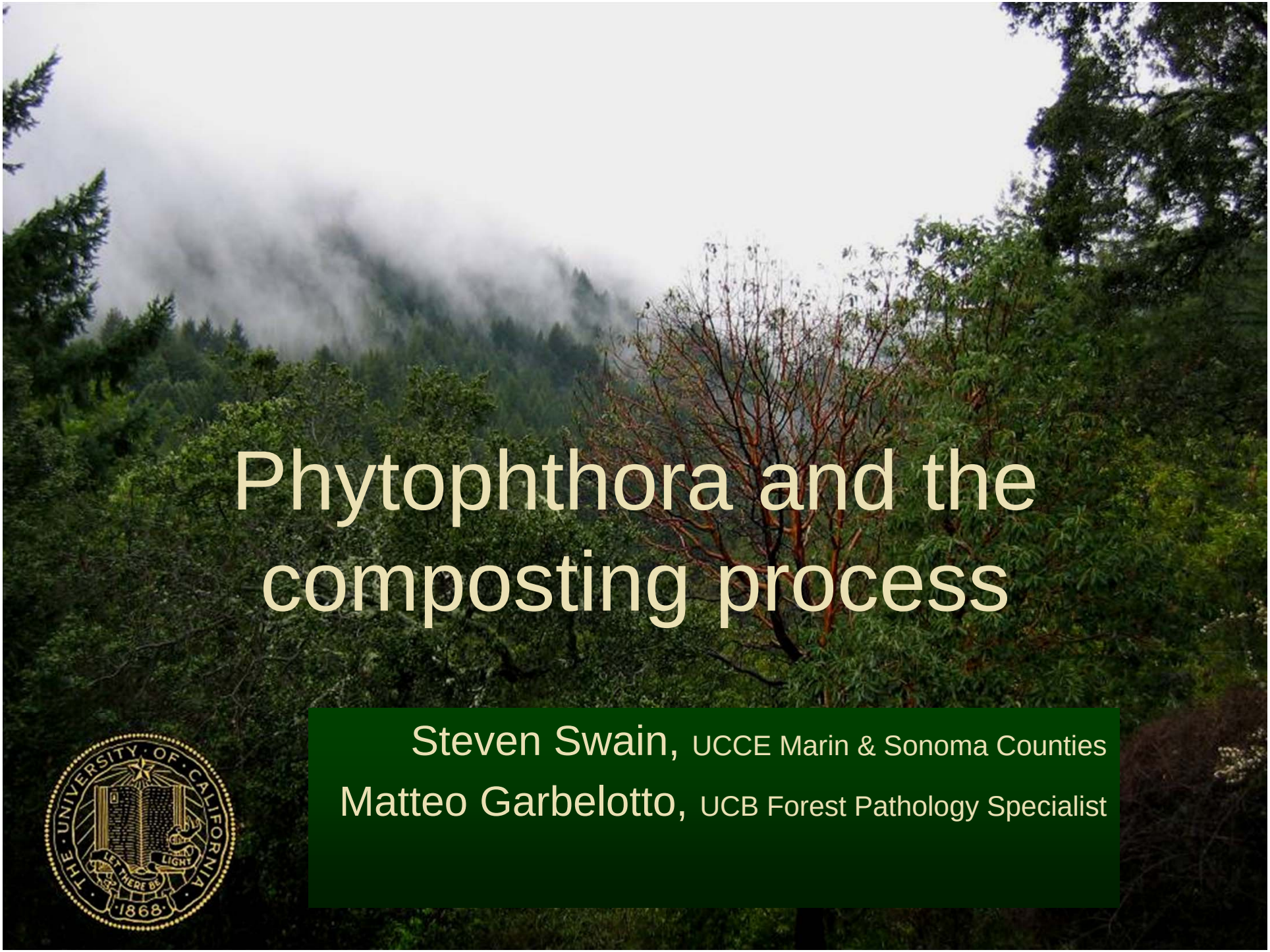


Phytophthora and the composting process

Steven Swain, UCCE Marin & Sonoma Counties

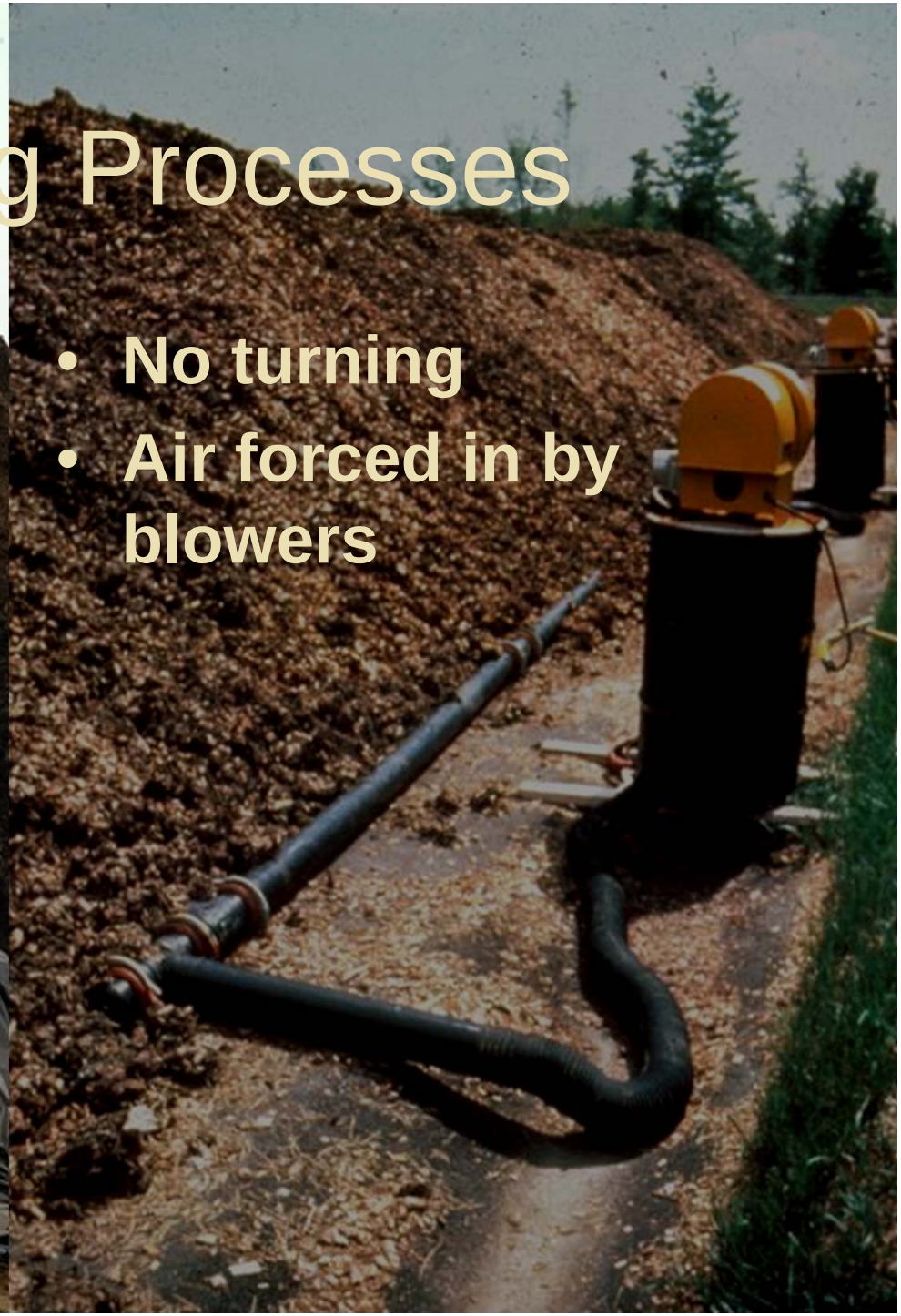
Matteo Garbelotto, UCB Forest Pathology Specialist

Background

- Article in California Agriculture on *Phytophthora ramorum* infesting finished compost
  - Somewhat esoteric angle on the subject
  - http://californiaagriculture.ucanr.edu/landingpage.cfm?article=ca.v069n04p237&fulltext=yes
- Perhaps more relevant article in the Journal of Applied Microbiology
  - More comprehensive study, and sort of a basis for the newer article
  - https://nature.berkeley.edu/garbelotto/downloads/Swainetal.pdf

Composting Processes

- “Traditional” composting method
- Turned by various types of machinery



- No turning
- Air forced in by blowers

Process variables

- Main variables
  - Moisture content
  - C:N ratio
  - Ambient temperature
  - Turning frequency
- Secondary variables
  - Feed stock
  - Turning type
  - Open versus closed container
  - Urban / Rural location
  - Curing time
  - Post process inoculation

Curing time

- None technically required
- Young (low curing times, typically <1 wk)
  - Low biodiversity, high chemical diversity
  - Recolonization easy(ish)
- Mesic (1-4 weeks)
  - Higher biodiversity
- Mature (^ curing times, typically >4 wks)
  - Low biodiversity, chemically homogenous and stable
  - Recolonization finished
- NOTE: These times vary with location & climate

The problem with mulch

- No formal definition of product or process
  - Mylar
    - shredded reflective plastic for thrips control
  - Sheet mulching
    - Newspaper/cardboard/manure/wood chip lasagna
  - Wood chips
    - Straight from chipper
    - Pallets
  - BUT fresh wood chips can self-compost
    - Especially if chipped with leaves (unregulated)


http://onelittlefarm.blogspot.com

Compost as a cure?

- Harry A.J. Hoitink at the Ohio State U.
  - Composted green-waste (bark) is disease suppressive in potting mixes (1970's – 2009+)
  - Bacillus, Trichoderma, etc.
  - e.g.: http://plantpath.osu.edu/sites/plantpath/files/imce/files/Hoitink/BioCycle_2009.pdf
- The Ashburner system: Guy Ashburner (Australian avocado grower, 1970's)
  - cover crop / mulches, and amends soil beneath trees
  - Reduces *P. cinnamomi* infections after several years
  - Ref: Magdoff F. & Weil R.R. (2004) Soil Organic Matter in Agriculture, CRC Press, p.162
  - Adopted wholesale by Australian avocado industry

The problems with compost

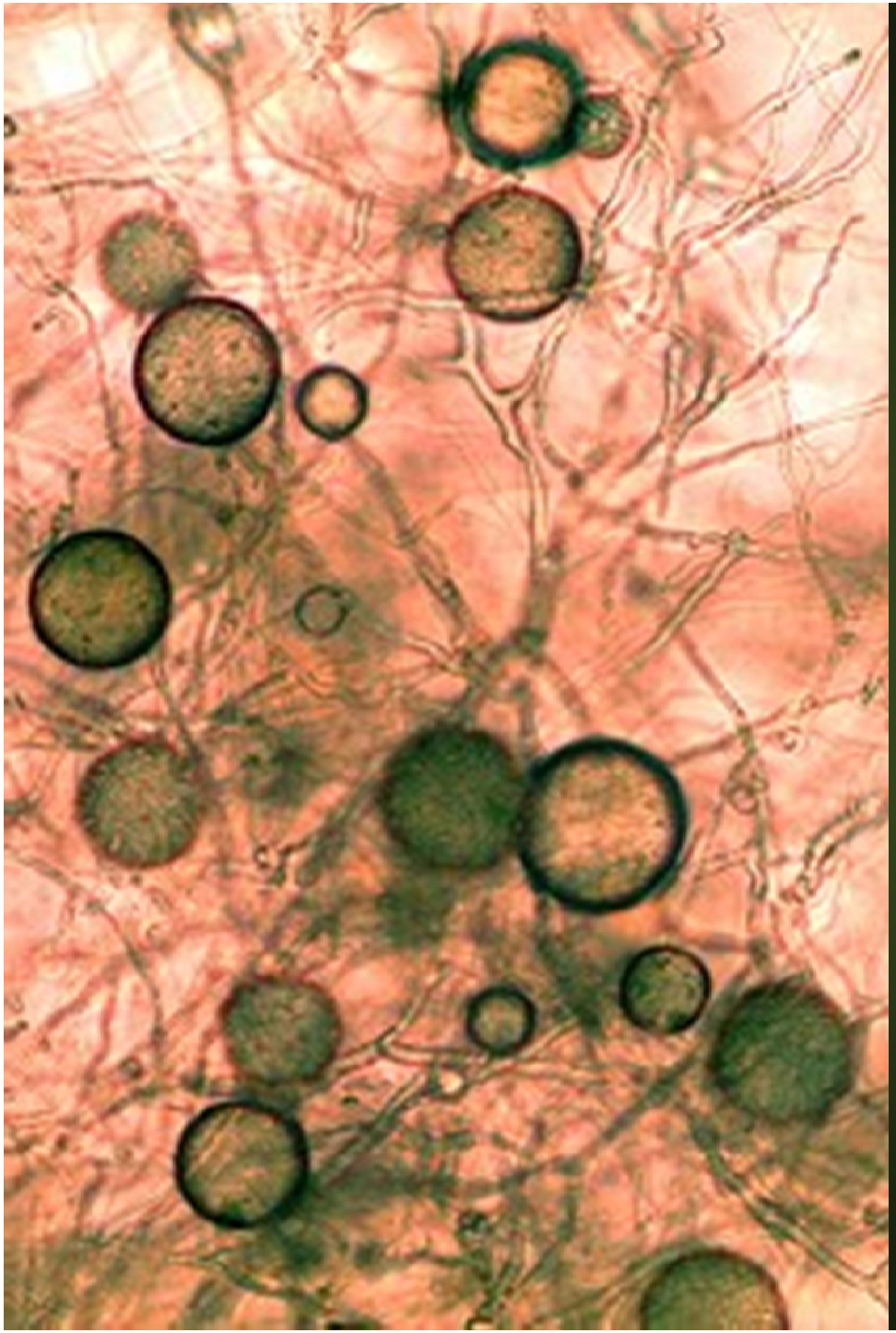
- Field efficacy
  - Results all over the board
  - Product consistency
    - Process is regulated (kills most pathogens)
    - Product is not regulated (may not be effective vs pathogens)
  - Suggestions for post-process inoculation
    - Trichoderma, other bio-fungicides
    - Cost is already a factor
      - Full circle?
- Giles Hardy and others show that some (many?) soilborne Phytophthora species can survive in finished compost

The problems with compost

- Quarantine on *P. ramorum*
  - Not typically soil-borne
  - Composting eliminates it from green-waste
  - Can it survive if introduced to finished compost?
- We know *P. ramorum* can survive in soil

Spore types

- Oospores
  - Sexually produced survival structures (~seeds)
- Chlamydospores
  - Asexual survival structures
- Sporangia
  - Delicate football shaped dispersal structures
- Zoospores
  - Delicate hunting spores



Spore types

- Oospores
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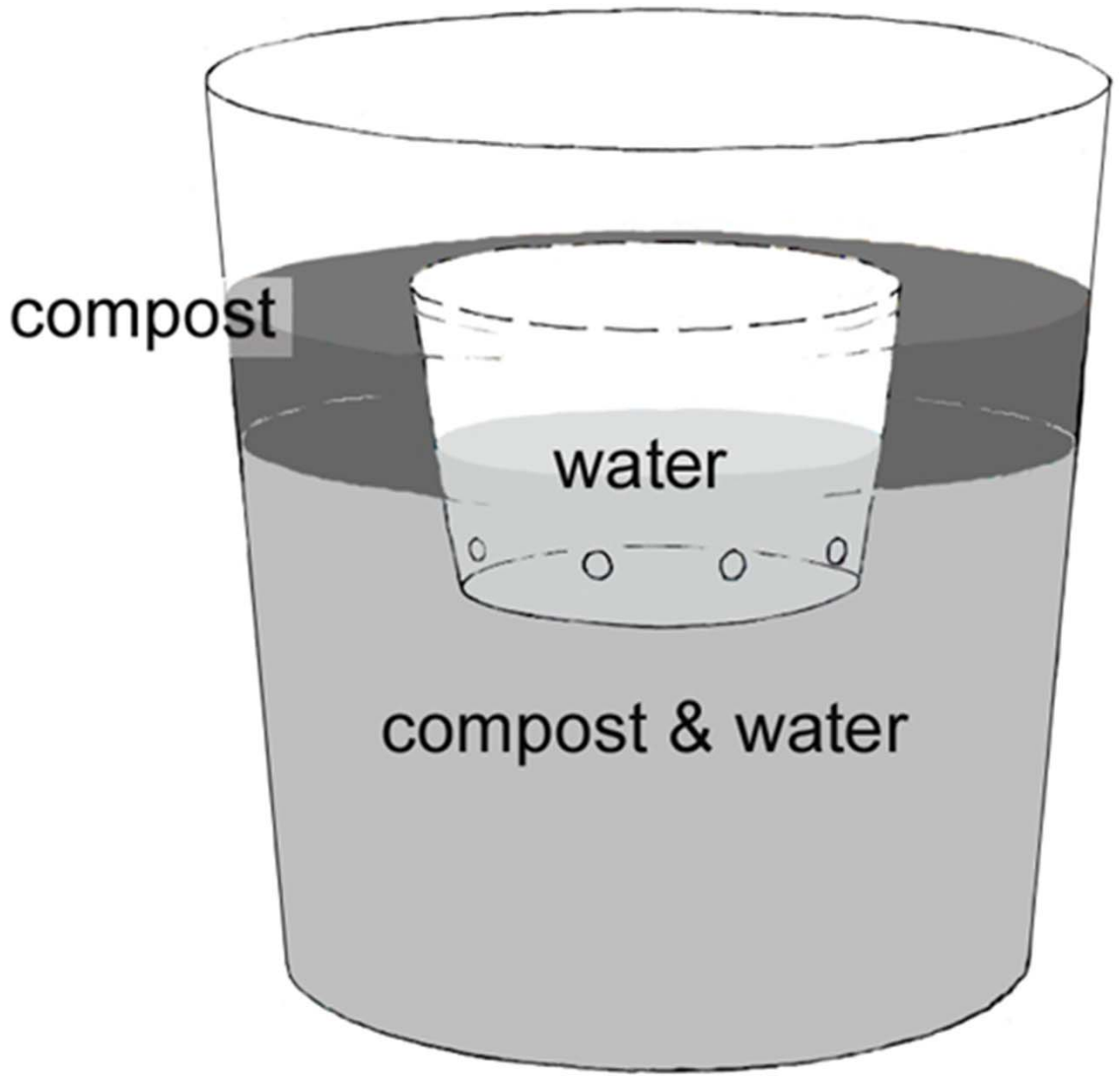
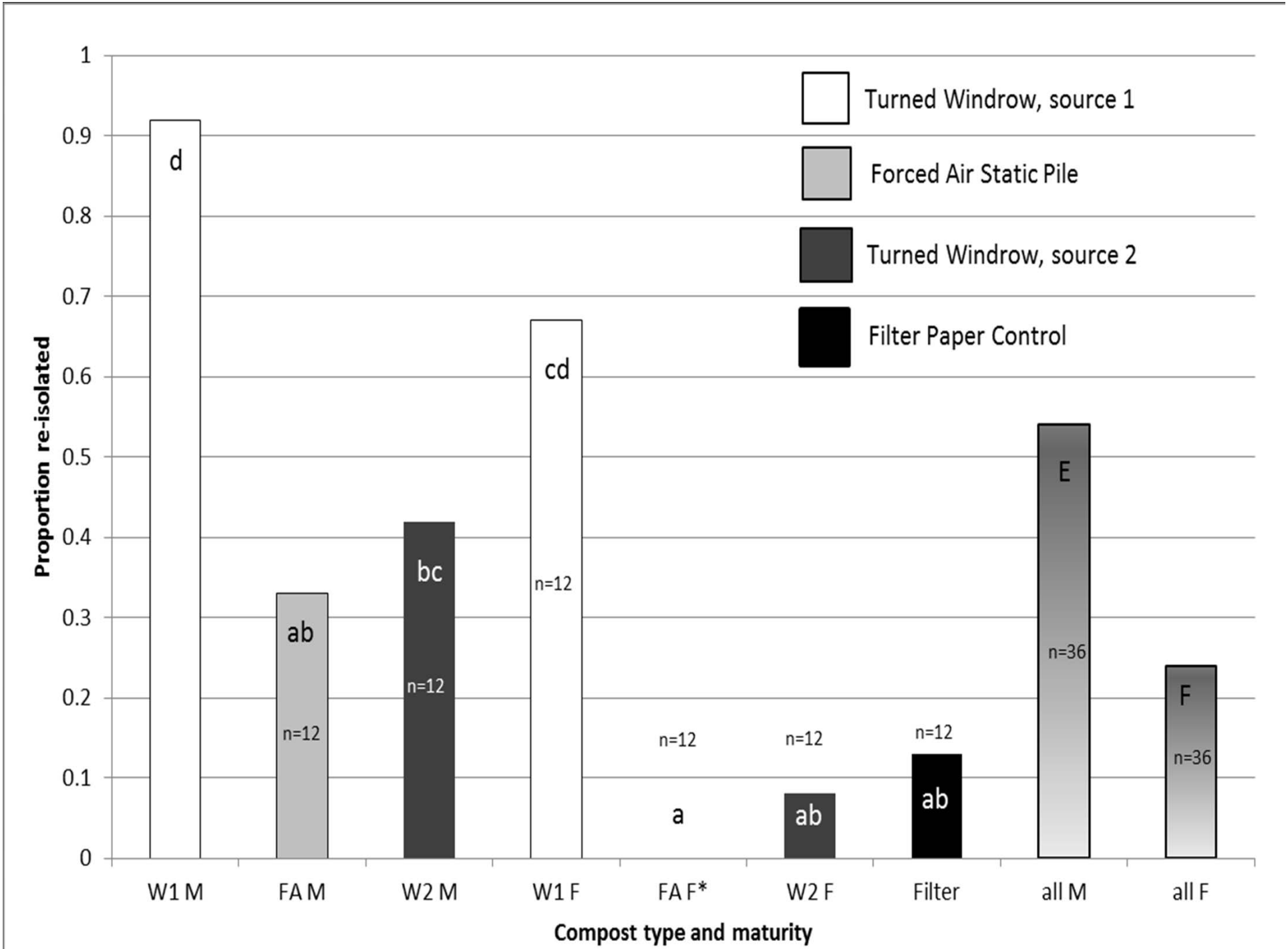
Image: Rizzo Lab, UC Davis

Spore types

- Oospores
  - Sexually produced survival structures (~seeds)
- Chlamydospores
  - Asexual survival structures
- Sporangia
  - Delicate football shaped dispersal structures
  - https://www.youtube.com/watch?v=hsdYrSgR4Ag
- Zoospores
  - Delicate hunting spores
  - Cysts


compost
water
compost & water


Turned Windrow, source 1
Forced Air Static Pile
Turned Windrow, source 2
Filter Paper Control
Proportion re-isolated
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
d
ab
n=12
bc
n=12
cd
n=12
n=12
a
n=12
ab
n=12
ab
E
n=36
F
n=36
W1 M
FA M
W2 M
W1 F
FA F*
W2 F
Filter
all M
all F
Compost type and maturity

Conclusions

- Can it survive if introduced into finished compost?
  - Yes, even zoospores can survive …
  - if introduced at high enough rates, and held under relatively ideal conditions (cool and moist).
  - Survival is much higher in aged composts than in fresh composts
  - Caveat: This was an “Is it possible?” kind of question, not necessarily “is it likely?”
    - We’d also need to consider the Phytophthora species in question if extrapolating

Compost production

- Facilities should be distant from contamination sources
  - Wind blown water
  - Surface flow
  - How far?
    - 3 miles?!
    - 30 feet?
- Tarping?

Compost production

- Loaders used for moving fresh material should be cleaned before moving to finished composts


Image: Scott Berndt, Fox Farm

Compost consumption

- Is compost safe?
  - Probably
    - Still hot is good
    - If bagged, is it less likely to be contaminated?
  - It’s hard to get aged compost
  - Beneficials can infest it too
    - At your site …


Image: Urban Forest Collaborative

Mulch consumption

- Is mulch safe?
  - Probably
    - Still hot is good
    - Lava rock and mylar aren't typically good growth media …
  - Compost on site first?

Thanks!

- www.suddenoakdeath.org
- This presentation is on line at: http://ucanr.edu/MarinIPM
- Steven Swain: svswain@ucanr.edu
  415 473 4226

Phytophthora ramorum

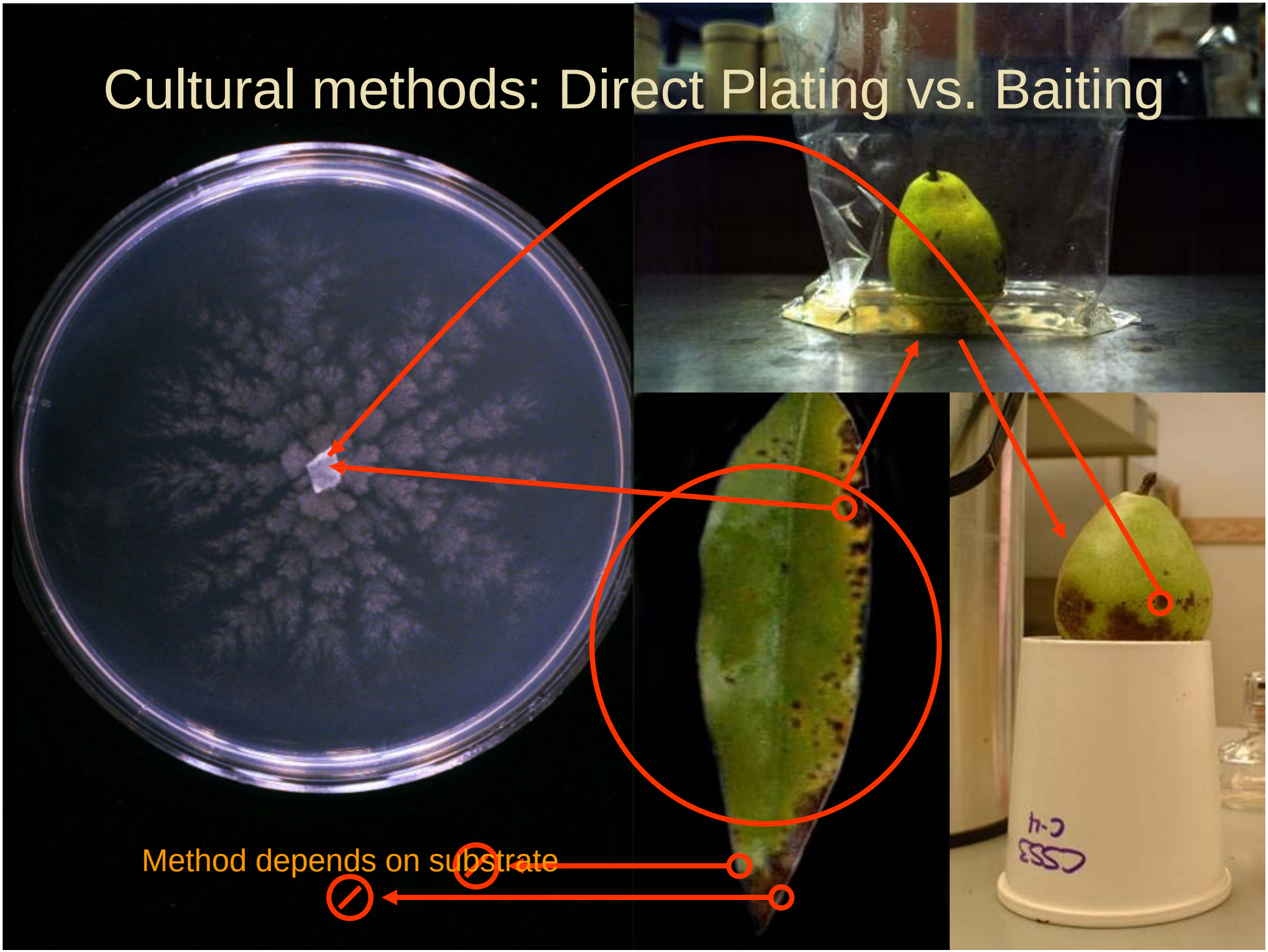
- Sudden Oak Death
- Rain, wind, water dispersed
- Large host list
  - Many landscape species
- Devastating to oak trees and relatives
- Believed to be introduced
- Federal quarantine
  - Infected material regulated

Phytophthora ramorum and composting

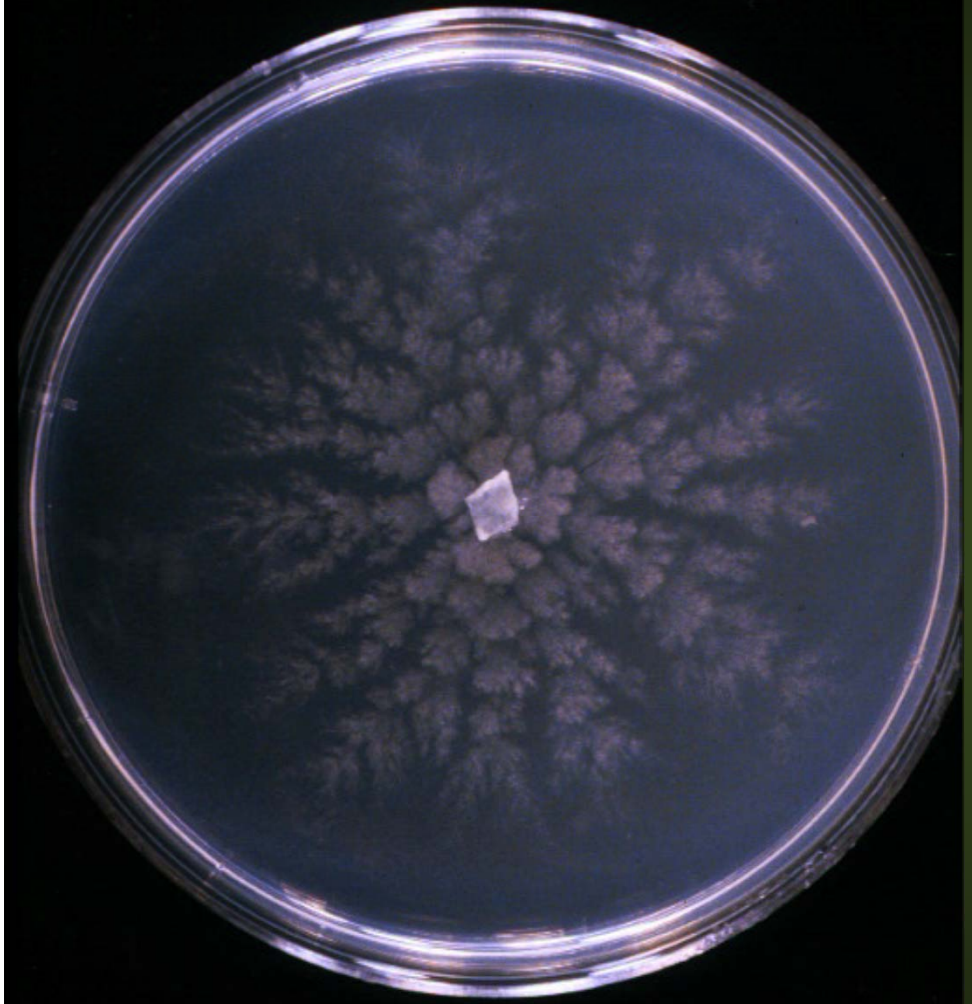
- More than 50,000 tons composted per day in California
- Composting effective against other diseases
- USDA & CIWMB requested study
  - Validate quarantine

    or
  - Provide exemption

Cultural methods: Direct Plating vs. Baiting



Heat Treatment of Pure Culture



Time to Mortality

55 deg C

45 deg C

40 deg C

Lower tempera-tures did not cause mortality within the experimental time frame

Heat Treatment on Natural Substrates

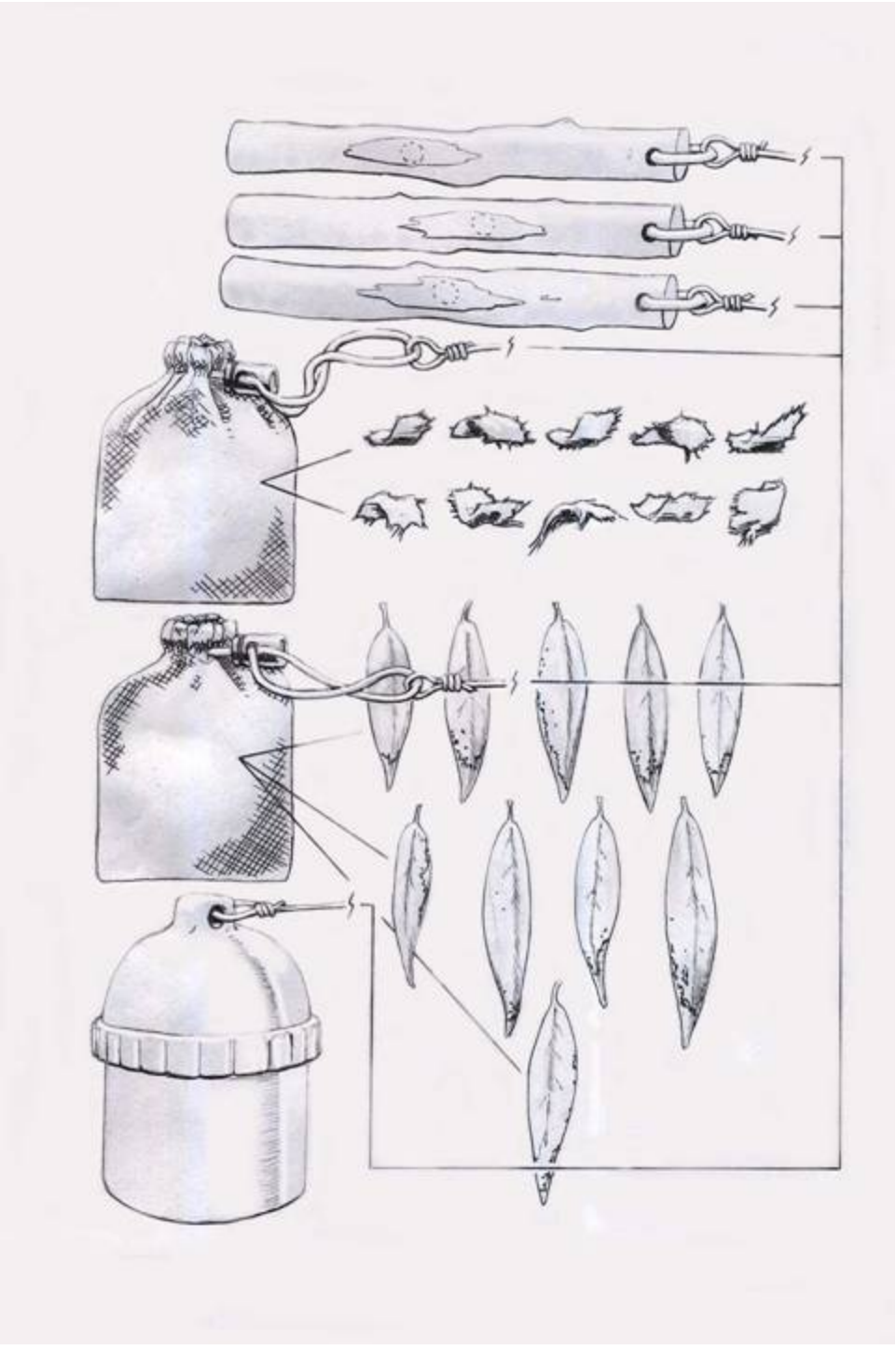
Composting Processes

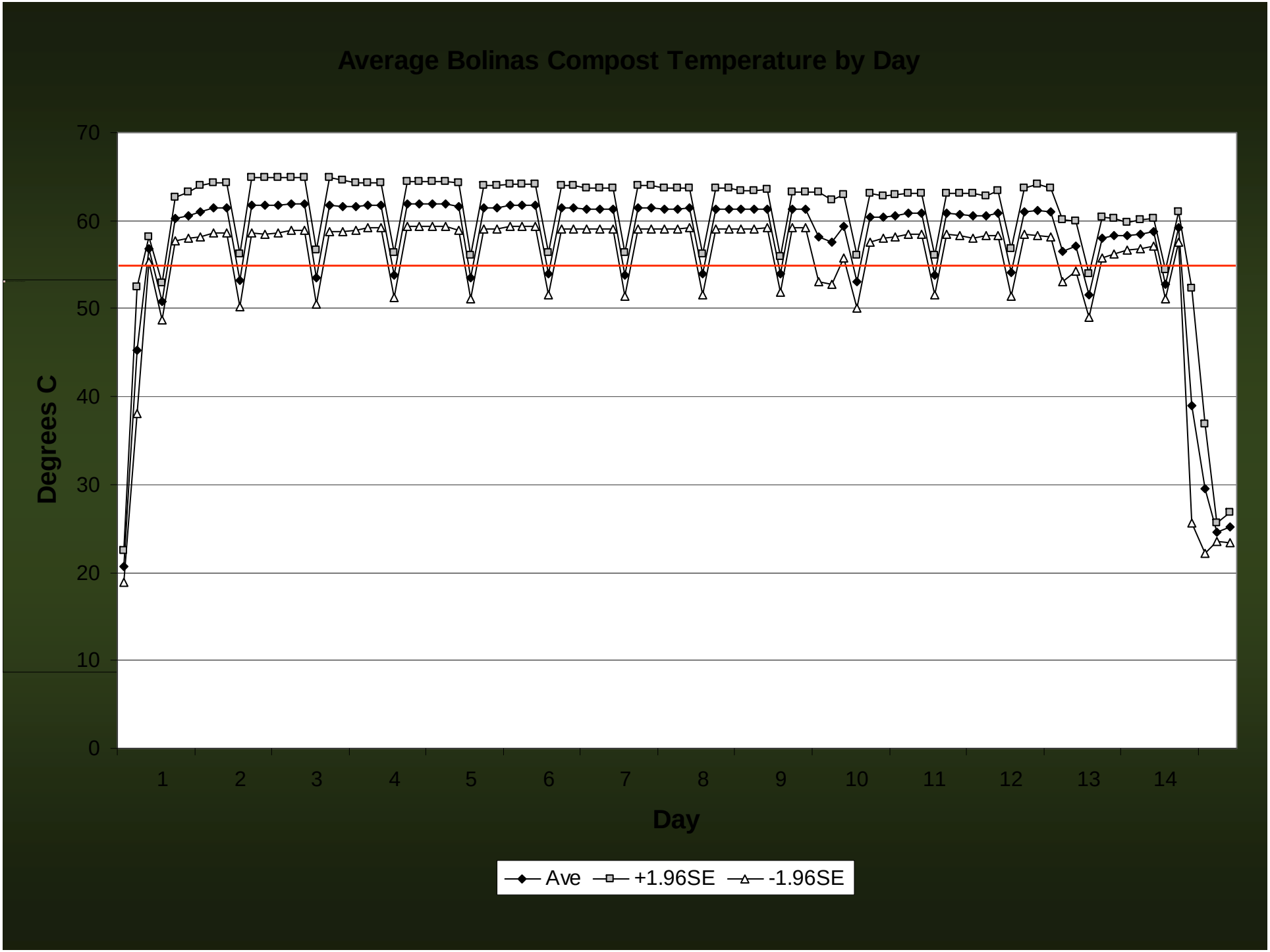
- “Traditional” composting method
- Turned by various types of machinery

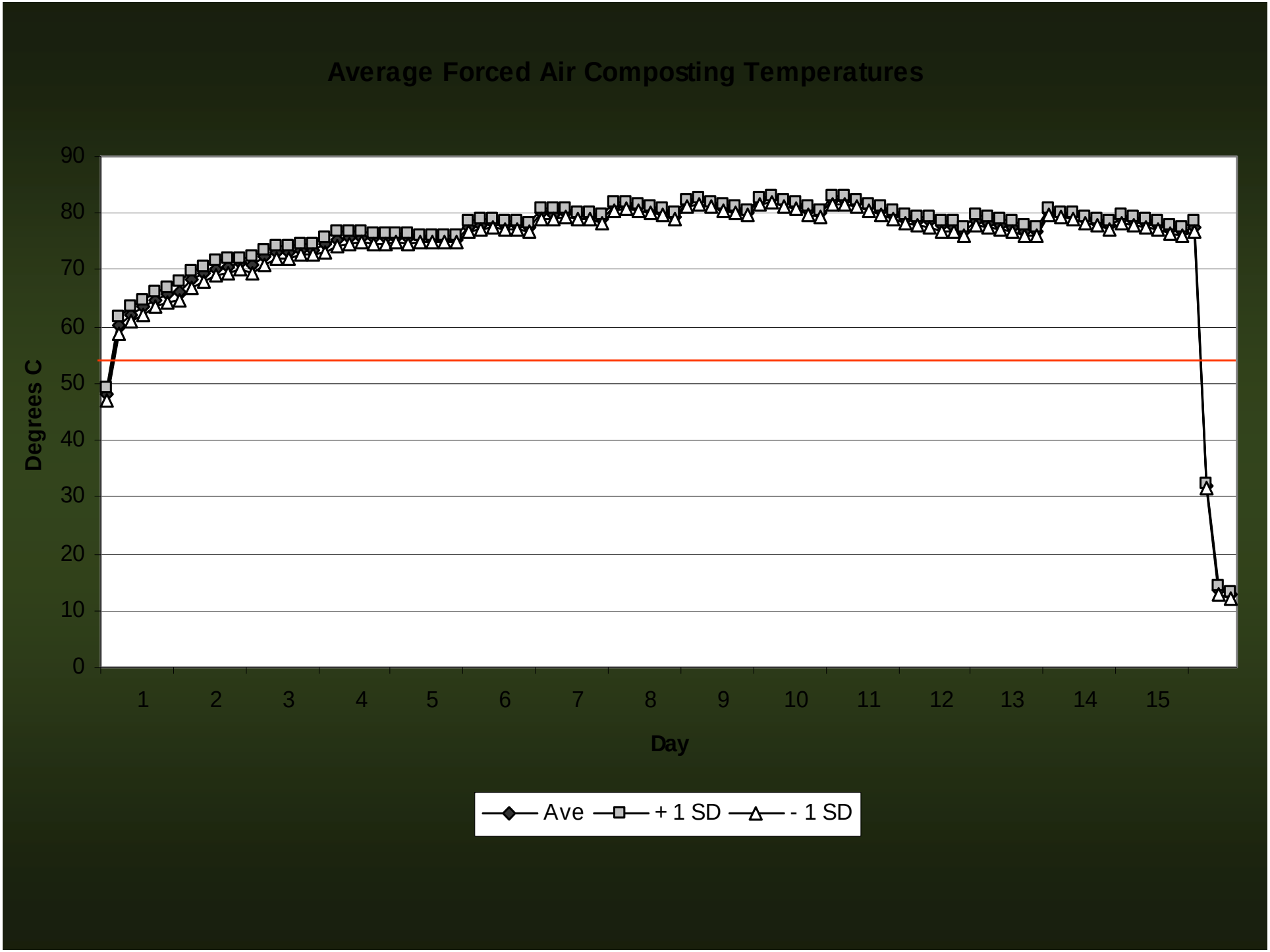
- No turning
- Air forced in by blowers

Can composting do the job?

- “Direct Process Evaluation”
- Test probe composition:
  - 3 Stems
  - 10 Chips (mesh bag)
  - 10 Laurel leaves (mesh bag)
- Temp. Recorder
- 4x in each pile




Average Bolinas Compost Temperature by Day
Degrees C
70
60
50
40
30
20
10
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Day
Ave
+1.96SE
-1.96SE


Average Forced Air Composting Temperatures
Degrees C
90
80
70
60
50
40
30
20
10
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Day
Ave
+ 1 SD
- 1 SD

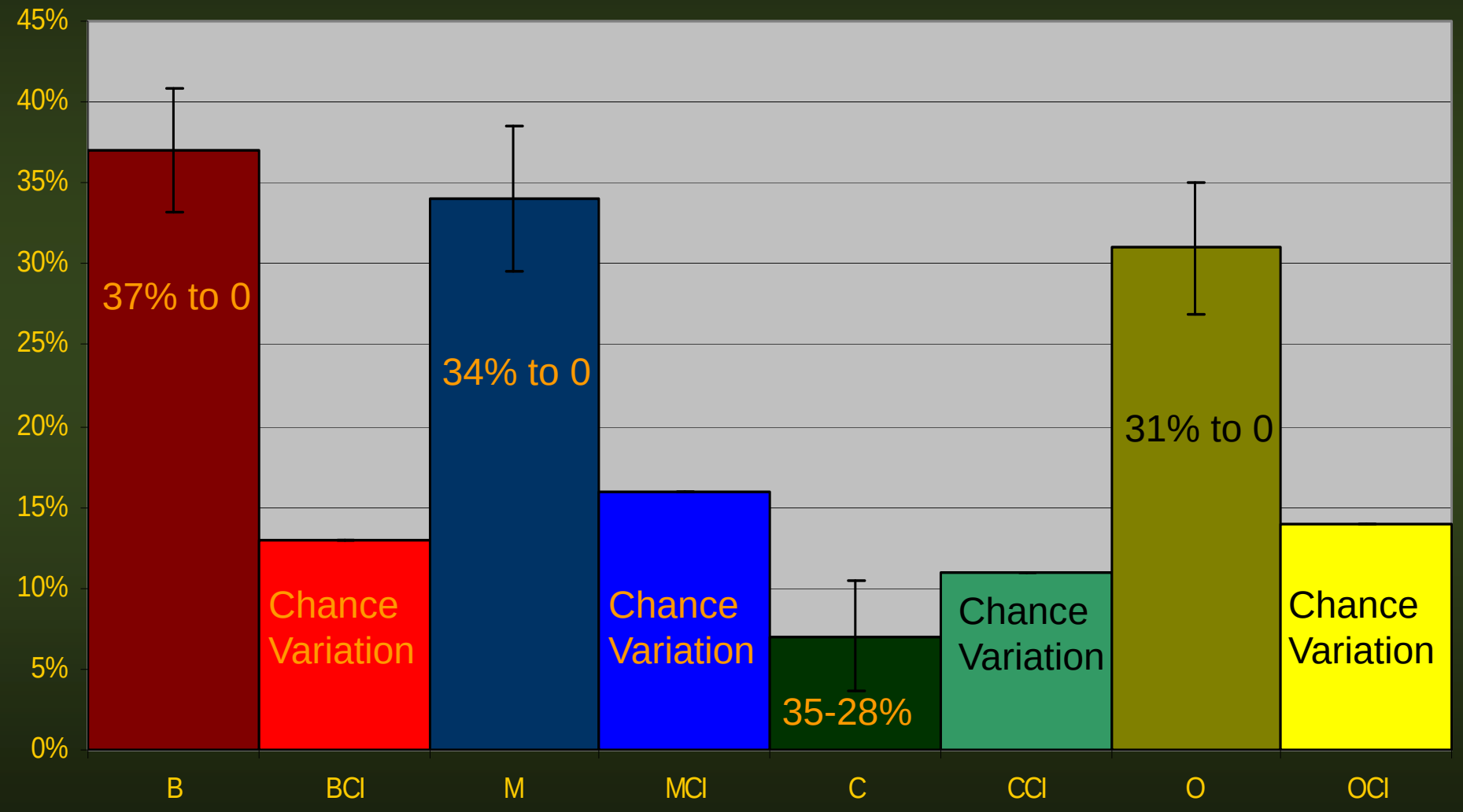
Turned Windrow and Oven Results by Site

Site	n	Pre	% Pre	SE	Post	% Post	SE	Delta mean	SEdiff	99% CI for 0
B	8	66/180	37%	3.85%	0/180	0%	0.00%	-37%	3.85%	0 +/- 13%
M	8	61/180	34%	4.49%	0/180	0%	0.00%	-34%	4.49%	0 +/- 16%
C	8	63/180	35%	3.08%	50/180	28%	1.38%	-7%	3.38%	0 +/- 11%
O	8	52/168	31%	4.03%	0/168	0%	0.00%	-31%	4.03%	0 +/- 14%

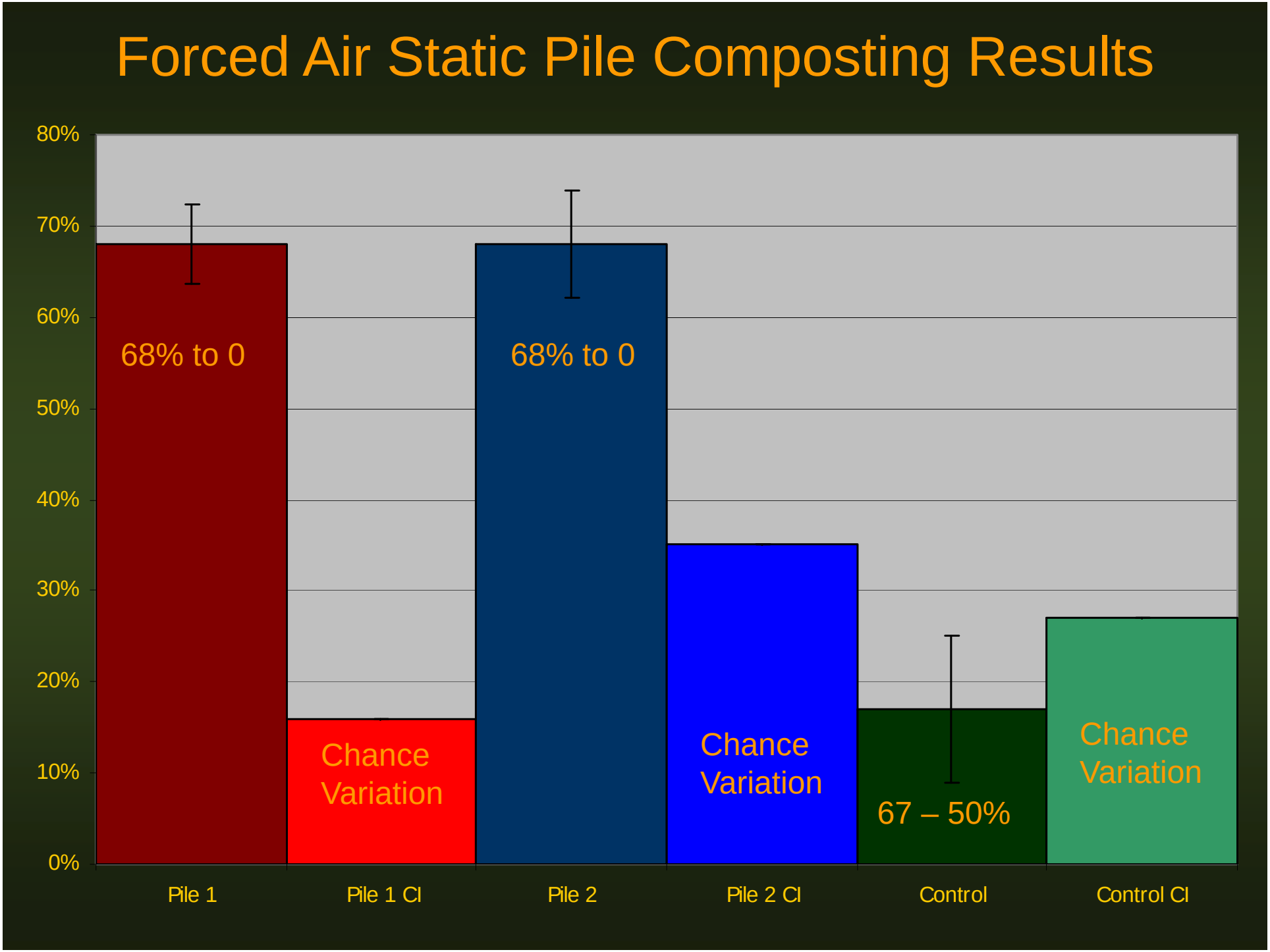
Forced Air Static Pile Results

Pile	n	Pre	%Pre	SE	Post	%Post	SE	delta mean	SEdiff	99% CI for 0
1	8	125/184	68%	4.45%	0/184	0%	0.00%	-68%	4.45%	0 +/- 16%
2	4	63/92	68%	5.95%	0/184	0%	0.00%	-68%	5.95%	0 +/- 35%
C	8	123/184	67%	2.40%	92/184	50%	7.79%	-17%	8.15%	0 +/- 27%

Turned Windrow and Oven Results by Site

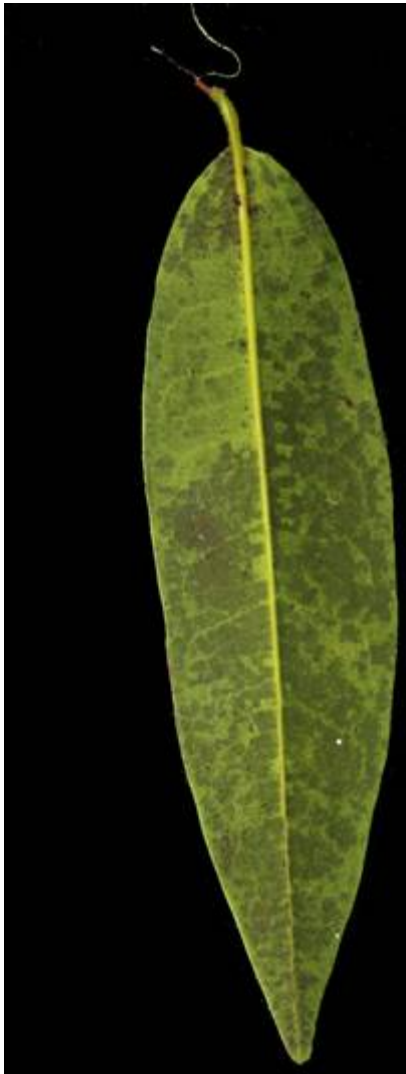


Forced Air Static Pile Composting Results



Oven and Compost Trial Conclusions

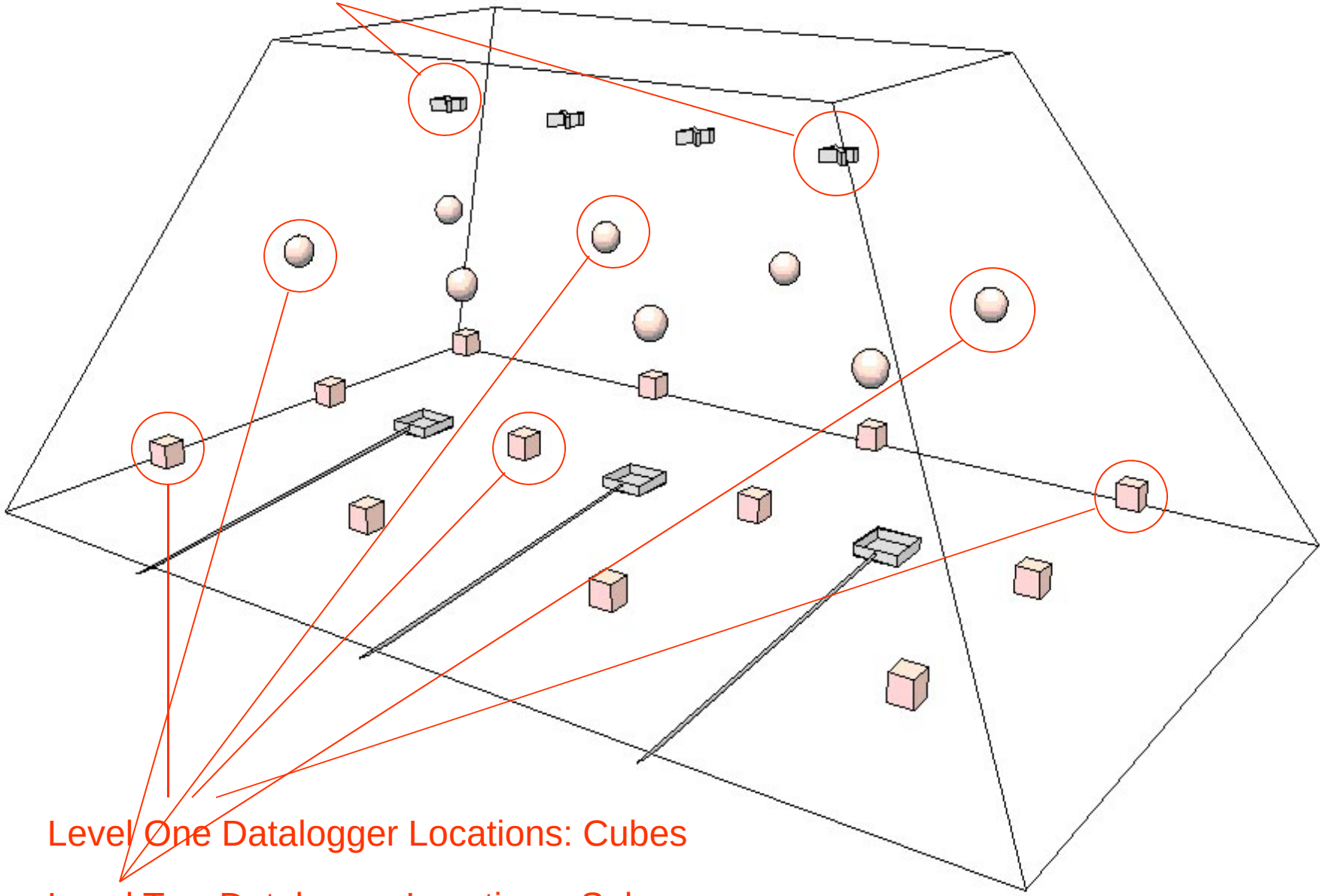
- Composting is capable of eliminating *P. ramorum* from green-waste
  - Cal. Integrated Waste Mgmt. Board guidelines
- Heat alone is sufficient to kill *P. ramorum*
  - Biotic and chemical interactions may augment the kill rate



Is it effective?

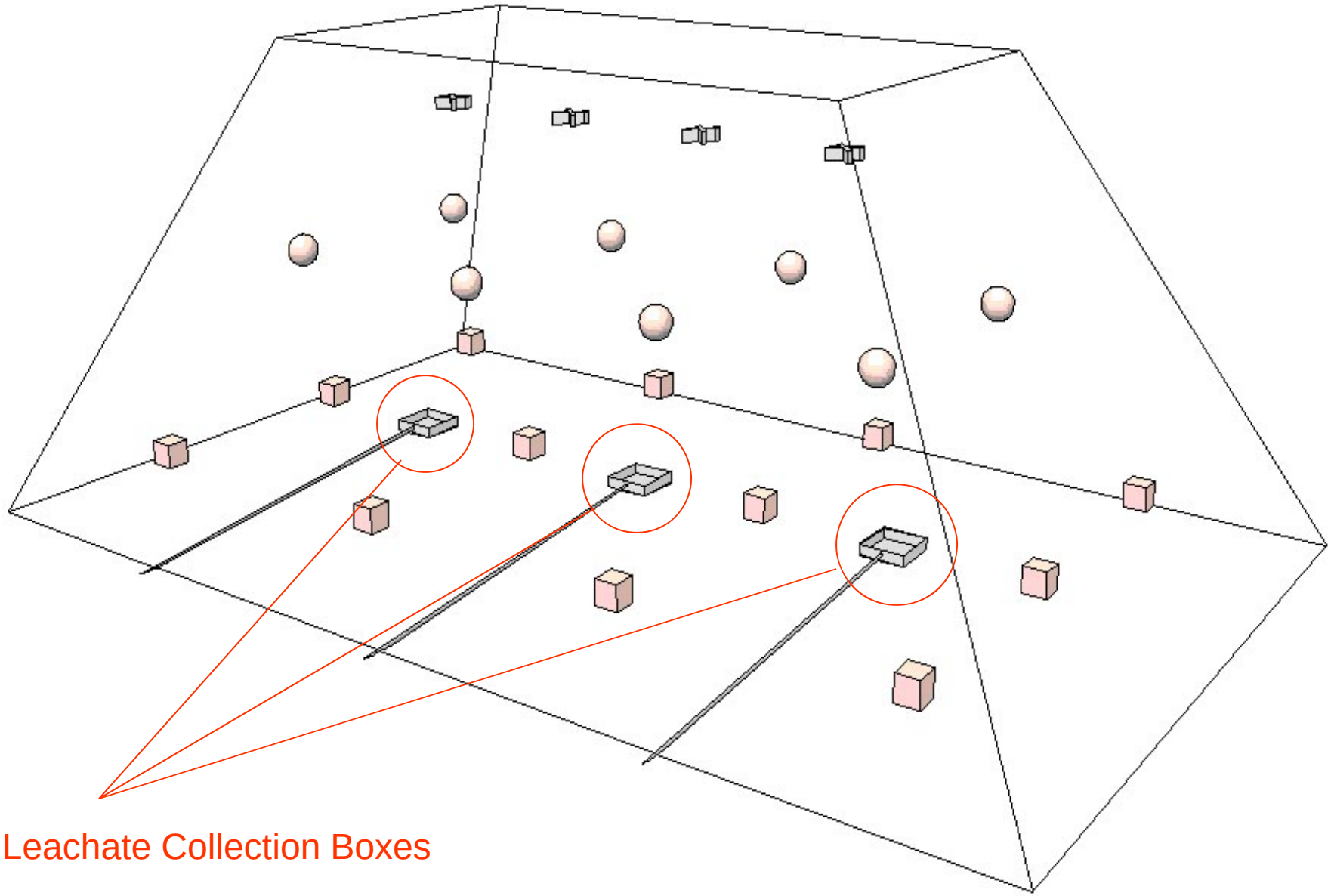
- "Spot Test Evaluation"
- Large compost pile
  - 10% artificially inoculated bay leaves
  - Estimated equivalent of 30% naturally infected material
- Cultural tests (contagion)
  - Runoff collection
  - Flooding
  - Sentinel plants 1-15m around compost pile
  - Planting Rhodies in contaminated compost
- DNA detection (presence)
  - Comparison of DNA levels beginning and end

Level Three Datalogger locations: “X”’s



Level One Datalogger Locations: Cubes

Level Two Datalogger Locations: Spheres



Leachate Collection Boxes

Runoff collection

- Test contagion in rain
- Collection after limited irrigation
- Pear bait collected water
- Turn pile to dry and aerate

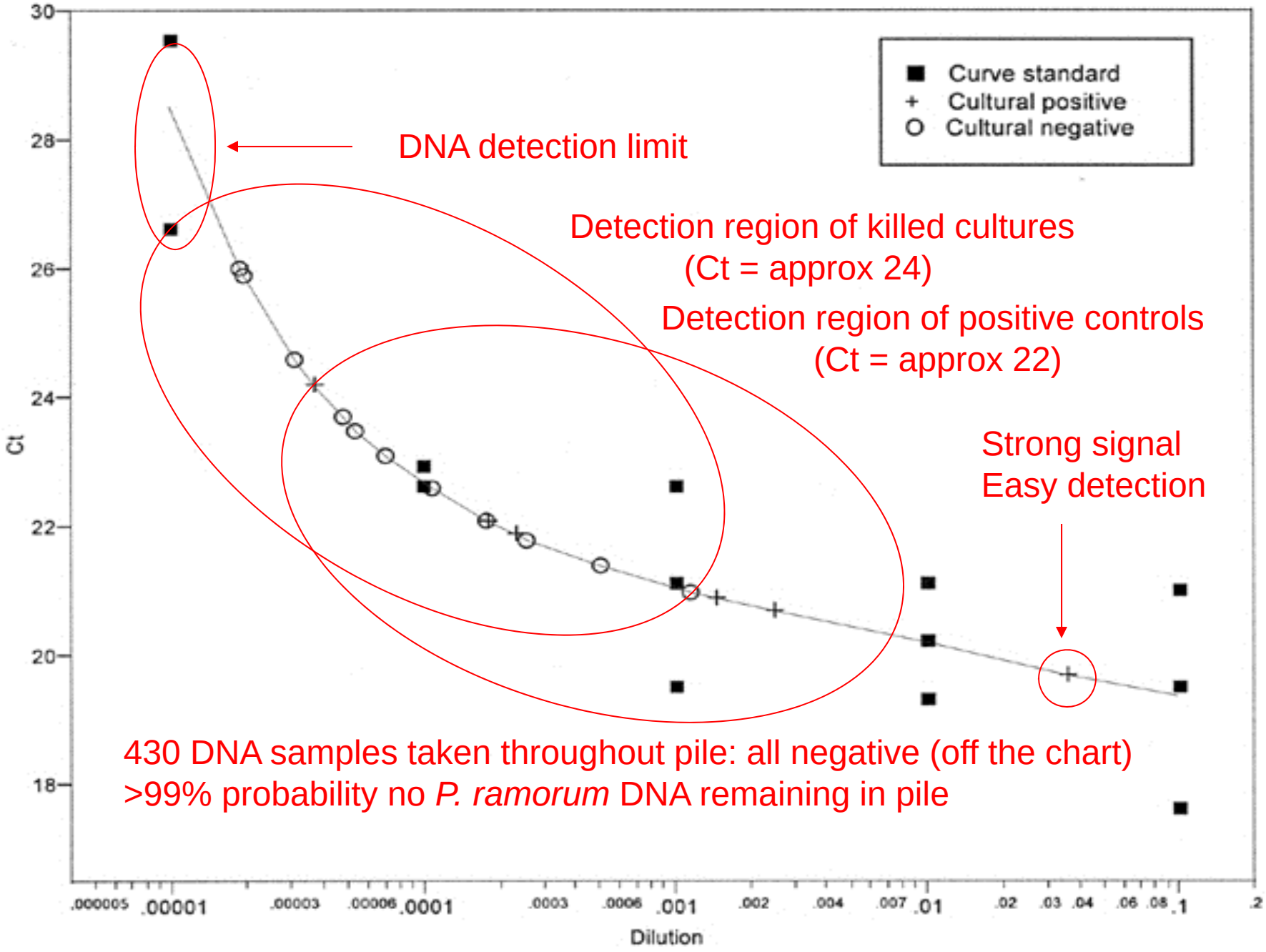
- Flood sampling: tests contagion in water
  - ½ of pile flooded in pools
  - Drained
  - Pear baited

Planting tests

- Tests contagion in planting material
- Sentinel Rhodies planted in compost
  - After pile disassembled
- Leaves and stems evaluated for symptoms
- Any symptoms found are plated and baited

Cultural test Results

- All 48 direct samples from the pile were negative
- All runoff tested negative
- All 120 flood samples tested negative
- All 248 direct plating and 36 pear baitings of sentinel plant leaves tested negative
- After three months from experiment end, all planted rhododendrons tested negative


Curve standard
Cultural positive
Cultural negative
DNA detection limit
Detection region of killed cultures
(Ct = approx 24)
Detection region of positive controls
(Ct = approx 22)
Strong signal
Easy detection
430 DNA samples taken throughout pile: all negative (off the chart)
>99% probability no P. ramorum DNA remaining in pile
Ct
30
28
26
24
22
20
18
.000005
.00001
.00003
.00006
.0001
.0003
.0006
.001
.002
.004
.007
.01
.02
.03
.04
.06
.08
.1
.2
Dilution

Conclusions

- Contagion risk from wind, water, or finished compost undetectably low
- DNA levels at end of process undetectably low
- Composting effectively eliminates *P. ramorum* from greenwaste
- Compost contagion risk negligible

Acknowledgements

- This research was funded in part by:
  - the California Integrated Waste Management Board http://www.ciwmb.ca.gov/
  - the USDA Forest service Pacific Southwest Region
  - the Gordon and Betty Moore Foundation.
- Many thanks to McEvoy Ranch, Grab & Grow Soil Products, Chip Sanborne and Don Liepold for their invaluable assistance
- Forced air and windrow composting images: Washington State University website, http://organic.tfrec.wsu.edu/compost/ImagesWeb/CompSys.html
- All other images by Garbelotto or Rizzo labs, UC Berkeley and Davis respectively