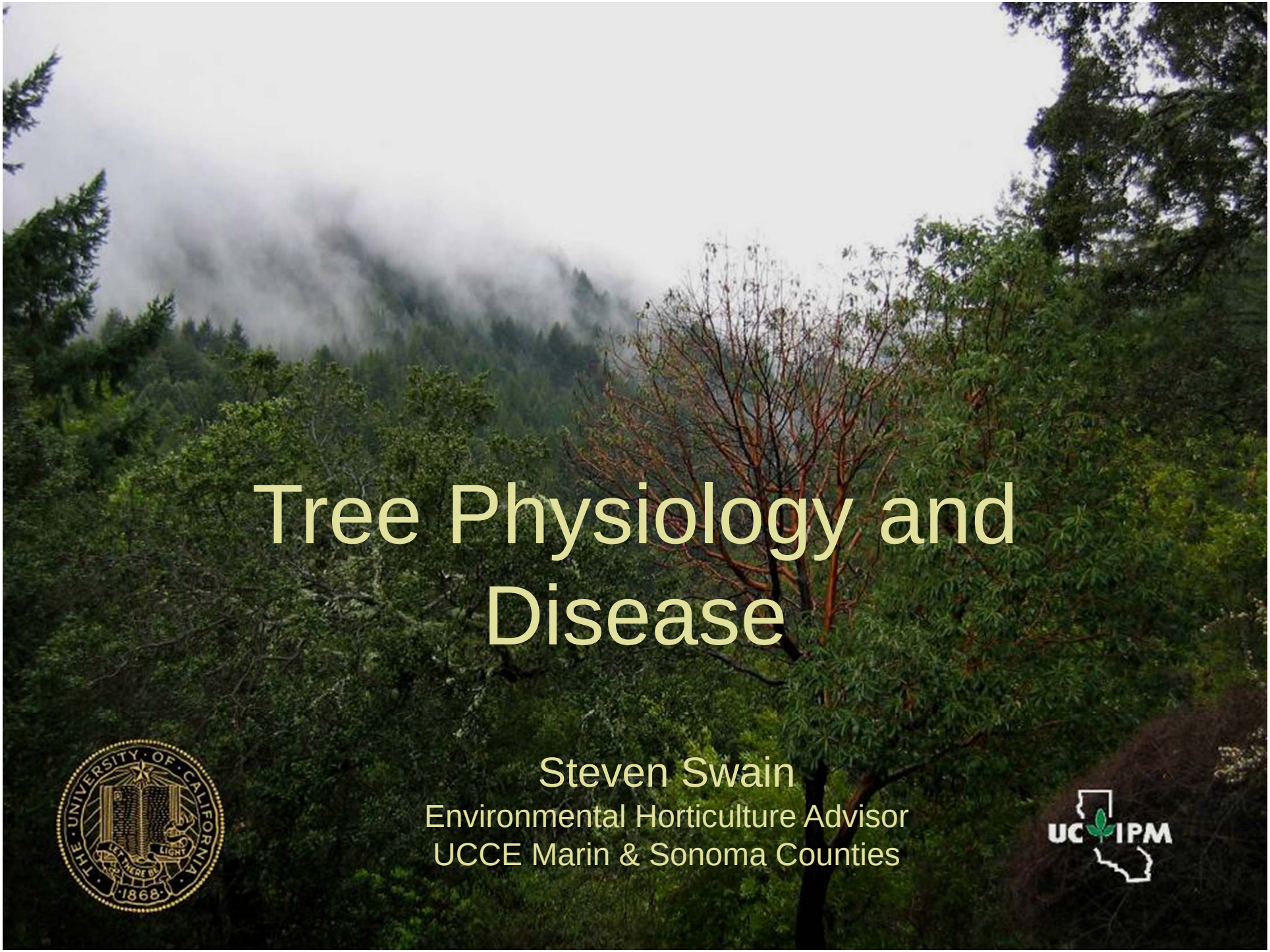


Tree Physiology and Disease

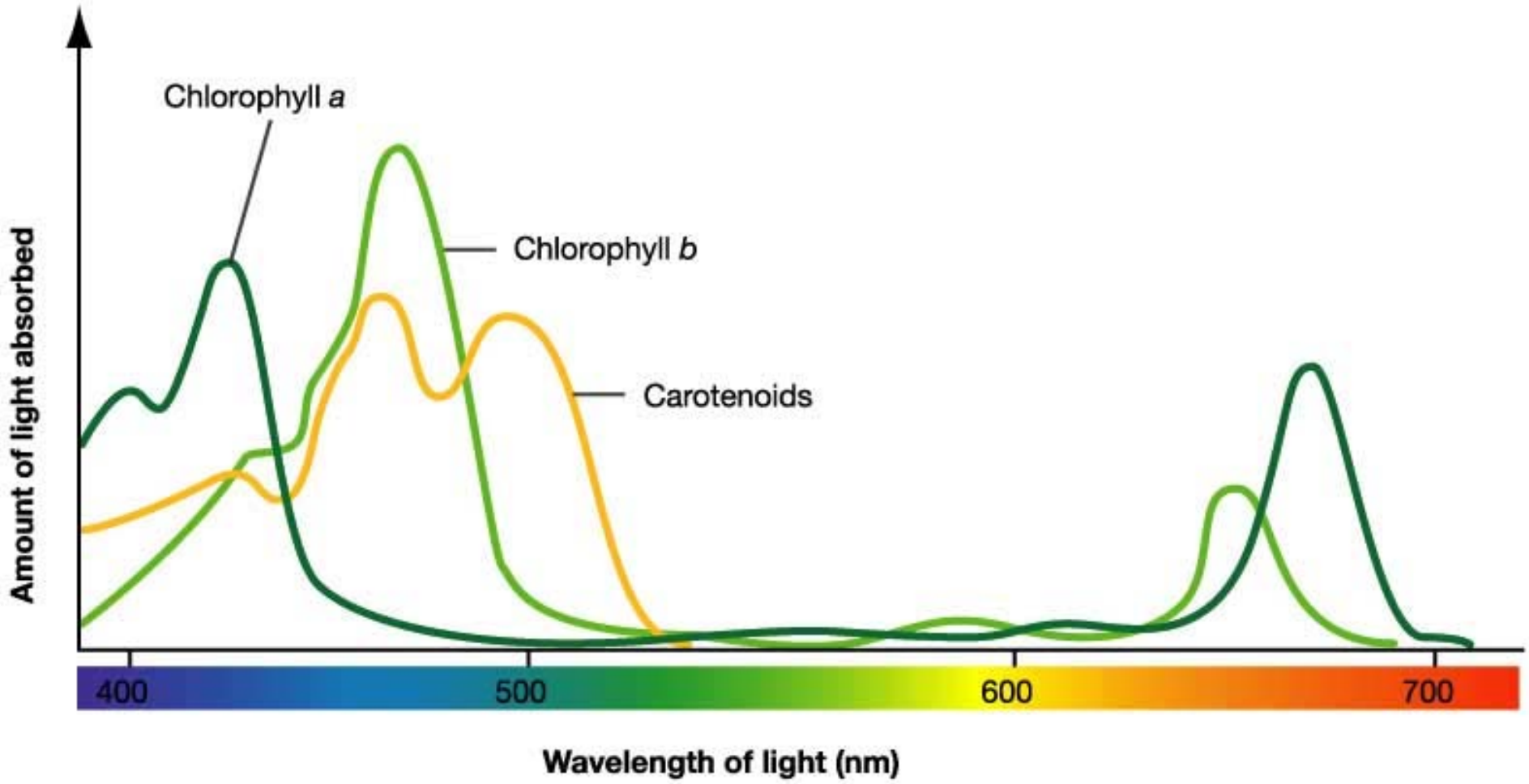
Steven Swain
Environmental Horticulture Advisor
UCCE Marin & Sonoma Counties

Physiology

- All of the biological processes that allow an organism to function
- Mostly what we're going to talk about is photosynthesis and energy storage, and how these things do (or do not) affect the disease cycle

Photosynthesis

- Trees make their food from sunlight
  - Red and blue light drive two different photosystems
    - Each photosystem makes a 3 (or 4) carbon sugar
    - Lots of different chlorophylls
    - Lots of accessory pigments
      - Carotenoids
      - Anthocyanins
  - Green light reflected
- Trees metabolize these same sugars to live, grow, and reproduce
  - Energy budget



http://www.bio.miami.edu/dana/pix/chlorophyll_spectrum.jpg

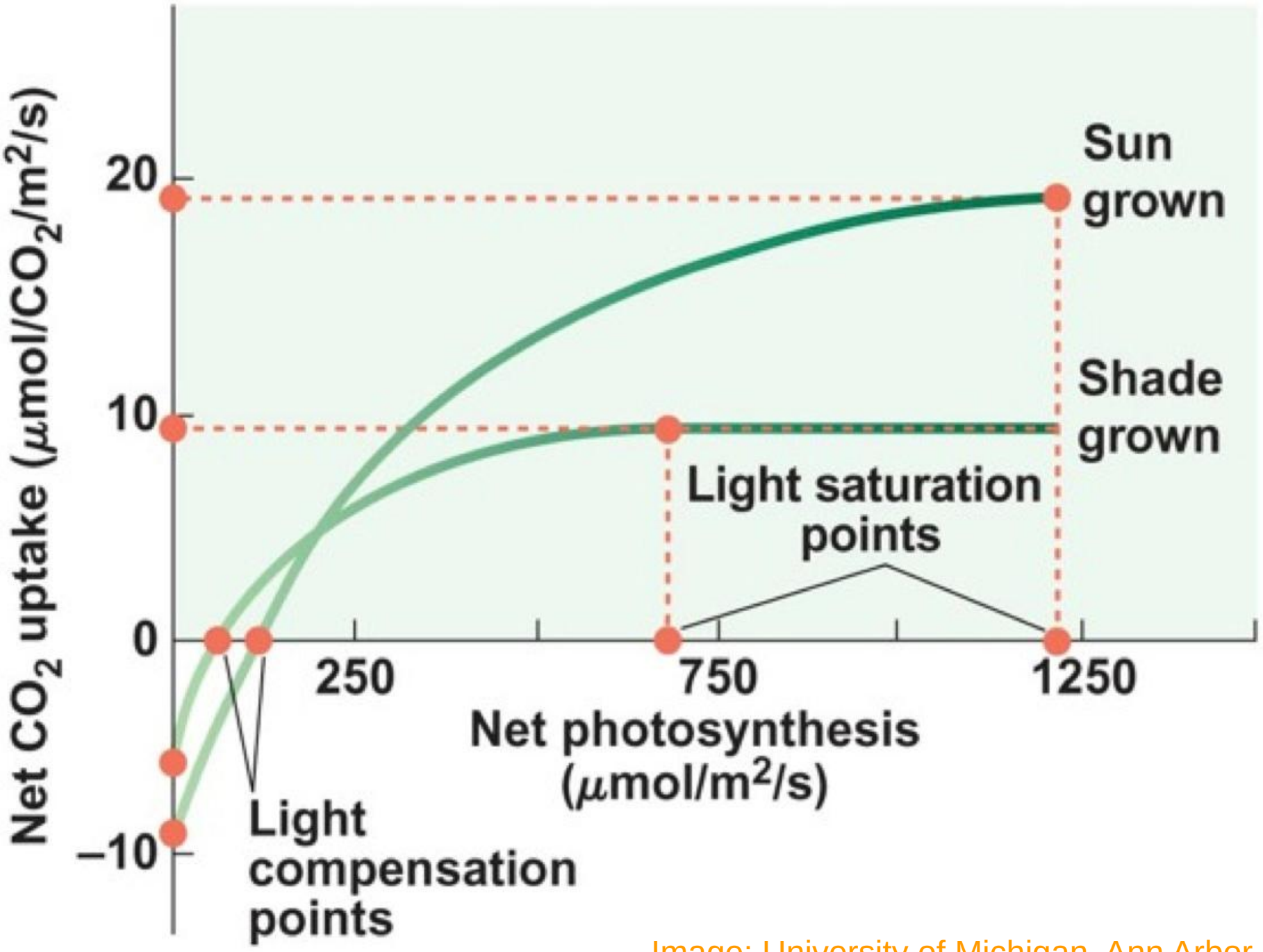
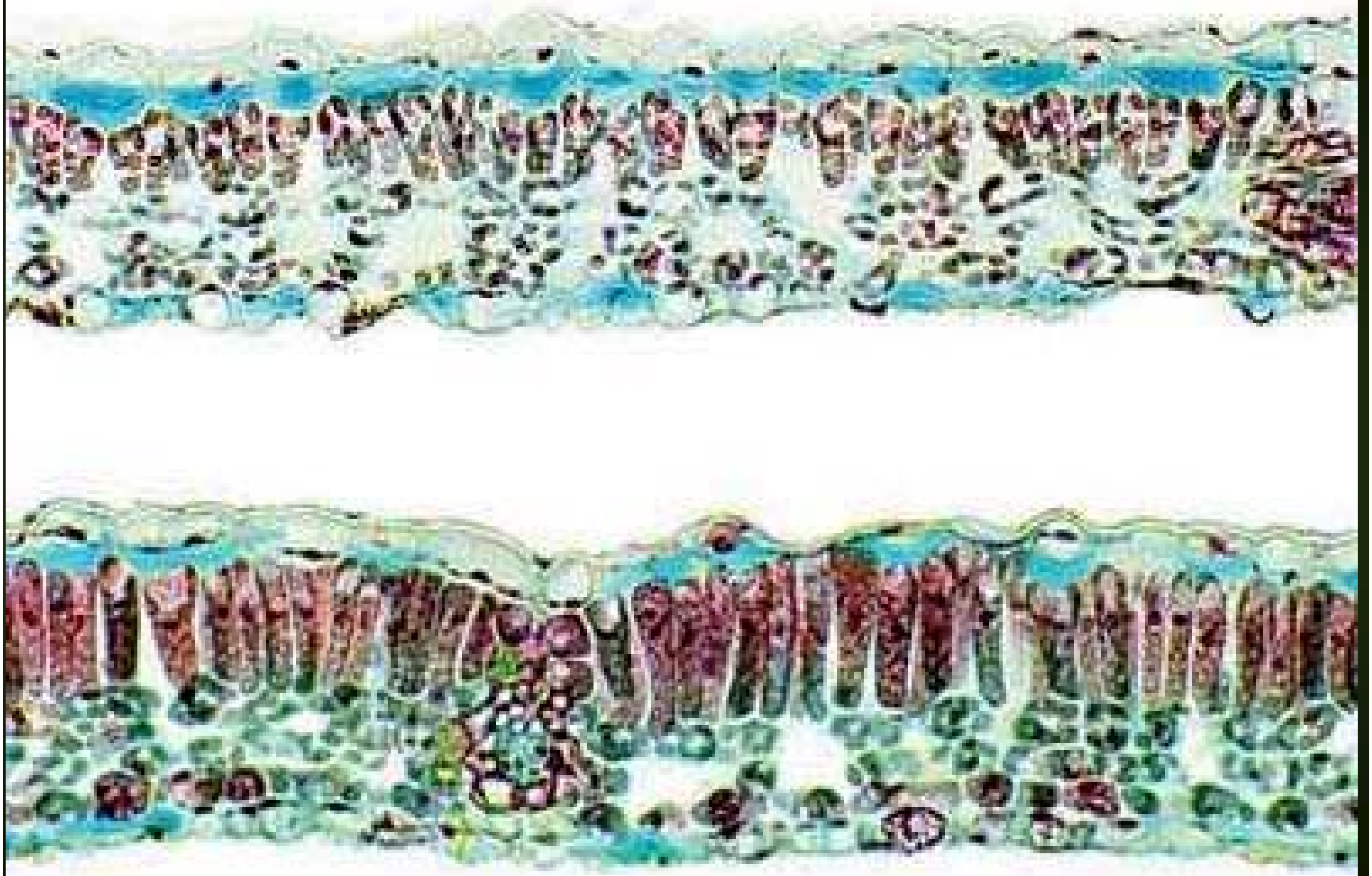


Image: University of Michigan, Ann Arbor



Sunburn

- When accessory pigments cannot shield chlorophyll from excess light

Storage

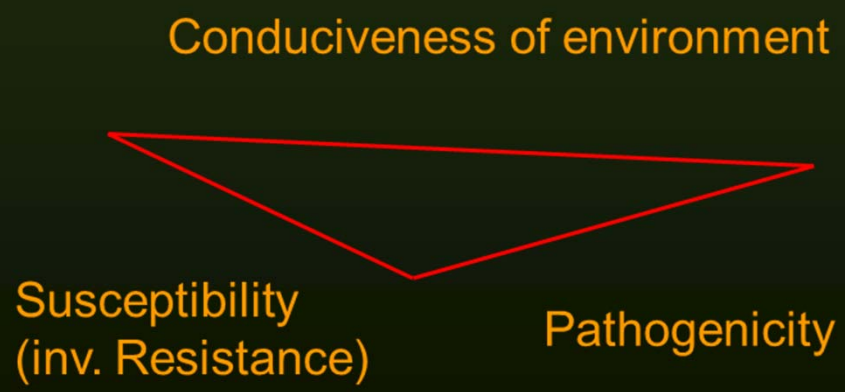
- All trees store energy
  - 3 and 4 carbon sugars made via photosynthesis are joined to make sucrose and/or glucose
  - Stored sugars are used for producing new leaves, roots, and wood
  - Deciduous trees store all of next year's energy in trunk and root tissues
    - Sugar maple in early spring
  - Evergreen trees store less energy, but have higher leaf production costs

Annual cycle of growth

- The life of a pathogen isn’t easy
- Deciduous trees drop all leaves every year
- Evergreen trees are heavily defended
- Most pathogens have to look for weak spots

Disease triangle

- Host susceptibility varies over time
- Host susceptibility varies in the canopy (space)
- Genetic susceptibility varies within a population (time and space)
- To control the disease, we don't have to control all of these, just one



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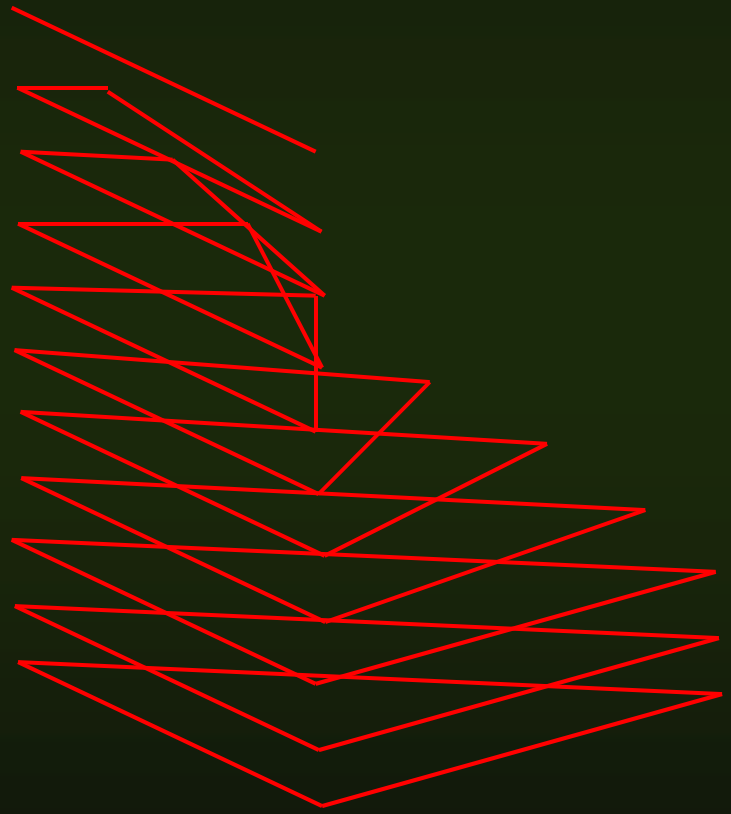
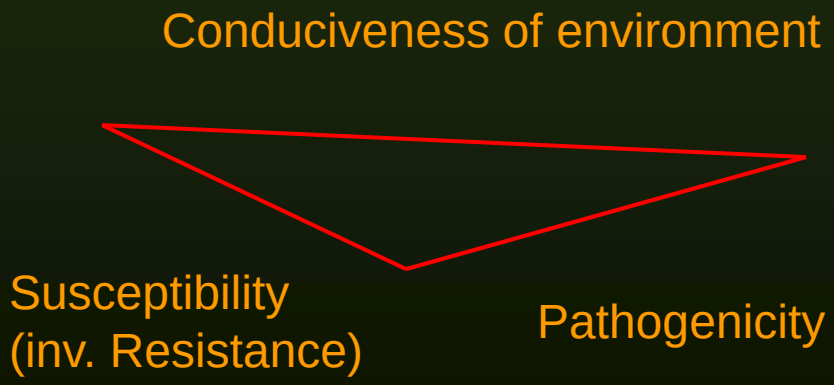


Pine Pitch Canker

- *Fusarium circinatum*
- Monterey pine (others)
- Acquired resistance
  - Takes years
  - Via asymptomatic infection in roots?
  - Pine has to live long enough
- Host resistance increases over time
  - Keep inoculum pressure low?

Abiotic Disease

- Where is the pathogen in the disease triangle?
- Most commonly a water or nutrient issue, sometimes a climate or pesticide issue



Morus alba in Terra Linda

- Populations in 1950's were:
  - People: half of what it is now (US Census)
  - Mulberries in Terra Linda: almost double what it is now (according to long-time locals)
- Lawns and fruitless mulberries planted in tract homes
- Homes still there, some mulberries still there, but the landscape has changed

Symptoms

- Upper canopy:
  - Leaves small and yellow
  - Branch dieback
- Lower canopy
  - Leaves full and green
  - Some sprouting


LIMIT
25


STOP
401

One lawn left

- Gophers active in this lawn
  - Limited yellowing and branch dieback


STOP
401


STOP
401

Changing times

- Changing canopies
  - Lack of resources
- Cultural shifts
  - Economic
  - Environmental
    - Cheaper water in 1950’s?
- Environment never static
  - Species adapt or die out
  - Survivors not the toughest, but the most adaptable

Seasonal growth patterns

- New growth
  - Nutrient packed
    - Plant moves nutrients around
  - Not well defended (hardened off)

Powdery mildew

- Common this summer
- Many hosts
- Warm days
- Humid nights
- New growth
- Many species
  - Variable growth habits

Powdery mildew

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Powdery mildew

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- Many hosts
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- Humid nights
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- Many species
  - Variable growth habits

Photo: Phytosphere Research

Powdery mildew

- 3 species common on “Native” oaks
  - Early summer
  - Coastal locations
  - Many “native” oaks not grown in or endemic to the region

Brasiliomyces trina

Photo: Phytosphere Research

Powdery mildew

- 3 species common on “Native” oaks
  - *Cystotheca lanestris*
    - Witches broom
    - Lower leaf surfaces
  - *Microsphaera extensa*
    - Leaf blistering
    - Upper leaf surfaces

Oak Leaf Blister

- *Taphrina caerulescens*
  - *NOT powdery mildew*
  - Symptoms similar to *Microsphaera extensa*
    - Also only attacks new growth
    - But fungus on lower leaf surface
  - Wet springs with prolonged rains

UNIVERSITY OF CALIFORNIA AGRICULTURE & NATURAL RESOURCES

UC IPM Online

Statewide Integrated Pest Management Program

Solve your pest problems with UC's best science

Announcements

- UC IPM Web site begins makeover
- New! Vineyard Pest Identification and Monitoring Cards

What's New

- Green Bulletin November 2011 issue
- New Year-Round IPM Programs: Asparagus, Corn, Cucurbits, Peppers
- Revised Pest Notes: House Mouse, Rats, Lawn Diseases, Bee and Wasp Stings
- More...

QUICK LINKS

- Newsletters
- Recursos en español
- Weather, models, & degree-days
- Subscribe (RSS)

Home, Garden, Turf & Landscape Pests

Agricultural Pests

Natural Environment Pests

Exotic & Invasive Pests

Agriculture and Natural Resources, University of California

Enter Search Terms

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Statewide Integrated Pest Management Program

PRINT

Home, garden, turf, & landscape pests

University of California's official guidelines for managing pests with environmentally sound methods. (More...)

Search home & landscape:

Go

Pests of homes and structures

- Household: pests of homes, structures, people and pets
  - Pests that sting, bite, or injure
  - Wood-destroying, food, fabric, and nuisance pests
  - Verbebrate pests birds, mammals, and reptiles

Pests in gardens and landscapes

Choose a plant to find the most likely source of your pest problem

- Flowers
- Fruit trees, nuts, berries, and grapevines
- Lawns and turf, including comprehensive lawn guide
- Trees and shrubs, including roses and other ornamentals
- Vegetables and melons

Some common pests and methods

- Birds, mammals, and reptiles: vertebrate pests

Metrosideros	*Metrosideros* spp.	Myrtaceae (Myrtle family)
Mexican blue palm	*Brahea armata*	Arecaceae (Palm family)
Mexican fan palm	*Washingtonia robusta*	Arecaceae (Palm family)
Mexican orange	*Choisya ternata*	Rutaceae (Rue family)
Mimosa	*Albizia* spp.	Fabaceae (Pea family)
Mock orange	*Choisya ternata*	Rutaceae (Rue family)
Monkey flower	*Diplacus* spp.	Scrophulariaceae (Figwort family)
Monkey flower	*Mimulus* spp.	Scrophulariaceae (Figwort family)
Monkey puzzle tree	*Araucaria* spp.	Araucariaceae (Araucaria family)
Mountain ash	*Sorbus* spp.	Rosaceae (Rose family)
Mountain mahogany	*Cercocarpus* spp.	Rosaceae (Rose family)
Mugwort	*Artemisia* spp.	Asteraceae (Sunflower family)
Mulberry	*Morus* spp.	Moraceae (Mulberry family)
Myoporum	*Myoporum* spp.	Myoporaceae (Myoporum family)
Myrtle	*Melaleuca* spp.	Myrtaceae (Myrtle family)
Nandina	*Nandina domestica*	Berberidaceae (Barberry family)
Natal plum	*Carissa grandiflora*	Apocynaceae (Dogbane family)
Natal plum	*Carissa macrocarpa*	Apocynaceae (Dogbane family)
New Zealand Christmas tree	*Metrosideros* spp.	Myrtaceae (Myrtle family)
Norfolk island pine	*Araucaria* spp.	Araucariaceae (Araucaria family)
Oak	*Quercus* spp.	Fagaceae (Beech family)
Oleander	*Nerium oleander*	Apocynaceae (Dogbane family)
Olive	*Olea europaea*	Oleaceae (Olive family)
Orchid tree	*Bauhinia* spp.	Fabaceae (Pea family)
Oregon grape	*Mahonia* spp	Berberidaceae (Barberry family)
Oregon myrtle	*Umbellularia californica*	Lauraceae (Laurel family)
Ornamental pear	*Pyrus* spp.	Rosaceae (Rose family)
Palm	Many species	Arecaceae (Palm family)
Palmetto palm	*Sabal palmetto*	Arecaceae (Palm family)
Palo verde	*Cercidium* spp.	Fabaceae (Pea family)
Paperbark	*Melaleuca* spp.	Myrtaceae (Myrtle family)
Pepper tree	*Schinus molle*	Anacardiaceae (Sumac family)
Pepperwood	*Umbellularia californica*	Lauraceae (Laurel family)
Persimmon	*Diospyros* spp.	Ebenaceae (Ebony family)
Photinia	*Photinia* spp.	Rosaceae (Rose family)
Pindo palm	*Butia capitata*	Arecaceae (Palm family)
Pine	*Pinus* spp.	Pinaceae (Pine family)
Pittosporum	*Pittosporum* spp.	Pittosporaceae (Pittosporum family)
Podocarpus	*Podocarpus* spp.	Podocarpaceae (Podocarpus family)

Oak—*Quercus* spp.
Family Fagaceae (Beech family)

Plant identification

Oaks are deciduous or evergreen trees with acorns.

Optimum conditions for growth

Oaks grow in various climatic zones and do well in full sun.

Leaves of valley oak

Fall color of pin oak

Pests and disorders of *Quercus* spp.

Invertebrates

- Acorn moth
- Aphids
- Armored scales
  - Obscure scale
- Bark beetles
  - Ambrosia beetles
  - Oak bark beetles
- Carpenterworm
- Clearwing moth borers
  - Sycamore borer
- Filbertworm, filbert weevil, and acorn moth
- Flatheaded borers
  - Flatheaded appletree borer
  - Goldspotted oak borer (5 MB, PDF)
  - Oak twig girdler
  - Pacific flatheaded borer
- Foliage-feeding caterpillars
  - California oakworm
  - Fruittree leafroller
  - Tent caterpillars
  - Tussock moths
- Foliage miners
  - Leafminers
  - Oak ribbed casemaker
  - Shield bearers
  - Skeletonizers
- Fuller rose beetle and Live oak weevil
- Gall and blister mites
  - Live oak erineum mite
- Gall makers
  - California gallfly
  - Cynipid gall wasps
  - Ichneumonid wasps
  - Jumping oak gall wasp
  - Twohorned oak gall wasp
- Glassy-winged sharpshooter
- Mealybugs

Invertebrates (cont.)

- Roundheaded borers
  - Roundheaded oak twig borer
- Soft scales
  - Kermes scales, black-punctured kermes
  - Oak lecanium scale
- Spider mites
  - Sycamore spider mite
- Treehoppers
  - Oak treehopper
- Whiteflies
  - Crown whitefly
  - Gelatinous whitefly
  - Stanford whitefly
- Woolly aphids
  - Woolly oak aphid

Diseases

- Anthracnose
- Armillaria root rot
- Canker diseases
  - Hypoxylon canker
  - Nectria canker
- Drippy oak acorns
- Foamy canker
- Oak branch dieback
- Oak leaf blister
- Oak twig blight
- Powdery mildew/Witches' broom
- Root and crown rots
- Rusts
- Sudden oak death
- Wetwood
- Wood decay

Environmental disorders

- Leaf burn
- Leaf scorch
- Mineral deficiencies

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UC IPM Online

Statewide Integrated Pest Management Program

How to Manage Pests

Pests in Gardens and Landscapes

Powdery Mildew on Ornamentals

Download PDF | Quick Tip | Nota Breve

Revised 4/09

In this Guideline:

Powdery mildew is a common disease on many types of plants and is prevalent under the diverse conditi
cause disease on different plants. These fungi tend to infect either plants in the same family or only one

IDENTIFICATION AND DAMAGE

You can recognize this disease by the white, powdery mycelial and spore growth that forms on leaf surfa
may infect new or old foliage. This disease can be serious on woody species such as rose, crape myrtle,
flowers, and leaves. New growth may be dwarfed, distorted, and covered with a white, powdery growth.
healthy leaves.

LIFE CYCLE

All powdery mildew fungi require living plant tissue to grow. On perennial hosts such as roses, powdery m
buds or as spherical fruiting bodies, called chasmothecia, on the bark of branches and stems.

Most powdery mildew fungi grow as thin layers of mycelium on the surface of the affected plant parts. Sp
powdery appearance of this fungi and are produced in chains on upper or lower leaf surfaces or on flowe
fungal disease that produces visible powdery growth, has spores that grow on branched stalks and look li
leaf surface. Environmental conditions that favor the growth of downy mildew are different from those tha
relative humidity of 90% or higher, and free moisture.

Wind carries powdery mildew spores to new hosts. Although relative humidity requirements for germinati
absence of free water. In fact, water on plant surfaces for extended periods inhibits germination and kills
60° to 80°F and shady conditions generally are the most favorable for powdery mildew development. Po
sunlight, and leaf temperatures above 95°F may kill the fungus.

MANAGEMENT

The best method of control is prevention. Avoiding the most susceptible cultivars, placing plants in full su
mildew in many situations. Some ornamentals do require protection with fungicide sprays if mildew condi
crape myrtle. (See Table 1.) For a list of other common ornamentals susceptible to powdery mildew, see

Table 1. Host Plants and Control Measures for Powdery Mildew Species.

Fungus species	Hosts
Golovinomyces cichoracearum	begonia, Composite family (chrysanthemum, dahlia, phlox, sunflower, a
Erysiphe lagerstroemiae	crape myrtle
Sphaerotheca pannosa	rose

Table 2. Common Ornamentals Susceptible to Powdery Mildew.

	Suscepti
aster	crape myrtl
azalea (deciduous)	dahlia

Cenicilla

Puntos de un blanco cenizo en las hojas y brotes pueden ser señal de cenicilla. Esta enfermedad afecta muchas plantas y puede ser causada por diferentes tipos de hongos. Para combatir la cenicilla use variedades de plantas resistentes a este hongo y altere el ambiente en que crecen. En algunos casos, ciertas especies de plantas susceptibles a estos hongos requerirán tratamiento con fungicidas.

Los síntomas pueden variar de una especie a otra.

- Use piedra lisa o baldosas, adoquines o concreto permeable para senderos y patios en lugar de superficies impermeables como el concreto y asfalto.
- Las hojas se tornan amarillentas o café y se caen, exponiendo a la planta o fruto a las quemaduras del sol.
- En algunos casos, las hojas o los brotes se tuercen o distorsionan.
- Las frutas y verduras usualmente no se ven afectadas, pero los manzanos, vid y otras frutas con hueso pueden desarrollar unas marcas rojizas en forma de telaraña o áreas suberosas.

La cenicilla es común en condiciones cálidas y secas.

- A diferencia de muchas enfermedades, la cenicilla no necesita de condiciones húmedas para desarrollarse y su crecimiento es inhibido por el agua en la primavera.
- Las temperaturas moderadas (60°F a 80°F) y la sombra favorecen el desarrollo de la enfermedad.

Haga a las plantas menos susceptibles alterando el ambiente en el que crecen.

- Cultive las plantas en sitios soleados.
- Pode el exceso de follaje para permitir el paso del aire.
- No fertilice en exceso con nitrógeno ya que el follaje frondoso y la sombra favorecen a la enfermedad.

Plante variedades resistentes.

Las variedades de plantas muy susceptibles que son resistentes o menos susceptibles, incluyen:

- Las ornamentales: mirto, rosal, platanero, rododendro y zinnia.
- Frutas: manzano, duraznero y frambuesa.
- Verduras: melones, calabazas, pepinos, frijoles y chícharos.

Considere usar metodos sin el uso de materiales químicos.

- Rocíe las plantas infectadas con agua. Para prevenir problemas con otras enfermedades, haga esto a media mañana para que se sequen rápidamente. Agregue un poquito de jabón al agua para puede aumentar la efectividad.
- Durante la temporada en la que no se produce fruto, corte las partes y los brotes que muestren una infección leve. Asegúrese de sacar de su jardín cualquier material infectado para que las esporas no se esparzan a nuevas áreas.

Las variedades susceptibles de algunas plantas pueden requerir el uso de fungicidas.

- Las plantas que requieren de tratamiento con mayor frecuencia son los manzanos, zarzamora, vid, rosales y cucurbitáceas.
- Controle las infecciones leves a moderadas de la cenicilla usando aceite de horticultura o aceites a base de plantas como el de árbol de neem o de jojoba, o fungicidas a base de bicarbonato de sulfuro. No aplique los aceites en donde haya usado bicarbonato de sulfuro o cuando la temperatura rebase los 90°F.
- Prevenga las infecciones usando sulfuros solubles en agua, en especial los que vienen listos para usarse y formulados con agentes tensoactivos parecidos al jabón. Estos productos son ineficaces si se aplican cuando la infección ya ha aparecido. Podría ser necesario repetir la aplicación.
- Existen otros fungicidas para otros tipos de plantas, pero la mayoría se deben aplicar antes de que aparezcan los primeros brotes de la enfermedad.

Para mayores detalles en inglés, vea Pest Notes: Powdery Mildew on Fruits and Berries, Powdery Mildew on Ornamentals, and Powdery Mildew on Vegetables a www.ipm.ucdavis.edu, o visite las oficinas de Extensión Cooperativa.

Reduzca al mínimo el uso de pesticidas que contaminan nuestros canales. Utilice alternativas sin químicos o productos pesticidas menos tóxicos siempre que sea posible. Lea las etiquetas de los productos cuidadosamente y siga las instrucciones sobre el uso, almacenaje y desecho correcto.

Pida mayores informes sobre control de plagas a la oficina local de **Extensión Cooperativa de la Universidad de California** que se encuentra en las páginas del gobierno del condado en el directorio telefónico o visite la página en la Red del Programa Integrado de Control de Plagas de la UC, www.ipm.ucdavis.edu.

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UC IPM

- Environmental themes mentioned in management section
- Many other treatment options too
- Cultural and design options a good starting point
  - Especially if you can cure more than one problem

All powdery mildew fungi require living plant tissue to grow. On perennial hosts such as roses, powdery mildew survives from one season to the next as vegetative strands in buds or as spherical fruiting bodies, called chasmothecia, on the bark of branches and stems.

Most powdery mildew fungi grow as thin layers of mycelium on the surface of the affected plant parts. Spores, which you can see with a hand lens, are part of the white, powdery appearance of this fungi and are produced in chains on upper or lower leaf surfaces or on flowers, fruits, or herbaceous stems. In contrast, downy mildew, another fungal disease that produces visible powdery growth, has spores that grow on branched stalks and look like tiny trees. Also, downy mildew spores occur mostly on the lower leaf surface. Environmental conditions that favor the growth of downy mildew are different from those that favor powdery mildew and include low temperatures of 50° to 70°F, a relative humidity of 90% or higher, and free moisture.

Wind carries powdery mildew spores to new hosts. Although relative humidity requirements for germination vary, all powdery mildew species can germinate and infect in the absence of free water. In fact, water on plant surfaces for extended periods inhibits germination and kills the spores of most powdery mildew fungi. Moderate temperatures of 60° to 80°F and shady conditions generally are the most favorable for powdery mildew development. Powdery mildew spores and mycelium are sensitive to extreme heat and sunlight, and leaf temperatures above 95°F may kill the fungus.

MANAGEMENT

The best method of control is prevention. Avoiding the most susceptible cultivars, placing plants in full sun, and following good cultural practices will adequately control powdery mildew in many situations. Some ornamentals do require protection with fungicide sprays if mildew conditions are more favorable, especially susceptible varieties of rose and crape myrtle. (See Table 1.) For a list of other common ornamentals susceptible to powdery mildew, see Table 2.

Table 1. Host Plants and Control Measures for Powdery Mildew Species.

Fungus species	Hosts	Cont
Golovinomyces cichoracearum	begonia, Composite family (chrysanthemum, dahlia, phlox, sunflower, and zinnia)	wate
Erysiphe lagerstroemiae	crape myrtle	resist
Sphaerotheca pannosa	rose	resist neces

Table 2. Common Ornamentals Susceptible to Powdery Mildew.

Susceptible Plant		
aster	crape myrtle	oa
azalea (deciduous)	dahlia	pa
begonia (tuberous)	delphinium	ph
calendula	euonymus	ra
California poppy	forget-me-not	ro

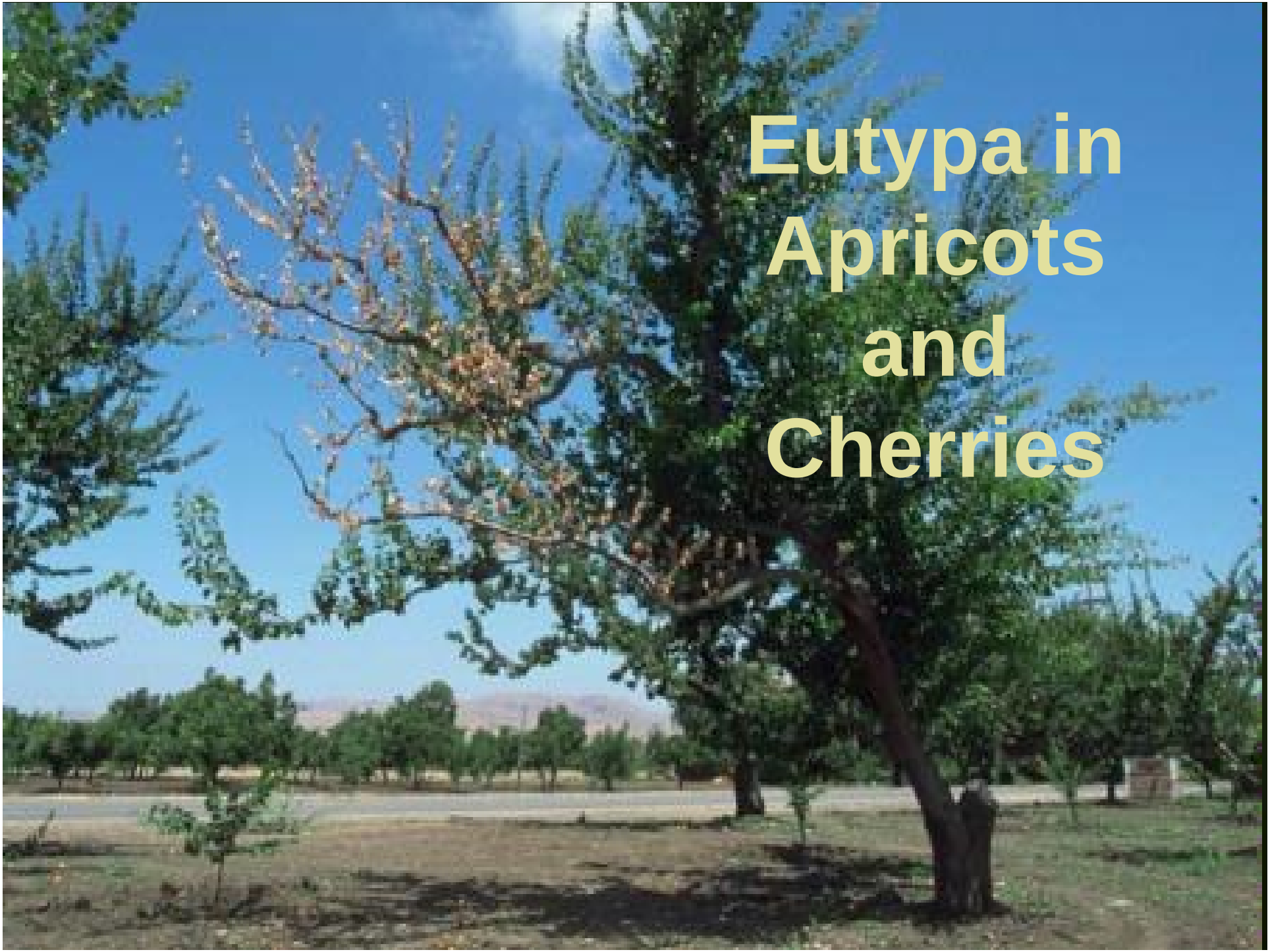
Chinese elm anthracnose

- Thrives in cool, wet springs
  - Again on new growth
  - Spread by water
  - Prefers
    - Still air
    - Damp conditions
- In nature, most elms are relatively solitary
  - In landscapes, this is rare
- Specific cultivars susceptible
  - True green
  - Evergreen
  - Both widely planted in ‘70’s and ‘80’s
  - Both have lush, dense canopies


Photo: Larry Costello

Chinese elm anthracnose

- No effective fungicides
- Control
  - Resistant cultivars
    - Drake
  - Cultural
    - Sanitation
    - Prune out infested branches in dry weather
    - No fertilization
    - No sprinklers
    - Prune for air & light
  - Perennial cankering of large limbs may be cause for removal


Eutypa in
Apricots
and
Cherries

Eutypa

- Gummosis
- Whole branch dieback
- Wood discoloration
- Symptoms appear in summer
- UC IPM website

Home, garden, turf, & landscape pests

University of California's official guidelines for managing pests with environmentally sound methods. (More...)

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- Vegetables and melons

Some common pests and methods

- Birds, mammals, and reptiles: vertebrate pests

Eutypa

- Naturally infects fresh leaf abscission scars in rainy weather
  - Physiological weak point (reliable)
- Loves pruning wounds in winter
- Prune in summer after harvest
- If you have to prune in wet weather, cauterize with torch

Oak moth

- *Phryganidia californica*
- Outbreaks occur every 5-7 years after warm winters
  - Last big outbreak 2007
  - Last winter was warm
  - Warned folks of outbreaks
- Localized defoliation of oaks
  - Especially at end of summer (end of 2nd gen.)

Oak moth

- If this winter is warm, it will be worse next summer
  - And then the population should crash
- Oaks can normally take repeated defoliation
  - Looks bad, but disease triangle is small
- Bt to control early in cycle if damage not tolerable

Exotic Diseases

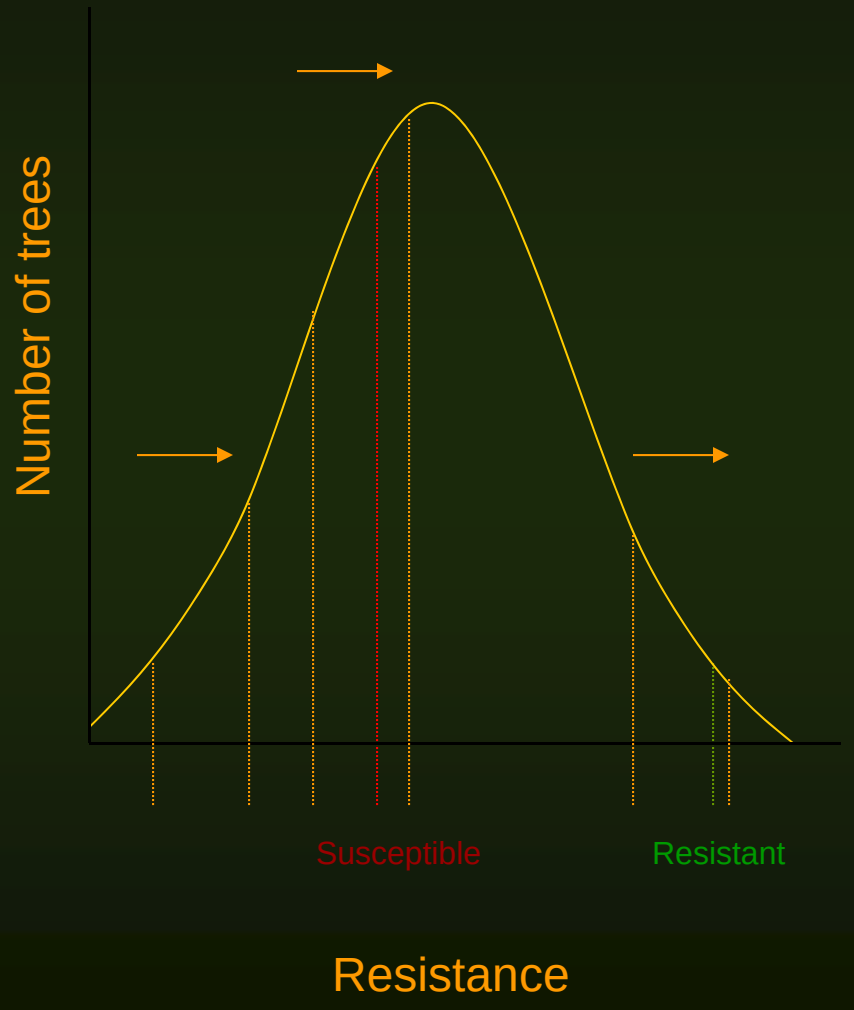
- Not so dependent on finding weak spots like new growth
  - e.g.: Sudden Oak Death
  - Infection increases occur 1-2 years after years with a rainy, warm spring
  - 2010 & 2011 both had rainy springs
  - Uptick in oak death this year

AgriFos application

- Currently:
  - Spring and fall
  - First two
    - 6 months apart
  - All subsequent
    - 12 months apart
- Flexibility
- Variables:
  - Application technique
  - Tree size (age)
  - Inherent resistance

AgriFos Efficacy

- Anna Conrad
  - Ohio State Universtiy
  - Genetic Markers for Resistance
  - ~ 16% at top end?
- Laboratory results in 2003 promising
  - Subject to interpretation
- Field effectiveness more equivocal
  - Some trees die even after years of prophylactic treatment
- Many “alternative” treatments are simply ineffective
- Still used largely due to lack of more effective treatment

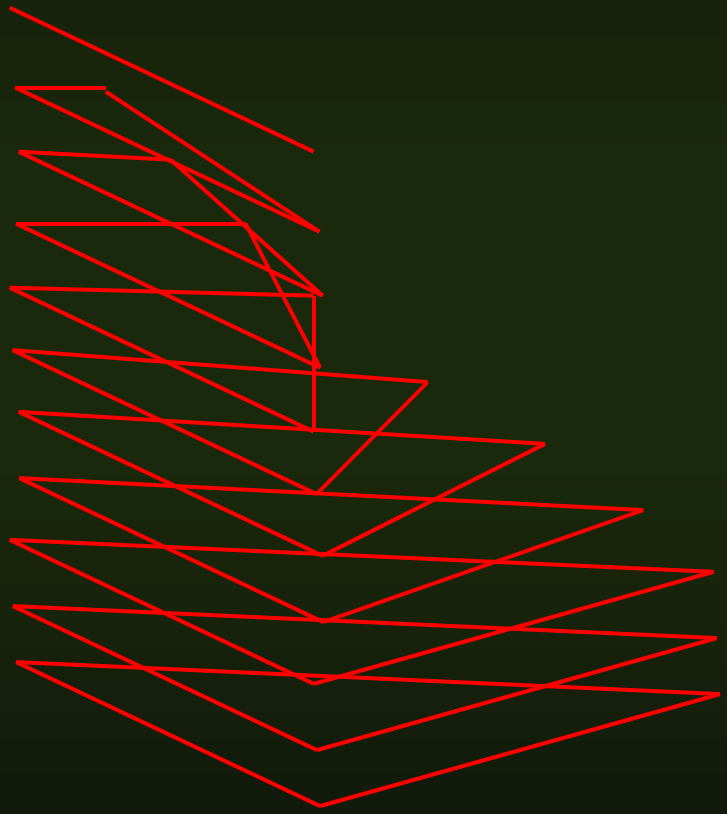


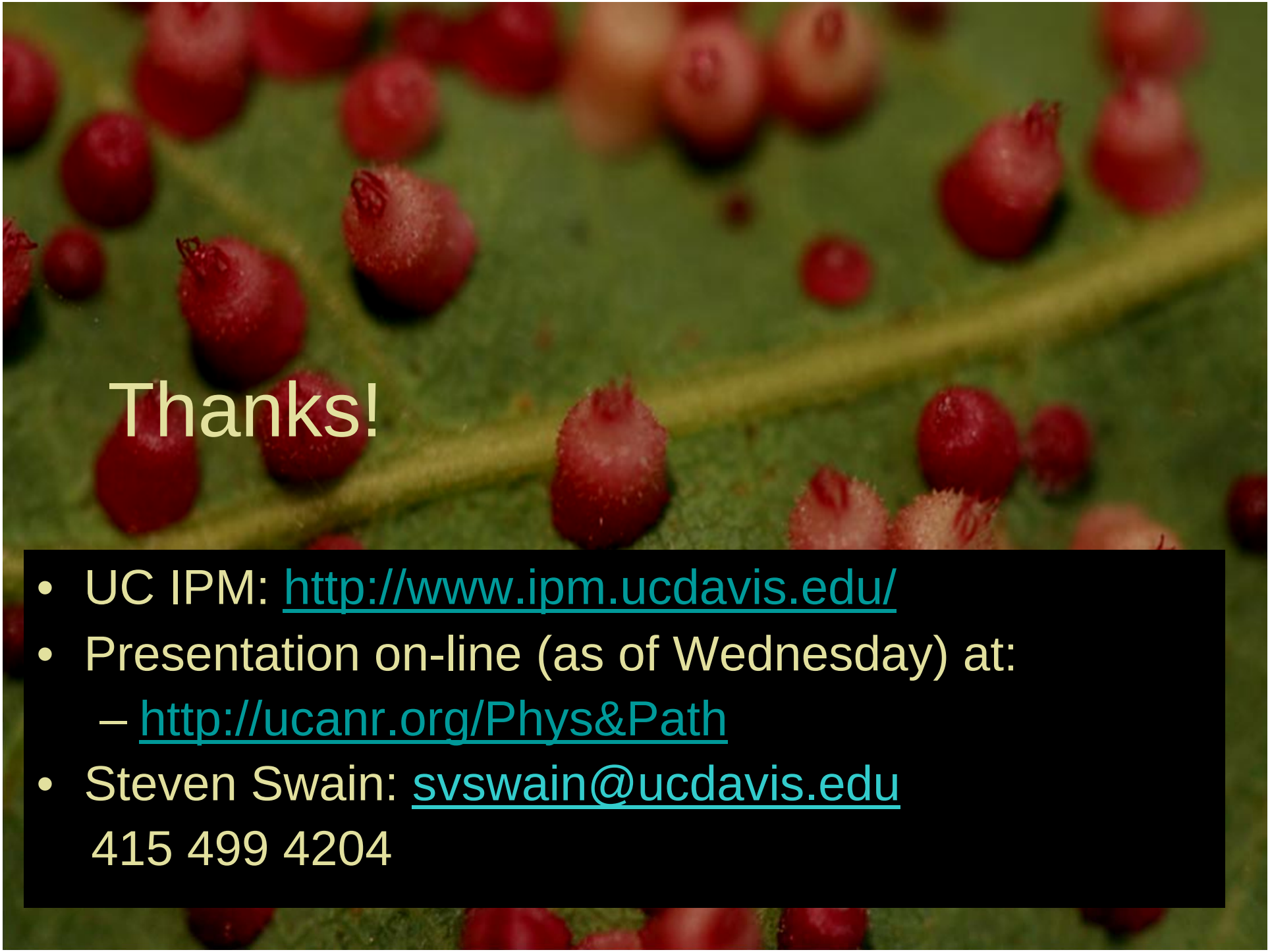
Bark scribing

- Evaluating “new” technique
  - Early trials show some promise
    - Bartlett: anecdotal
    - Mine: experimental
  - Cankers may need to be small

Knocking out the triangle

- If you can find symptoms or signs to test
  - ID the pathogen or pest
  - Work with plant's lifecycle to interrupt the pest's lifecycle
- If you can't ID a pathogen or pest
  - Probably abiotic
  - All about the plant's lifecycle and environment
- UC IPM as a resource





Thanks!

- UC IPM: http://www.ipm.ucdavis.edu/
- Presentation on-line (as of Wednesday) at:
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