

Collaborative Simulation of Emerging Infectious Disease Using Tangible Landscape

Francesco Tonini¹, Douglas Shoemaker¹, Vaclav Petras², Anna Petrasova², Helena Mitasova², Ross K. Meentemeyer¹

¹ Center for Geospatial Analytics, NC State University

² Marine, Earth, and Atmospheric Sciences (MEAS), NC State University

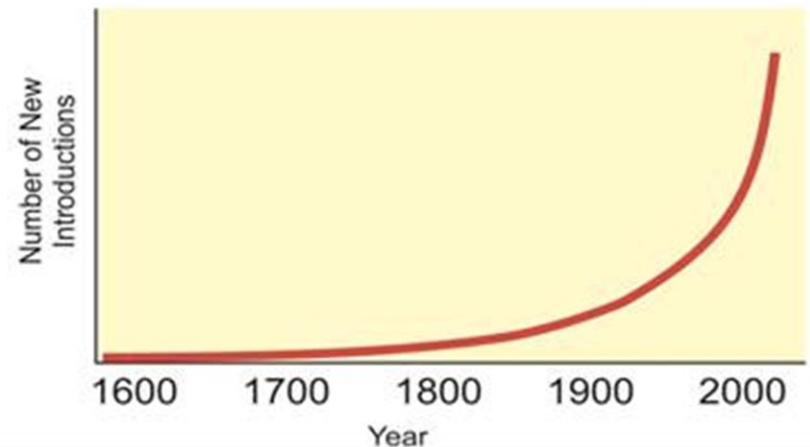
The 2015 ESA Annual Meeting
August 11, 2015
Baltimore, MD USA

Biological Invasions

- Global change: increased human mobility, land-use change

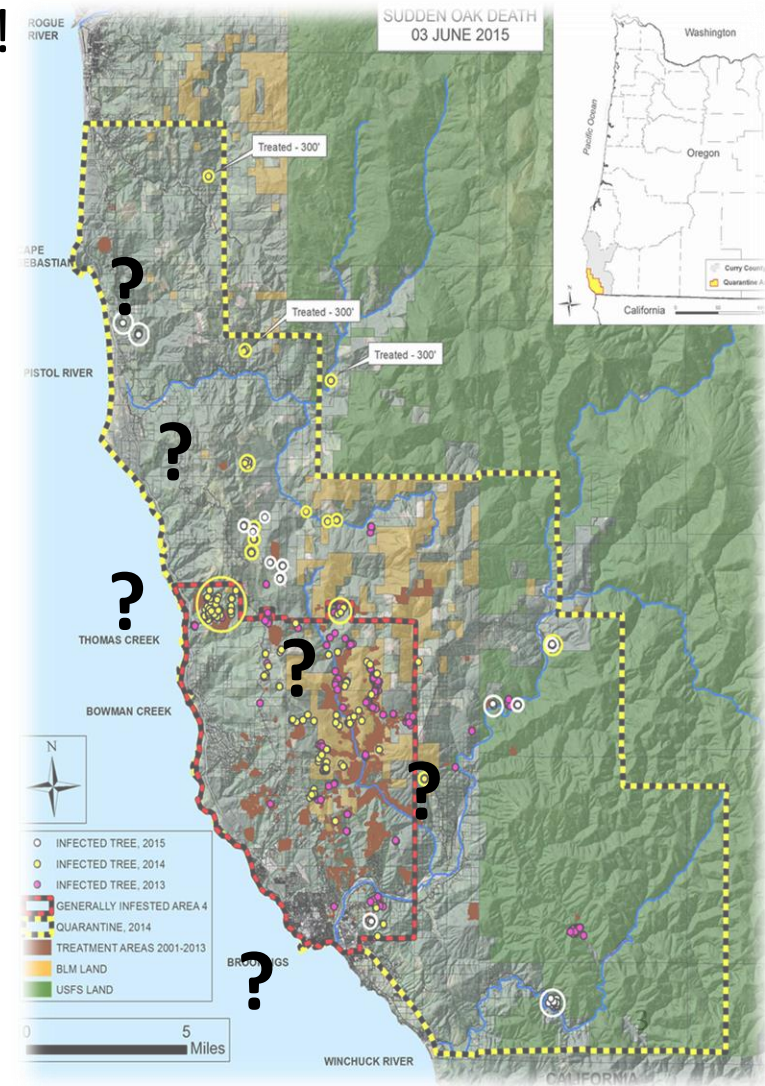


- Introductions and impacts continue to rise



Key Management Issues

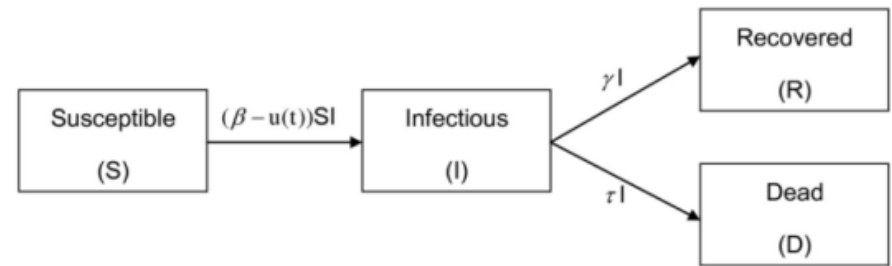
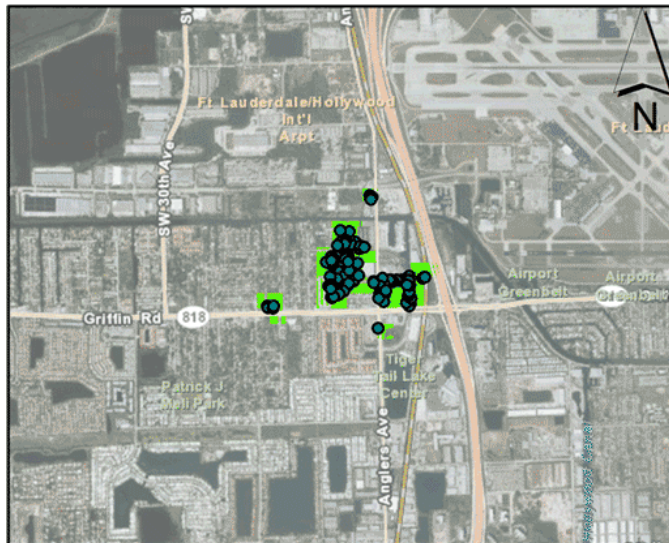
- Late identification: time to action counts!
- Deployment of funding
- What do we manage for?
- What type of treatments are effective?
- Allocation of management areas



Dynamic Spread Models

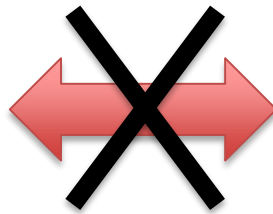
- Scientists build sophisticated models of invasion processes
- **Application of dynamic landscape models for direct management of invasive species is rare**

2003



$$\begin{aligned}
 \frac{dS}{dt} &= -\beta \frac{SI}{N} - \nu S \\
 \frac{dI}{dt} &= \beta \frac{SI}{N} - \gamma I \\
 \frac{dR}{dt} &= \gamma I + \nu S \\
 N &= S + I + R
 \end{aligned}$$

Disconnect Researchers-Stakeholders



- Encouraging collaboration: collective action needed between multiple stakeholders
- Incorporation of place-based knowledge (GIS often not understood by lay public)
- Opportunities to “fail” and learn without consequences

Objectives

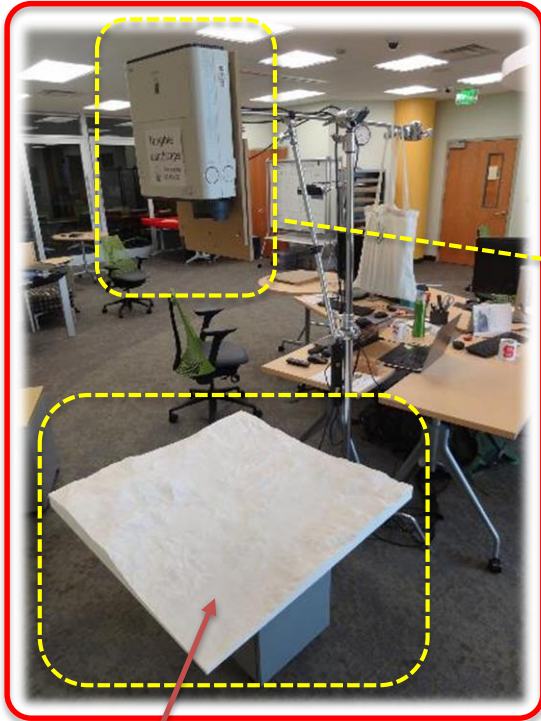
- Address this “wicked” socio-ecological problem using participatory science
- Spark collaboration among stakeholders using novel geospatial modeling and visualization techniques
 - ✓ Stakeholders gather around a geographically realistic “sandbox” and explore “what if” scenarios with instant feedback as to impacts
 - ✓ Speed decision making by eliminating non-starters
 - ✓ Facilitate “on-the-fly” evaluation of alternative management strategies

Key Questions

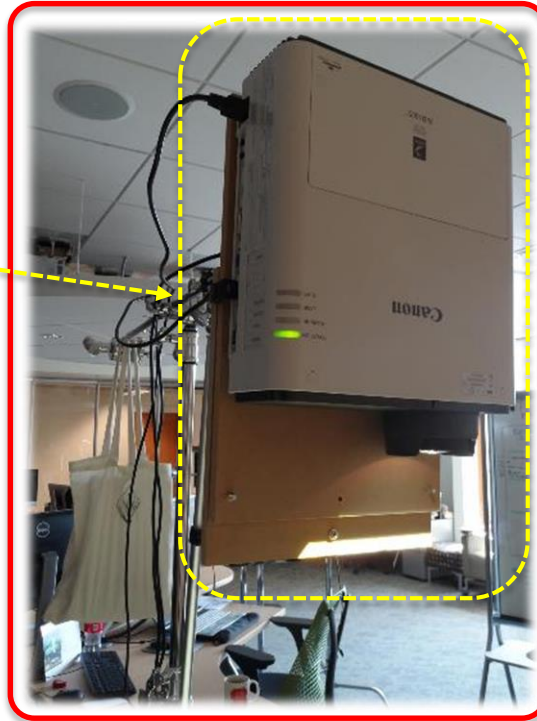
- Does a tangible modeling environment facilitate the active participation of local decision makers and resource managers in the modeling process?
- Given a budgeted set of disease management treatments, could stakeholders individually and in groups develop “successful” disease control scenarios on-the-fly?



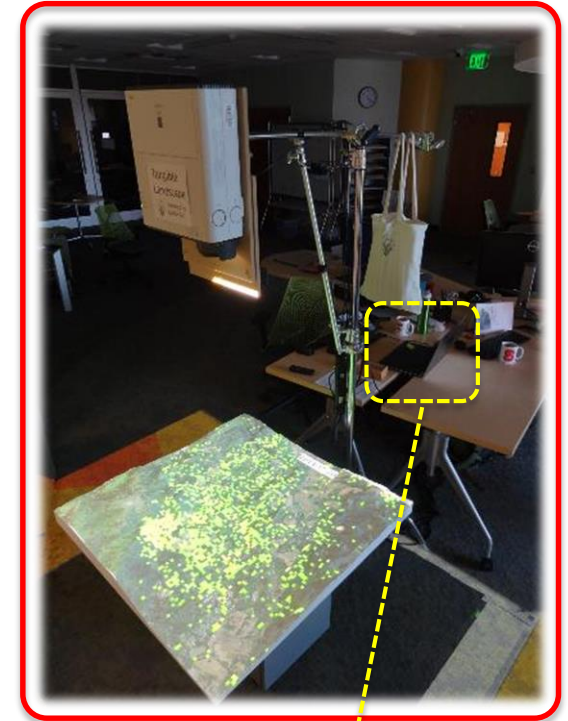
What is Tangible Landscape?



Physical terrain
model (3D)



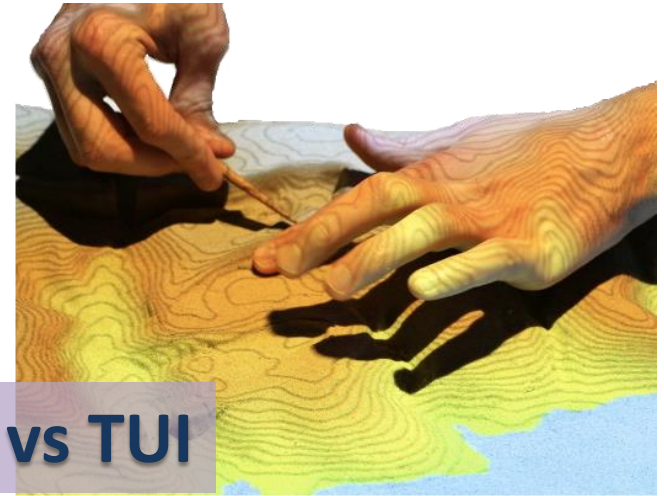
Projector + Scanner
(Kinect)



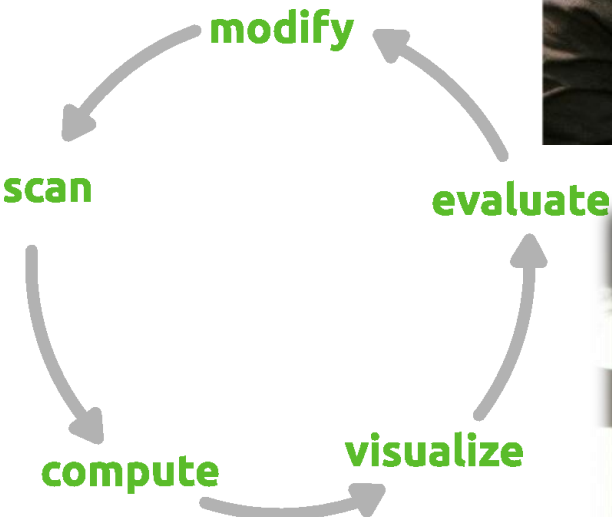
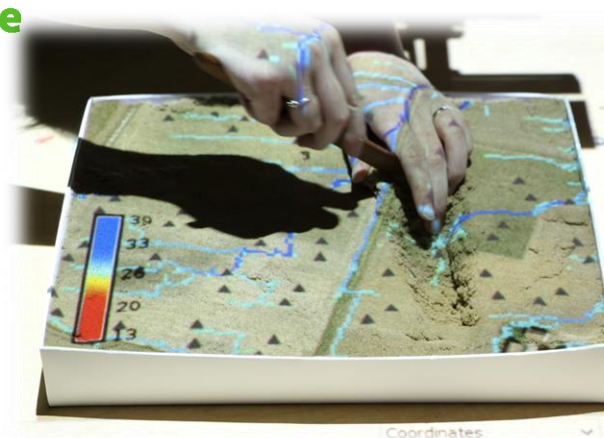
Computer with
GRASS GIS

What is Tangible Landscape?

Interactive exploration of how landscape modifications affect various phenomena by combining powerful capabilities of GIS with a tangible interface

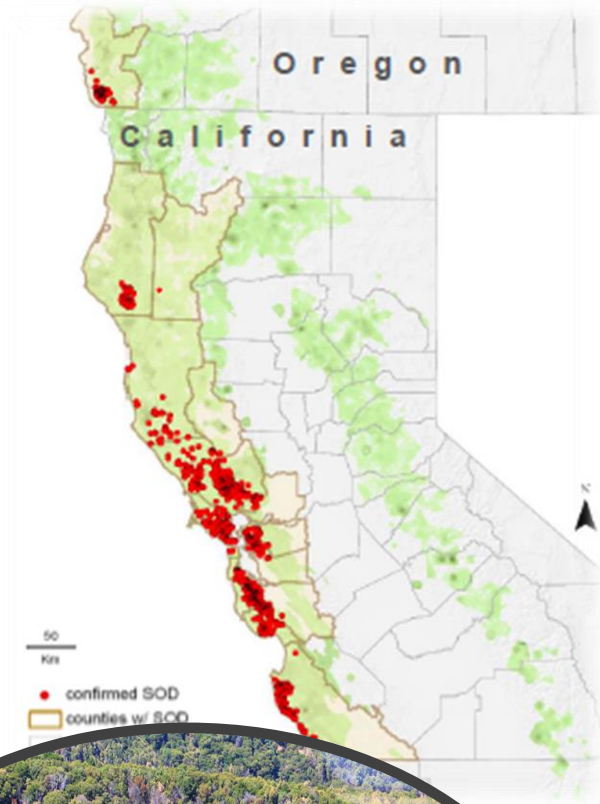


GUI vs TUI

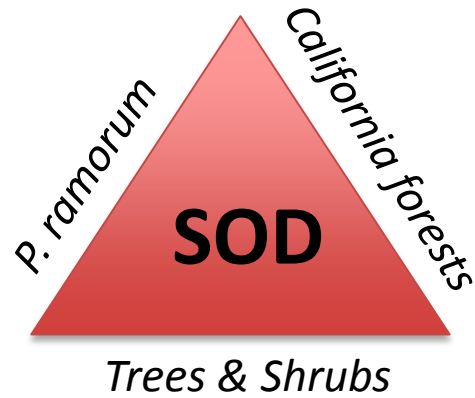


A “Landscape Epidemic”

- Forest disease ravaging in California
- Threatening high-value oak woodlands
- Classic “freeze dried” appearance of mortality
- Spotted in mid 1990s

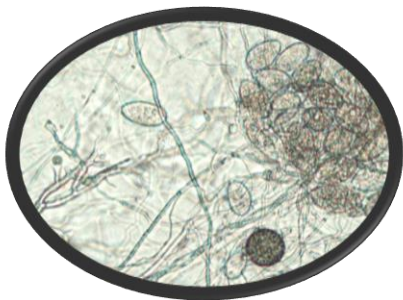
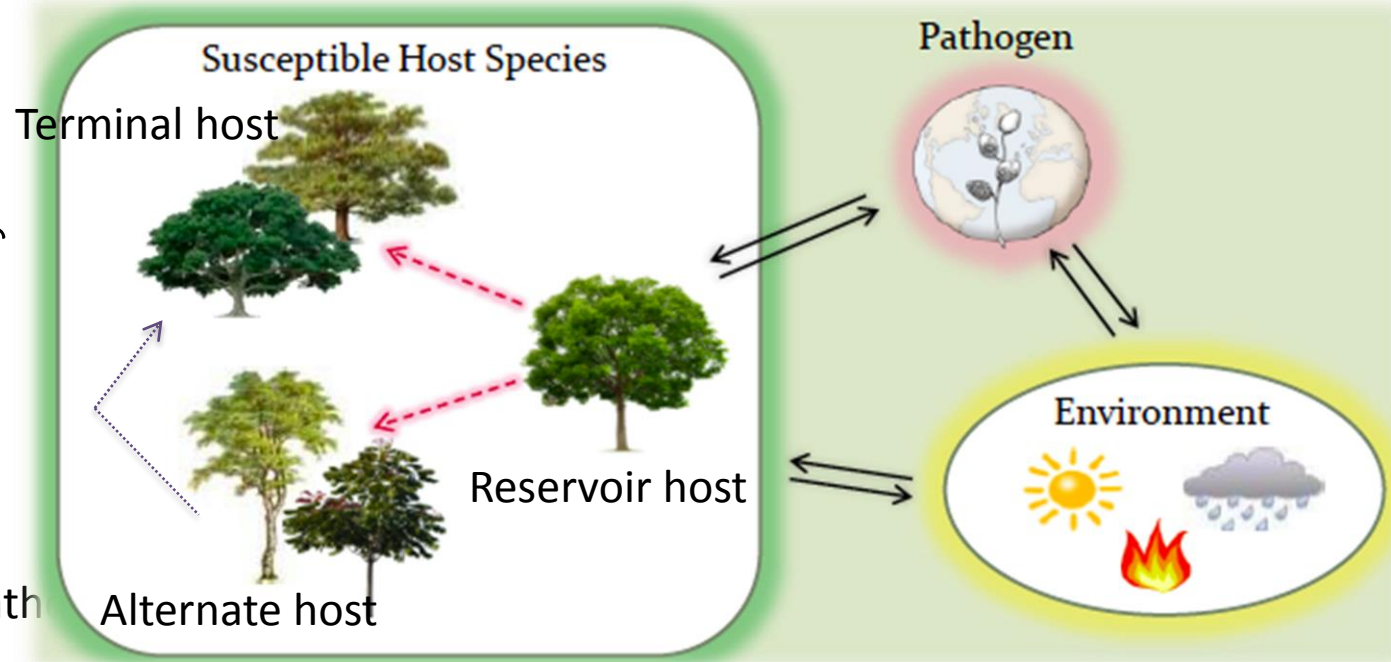


Sudden Oak Death (SOD)

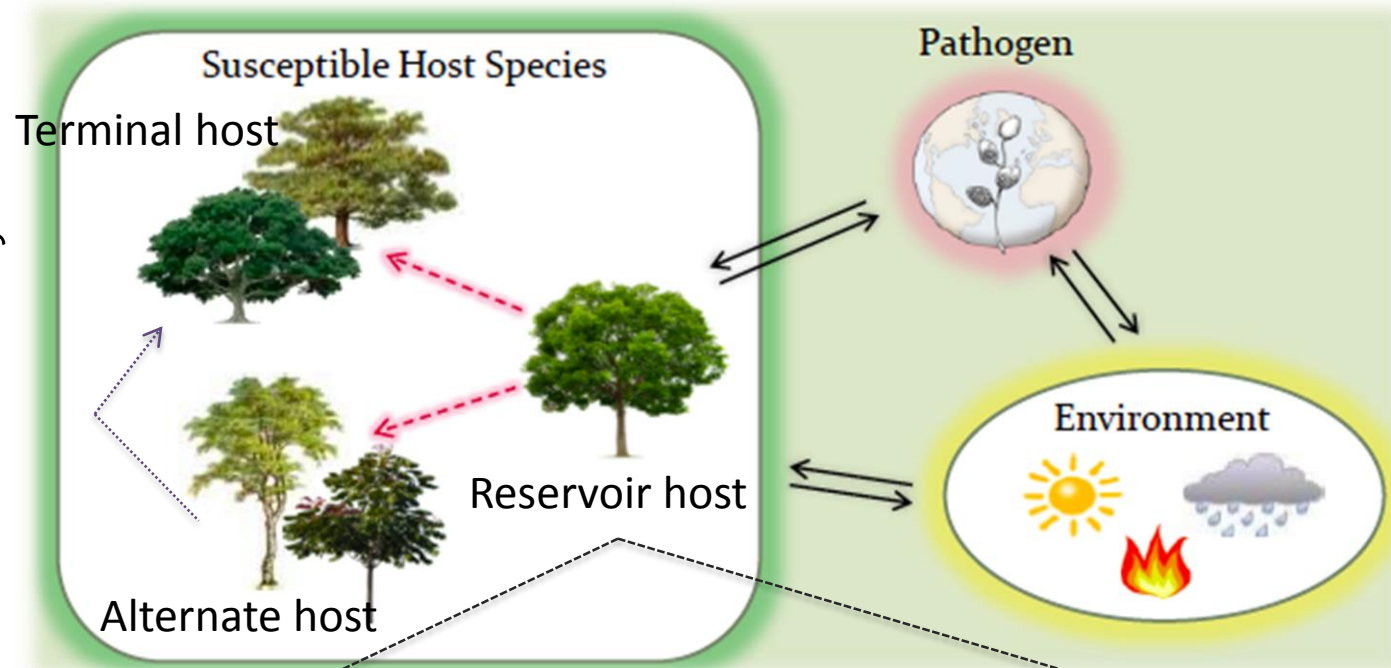
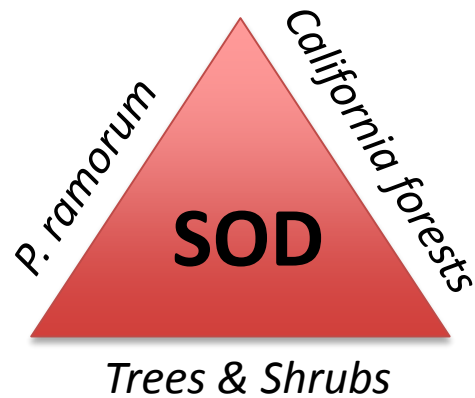


Phytophthora ramorum:

- water mold
- Invasive, generalist pathogen



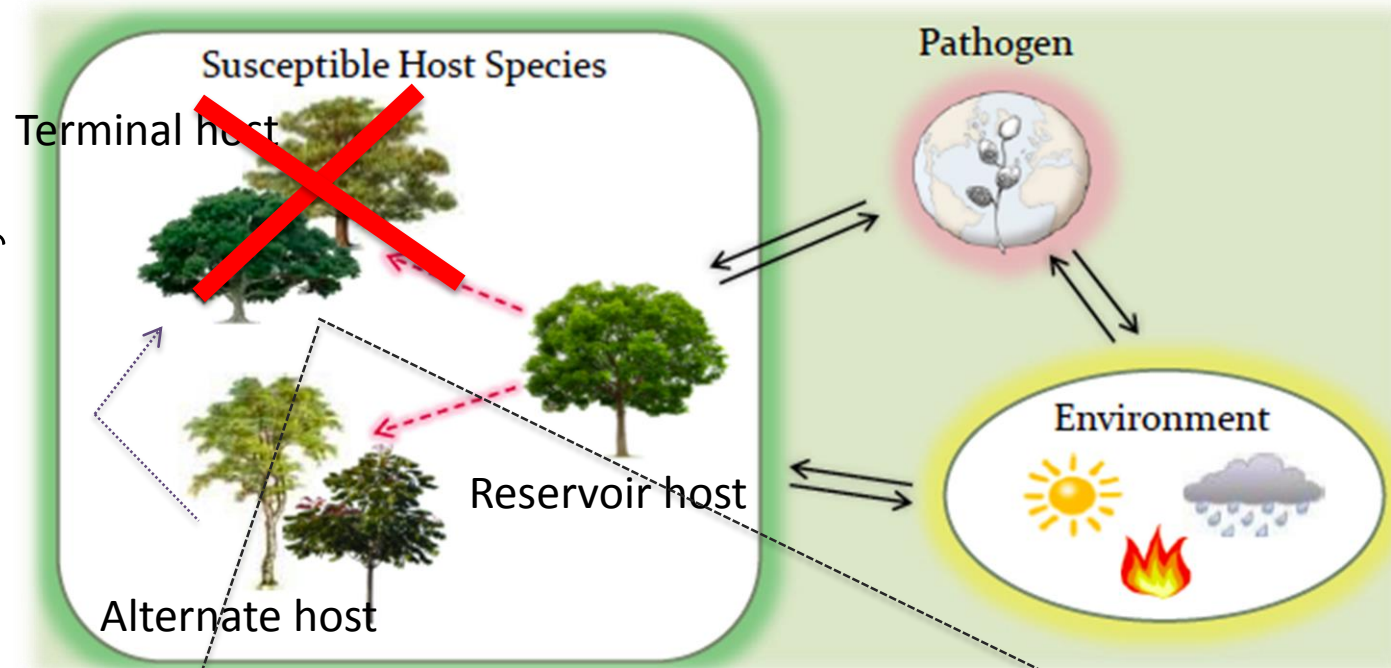
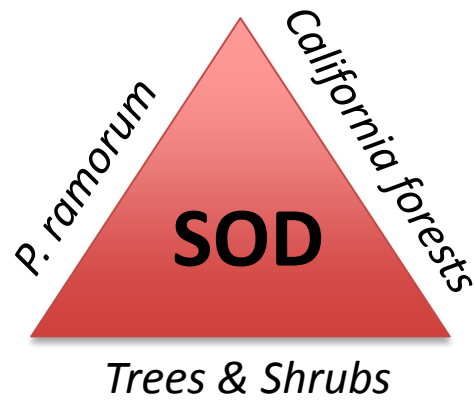
Sudden Oak Death (SOD)



California Bay Laurel



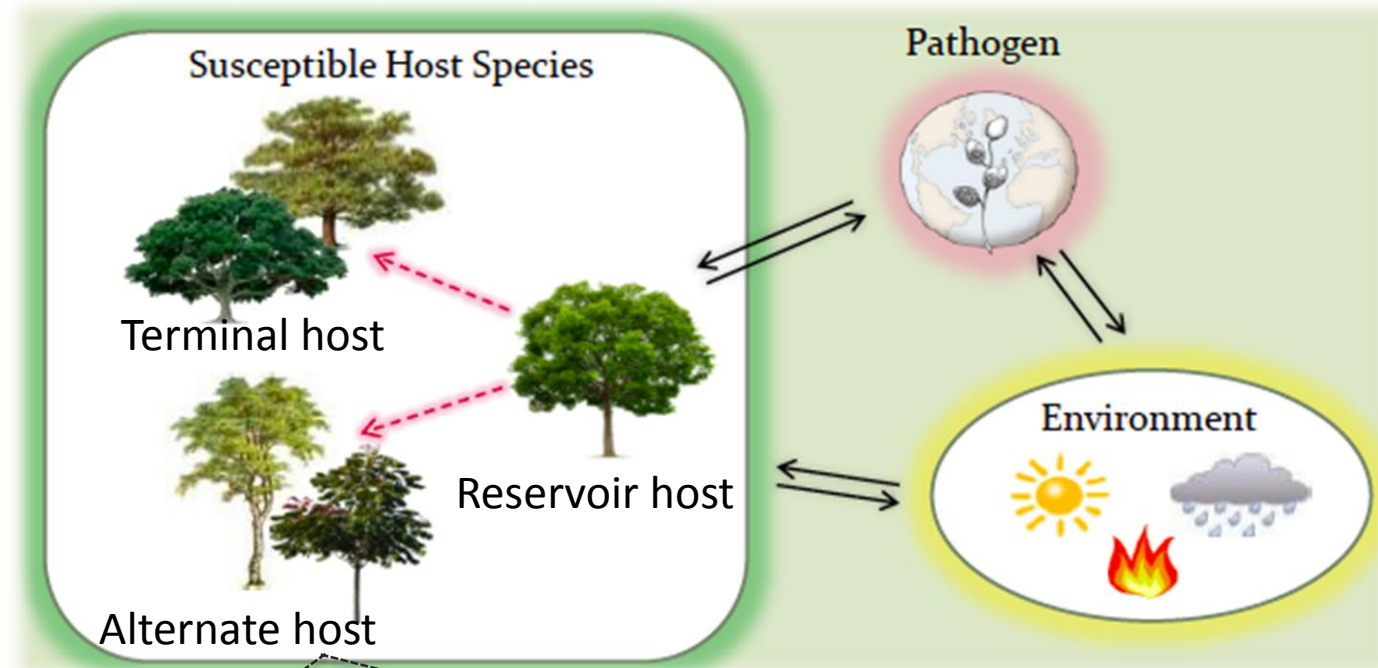
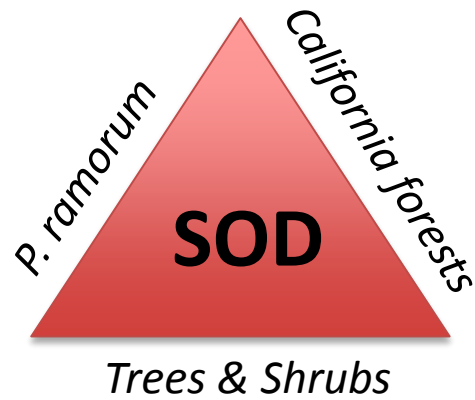
Sudden Oak Death (SOD)



Oaks spp.



Sudden Oak Death (SOD)



A Serious Game:

Managing Sudden Oak Death (SOD) in Sonoma

The Challenge: If you had perfect knowledge of where and when SOD arrived on Sonoma Mountain, could you stop it from spreading with well-placed treatments?

GOAL: protect the maximum number oak (Quercus) individuals

RULES:

- Max management area restricted to **62 ha** (153 ac). CEQ/NEPA regulations for treatments > 150 ac per year cost 1+ million USD
- Disease management treatment: 100% culling of California bay laurel (UMCA)
- One opportunity to treat in 2000, and results calculated on 2014 estimates

A Serious Game:

Managing Sudden Oak Death (SOD) in Sonoma

- *The Players*: three “virtual” stakeholders identified along with their behaviors

TREE HUGGER



THE ENVIRONMENTALIST

- Advocates the lawful preservation, restoration and/or improvement of the natural environment
- Opposed to deforestation unless it saves old growth trees



THE LAND OWNER

- Driven by reduction of fuel accumulation
- Not concerned with total infested area
- Inclined to manage along straight lines (similar to fire management)



THE FOREST MANAGER

- Particularly concerned with forest health within national/state park boundaries
- Inclined to manage close to park entrances/trails
- Save old growth trees

- The research scientist helps coordinating and runs the simulation

A Serious Game:

Managing Sudden Oak Death (SOD) in Sonoma

Details:

Basis of comparison: No treatment 2000-2014

“What if” scenarios: Single treatment event in 2000

Responses tracked:

- Number of dead oaks
- % dead oaks
- Infected area (ha)
- Money spent (\$)

- Cost of treatment:

$$\text{\$USD / ha} = \% \text{ Host tree} * 13 * 18 + 800$$

- Cost per saved oak (\$)

Evaluation metrics:

- Oaks saved from disease
- Area saved from infection
- Budget allocation efficiency
- Spatial evaluation (visual inspection)

relative cover

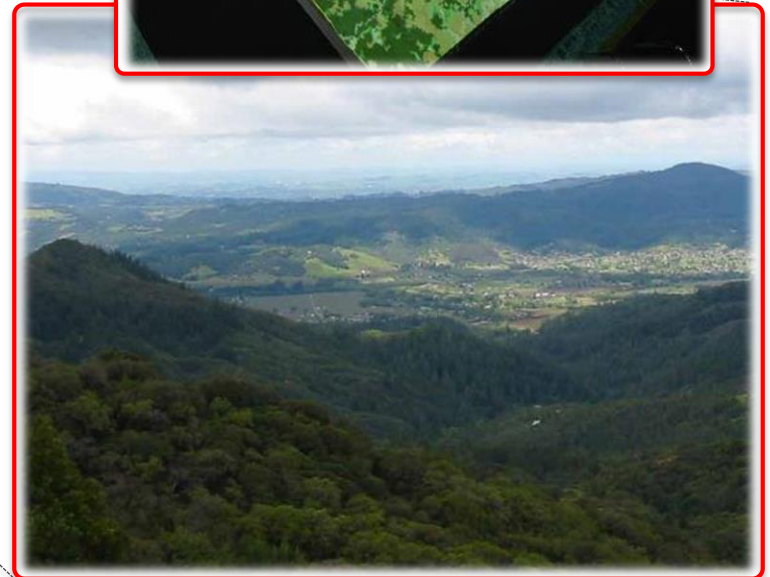
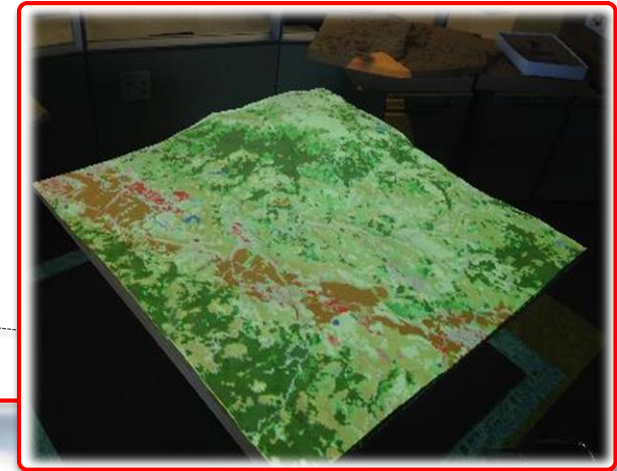
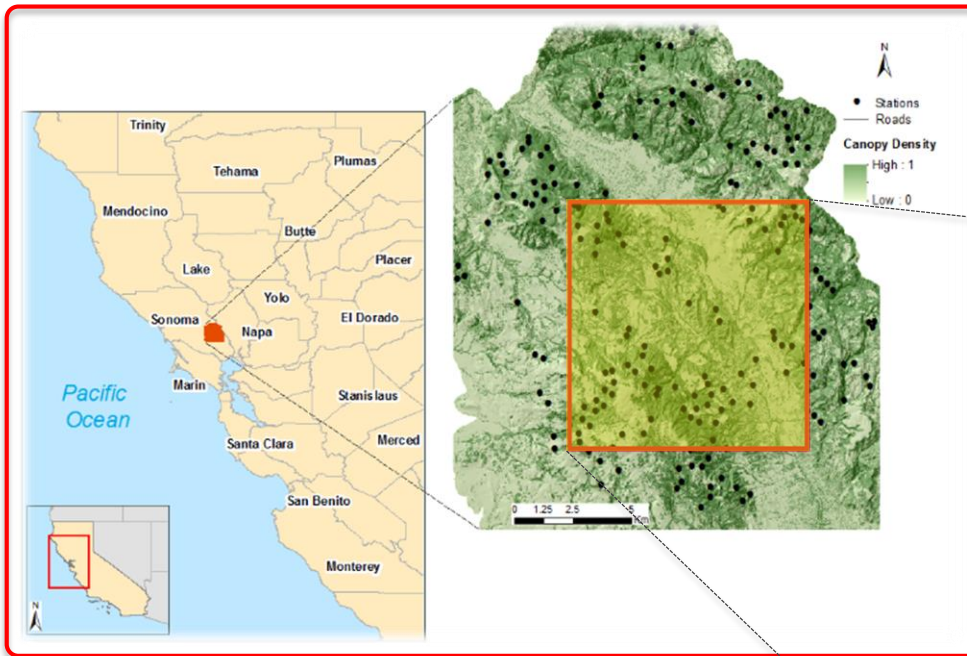
man hours to
cull 1% UMCA

Labor(\$)/hr

Flat
prep
fee

A Serious Game: *Managing Sudden Oak Death (SOD) in Sonoma*

"Playing board": Sonoma county, California



A Serious Game: *Managing Sudden Oak Death (SOD) in Sonoma*

Tangible Landscape: study area context



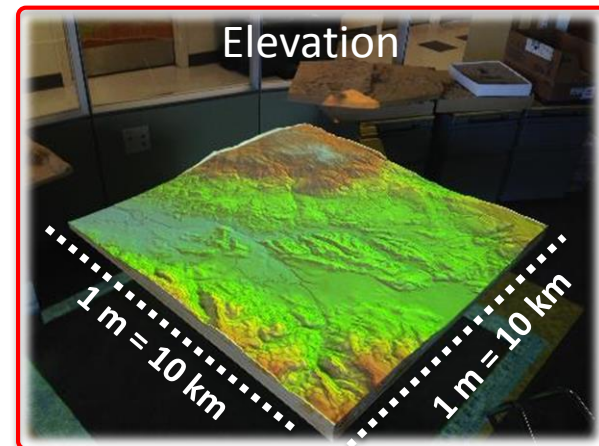
3D physical model

extent

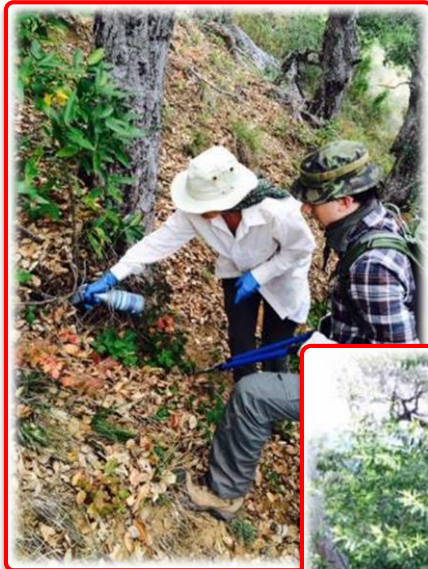
$1 \text{ m}^2 = 10 \text{ km}^2$

resolution

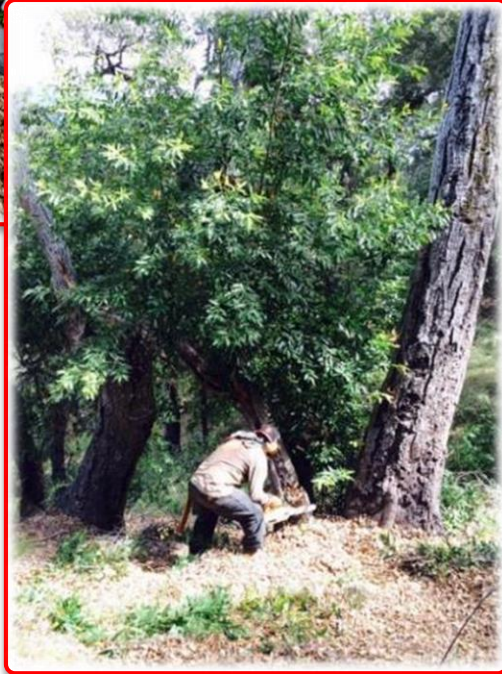
$1 \text{ cm}^2 = 100 \text{ m}^2$



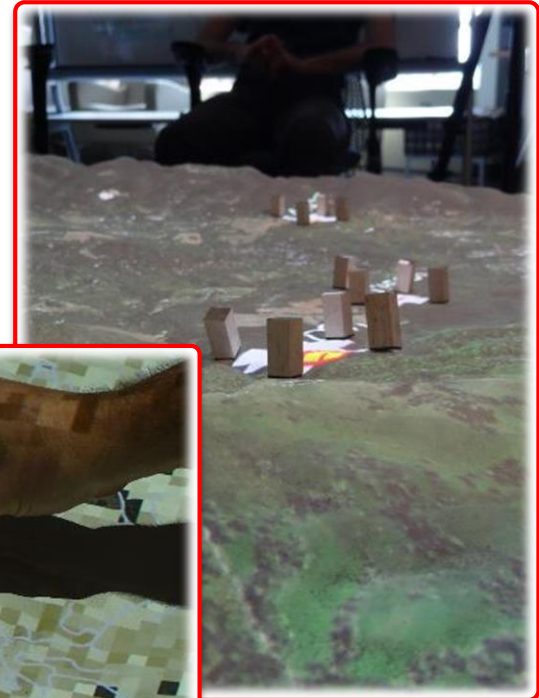
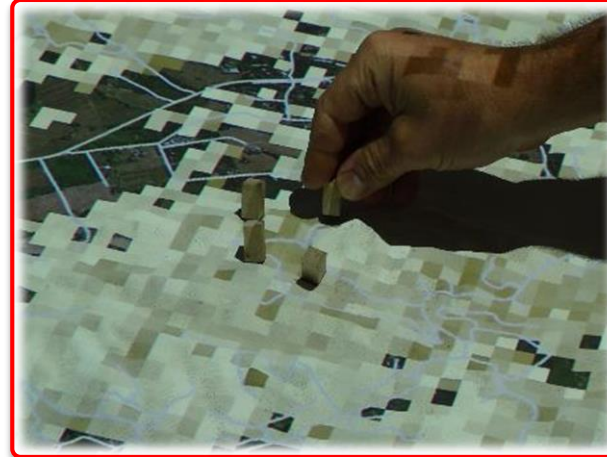
A Serious Game: *Managing Sudden Oak Death (SOD) in Sonoma*



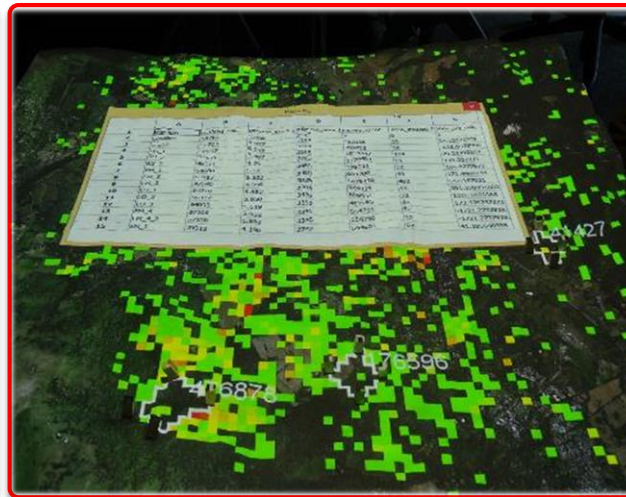
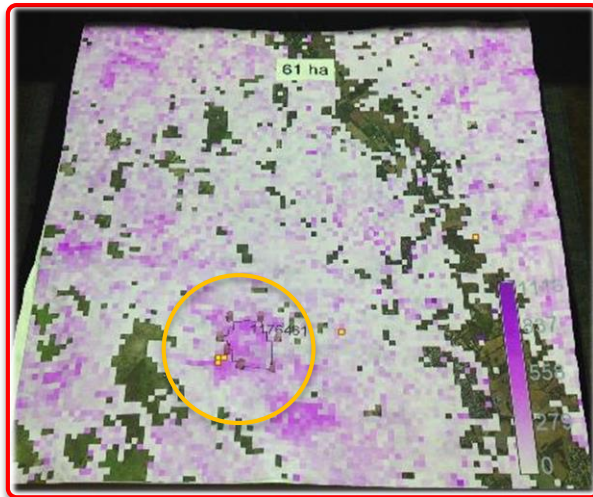
In the field



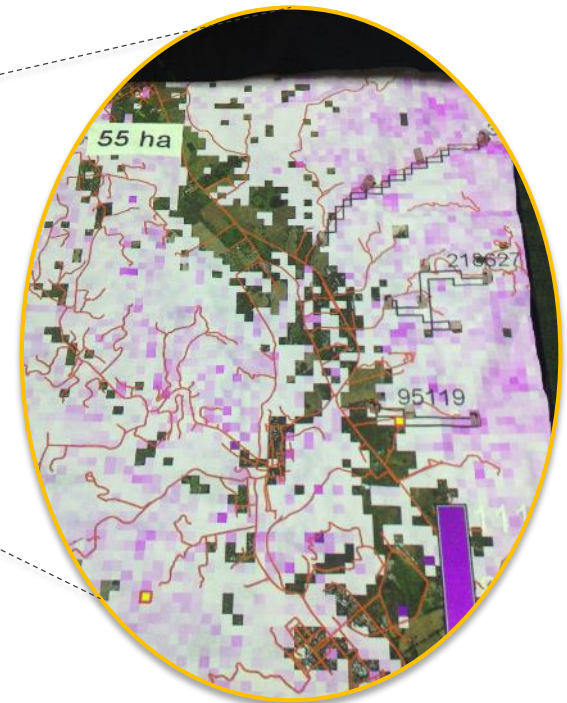
Tangible Landscape



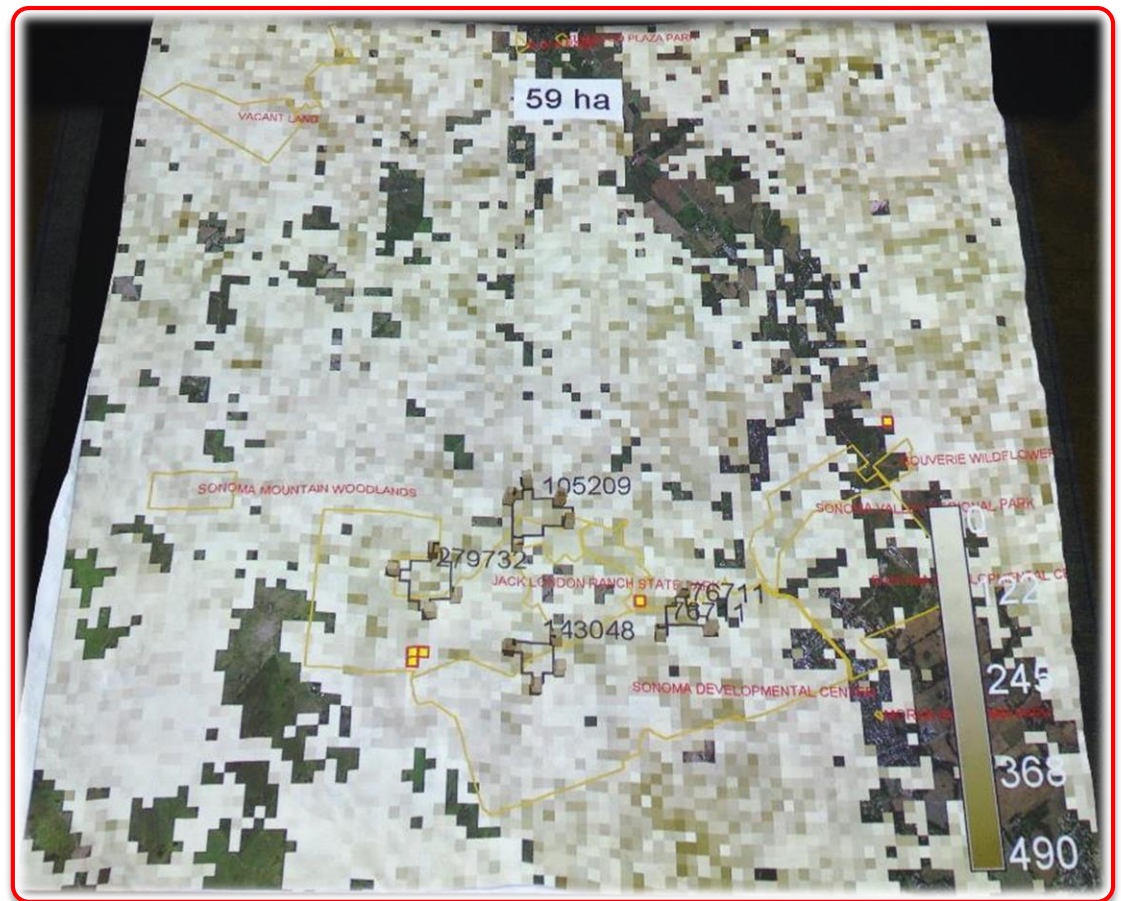
A Serious Game: *Managing Sudden Oak Death (SOD) in Sonoma*



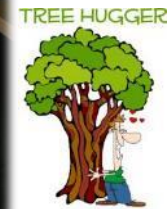
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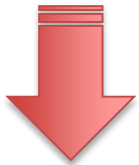
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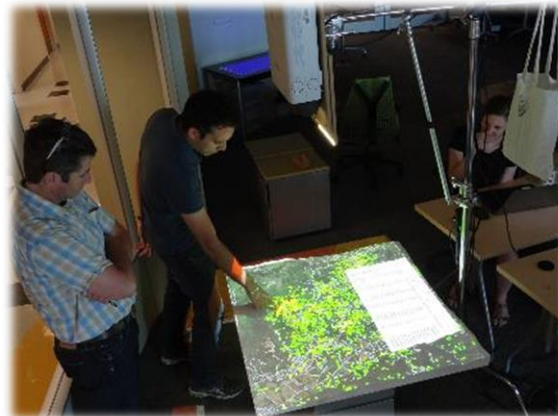
TREE HUGGER



A Serious Game: *Managing Sudden Oak Death (SOD) in Sonoma*



Stakeholders see the
result of their
combined actions...



Stakeholders adjust their
management based on the new layer

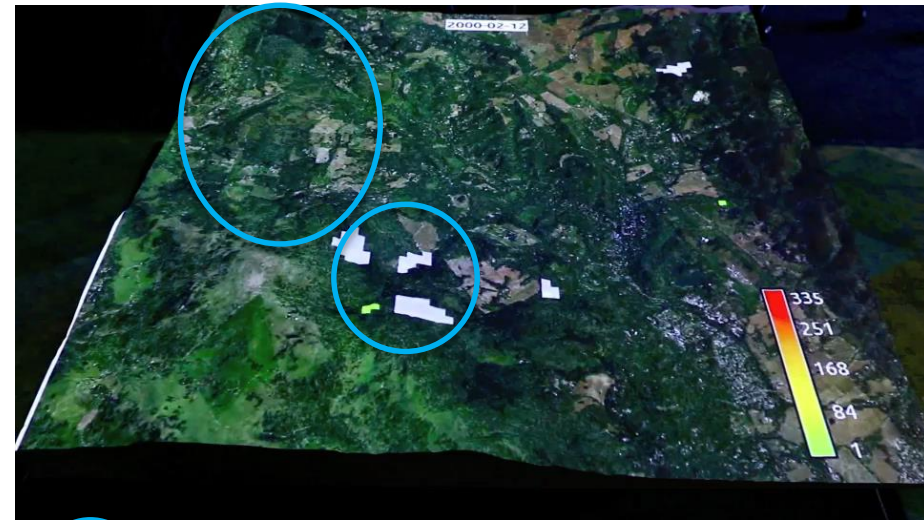
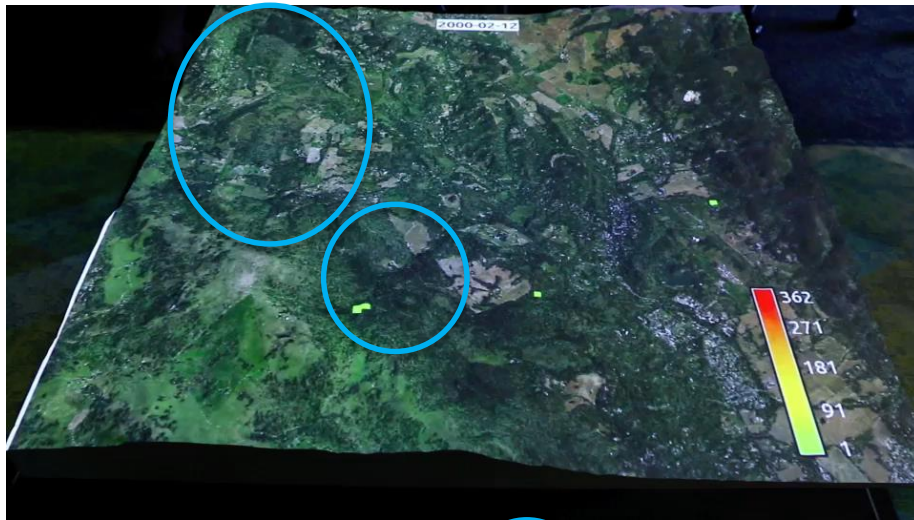


...the discussion sparks new
ideas!

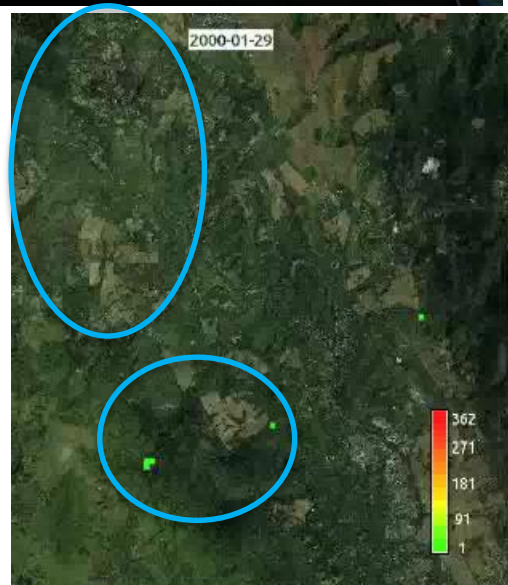


Preliminary Results: Animations

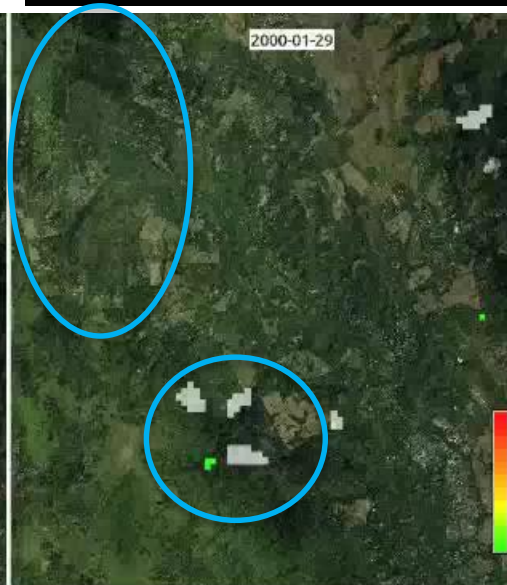
Sudden Oak Death (SOD)



NO TREATMENT



TREATMENT



Preliminary Results:

Sudden Oak Death (SOD)

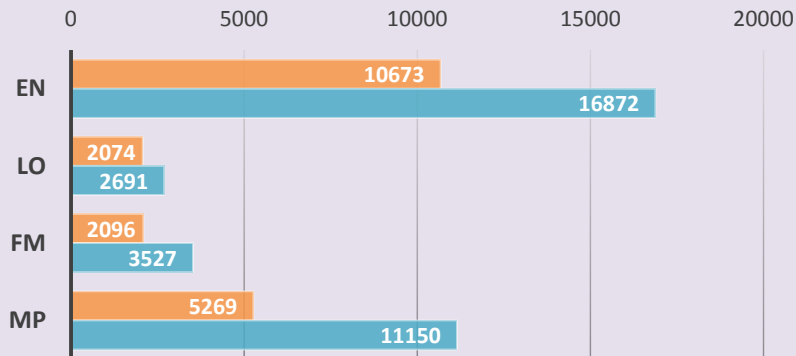
TR 1



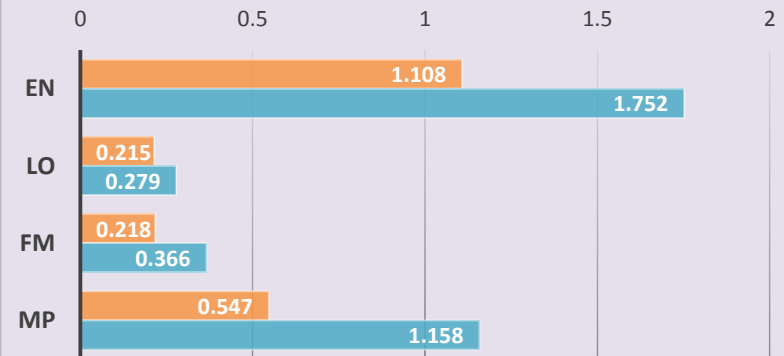
TR 2



Number of Oaks Saved from Disease

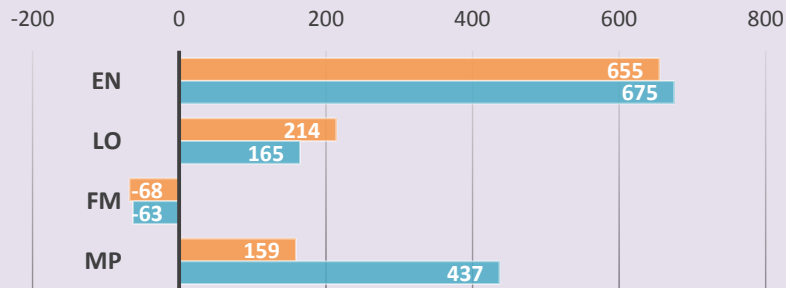


% of Oaks Saved from Disease

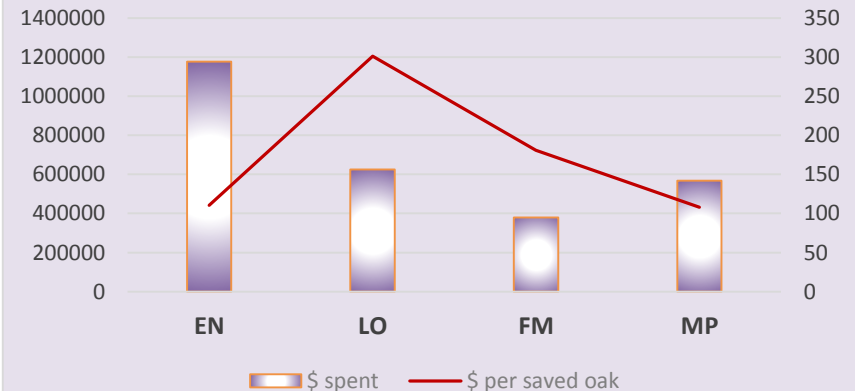


Year 2014

Area Saved from Infection (ha)



Budget Allocation Efficiency



Conclusions

Take-home messages

- What do we manage for?
 - Save oaks
 - Carbon stock
 - Woody tree diversity (evenness)
 - Total infected area
 - Quarantine: track units (e.g. spores/termites) leaving study area
- Collaboratively shaping disease management solutions using novel geospatial modeling and visualization techniques
- Participatory science to spark collaboration among stakeholders
- Budget resources and size of management area have large impact

Questions?

