lauri Green* and Theodore DeWitt

*ORISE, US Environmental Protection Agency

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Transferability

Apply estimate/model from one site to another

Estimate/model

Previous site

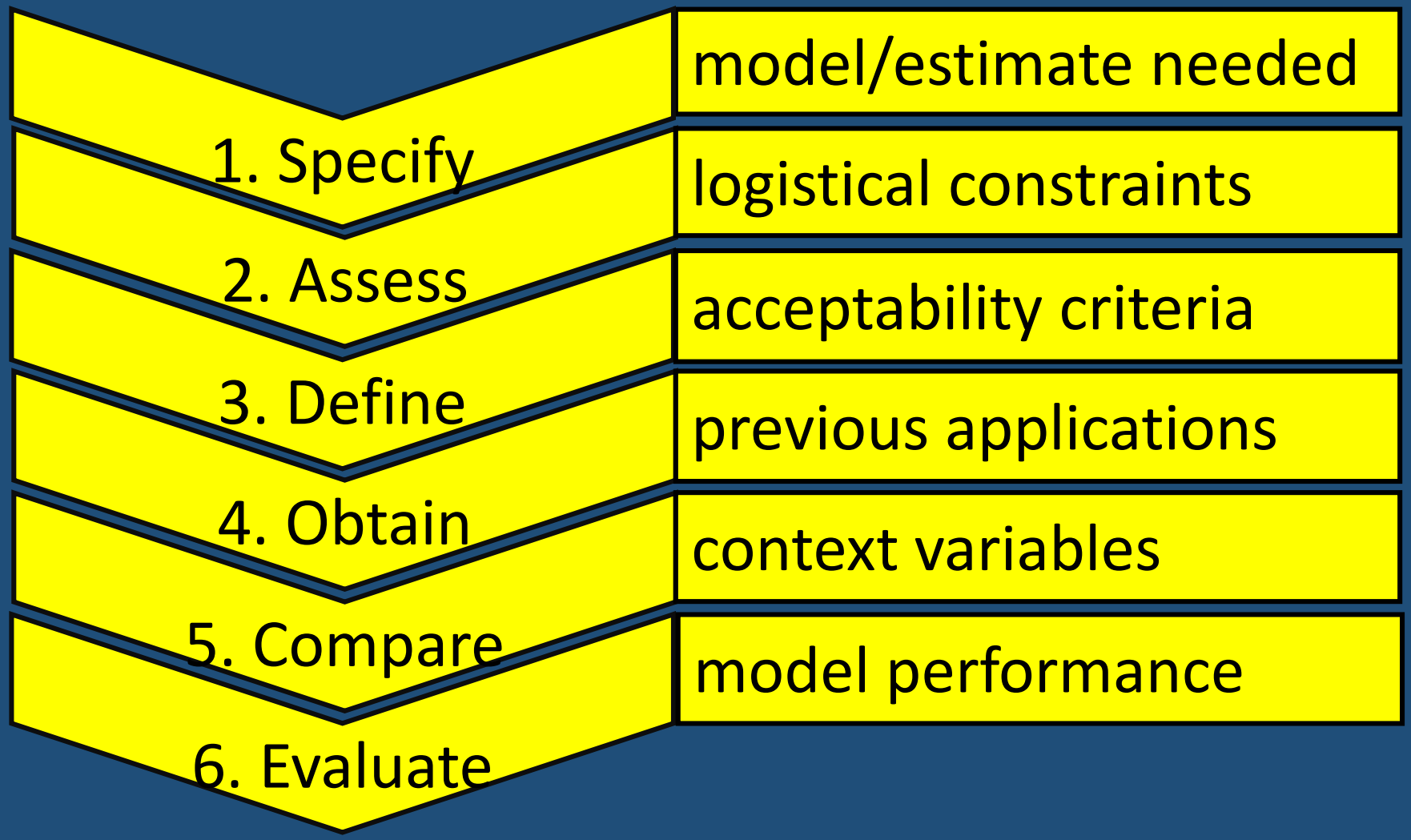
New site

Model transferability framework

Goal:

Standardize methodology to maximize performance of transferred models

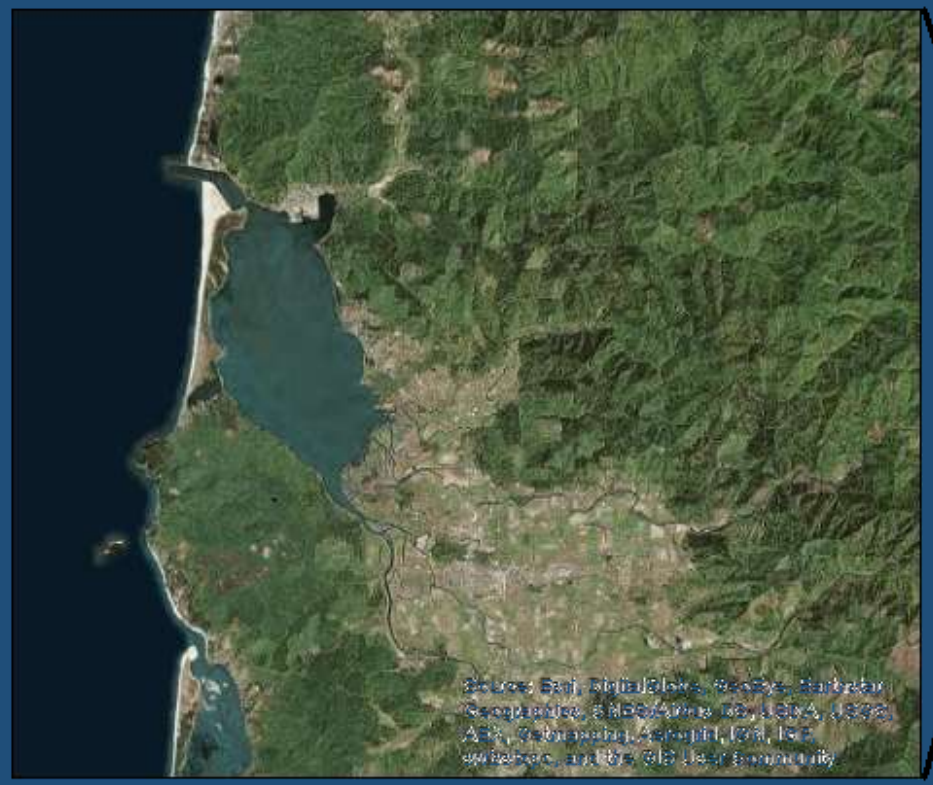
Model transferability framework

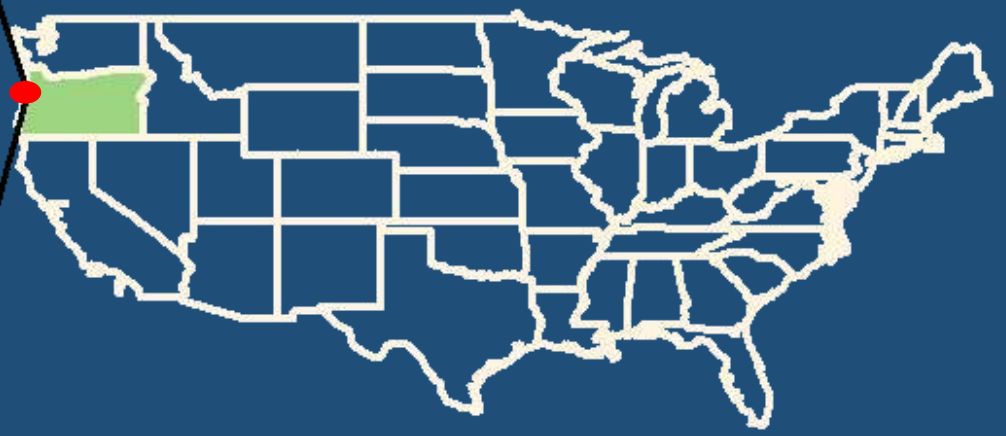


Case study

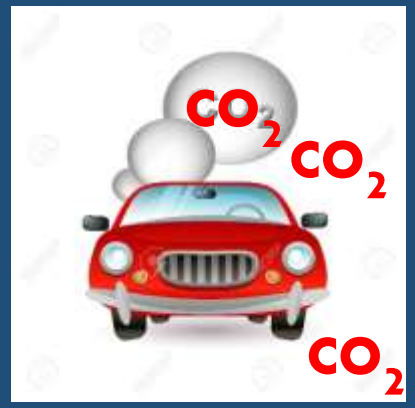
Forested watershed of Tillamook

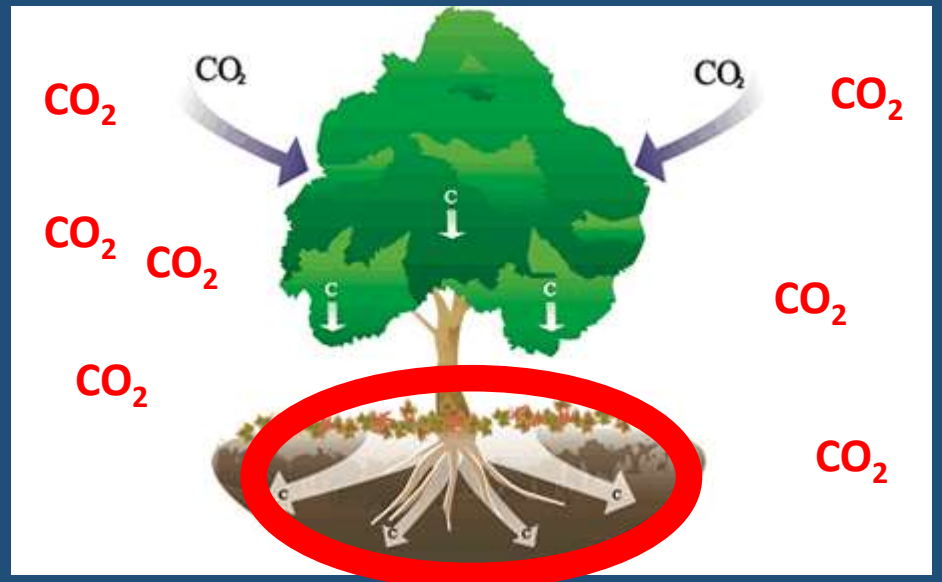
Tillamook





Carbon sequestration as an ecosystem service





Key Points

- Soils capture carbon & offset CO_2 emissions
- Industries buy carbon credits $$
- Oregon regional leader

1. Select model

- COMET Farm
- CarbOn and Management & Evaluation Tool
- DAYCENT model
- Carbon sequestration
  - Tonnes CO_2 captured
- Converted to credit value
  - $12.95 per tonne: *calcarbondash.org*
- Converted to kg C m^{-2}

2. Assess logistical constraints

	Easy to use	Cost	Good documentation	Spatially explicit	Data available
COMET-Farm	√	√	X/√	√	√

3. Define acceptability criteria

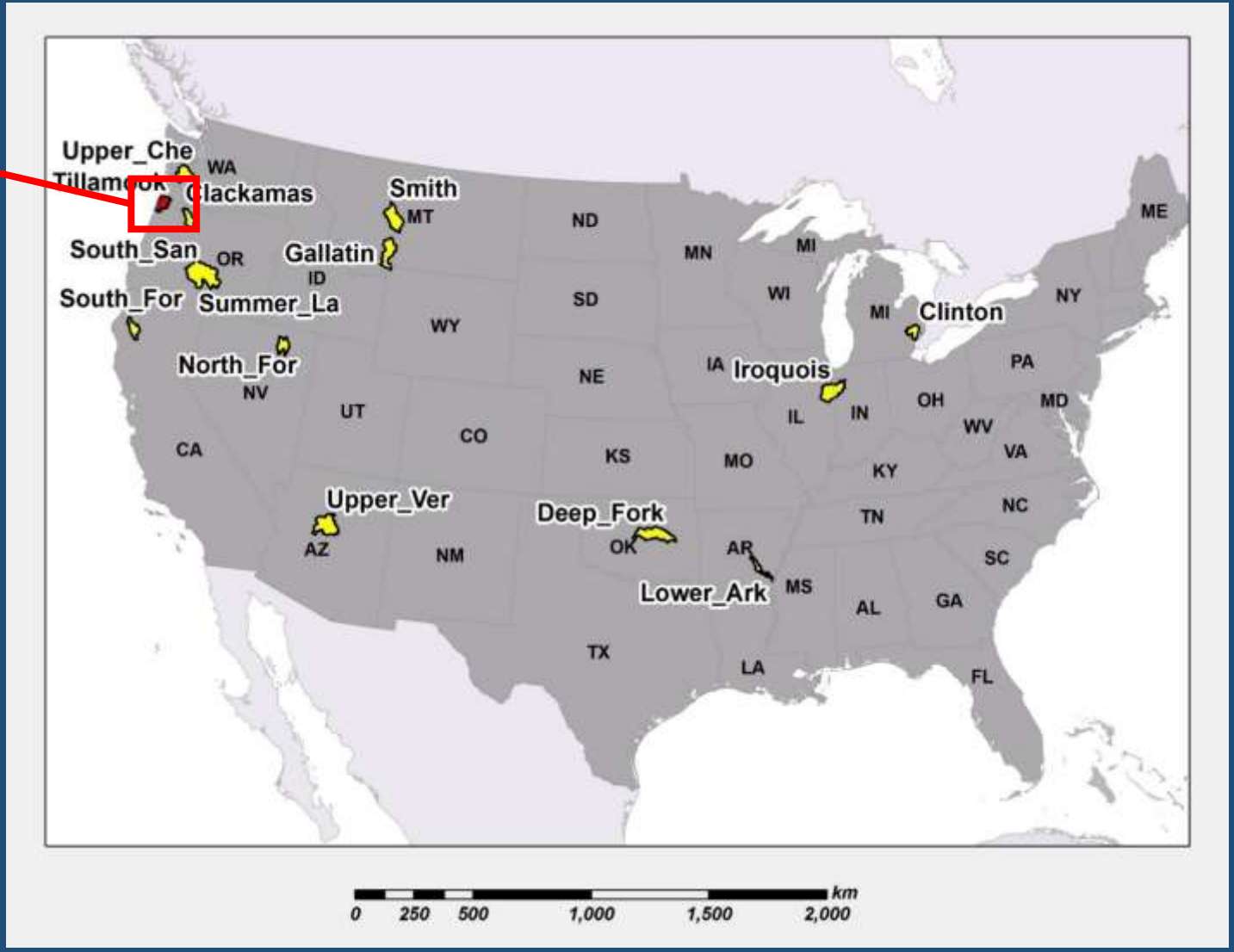
Coefficient of variation $\leq$ 30%

- Tonnes CO_2 captured
- Carbon value ($)
- kg C m^{-2}

4. Obtain previous applications

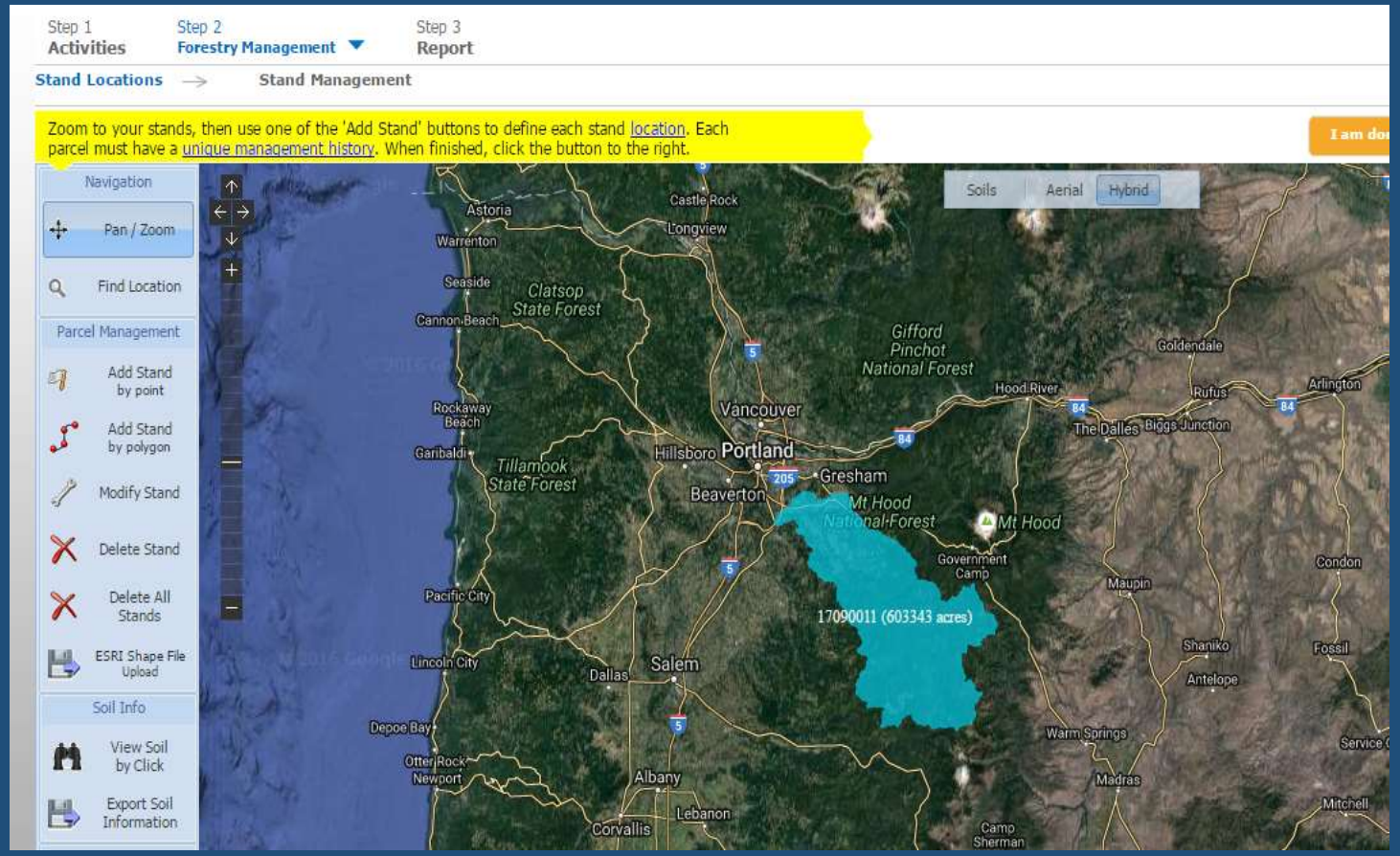
Among sites

Tillamook



4. Obtain previous applications

Applied **COMET Farm** model to each site



Data Entered

1. Shapefiles
2. Dominant vegetation
3. Age of forest (50 yrs)
4. Grow only scenario

5. Compare context variables

Intrinsic vs extrinsic

Not in the model (Extrinsic variables)

Temperature

Precipitation

In the model (Intrinsic variables)

Vegetation cover

Vegetation species

Carbon sequestration in soil

Bulk density

Land management

Ecotype

Soil type

5. Compare context variables

Site	State	Ecotype	Soil type	Vegetation	PPT (mm)	Temp˚C	Canopy (%)	Bulk (g cm^{-3})
Lower Arkansas	AR	Wet Plains	Unconsolidated	Cropland	1292	17	28	1.5
Iroquois	IL,IN	Plains	Carbonate Rock	Cropland	969	10	4	1.5
Gallatin	MT	Mountains	Carbonate Rock	Evergreen	688	4	25	1.3
Clackamas	OR	Mountains	Non-acidic Volcanics	Evergreen	1861	8	65	1.5
South Fork Trinity	CA	Mountains	Carbonate Rock	Evergreen	1462	11	68	1.3
Upper Chehalis	WA	Mountains	Non-acidic Volcanics	Evergreen	1590	10	59	1.4
Tillamook	OR	Mountains	Non-acidic Volcanics	Evergreen	2896	10	69	1.4
Summer Lake	OR	Hills	Non-acidic Volcanics	Grassland, Scrub	329	7	10	1.5
Smith	MT	Mountains	Carbonate Rock	Grassland, Scrub	488	5	19	1.5
Upper Verde	AZ	Mountains	Carbonate Rock	Grassland, Scrub	498	12	4	1.5
North Fork Humboldt	NV	Mountains	Mixed Rock	Grassland, Scrub	352	6	1	1.4
Deep Fork	OK	Wet Plains	Carbonate Rock	Grassland, Scrub	1022	16	34	1.3
Clinton	MI	Artificial			840	9	21	1.7

5. Compare context variables

Qualitative approach

Site	State	Ecotype	Soil type	Vegetation	PPT (mm)	Temp ˚C	Canopy (%)	Bulk (g cm^{-3})
Tillamook	OR	Mountains	Non-acidic Volcanics	Evergreen	2896	10	69	1.4
Upper Chehalis	WA	Mountains	Non-acidic Volcanics	Evergreen	1590	10	59	1.4
Clackamas	OR	Mountains	Non-acidic Volcanics	Evergreen	1861	8	65	1.3
Summer Lake	OR	Hills	Non-acidic Volcanics	Grassland, Scrub	329	7	10	1.4

6. Evaluate model performance

Qualitative approach

Site	State	Million tonnes CO_2 captured	Credit value $Millions	COMET Farm kg C m^{-2}
Tillamook	OR			
Upper Chehalis	WA	77	991	6.2
Clackamas	OR	74	1099	9.4
Summer Lake	OR	372	4820	9.4
COV		**98%**	**94%**	**22%**

5. Re-compare context variables

Soil variables

Site	State	Ecotype	Soil type	Vegetation	PPT (mm)	Temp ˚C	Canopy (%)	Bulk (g cm^{-3})
Tillamook	OR	Mountains	Non-acidic Volcanics	Evergreen	2896	10	69	1.4
Upper Chehalis	WA	Mountains	Non-acidic Volcanics	Evergreen	1590	10	59	1.4
Clackamas	OR	Mountains	Non-acidic Volcanics	Evergreen	1861	8	65	1.3
Summer Lake	OR	Hills	Non-acidic Volcanics	Grassland, Scrub	329	7	10	1.4

5. Re-compare context variables

Multivariate approach

Site	State	Ecotype	Soil type	Vegetation	PPT (mm)	Temp˚C	Canopy (%)	Bulk (g cm^{-3})
Tillamook	OR	Mountains	Non-acidic Volcanics	Evergreen	2896	10	69	1.4
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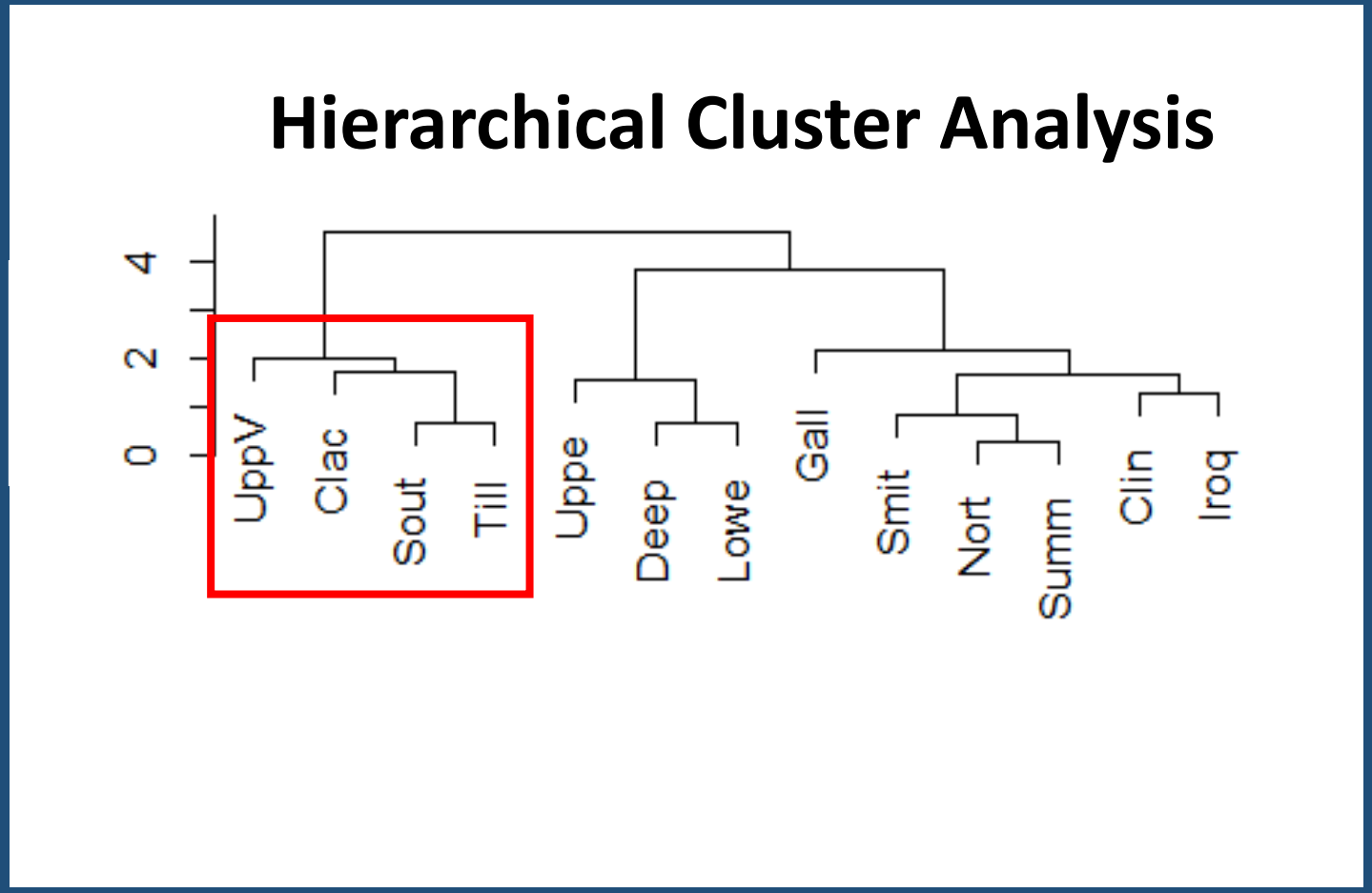
Iroquois	IL,IN	Plains	Carbonate Rock	Cropland	969	10	4	1.5
Clinton	MI	Artificial			840	9	21	1.7
Gallatin	MT	Mountains	Carbonate Rock	Evergreen	688	4	25	1.5
Upper Verde	AZ	Mountains	Carbonate Rock	Grassland, Scrub	498	12	4	1.3
Smith	MT	Mountains	Carbonate Rock	Grassland, Scrub	488	5	19	1.5
North Fork Humboldt	NV	Mountains	Mixed Rock	Grassland, Scrub	352	6	1	1.5
Summer Lake	OR	Hills	Non-acidic Volcanics	Grassland, Scrub	329	7	10	1.4

5. Re-compare context variables

Multivariate quantitative approach

Similarity



Site

Extrinsic

- Precipitation
- Temperature

Intrinsic

- Vegetation cover
- Bulk density

6. Evaluate model performance

Multivariate approach

Site	State	Million tonnes CO_2 captured	Credit value $Millions	COMET Farm kg C m^{-2}
Tillamook	OR			
South Fork Trinity	CA	44	571	5.0
Clackamas	OR	85	1099	9.4
Upper Verde	AZ	57	743	2.4
COV		**34%**	**33%**	**63%**

5. Re-compare context variables

Ecotype, Vegetation, Climate, Soil

Site	State	Ecotype	Soil type	Vegetation	PPT (mm)	Temp˚C	Canopy (%)	Bulk (g cm^{-3})
Tillamook	OR	Mountains	Non-acidic Volcanics	Evergreen	2896	10	69	1.4
South Fork Trinity	CA	Mountains	Carbonate Rock	Evergreen	1462	11	68	1.3
Clackamas	OR	Mountains	Non-acidic Volcanics	Evergreen	1861	8	65	1.3
Upper Verde	AZ	Mountains	Carbonate Rock	Grassland, Scrub	498	12	4	1.3

6. Evaluate model performance

Site	State	COMET Farm kg C m^{-2}	USDA kg C m^{-2}
Tillamook	OR		
South Fork Trinity	CA	5.0	4.0
Iroquois	IL,IN	4.6	0.2
Deep Fork	OK	4.2	2.5
Smith	MT	3.9	1.4
Gallatin	MT	3.4	2.1
Upper Verde	AZ	2.4	1.4
North Fork Humboldt	NV	2.4	0.1
Clackamas	OR	9.4	7.9
Upper Chehalis	WA	6.2	7.2
Summer Lake	OR	9.4	1.7
Lower Arkansas	AR	4.2	1.4
Clinton	MI	13.4	2.5

Soil Carbon

6. Evaluate model performance

Quantitative approach

Site	State	% Difference USDA/COMET
Tillamook	OR	
Upper Chehalis	WA	15
Clackamas	OR	19
South Fork Trinity	CA	25
Gallatin	MT	59
Deep Fork	OK	67
Upper Verde	AZ	77
Smith	MT	173
Lower Ark	AR	195
Clinton	MI	437
Summer Lake	OR	440
Iroquois	IL,IN	2094
North Fork	NV	2117

Top three

6. Evaluate model performance

Quantitative approach

Site	State	Million tonnes CO_2 captured	Credit value $Millions	COMET Farm kg C m^{-2}
Tillamook	OR			
Upper Chehalis	WA	77	991	6.2
Clackamas	OR	85	1099	9.4
South Fork Trinity	CA	44	571	5.0
COV		**31%**	**31%**	**33%**

5. Re-compare context variables

Ecotype, Vegetation, Climate, Soil

Site	State	Ecotype	Soil type	Vegetation	PPT (mm)	Temp˚C	Canopy (%)	Bulk (g cm^{-3})
Tillamook	OR	Mountains	Non-acidic Volcanics	Evergreen	2896	10	69	1.4
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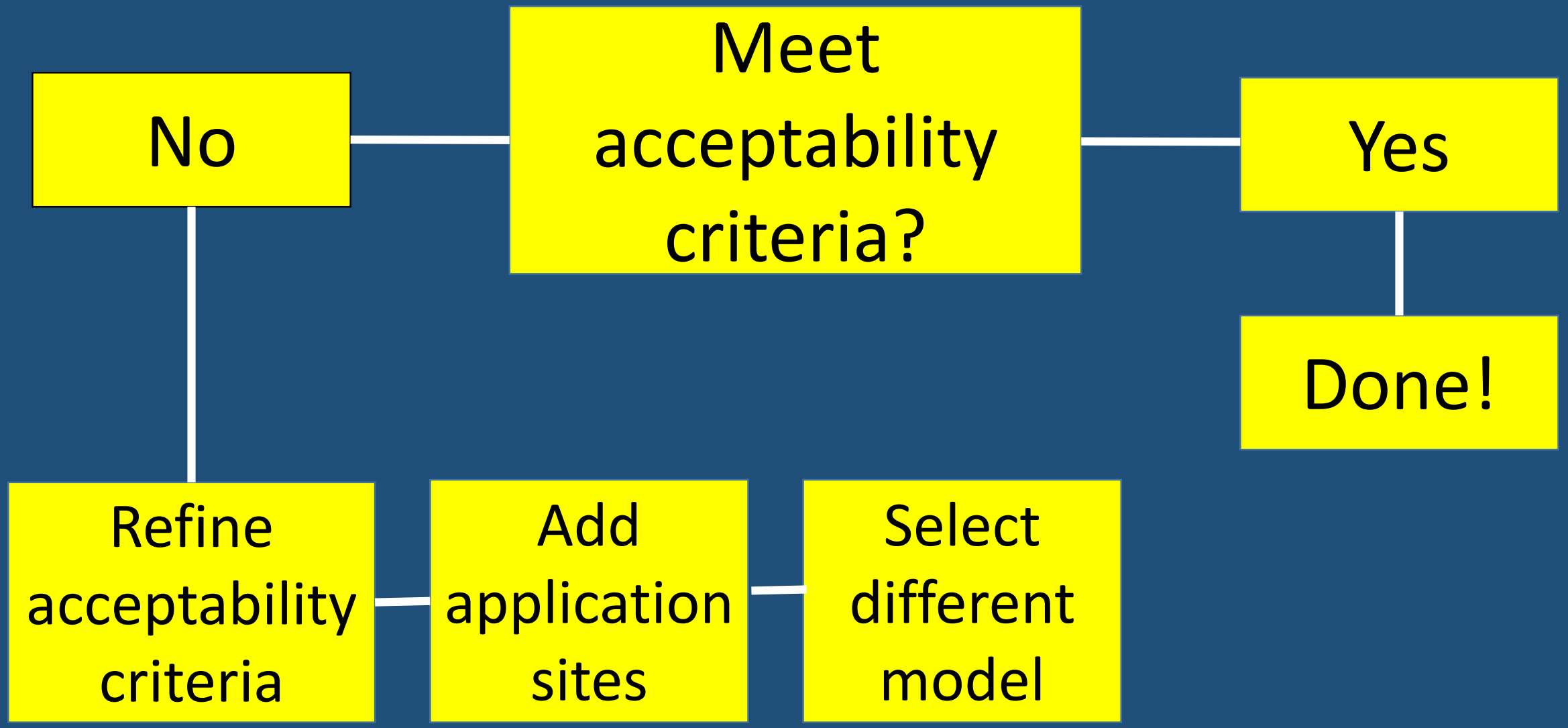
Conclusions



Conclusions

Goal:

Standardize methodology to maximize performance of transferred models

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Next steps

Additional multivariate analyses

- Add continuous variables to HCA
- Include categorical variables
- DFA to identify groups and context variables
- PCA to identify context variables

Apply additional models

- Yasso, ROTHC, InTEC

Acknowledgements

Oak Ridge Institute for Science and Education

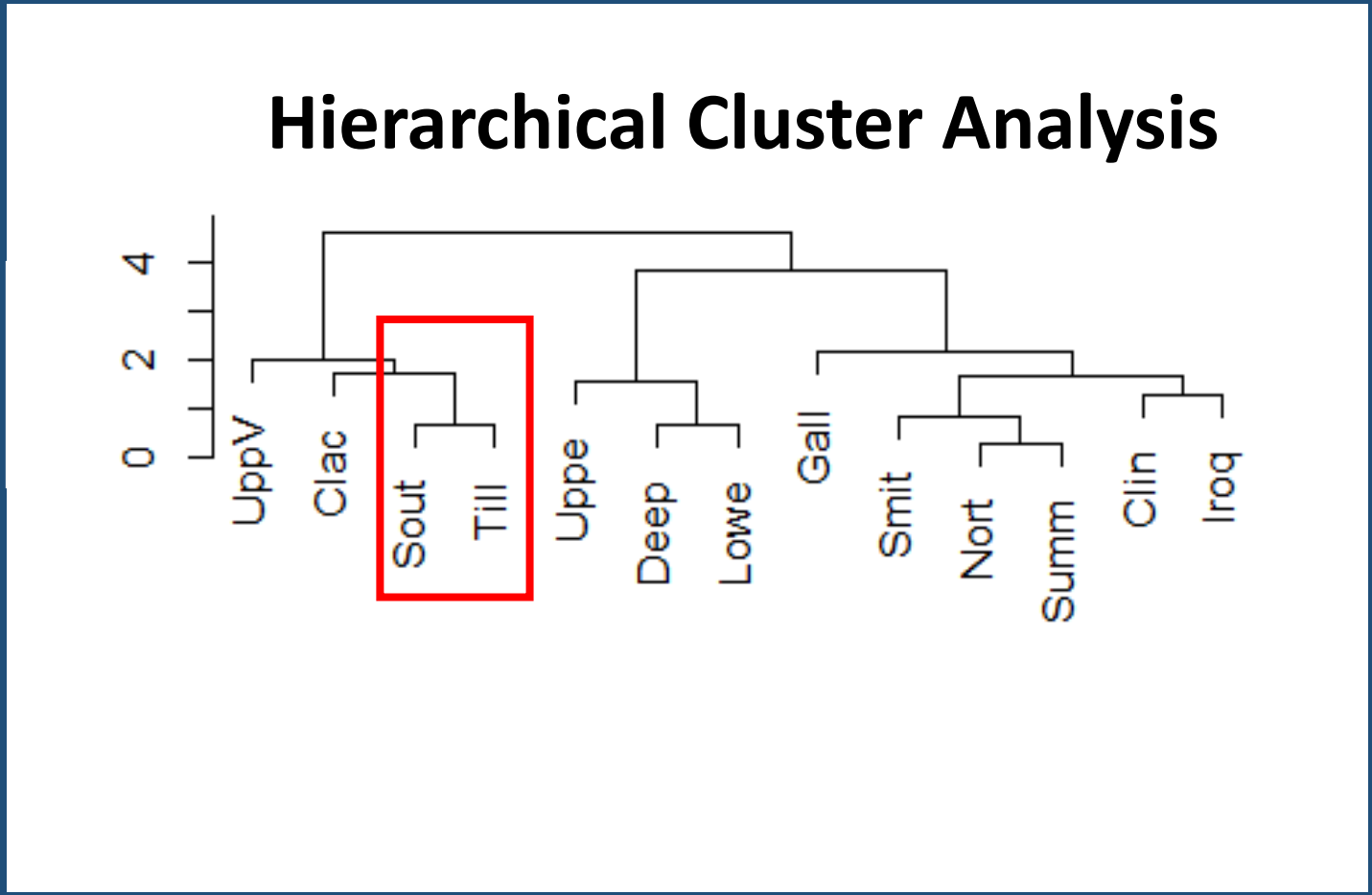
Pat Clinton, Chanda Littles, Jari Liski, Mark Easter, Melissa Errend, JB Moon

Contact me:

Lauri Green (ruiz-green.lauri@epa.gov)

South Lake Trinity most similar to Tillamook

Similarity



Site

South Fork Trinity most similar

Site	State	COMET Farm kg C m^{-2}	Million tonnes CO_2 captured	Credit value $Millions
Tillamook	OR	9.4	47	631
South Fork Trinity	CA	5.0	44	571
Clackamas	OR	9.4	85	1099
Upper Chehalis	WA	6.2	77	991
Upper Verde	AZ	2.4	57	743

Look for additional similarities to reduce COV?

Site	State	Ecotype	Soil type	Vegetation	PPT (mm)	Temp ° C	Canopy (%)	Bulk (g cm^{-3})
Tillamook	OR	Mountains	Non-acidic Volcanics	Evergreen	2896	10	69	1.4
South Fork Trinity	CA	Mountains	Carbonate Rock	Evergreen	1462	11	68	1.3

Transferability Decision Tree