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Response of Two Oak Species to Reduction Pruning Cuts

Jason C. Grabosky and Edward F. Gilman

Abstract. Reduction pruning cuts were used to prune *Quercus virginiana* (live oak) and *Quercus Shumardii* (shumard oak). One-half of the pruning wounds were harvested and dissected 3 years later to observe extent of discoloration in response to the pruning cut. Shumard oak did not limit discoloration as effectively as live oak. Discolored area in the wood increased with size of the pruning cut surface in shumard oak and less so in live oak. Dissections showed that the shape of the discolored area attenuated with depth. The branch connection morphology and response (branch–trunk aspect ratio, branch angle, release growth after pruning) appeared to influence discoloration pattern in reduction pruning. The angle of the reduction cut relative to the American National Standards Institute-recommended angle bisect method was not found to influence discoloration. Discoloration in the less efficient compartmentalizing species (Shumard oak) was related to cut surface area, but not to cut angle. There was no relationship between aspect ratio and discoloration in the 3 years after pruning. The data suggest that reduction cuts can be made back to lateral branches as small as one-third the diameter of the removed stem.

Key Words. CODIT; live oak; reduction pruning; shumard oak; wood discoloration.

Reduction pruning cuts shorten a growth axis (branch or stem) by removing the distal end to a smaller lateral branch (Gilman 2002; Gilman and Lilly 2002). Reduction cuts are commonly used in reduction, subordination, and directional pruning (ANSI 2001; Gilman and Lilly 2002). It is acknowledged that the remaining lateral branch should be at least one-third to one-half of the diameter of the removed portion to encourage the residual lateral branch to assume the terminal role for the remaining branch (Gilman and Lilly 2002; Harris et al. 2004). When locating the final cut of the main axis, the desired cut is conventionally defined by bisecting the angle between the remaining lateral branch's branch bark ridge and the plane perpendicular to the direction on the main growth axis (Gilman 2002; Harris et al. 2004). Cutting too far such as flush with the branch bark ridge would potentially harm the remaining lateral branch as a result of dieback from the cut stem. No published data are generally available that suggests or explicitly tests the validity of the accepted practices in determining the preferred lateral branch size or angle of reduction pruning cut.

Pruning wounds can serve as points of desiccation and entrance sites for decay organisms. Discoloration at wounding sites is associated with development of reaction zones to compartmentalize decay processes (Santamore 1979; Bauch et al. 1980; Duchesne et al. 1992; Schwarze et al. 2000). The CODIT model has been accepted as a means to describe the containment in temperate tree species (Harris et al. 2004). The reaction zones described in the CODIT model are minimally defined for predicting reaction zone positioning below a reduction or heading cut, with ad hoc Wall III and Wall II developing as the discoloration and decay progress down from the cross-sectional cut surface. Many anecdotal lists and limited research observations of reaction zone formation and compartmentalization ability exist given the matrix of tree species, growing environments, wound positions, and decay organisms under consideration. The goal of this study was to examine two tree species presumed to be either efficient or poor at compartmentalization of decay after pruning and test the influence of cut size, cut angle, and branch–trunk ratio in decay development after pruning with reduction cuts.

MATERIALS AND METHODS

Trees were selected from established blocks of research trees at the Environmental Horticulture Landscape Teaching Laboratory at the University of Florida in Gainesville (29.4% N, USDA hardiness zone 8b) established on a well-drained Millhopper sand (loamy, siliceous, hyperthermic, Grossarenic *Paleudults*) soil. Sixteen *Quercus Shumardii*, shumard oak ranging from 46 to 56 cm (18.4 to 22.4 in) diameter at breast height (dbh) were selected from a possible 25 individuals remaining in a block of mixed species in a grid of 6.1 m (20.1 ft) spacing planted in 1990. Trees were randomly selected. Sixteen *Quercus virginiana*, live oak ranging from 26 to 61 cm (10.4 to 24.4 in) dbh, were selected from an existing block of the species planted in 1992 (Gilman et al. 1998) and later studied by Eisner et al. evaluating branch morphology and compartmentalization (Eisner et al. 2002). Live oak were selected from the outside southern and western perimeter of the 9 × 8 block of 72 trees, because the grove interior was at canopy closure and shading effects would heavily influence the results of the study.

Branches suitable for reduction cuts were chosen with a maximum of six branches per tree, each arising on different first-order lateral branches, with total foliage removed comprising no more than 20% of the total live canopy by visual estimate. As such, the branch replicates as sampling units were analyzed with their source tree as a blocking parameter. Because a previous study in the live oak block suggested a tree individual effect (Eisner 2001; Eisner et al. 2002), tree number was entered into each model during regression analysis of the data. If there was no significant impact of the tree as a predictor in the model, the term was dropped to avoid inflation of the regression coefficient of multiple determinations. To test our a priori assumption that the species differed in compartmentalization ability, discoloration between species as a model predictor was tested after within-species analysis was complete. Species were treated separately in simple linear and multiple regression analysis.

The target reduction cut angle was based on the American National Standards Institute A300 standard in which the cut angle bisected the line perpendicular to the removed shoot and the branch bark ridge of the remaining lateral branch (ANSI 2001); however, the actual angle varied between a perpendicular cut and the targeted bisected angle. Branches were chosen as randomly occurring opportunities within the canopy where the possibility for a reduction cut existed. Diameter of the pruned branch and the remaining lateral were recorded as the mean of the widest diameter and the diameter perpendicular with dial calipers to the nearest millimeter. Measures were taken as less than 5 cm (2 in) above the cut and at 5 cm (2 in) from the branch connection on the remaining branch. Aspect ratio was calculated by dividing the diameter of the remaining secondary lateral branch into the diameter of the cut primary growth axis. An aspect ratio of 1.0 would be considered codominant and a ratio of 0.25 would indicate the remaining lateral branch was one-fourth the diameter of the removed stem. Diameter of the cut branches ranged from 3.5 to 11.4 cm (1.4 to 4.6 in). Heartwood was not visually present in the pruning cuts made in this study.

Pruning occurred in April 2002. Measurements collected and derived at the time of pruning were diameter of cut axis, diameter of remaining lateral branch, and aspect ratio. The total number of reduction cuts for each species was 71 cuts over 15 trees for live oak and 78 over 16 trees for shumard oak. Aspect ratios ranged from 0.34 to 1.15. Aspect ratios over 1.00 were lateral branches that were slightly larger than the removed primary axis. Initial aspect ratios and cut size were tabulated and descriptive statistics developed to ascertain balance and continuity of the sampling distribution within species sets because the data were to be analyzed as continuous variables in regression analysis, specifically checking for normality of sample distribution using an Anderson-Darling normality test in Minitab 12.23 and histogram plots to verify continuity of sample size groups to avoid large gaps within the testing range.

In January 2005, eight trees of each species were randomly chosen and destructively harvested. Thirty-six live oak sections and 37 shumard oak sections were removed from the trees approximately 50 cm (20 in) below the initial reduction cut. The associated lateral branch was cut to a stub approximately 20 cm (8 in) from the branch union. The diameter of the remaining lateral branch was measured to the nearest millimeter with a diameter tape 5 cm (2 in) from the branch union. Sprouts released or developed within 20 cm (8 in) of the cut or at the callous dieback line were counted and base diameter measured. If discoloration columns exceeded the initial harvest depth, a second lower section of 1 m (3.3 ft) was harvested.

At harvest, the wood sections were split (medial longitudinal section) longitudinally in a plane through the center of the initial cut primary and the center of the remaining lateral (Figure 1). Discoloration of the wood was recorded as an indicator of reaction zone boundaries. The discolored zone

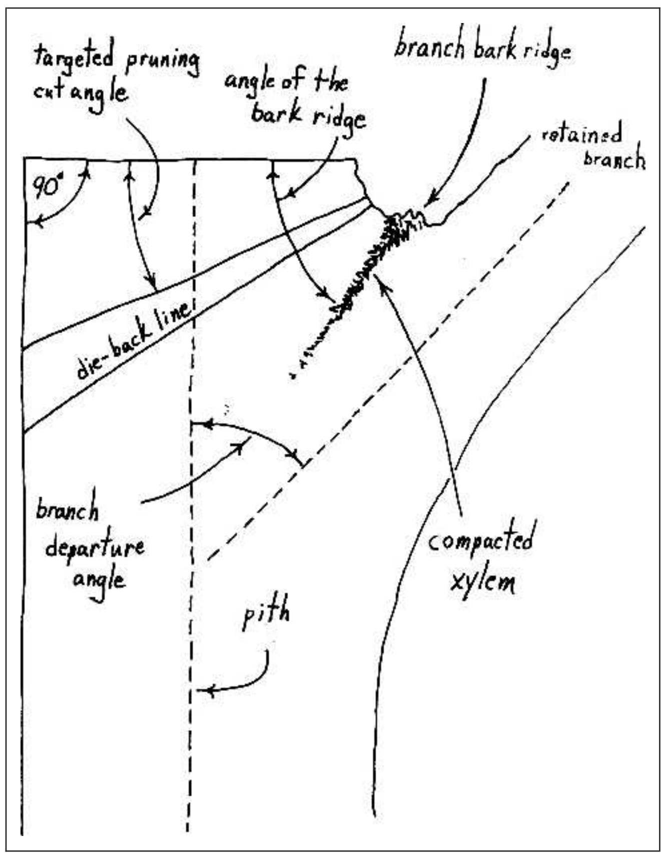

Figure 1. Sectioning position of dissected reduction cut pruning site.

was etched to tracing paper and the maximum depth of the discoloration from the initial pruning cut surface running parallel to the wood grain was recorded. An area light meter (Δ T model RS 232C; Δ T Devises Inc., Cambridge, U.K.) was calibrated with black surface cards of comparable known areas of similar shape and used to determine area of discolored wood resulting from each reduction cut. Area of discoloration and depth of discoloration from the cut were recorded.

Relative growth rate was derived from the initial lateral branch diameter compared with the final diameter at harvest. Branches were modeled as circular areas calculated from their measured average diameter. Relative growth rate was characterized as the decimal percentage difference between initial branch cross-sectional area and the final branch area. Given the initial size range of remaining lateral branches, the percentage difference was then divided by the initial branch area to account for the differences in measured growth as a consequence of initial size and age within the test population.

Relative growth rate = percentage cross-sectional area increase ÷ initial area

where

(percentage cross-sectional area increase = final area ÷ initial area)

Determination of branching angle of departure was measured from pith direction in the section plane at the point of attachment. After harvest, the angle of cut relative to main growth axis, angle of remaining lateral branch departure, angle of the bark ridge, and angle of dieback to the point where callous growth initialed were measured (Figure 1).

Data were analyzed in Minitab version 12.23. The 19 parameters were sorted and were arranged into discoloration, growth, dimensioning, and angle groups (Table 1). Area of discoloration, discoloration influence, normalized discoloration, and depth of discoloration were tested against individual measured parameters in simple linear regression. A best subsets procedure was used to identify appropriate multiple regression models. Relative growth rate was then assessed by plotting (final area ÷ initial area) against initial area to verify reasonableness of the chosen method as a parameter. Significance tests were set at $\alpha = 0.05$, except tree influence in model testing, which was set at $\alpha = 0.1$.

The area of discoloration narrowed with depth to form an irregular, somewhat triangular shape, typically with greater depth opposite from the remaining branch. Often the discoloration continued as one to several long thin columns. Discoloration area was characterized as a percentage of the available area in the total depth of the longest thin column in the medial longitudinal section to provide a unitless number. The available area was defined as the product of the cut diameter and discoloration depth as a rectangle. Area of discoloration was also normalized by dividing each pruning cut discoloration area by the species mean discoloration area.

RESULTS

Comparison of discoloration behind the reduction pruning cuts showed a greater discoloration area ($P < 0.001$) and discoloration depth ($P = 0.001$) in shumard oak than live oak. There was no direct relationship between aspect ratio and angle of branch departure in either species. Additionally, there was no direct relationship between initial diameter of the remaining lateral branch and the angle of departure.

In the 3 years after pruning, growth of the remaining lateral branches increased as their initial branch diameter decreased in both species (equations 2 and 3; Table 2). In both species, relative growth rate in the 3 years after pruning was significantly influenced by aspect ratio (equations 4 and 5), where more subordinate branches showed more growth relative to initial size after pruning. There were no individual tree influences for either species found for the previously mentioned dimensional relationships.

In live oak, sprouts occurred on 18 of 37 sites ranging from one to nine sprouts. In shumard oak, sprouts occurred on 22 of 38 sites ranging from one to four sprouts. Sprouting was not influenced by the diameter or aspect ratio of the cut. There was no dimension, angle parameter, or relative growth rate relationships with sprouting in either species.

Table 1. A listing of parameters used in analysis.

Discoloration	Growth	Dimensioning	Angle	Tree individual
Depth discoloration	Relative growth rate	Initial branch diameter	Actual cut angle	
Area discoloration	Aggregated sprout diameter	Cut diameter	Branch bark ridge angle	
Discoloration area percentage		Aspect ratio	Target angle	
Normalized discoloration area		Final branch diameter	Dieback angle	
		Branch departure angle	Difference: dieback angle from cut angle	
			Difference: cut angle from target angle	

Table 2. Significant growth rate relationships in live oak and shumard oak in response to reduction pruning.

Equation 2[y]	RGR (live oak) = 0.807 − 0.121 initial branch diameter r^2 = 0.559, regression model P < 0.001
Equation 3[z]	RGR (shumard oak) = 1.93 − 0.361 initial branch diameter r^2 = 0.462, regression model P < 0.001
Equation 4[z]	RGR (live oak) = 0.674 − 0.583 aspect ratio r^2 = 0.338, regression model P < 0.001
Equation 5[z]	RGR (shumard oak) = 1.96 − 1.90 aspect ratio r^2 = 0.42, regression model P < 0.001

[z]Confidence intervals at α = 0.05 reject zero slope line in scatterplot.
[y]Prediction intervals at α = 0.05 reject zero slope line in scatterplot.
RGR = relative growth rate.

Discoloration depth in shumard oak averaged 47.9 cm (19.2 in) with a maximum depth of 116.8 cm (46.2 in). Discoloration depth in live oak was 22.7 cm (9.1 in) with a maximum depth of 140 cm (56 in). Discoloration depth was not related to branching angle in shumard oak (P = 0.887). Discoloration depth in live oak was significantly related to branching angle (equation 6; Table 3), decreasing as the angle increased to a wider angle. No relationships were found for discoloration depth in shumard oak. Sprouting was not related to depth of discoloration in either species. Tree individual effect was not significant in any test analysis performed.

As expected, measured raw area of discoloration increased with cut diameter (equations 7 and 8; Table 3). The relationship was much stronger in shumard oak, and the larger parameter coefficient multiplier (3.35) associated with cut diameter suggests a discoloration response nearly five times greater than in live oak (parameter coefficient multiplier 0.68). Although a strong relationship was observed in shumard oak (r^2 = 0.615), the relationship for live oak was weak (r^2 = 0.123), so we were unable to reject the hypothesis that discoloration from pruning in live oak was unrelated (independent) to pruning cut diameter. When the diameter of sprouts was summed, greater total sprout diameter was associated with lower discoloration area in live oak (equation 9) but had no impact in shumard oak. For area of discoloration, no improved models were suggested in best subset regression analysis.

Table 3. Significant discoloration relationships in live oak and shumard oak in response to reduction pruning.

Equation 6[z]	Depth of discoloration (live oak) = 73.8 − 1.02 branch departure angle r^2 = 0.156, regression model P = 0.017
Equation 7	Area of discoloration (live oak) = 41.6 + 0.683 initial cut diameter (cm) r^2 = 0.123, regression model P = 0.033
Equation 8[z]	Area of discoloration (shumard oak) = 35.0 + 3.35 initial cut diameter (cm) r^2 = 0.615, regression model P < 0.001
Equation 9[z]	Area of discoloration (live oak) = 46.9 − 0.124 aggregated sprout base diameter r^2 = 0.17, regression model P = 0.011

[z]Confidence intervals at α = 0.05 reject zero slope line in scatterplot.
NDA = normalized discoloration area; RGR = relative growth rate.

Table 4. Significant dieback angle relationships.

Equation 10[y]	Dieback angle (live oak) = 13.3 + 0.735 angle of cut r^2 = 0.611, regression model P < 0.001
Equation 11[z]	Dieback angle (shumard oak) = 18 + 0.667 angle of cut r^2 = 0.276, regression model P < 0.001 (one outlying datum removed)
Equation 12[z]	Dieback angle (shumard oak) = 27 + 0.798 angle of cut − 2.24 initial cut diameter r^2 = 0.356, regression model P < 0.001

[z]Confidence intervals at α = 0.05 reject zero slope line in scatterplot.
[y]Prediction intervals at α = 0.05 reject zero slope line in scatterplot.

Discoloration area as a percentage of available area systematically overestimated the degree of discoloration in the section view when discoloration was limited to shallow depths in sections with the least discoloration. Discoloration area as a percentage was discarded from analysis. For shumard oak depths less than 25 cm (10 in) and live oak less than 7 cm (2.8 in), skewed percentage of discolored area exceeded 100% as a result of influences of cut angle versus pith direction and taper of the growth axis coming into the branch protection zone. Normalization of discolored area yielded no relationships.

The final angle of dieback was best described by the actual angle of cut (equations 10 and 11; Table 4). Relative growth rate or sprouting presence/diameter was not related to final dieback angle in either species. In live oak, the cut angle from perpendicular to growth axis ranged from 2° to 33°, or 30° too shallow to 3.5° beyond target cut. In shumard oak, the cut angle range was 4° to 40°, or 24° too shallow to 2° beyond target cut. One pruning site in shumard oak was identified as an outlying response in dieback angle, occurring nearly 30° lower than the next largest differential from actual cut to dieback angle. No other parameter was significantly associated with location of dieback angle, and no models were advanced through best subsets regression methods in live oak. Although pruning cut diameter was not related to dieback angle in shumard oak as a single parameter, it was significant when considered with the angle of actual cut in a multilinear regression model. In the multiple parameter model, the dieback angle in shumard oak decreased as the size of the pruning cut increased.

For comparison to shumard oak, although not significant at $\alpha = 0.05$, live oak, dieback angle tended to decrease as cut size increased ($P = 0.092$) and dieback angle tended to increase as growth rate of the remaining lateral branch increased ($P = 0.083$). Bisecting the angle for a target cut had no influence on discoloration or dieback angle, and departure from the target cut had no apparent effect on any measured parameter.

DISCUSSION

Given the diversity of tree species subject to pruning, tree response to reduction pruning is complex and may be inconsistent. Larger pruning cuts resulted in greater discoloration from the increased initial cross-section of exposed wood. Although it is convenient to simply state larger cuts yielded larger discoloration zones, it was observed to be contradicted in some live oak replicates and a weak assertion with the live oak species data set in general. Given the small data set for each species, it is quite likely that subtle relationships were not developed in the analysis as a result of the natural variability within seed propagated species. With such consideration, several points are worth noting.

Reduction pruning released the smaller remaining lateral branches as the new primary growth axis on the shoot more than larger lateral branches. Novel explanations to explore in future data collection should be to consider the release of the subordinate lateral branch given the loss of hydraulic competition for resources by the removed main growth axis. This influence would be less apparent in branches already provided a relatively large component demand for hydraulic resources by virtue of size or aspect ratio. Research in *Acer rubrum* (red maple) has shown a correlation between decreasing aspect ratio toward subordinate branches and increased hydraulic partitioning/segmentation (Eisner 2001). Reduction cuts in live oak were made primarily within the shaded part of the canopy. Light exposure is a factor to consider in supporting sprouts over several years as is environmental exposure of the cut surface, neither of which was considered in this field study. Sprouting occurrence was not related to branch dimension characteristics or the severity of the reduction cut, but sprouting was significantly linked to decreased discoloration area in live oak. This suggests that sprouts should be left in place near pruning wounds to help minimize discoloration behind the cut. These could be reduced in number or size at a later time as necessary.

It was generally observed that the discoloration column narrowed from the cut surface with depth. Medial longitudinal sections suggested the difference between species in discoloration response was related to the manner of discoloration column attenuation and the ability to limit discoloration depth with CODIT Wall I reaction zones. The observations pose a question about the role the lateral branch connection plays in limiting the advance of the discoloration column. One of two general observations in both species was of long discoloration streaks in individual narrow columns below the major zone of discoloration, which attenuated to discrete columns quickly. The narrow columns confounded inference power in the analysis. The second general pattern showed no marked thinning of the column but a gradual thinning with depth, more so with shumard oak.

As aspect ratio in shumard oak increased to codominant leaders, the remaining lateral branch was larger and associated with less release growth after pruning. This would suggest a lack of initial segmentation architecture in those larger aspect ratio branches functioning as a primary growth axis. As aspect ratio increased toward codominance, discoloration depth did not increase, but discoloration area increased, suggesting a lack of attenuation of discoloration columns in codominant branch connections. Archived samples will be used and compared with the remaining branches at the next harvest interval (Summer 2007) for a shape analysis to further define this response effect.

Wider live oak branch angles were related to decreased discoloration depth, but as the aspect ratio increased toward codominance, discoloration depth was not directly impacted. Branch angle was not related to aspect ratio in live oak. Increasing pruning cut diameter in live oak did not influence discoloration depth and was only weakly related to discoloration area suggesting column attenuation is important for live oak as well. The implication is that: 1) live oak may be more effective in establishing reaction zones along the growth axis (Wall I); 2) the reaction zone stability, once established in live oak, is greater; and/or 3) the fungal decay organisms (which may be different between species and not identified in this study) is more effective in breaching the Wall I reaction zone with the shumard oak.

Smaller lateral branches were associated with greater release growth. Subordinated branches initially segmented from primary flow might be expected that assume the primary flow of resources in the following 3 year's growth pattern of xylem vessel connection with the source branch. Increased growth rate in live oak was associated with smaller initial branches; however, branching angle or aspect ratio was not reliable in predicting growth response. Growth rate on the lateral branch after pruning also had little relationship to discoloration. Decreased discoloration area in live oak was associated with sprouting, but not with growth rate of the remaining lateral branch. Sprouts did not have a discernible relationship with discoloration depth. Because sprouts did not uniformly occur, one possible explanation of this effect is that a similar branch connection impact on attenuation of the discoloration column as that observed from the lateral shoots is present. Archived samples will be used and compared with the remaining branches at the next harvest interval for a shape analysis to further define these response effects.

The data would suggest that the anatomic changes at branch attachments (Sachs and Cohen 1982; Lev-Yadun and Aloni 1990), the concept of a branch protection zone (BPZ) (Gilman 2002) and the associated concept of hydraulic segmentation of the tree stem to branch (Tyree et al. 1993), which governs the natural target pruning approach (Shigo 1983) in removal pruning cuts, may also play a role in reduction pruning. The role of the internal BPZ architecture is twofold. Much as the BPZ is thought to limit ingress of decay from a removal cut, this internal structure would impact the attenuation of a discoloration zone downward from a reduction cut, thus potentially limiting discoloration depth. The ability to restrict flow into the branch may also influence the nature of discoloration and decay from trunk to branch if lateral spread of decay moves below the BPZ and into the hydraulic flow column of the remaining lateral branch (defined here as column jump), then moving upward along the pith of the lateral branch assuming the terminal leader. This column jump was observed in seven shumard oak sites and one live oak site. Column jump occurrence was not related to any parameter in the study.

If the suggested role of the BPZ in limiting reduction cut discoloration is accepted for the purpose of this study, several responses fall into place. The trunk–branch dimensioning relationships related to BPZ presence and hydraulic segmentation should follow the relationships observed in this study. Morphologic indicators such as aspect ratio and branch collars as well as the section views of the discoloration zones collaborate earlier data on the same field of live oak (Eisner 2001; Eisner et al. 2002) for hydraulic partitioning through the branch connection zone. Discoloration from removal cuts branch to stem were limited by a BPZ and in a similar manner hydraulic segmented in flow stem to branch. Three-dimensional sectioning of the remaining reduction cuts will attempt to better define and clarify the nature of decay establishment in these species.

The data do not provide any explicit validation for the current preferred target angle of reduction pruning cut. Angle of dieback was associated with the actual cut angle in both species and had little if any influence on tree growth response or discoloration. It is noteworthy, however, that discoloration in the less efficient compartmentalizing species (shumard oak) was related to cut surface, but not to cut angle, so a crosscut perpendicular to the growth axis, minimizing cut surface, may be preferred over the angle bisect method for the that species in this study.

There was no relationship between aspect ratio and discoloration in the 3 years after pruning. The data suggest that reduction cuts can be made back to lateral branches as small as one-third the diameter of the removed stem.

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Résumé. Des coupes de réduction de cime ont été employées pour l'élagage de *Quercus virginiana* (chêne vert) et de *Q. shumardii* (chêne de Shumard). La moitié des blessures d'élagage ont été récoltées et disséquées trois ans plus tard afin d'observer l'étendue de la décoloration du bois, et ce en réponse à la coupe d'élagage. Le chêne de Shumard n'a pas limité aussi efficacement la décoloration que le chêne vert. La zone de décoloration dans le bois augmentait avec la dimension de la surface de coupe chez le chêne de Shumard, mais moins chez le chêne vert. Les dissections ont montré que la forme de la zone de décoloration s'atténuait avec la profondeur. La morphologie de l'attache de la branche et la réponse (ratio branche-tronc, angle de la branche, croissance résiduelle après la coupe) sont apparues comme ayant une influence sur la patron de décoloration lors de la réduction de cime. L'angle de la coupe tel que recommandé dans la norme ANSI (selon la bissectrice...) n'avait pas d'influence sur la décoloration. La décoloration chez l'espèce à moins bonne compartimentation (chêne de Shumard) était reliée à la surface de la coupe, mais pas à l'angle de la coupe. Il n'y avait pas de relation entre le ratio branche-tronc et la décoloration dans les trois ans suivants l'élagage. Les données suggèrent que les coupes de réduction de cime peuvent être faites jusqu'à des branches latérales aussi petites que le tiers du diamètre de la branche-mère élaguée.

Zusammenfassung. Um Quercus virginiana und Quercus shumardii zu bescheiden, wurden Kronenerziehungsschnitte angewendet. Eine Hälfte der Schnittwunden wurden drei Jahre später geerntet und untersucht, um die Ausdehnung der Verfärbung in Resonanz auf die Schnittmaßnahme zu untersuchen. Die Shumard-Eiche begrenzte die Verfärbung nicht so effektiv wie die Lebenseiche. Bei der Shumard-Eiche vergrößerte sich die verfärbte Fläche im Holz sich mit der Oberfläche der Wunde. Die Querschnitte zeigten, dass die Form der verfärbten Fläche sich mit der Tiefe abschwächt. Die Morphologie der Astanbindung und Resonanz (Ast-Stamm-Verhältnis, Astwinkel, Austrieb nach dem Schnitt) schien offenbar die Verfärbungen nach der Schnittmaßnahme zu beeinflussen. Der Winkel des Rückschnitts in Relation zur ANSI empfohlenen Winkel-Methode hat nicht die Verfärbung beeinflusst. Die Verfärbung in weniger abschottenden Arten (Shumard-Eiche) wurde in Beziehung gesetzt zur Schnittfläche, aber nicht zum Schnittwinkel. Es gab keine Beziehungen zwischen dem Aspektverhältnis und der Verfärbung in den drei Jahren nach dem Rückschnitt. Die Daten ergaben, dass die Rückschnitte bis hin zu lateralen Ästen mit ca. einem Drittel Durchmesser der entfernten Stämme durchgeführt werden können.

Resumen. Las cortas de reducción fueron usadas para podar los encinos *Quercus virginiana* (encino virginiana) y *Quercus Shumardii* (encino Shumard). La mitad de las heridas de las podas fueron cosechadas y disectadas tres años después para observar la extensión de la decoloración en respuesta a la corta de poda. El encino Shumard no limitó la decoloración tan efectivamente como lo hizo el encino virginiana. El área decolorada en la madera se incrementó con el tamaño de superficie de corta podada en el encino Shumard, fue menos en encino de virginia. Las disecciones mostraron que la forma del área decolorada se atenuó con la profundidad. La morfología de la conexión a la rama y la respuesta (razón rama-tronco, ángulo de la rama, liberación del crecimiento después de la poda) pareció influenciar el patrón de decoloración en la reducción de la poda. El ángulo de la reducción de la corta relativo al ángulo recomendado ANSI no se encontró que influya en la decoloración. La decoloración en la especie menos eficiente en la compartimentación (encino Shumard) estuvo relacionada a la superficie del área de corta, pero no al ángulo de corta. No hubo relación entre la relación rama-tronco y la decoloración en los tres años siguientes a la poda. Los datos sugieren que las cortas de reducción pueden ser hechas atrás de las ramas laterales y de 1/3 de del diámetro del tallo a ser removido.