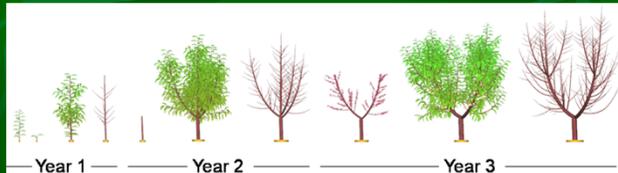


Using Concepts of Shoot Growth and Architecture to Understand and Predict Responses of Fruit Trees to Pruning

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Why prune?

- For training to produce a vigorous, mechanically strong, framework
- To obtain a well-shaped tree for convenience of orchard management
- For optimal capture and distribution of sunlight throughout the canopy
- Promote fruit size (crop reduction technique)
- Stimulate new fruiting wood (bearing wood renewal)
- Regulate crop production over years (decrease alternate bearing)



Basic concepts for understanding tree growth and responses to pruning

- Three types of shoots
- Two types of shoot growth
- The basic structure of shoots determines cropping and subsequent growth
- Duration of shoot growth
- Apical dominance
- Gravitropism
- Carbohydrate/resource balance
- Concept of “reiteration”
- Types of pruning cuts

Three types of shoots

- Proleptic: shoots that grow out from terminal or lateral meristems after a dormant bud has been formed and period of dormancy occurs.
- Syleptic: shoots that grow out from lateral meristems in the axils of leaves without an intervening period of dormancy.
- Epicormic: shoots that grow from dormant preventitious buds on older branches (usually after a pruning cut, limb break or extreme limb bend).



Syleptic

Proleptic

Epicormic

Two types of shoot growth

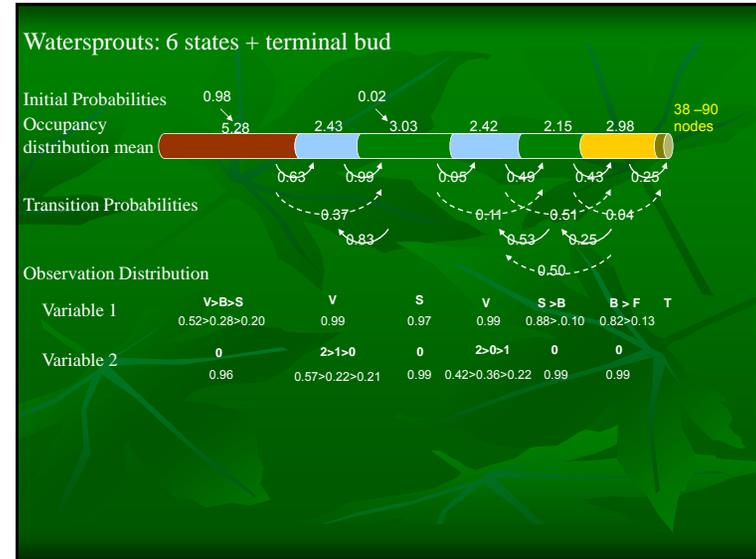
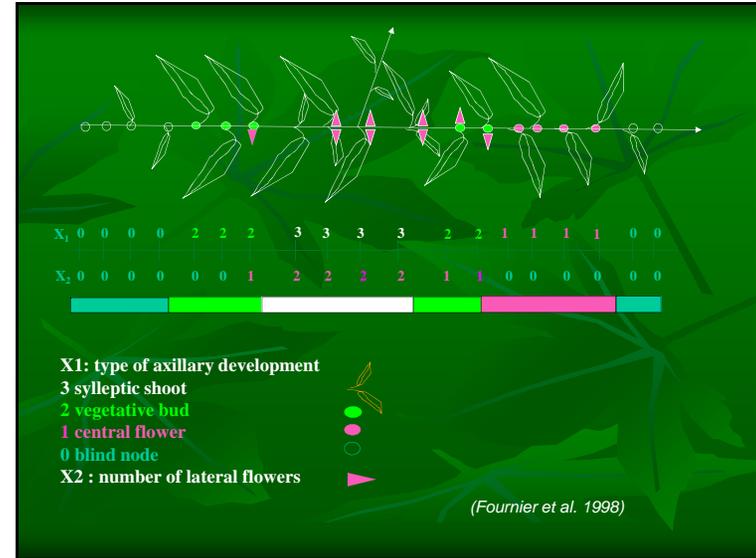
- Preformed shoot growth: shoot (or spur) growth that grows as an extension of internodes between nodes that were preformed in proleptic buds (usually limited to 6-10 nodes).

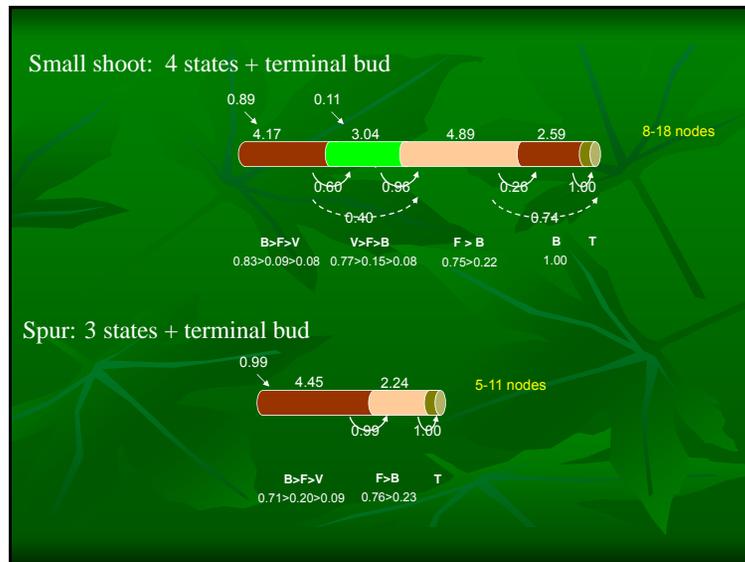
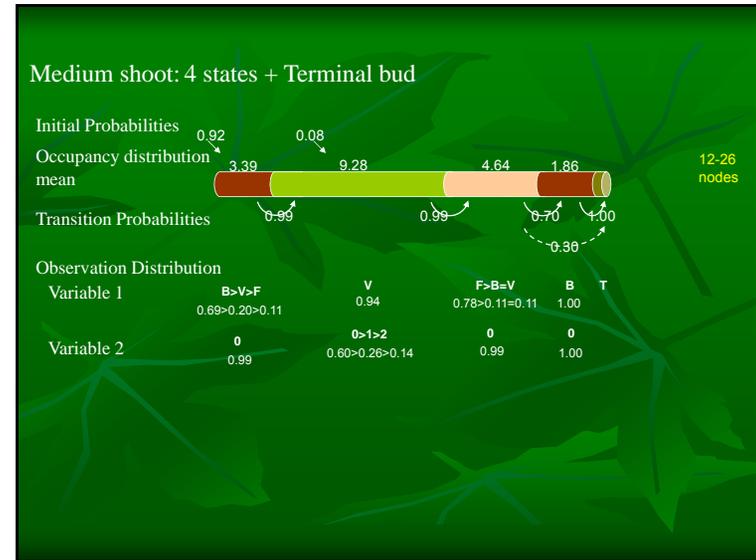
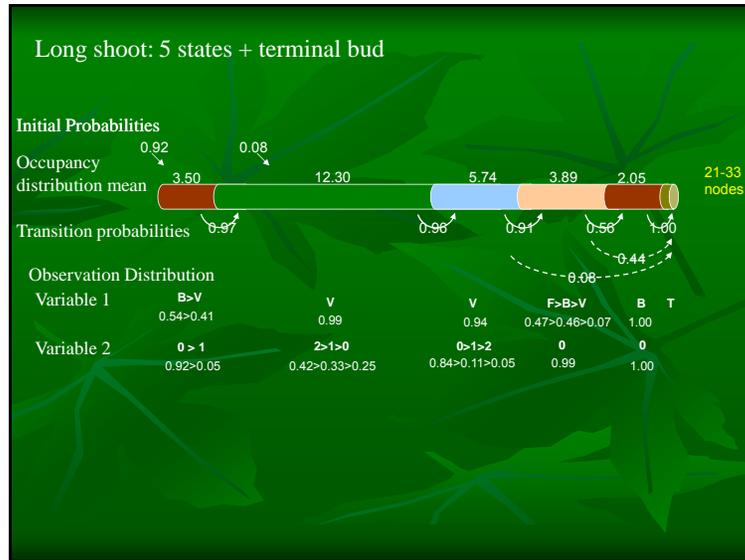


- Neoformed shoot growth: shoot growth that grows as a result of the production of new nodes that are produced during the current growing season.
- For shoots starting from proleptic buds this results in “mixed” shoots.



The basic structure of each shoot type is relatively consistent and can be systematically studied and characterized.





Differences in shoot growth duration are related to type of growth, type of shoot and plastochron. The average plastochron for peach is about 2-3 days.

- Spurs have fewer than 11 nodes, are entirely preformed and stop growing within 30 days after bud break. Most short shoots are similar.
- Medium and long shoots are mixed shoots with preformed and neoformed growth and up to 34 nodes. They stop growing within 90 days of bud break (by June 15 in California).
- Epicormic shoots are entirely neoformed, have up to 90 nodes and thus grow until fall.

Apical dominance: the influence or control of shoot development and growth of lower buds or shoots by more apical buds or shoots

Three manifestations of apical dominance

- Correlative inhibition: suppression of lateral shoot growth by a vigorously growing apical meristem during the current season's growth.
- Apical control: tendency for terminal and distal lateral shoots to depress the growth of more basal (subordinate) shoots.
- Shoot epinasty: tendency for actively growing upper, distal shoots to influence the branch angle of basal shoots (usually making them wider).

If shoot is not pruned all new shoots will be shorter than parent shoot.



Gravitropism

- Gravitropism is the behavior of growth in response to gravity.
- Shoot growth displays negative geotropism.
- Fruit species vary in the amount of gravitropism they exhibit (cherries a lot, peaches less).
- Gravitropism responses can vary with genotype within a species.



Carbohydrate/resource balance

- If allowed to grow naturally, when a tree goes into dormancy its natural shoot growth potential for the following spring is a function of a balance between the carbohydrate and nutrients stored prior to dormancy and the number of buds.
- Any pruning during dormancy will change this balance in favor of stimulating more growth, often in the form of epicormic shoots (watersprouts) from preventitious buds.

Reiteration

“Reiteration” is the tendency for a tree to “replace” any vegetative part of the tree that is lost or removed through limb breakage or pruning. In the case of loss of major pieces of individual units like shoots, the new shoot will have characteristics similar to the shoot that is being replaced.

The “strength” of reiteration after pruning depends on the type of pruning cut, the amount growth that was lost, and the timing of the pruning. The growth of epicormic shoots from preventitious buds is the tree’s natural way to rapidly replace parts of the canopy that is lost.

In orchards where heavy topping is used in California, reiterative growth can be 3 m in one season.



Without pruning the proportion of shoots in the small categories increases and fewer long shoots are produced. Watersprouts are not produced if trees are not pruned unless there is limb breakage or severe bending.



Types of pruning cuts

- Heading cuts: the terminal part of the main axis of the shoot is removed and the basal portion remains attached to the tree.
- Thinning cuts: the entire axis of a shoot is removed from the tree.

Application of the concepts

In young, vigorous trees the new growth on a previous year's shoot that expressed strong **correlative inhibition** in the first year, we can expect expression of strong **correlative inhibition** in the second year.

Apical control and **shoot epinasty** effects will also be apparent with new shoots being progressively shorter and branching angles progressively wider from the apex to the base of the shoot.



This behavior may be partially because of lower chilling requirements and earlier growth and flow of auxin from buds nearer to the apex to the more basal buds.

If we go back to the original one-year-old shoot and head it back to one-half its length we have substantially changed things:

- The inherent apical dominance affects have been reduced
- The new growth will be invigorated because more than half of the buds have been removed (nodes are closer together in the upper half of the shoot) and the mass and therefore the stored carbohydrates are greater in the basal half of the shoot.



The result is that the more distal buds that remain on the shoot will probably grow longer shoots than the shoots that would have been produced if the original shoot had been left un-pruned. Note also that the apical control and shoot epinasty are re-established in the new branch.

The reiteration rule tells us that the new longer shoots will have general characteristics similar to the original un-pruned parent shoot but the more distal shoots may be longer than the original parent shoot.

This is the basis for the general pruning rule: "cut what you want to grow."



In peach production heavy pruning leads to major tree management problems because of excessive stimulation of epicormic shoots.

These epicormic shoots are entirely neofomed because they are stimulated from latent preventitious buds. They are a problem because they grow until conditions are not favorable for growth.

We must find ways to minimize pruning cuts that stimulate the production and growth of these types of shoots in mature bearing fruit trees. This is probably where size-controlling rootstocks and controlled water deficits after harvest of early maturing cultivars can play a role.

However our current training systems are very dependent on the concept of reiteration and epicormic shoot production for the rapid development of tree canopies.



Putting the concepts together in the L-PEACH Model

Goals of the L-PEACH modeling project:

- Build a model of architectural tree growth, carbon assimilation and transport, and dry matter partitioning based on developmental and physiological concepts of how trees grow
- Model tree and fruit growth from the organ to whole plant level
- Visualization and quantification of plant growth
- Model responses of tree growth to the environment and to horticultural management practices
 - I will use the model to demonstrate how these concepts of tree growth are used in our current tree training practices.

In California we often use a very aggressive style of pruning to train young trees.

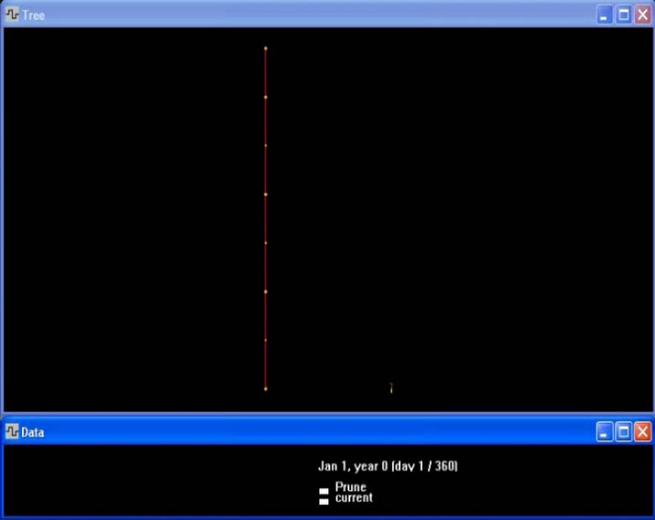
The tree on the right is a simulation of a vigorous tree at the end of the season in a nursery.



This tree would be transplanted into the orchard and pruned to ~0.5 m with all of the side shoots removed. Why do we remove all the side shoots?



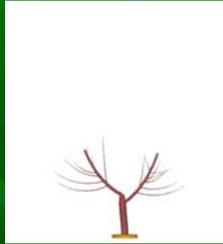
Unpruned syleptic shoots from the previous year only produce shoots from proleptic buds that are weaker than the parent shoot. If these are removed more "water sprouts" are produced.

In the first year in the orchard that tree develops several strong branches from water sprouts as a result of the strong pruning at the time of planting. These scaffolds are mainly epicormic shoots (watersprouts) stimulated by heavy pruning.



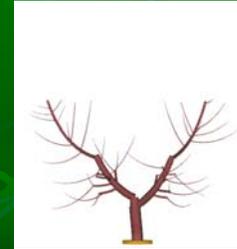
In the following dormant season the grower selects 2, 3 or 4 strong branches to develop the primary scaffolds and again heads them to stimulate more strong growth (water sprouts) to either continue the selected scaffolds or develop multiple secondary scaffolds.



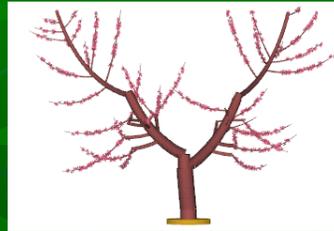
In the second year in the orchard the tree again responds to the heavy pruning and develops multiple branches (water sprouts) on the ends of the primary scaffolds.



In the following dormant season the grower again selects branches to either reinforce the previously selected scaffolds or develop multiple secondary scaffolds.



Later we would like to produce more "mixed shoots" and fewer or no water sprouts.



The L-PEACH model can simulate a reasonable *in silico* representation of a peach tree that can be pruned to any configuration normally used in California peach orchards.



Two other features that are implemented in L-PEACH that are a form of pruning are simulated topping (a practice that is increasingly being used by growers to manage pruning costs) and fruit thinning.



Fruit thinning can be done manually (as in the orchard) by selectively removing individual fruit or automatically by specifying the date of thinning and the minimum distance (number of metamers) between fruit at the beginning of a simulation.



Conclusions

- It is possible to take the “art” out of pruning by analyzing and integrating the factors that regulate shoot growth and development.
- Now that we have a better understanding of how peach trees actually grow we need to apply that knowledge to find effective means to minimize excessive tree growth to reduce labor costs and direct more carbohydrates and nutrients to fruit production.

Thank you for your attention



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