VT ANR Management Guidelines for Optimizing Mast Yields in Beech Mast Production Areas

Photo: Nick Fortin - VT ANR

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David Houston, a national expert on beech bark disease, exhibits a disease resistant American beech at a VT ANR beech management workshop in 2006.

Note: The recommendations in this document are intended for public land managers to apply to beech mast production areas as part of Long Range Management Planning for public lands. However, the recommendations are readily adaptable to private forest land as well. Because the guidelines are based upon principles of silviculture, forest pathology, and wildlife habitat management, landowners must seek the assistance of a wildlife habitat or forestry professional for proper application of the technical recommendations.

The guidelines in this document include compromises which balance several interests in forest resource management and utilization. The prescriptions are not ideal forestry practices for timber production, nor are they perfect for wildlife, or for forest pathogen management. Rather, the guidelines outline an approach to use active management to benefit all 3 interests (better timber quality for all tree species, improved beech mast production, and genetic selection for beech bark disease resistance) compared to the "passive management" approach of refraining from any vegetation treatments in beech areas with evidence of black bear feeding.

This document is not intended for use in identification or designation of clusters of beech trees as "significant and necessary wildlife habitat" as defined in 10 V.S.A Chapter 150 (Vermont Act 250 statute), nor is it intended to supersede or nullify any provisions or requirements prescribed under Act 250 or under 30 V.S.A. § 248. The guidelines are derived from synthesizing publications and personal communications available as of February 8, 2011.

VT ANR Management Guidelines for Optimizing Mast Yields in Beech Mast Production Areas

American beech (*Fagus grandifolia*) mast is widely recognized as providing significant resources for black bear, white-tailed deer, American marten (Jakubas et. al. 2005), fisher (Brown and Will 1979), wild turkey, ruffed grouse, and many small mammal and passerine species. Beechnuts have about the same protein content as corn but 5 times the fat content (Elowe and Dodge 1989). Compared to acorns, beechnuts have nearly twice as much crude protein (dry weight), and twice the fat of white oak acorns and about the same fat content as red oak acorns as reported by Serveillo and Kirkpatrick (1989). The special importance of beech mast for black bear reproduction has been well documented. "In northern Maine, 22% of the female black bears that were reproductively available reproduced following falls when beechnut production was poor. The proportion of reproducing females increased ($P < 0.001$) to 80% following falls when beechnut production was high." (Jakubas et. al. 2005) This effect is most pronounced in areas where beechnuts constitute a large proportion of the fall diet, and alternate food sources are scarce. In the north half of Vermont, beech is the predominant mast species, and the only source of hard mast in the northeastern region of the state. Black bears exhibit fidelity to beech mast production areas, feeding in them year after year when mast is abundant. Clusters of mast bearing beech which are remote from human developments are particularly important feeding areas, so maintaining connectivity to such areas is a vital element of maintaining habitat for a viable black bear population. Clusters of beech exhibiting significant levels of bear feeding activity are afforded legal protections under Act 250 and Act 248 in Vermont.

Beech Bark Disease (BBD), a disease complex caused by invasive species not native to North America, had spread throughout Vermont by the 1960's. It has been shown to significantly reduce beechnut production on large trees (Costello 1992 *in* Faison and Houston 2004). As noted by Faison and Houston (2004), "Beech mortality in Vermont from BBD was reported to be as high as 30% by the early 1980s (Miller-Weeks 1982), suggesting that beech mast availability in Vermont has been greatly reduced in the past several decades by the effects of this disease (Castello et al. 1995, Magasi and Newell 1982)." Costello (1992) formulated a model to calculate beechnut production for individual trees, and estimated that beechnut production in a non-managed stand in New York's Adirondacks has been reduced by 37% since 1948 as a result of BBD. However, research by Koch et. al. (2010) suggests that "silvicultural treatments may provide an effective management option for mitigating beech bark disease through managing the genetic composition of natural regeneration."

Aftermath Forest refers to stands that have experienced the first wave of beech mortality. These stands typically have lower populations of beech scale than during the initial stages of infestation (Advancing Front and Killing Front). Beech trees in the Aftermath Forest are mostly defective and many are at risk of declining. Some large trees remain – some of which simply escaped scale infestation or Nectria infection, but some are at least partially resistant to BBD. All of Vermont is considered to be Aftermath Forest. While it's true that beech mast production in the Aftermath Forest of Vermont is probably significantly lower than it was pre-BBD, beech stands and inclusions continue to supply a highly significant mast resource for black bears and other wildlife – at a reduced level of productivity - after 50 years of BBD in the state. The final Aftermath Forest phase results in an ecological accommodation of the disease, and when there are few other stressors acting on the beech, the trees can live for many years with sub-lethal Nectria infections (U.S. Forest Service website 2010). Costello (1992) monitored seed production on trees in different stages of disease and found that it dropped significantly only after trees became infected by Nectria sp. and had lost more than 25% of their crown (*in* Houston 2005). A very small percentage of beech have smooth bark without *any* evidence of BBD. Such trees are considered "Resistant (**R**)" to BBD (Burns and Houston 1987). Some trees are "partially resistant" to BBD; although they are infested by beech scale insects, they never build large populations and remain relatively free of damage (Burns and Houston 1987). In a Vermont study Faison and Houston (2004) investigated the relationship between bear foraging preferences and the severity of BBD in the Aftermath Forest. They found no significant relationship between bear feeding activity (freshly clawed and un-clawed trees) and the severity of Nectria fungus and beech scale, suggesting that bears do not have a strong preference for climbing healthier trees. This suggests that in addition to being a seed source for resistant progeny, partially resistant beech may continue to produce significant mast highly valued by bears and other wildlife for decades. McNulty and Masters (2005) studied beechnut production for 8 years in Adirondack beech with a 40 year history of BBD. They found a 2 year masting cycle, and beechnut production actually *increased* during the study period. These studies indicate that the assumption of continued decline of mast production may be incorrect; therefore the wholesale removal of diseased trees is unwarranted, and may be detrimental to beech mast production for wildlife.

In New England, recent approaches to management of beech stands with signs of bear feeding activity have varied from refraining from any type of harvesting or silvicultural practices in order to avoid adverse impacts to mast trees, to the opposite extreme of removal of all but completely smooth barked, disease free trees that are apparently resistant to BBD. Although beech has never been a highly desirable timber species, the further decline of beech for timber products due to BBD defects (see Burns and Houston 1987) often results in discrimination against beech in favor of higher value sugar maple. Discrimination continues even though long-term monitoring indicates that, when silviculture targets poor quality beech, overall beech condition in the stand will improve (Leak 2006).

Combined with the mast decrease caused by BBD, this discrimination against beech on timberland elevates the importance of active management for beech mast production wherever possible, including on public lands. These guidelines were developed based upon review of the most current literature on BBD, and in consultation with numerous resource managers. Experts in the fields of forest pathology, forestry, and wildlife biology from several agencies including the U.S. Forest Service, U.S. Fish and Wildlife Service, USDA Natural Resources Conservation Service, Vermont Agency of Natural Resources, New York Department of Environmental Conservation, New Hampshire Fish and Game, and Maine Forest Service have reviewed drafts and/or provided recommendations.

Purpose:

1. To define the term *Beech Mast Production Area* (BMPA) as applied to ANR lands for identification, mapping, planning and management.
2. To optimize long-term mast yields and minimize the impacts of BBD on BMPA's on ANR lands through active management.

Strategies:

1. Optimum beech silviculture via uneven-aged management.
2. Crown release of mast trees and healthy beech regeneration.
3. BBD management; a) genetic selection for resistance, b) injury prevention, and c) crown release to enhance tree vigor, bark thickness, and wound closure.

Definitions:

The term “stand” is often misused in discussions of forest characteristics. In strict forestry terms, most BMPA’s are not beech stands. For the purposes of VT ANR lands planning and management, the following definitions are provided to clarify semantics among ANR staff:

Stand is an area of at least 5-10 acres (depending upon management intensity and ownership size) of a certain tree species composition (cover type), age class or size class distribution and condition (quality, vigor, risk) usually growing on a fairly homogeneous site. A beech stand must have 80% of it’s stocking in beech to be called a “beech stand”. Stands with less than 80% stocking in beech are mixed stands (e.g. northern hardwood stand) with species listed in descending order, i.e. a 60% sugar maple, 30% beech, 10% yellow birch stand would be termed a sugar maple-beech-yellow birch stand.

Inclusion is defined as a discernible change in tree species composition, age, or size class distribution clustered within a stand, generally less than five (5) acres in size.
Clusters of American beech (*Fagus grandifolia*) exhibiting significant signs of bear feeding activity may be found in either beech stands or beech inclusions. In most cases, a Beech Mast Production Area is comprised of one or more beech inclusions within a larger northern hardwood mixed stand.

Beech Mast Inclusion (BMI)is defined as a discernible area within a stand with a minimum density of at least 1 American beech tree ≥ 10 inches dbh per acre exhibiting signs of black bear feeding activity (historic or recent clawing scars or feeding limb “nests”), generally less than five (5) acres in size but potentially much larger.

Beech Mast Production Area (BMPA) is defined as at least 15 acres comprised of a single *Beech Mast Inclusion,* or several BMIs clustered within close proximity of each other, intensively managed for beech mast production as a single unit.

Beech Bark Disease (BBD) is a pathogen complex affecting American beech that includes both insect (exotic beech scale) and fungal (Nectria) components. The fungus infects the tree after infestation by the scale insects, presumably through feeding wounds made by the scale. Heavy Nectria infection weakens the tree, often resulting in its eventual death by girdling, or by damage caused by additional pathogens. See Appendix A: Visual Evidence of Beech Bark Disease.

Aftermath Forest refers to stands that have experienced the first wave of beech mortality. These stands typically have lower populations of beech scale than during the initial stages of infestation (Advancing Front and Killing Front). Aftermath Forest beech are mostly defective and many are at risk of declining. Some large trees remain – some of which simply escaped scale infestation or Nectria infection, but some are at least partially resistant to BBD. All of Vermont is considered Aftermath Forest.

Crop Tree in these guidelines refers to beech ≥ 6” dbh that will be retained for their potential or demonstrated BBD resistance or tolerance, and tendency for high mast yield, or BBD resistant or tolerant progeny. There is no maximum age or diameter for crop trees; the crop is beech *mast*, so trees are retained indefinitely as long as they meet retention criteria in the guidelines.

Guard Tree is a co-dominant tree or group of trees of any species retained to provide shade on the south side of the bole of a beech retained for mast production (crop tree).

Sun Scald is localized injury to bark and cambium caused by freezing following warming by the sun in late winter or early spring. Rapid temperature fluctuations injure the side of the stem exposed to midday and afternoon sun, often resulting in wounds or cankers. Smooth, thin barked trees such as beech are highly susceptible to sunscald injury, which can become a site for decay or BBD infection.

Crown Release is removal of cull and less desirable trees to release the crown of a crop tree from competition for space.

Beech Mast Trees Respond to Crown Release

Faison and Houston (2004) noted that Costello (1992) found a strong positive relationship between beech tree size and nut production, and research indicates that even sawtimber size beech trees respond to release. Smith and Miller (1991) found that 75-80 year-old beech grew 1.5 inches dbh during 5 years following release, and Perky and Wilkins (2001) cite references noting that "Heavily released sawtimber-size beech trees have grown 3.0 inches per decade compared to 1.4 inches per decade for unreleased trees.", and "Trees with vigorous crowns respond well to release." (Perky and Wilkins. 2001). Crown size relative to dbh and crown position are important factors affecting mast production, and the greatest mast production in a stand comes from dominant and co-dominant trees. "Removing trees with small sparse crowns allows trees with large, healthy crowns to expand and produce more mast. One large, released crown produces more mast than two or three small crowns on trees of the same species." (Perky et. al. 1994). The optimum seed bearing age is 60+ years (Tubbs and Houston 1990), and the trees can live for 300-400 years (Perky and Wilkins 2001).

Evidence of BBD

Many visual indicators can help identify trees affected by beech bark disease. (Appendix A). These include diagnostic bark injuries, crown condition, and presence of the causal agents. When looking for injuries and causal agents, inspect both the mainstem and the branches.

Burns and Houston (1987) separate BBD bark injuries into 4 different types: 1. Raised lesions, 2. Sunken lesions, 3. Blocky bark, 4. Dead bark.

Raised lesions and blocky bark indicate that the tree has successfully walled off Nectria infection (Burns and Houston 1987). Trees with these injury types are considered "Tolerant" (**T**) of BBD.

Trees with sunken lesions and dead bark are considered "Susceptible" (**S**) to BBD. If the damage is extensive, they have a high probability of continued decline, decay, mortality, or wind snap. At minimum they will be less vigorous mast producers. Damage severity is evaluated as percent of the circumference affected. When > 20% of the circumference is affected, within a 3 foot vertical band around the trunk, wounds to the cambium are likely to impact tree health (Figure 1).

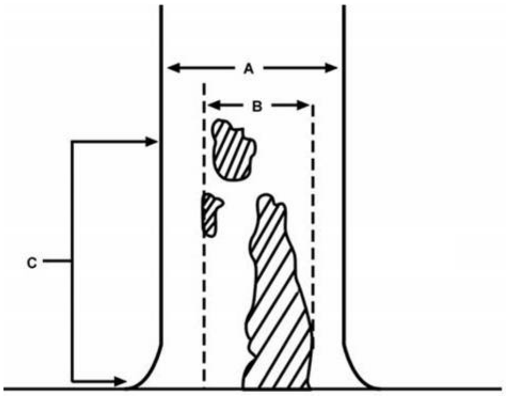

Figure 1. Damage severity is evaluated as a percent of the circumference affected. A=approximately 40% of tree circumference (% visible from one face); B=portion of tree circumference affected by damage; C=vertical distance within three feet (U.S. Forest Service, 2007).

Crown condition is also an indicator of tree vigor relative to BBD infection. Dead limbs and/or yellow leaves in summer indicate reduced vigor (Appendix A Figure 1). Trees with >10% dead or yellow crown have an elevated risk of mortality (Kelley et al. 2002). When over half the crown is affected, the risk of mortality exceeds 50%. These trees are also considered "Susceptible (**S**)" to BBD. When evaluating the percent of crown affected, large "snag" branches without small twigs and with the bark absent or peeling away are not included. These are assumed to have died earlier, and are not a good indicator of current health.

The presence of causal agents, the beech scale insect or Nectria fungus, indicates a tree where the disease complex is active. Recently infested trees may not yet have bark defects or crown symptoms.

The white woolly beech scale may be uniformly distributed on the bark, or limited to bark cracks and other irregularities. Trees with beech scale, but no other evidence of BBD, may be Tolerant (**T**) or Susceptible (**S**).

After bark is infected by the Nectria fungus, small red fruiting structures may be visible distributed on the bark face, or occurring in small oval patches. If oval patches dotted with ruptured bark are observed, these are scars of previous Nectria fruiting. Trees with evidence of Nectria fruiting, but not other evidence of BBD, may be Tolerant (**T**) or Susceptible (**S**).

A very small percentage of large beech have smooth bark without *any* evidence of BBD bark defect or causal organisms. Such trees are considered "Resistant" (**R**) to BBD (Appendix B. Fig. 6). If trees < 10" dbh are smooth barked, they may not have been challenged by BBD and are, by default, "**R**esistance **U**nknown" (Appendix B Figure 7).

<u>Evidence of Mast Potential</u>

Some beech trees are much more prolific mast producers than others. Bears seek out trees that produce significant quantities of mast and climb them to feed on nuts by breaking limbs inward toward the bole. Limbs are sometimes amassed into a "bear nest" and left as a visible indicator of feeding that can persist in the tree for over a year (Figure 2 and 3).

Toby Alexander – USDA-NRCS

Figure 2. Bear “nest” created by bear feeding on beechnuts.

Toby Alexander – USDA-NRCS

Figure 3. Signs of bears feeding in beech can persist for several years.

Trees that have been climbed repeatedly exhibit scratches and dot-like claw marks that are readily visible in the smooth bark of beech.   Bear claw scar marks start as very thin, light brown or green scratches (Figure 4a). The marks become more visible over years as the scars widen with the bark and darken as the tree ages (Figure 4b). For this reason small diameter "potential" mast trees must be examined very closely to assess mast potential; claw marks on trees climbed for the first time, and evidence of recent climbing, will only be visible upon very close inspection within 2-3 feet of the tree bole.

John Austin – VT ANR Photo.

Figure 4a. Fresh bear claw marks on Am. beech.

Paul Hamelin – VT ANR Photo.

Figure 4b. Old bear claw "dot scars".

Note: Individual claw marks that are not scratches will form "dot" scars. Do not misinterpret them to be small raised lesions caused by BBD on otherwise smooth-barked trees. Look for the distinctive 4-claw or 5-claw pattern of dots mixed with scratches (Appendix B Figure 4). Unfortunately, the injury caused by bear scars provides a potential site for BBD infection.

Both Faison and Houston (2004) and Zapisocki et. al. (1998) found that the minimum size beech that bears will climb is about 8" dbh, which is also the minimum size at which researchers are reasonably sure the trees are resistant to BBD (Houston 1983). These guidelines apply a conservative approach by setting the minimum threshold for evidence of high mast yield and BBD resistance at 10"dbh in order to ensure that the trees have had sufficient time to be exposed to BBD, and to mature to produce enough mast to attract a feeding bear.

Trees ≥10" dbh are considered **G**ood **M**ast (**GM**) producers if they exhibit any bear scars, nests, or other evidence of being climbed at least once. They are considered **P**oor **M**ast (**PM**) producers if they are not bear scarred. Trees not yet of significant mast producing age to have a history of being climbed (<10" dbh) are considered "**M**ast **U**nknown" (**MU**).

<u>Guideline Assumptions:</u>

1. The BMPA is within the home range of a viable population of black bears.

2. Bear claw scarring on the bole of each tree provides a continuous, permanent record of its mast production capacity; claw scarring is a reliable indicator of trees with the highest historic and future tendency for good mast production.

3. Crown size and condition are positively correlated with mast production capacity.

4. When selecting trees to retain or remove:
   a) Crown & bole condition can be used to assess tree health, and...
   b) Presence/absence of bear claw scarring can be accurately identified as an indicator of mast tendency.

BMPA MANAGEMENT GUIDELINES

A. Map BMPA with GPS, create GIS shapefile for Long Range Management Planning.

B. Use GPS to establish and map a 200' wide uneven-aged buffer zone around BMPA. Do not implement clearcuts within 200 feet of perimeter crop trees in a BMPA. This buffer width is prescribed to maintain shade to prevent winter injury to beech crop trees. In Vermont in late December the noon sun angle is about 22^0 above the horizon, allowing sun to penetrate approximately 200 feet into a stand of 80 ft. tall hardwoods. Winter shade may reduce injury and mortality of young and mature beech due to *sunscald* injuries, and summer shade retention favors beech regeneration over less tolerant species. Beech exposed to excessive sun eventually die (Ostrofsky 2005).

Exception: clearcuts on the north side of BMPA may be applied with discretion.

C. Apply uneven-aged management to the BMPA and a buffer 200 feet around it. In some cases other silvicultural systems which meet the objective to maintain shade may be applied (for example extended shelterwood) in combination with adjustments for local topography (slopes, tall conifers adjacent to the BMA, etc.)

D. Limit/restrict vehicle access to BMPA, especially in September and October.

Treatments:

A. Identify Mast Crop Trees for retention: Conduct work in summer to allow assessment of percent live crown. Circle trunk of crop trees with highly visible (pink) flagging. Mark location of each crop tree as a GPS point. Use aluminum nail to tag permanently with a numbered aluminum tag below stump height, leaving nail protruding 3 inches. DO NOT paint trees, it causes injury & disease.

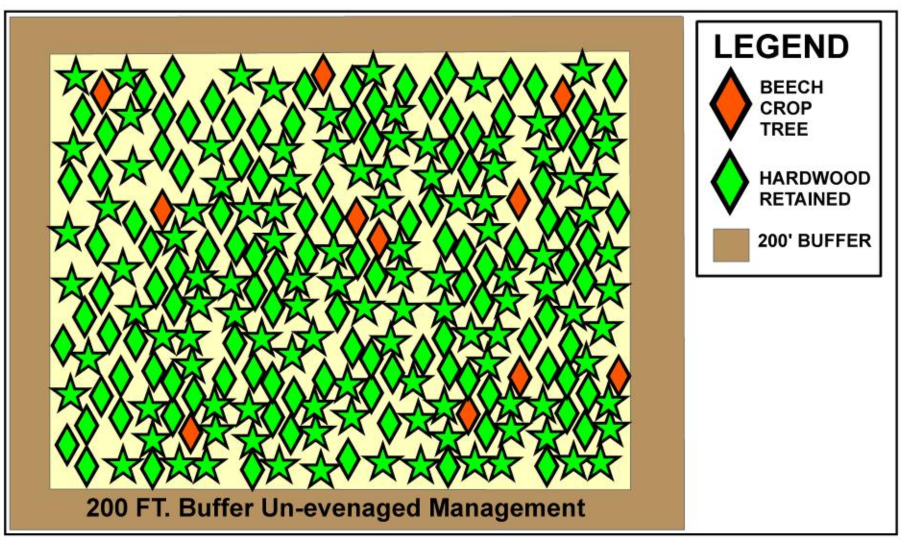

Figure 5. Identify mast crop trees for retention.

Select Beech Crop Trees in the following priority:

1. **<u>R-GM</u>**: **R**esistant to BBD, **G**ood **M**ast producer, "super-beech" of the BMPA. Large crown beech ≥ 10" dbh **<u>with</u>** <u>bear claw scarring</u>. Smooth bark, without any evidence of beech bark disease defects, scale, or Nectria; <10% of branches yellow or recently dead (Appendix B Figure 6),

2. **<u>T-GM:</u>** **T**olerant to scale/BBD, they repeatedly wall-off and cope with BBD, **and** produce **G**ood **M**ast while persisting in the BMPA (at least until next stand entry). Large crown beech ≥ 10" dbh **<u>with</u>** <u>bear claw scarring</u>. Trees with some smooth bark but with raised lesions (Appendix A Figure 11) and/or blocky bark (Appendix A Figure 7), or evidence of beech scale (Appendix A Figures 8 & 10); <20% of the circumference is affected by injuries which affect the cambium; <10% of branches yellow or recently dead. (Appendix B Figure 4).

3. **<u>R-PM</u>**: **R**esistant to scale, but **P**oor **M**ast producers - the 2-5% of ultra-smooth barked, disease free trees ≥ 10" dbh **<u>without</u>** <u>bear claw scarring</u>, desirable to retain for their contribution to resistance in the population via sexual reproduction. Smooth bark, without any evidence of beech bark disease defects, scale, or Nectria; <10% of branches yellow or recently dead (Appendix B Figure 6).

4. **<u>RU-MU:</u>** "**R**esistance **U**nknown - **M**ast **U**nknown" potentially resistant or tolerant future crop trees. Smooth barked, non-climbed <u>broad</u> <u>crown</u> beech 6-10" dbh, <10% of branches yellow or recently dead (Appendix A Figure 9, Appendix B Figure. 7.)

B. Mark to release crowns of crop trees from competition by crown-thinning on 3 sides (W-N-E). <u>Retain "guard trees"</u> (any species) for shade/ sun-scald protection on south side. To release crop trees mark to remove:

1. Beech trees that are BBD **S**usceptible (e.g. with extensive sunken lesions, dead bark patches, or > 50% yellow or recently dead crown).

2. Beech trees that are BBD **T**olerant but **P**oor **M**ast producers (with no bear scarring – Appendix B Figure 3).

3. Any beech trees ≥ 6" dbh with <u>*poor crown development*</u> or <u>*severe "wind snap" defect*</u> (Appendix B Fig. 8)

4. Other tree species ≥ 6" dbh which will release crop trees on 3 sides. See *Treatments: D*. regarding option to girdle <u>species other than beech</u>.

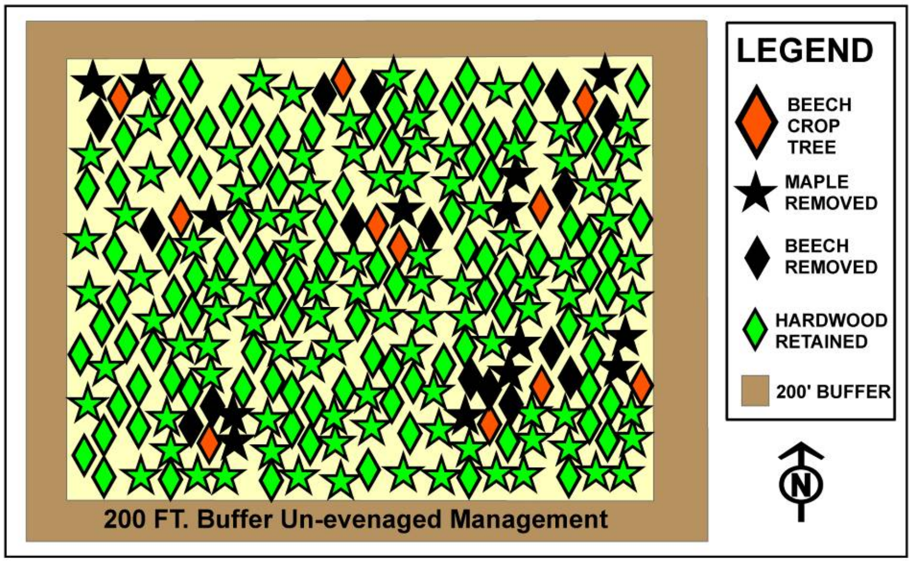

Figure 6. Mark to release crowns of crop trees on 3 sides (not south); retention of guard trees on SE, S, and SW aspects may adjusted for local topography.

C. In areas of the BMPA devoid of crop trees, single-tree and ½ acre group selection may be used to encourage crown development on healthy trees and to encourage regeneration. Maintain minimum residual basal area above minimum acceptable stocking according to uneven-aged management recommendations in *Silvicultural Guide for Northern Hardwood Types in the Northeast (revised)* (Leak et. al. 1987), as indicated in Table 1. **Where there is evidence of bear activity** on beech in these non-crop treatment areas**,** remove only beech with >50% of the branches yellow or recently dead, which have a high risk of mortality.

Table 1. Minimum acceptable stocking for un-evenaged northern hardwood stand.

	6-10” dbh	12-14” dbh	16+” dbh	Totals
BA/acre	30 sq. ft.	20 sq. ft.	20 sq. ft.	70 sq. ft.

D. Conduct operations in winter conditions, (frozen ground or > 12”snow) to minimize injury to beech roots and boles. Harvest with tracked equipment if feasible. Root injury stimulates regeneration of BBD-susceptible beech via root suckering (undesirable) (Houston 2001). Early winter harvest is best, some data indicate Nov.-Dec. root injuries sprout less than late winter. Minimize bole injuries, which stress mast producers and may provide sites for scale colonization.

SPECIES OTHER THAN BEECH may be girdled (instead of felled) to avoid damage to crop trees or regeneration where applicable. Paint “X” for double chainsaw girdle. DO NOT girdle near power lines, roads/trails, structures, campsites, or other potential hazard areas. DO NOT girdle beech – it will regenerate via sprouting before it dies.

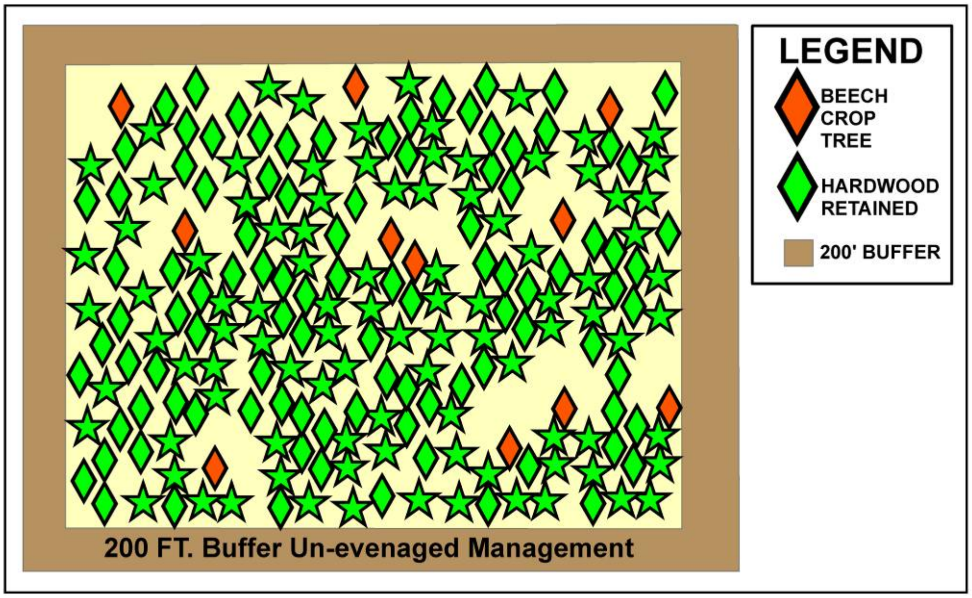

Figure 7. Crop trees (mast producers and/or BBD resistant trees) crown-released. Intermediate thinning of all species in BMPA, and ½ acre group selection cuts not illustrated.

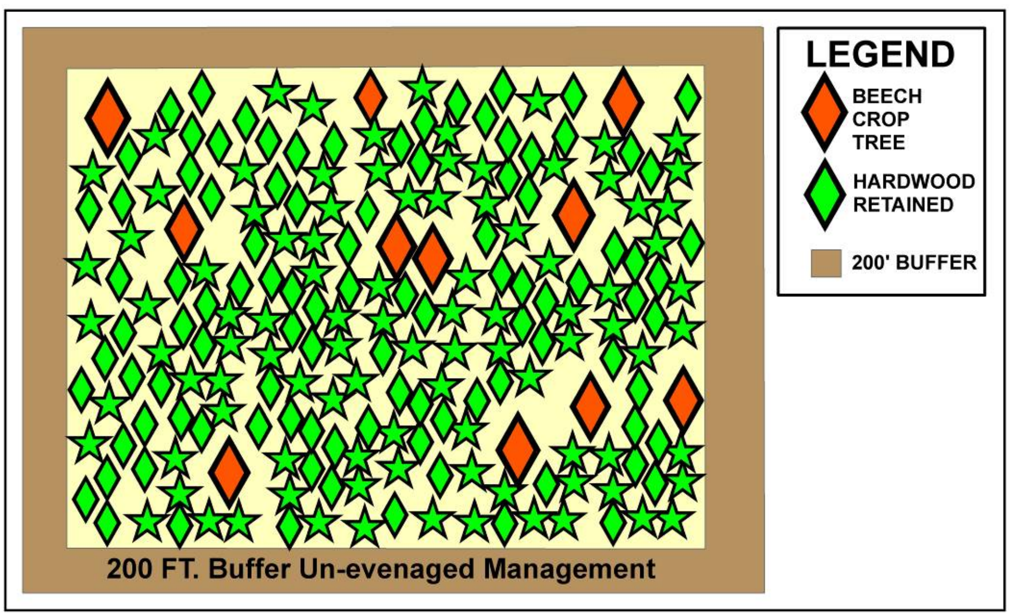

Figure 8. Mature crown-released beech respond with increased crowns and mast production.

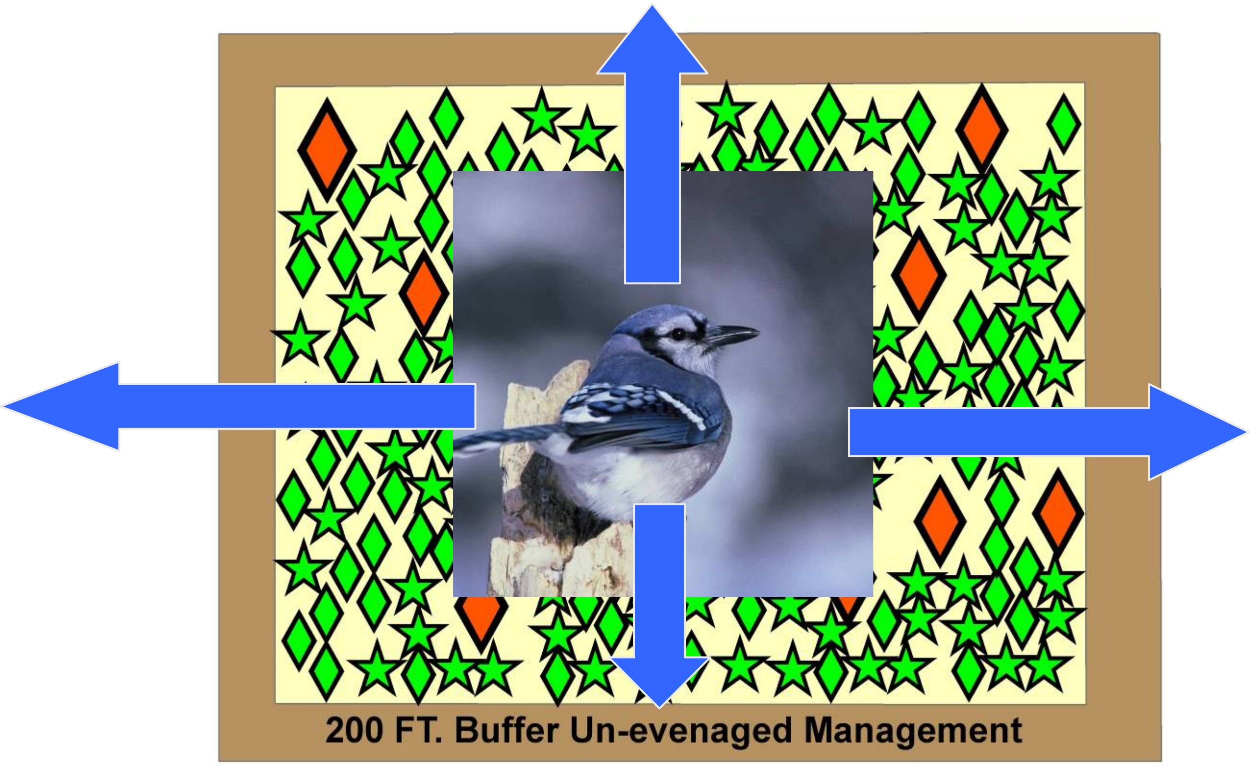

Figure 9. Blue-jays transport and bury large amounts of seed miles from parent trees.

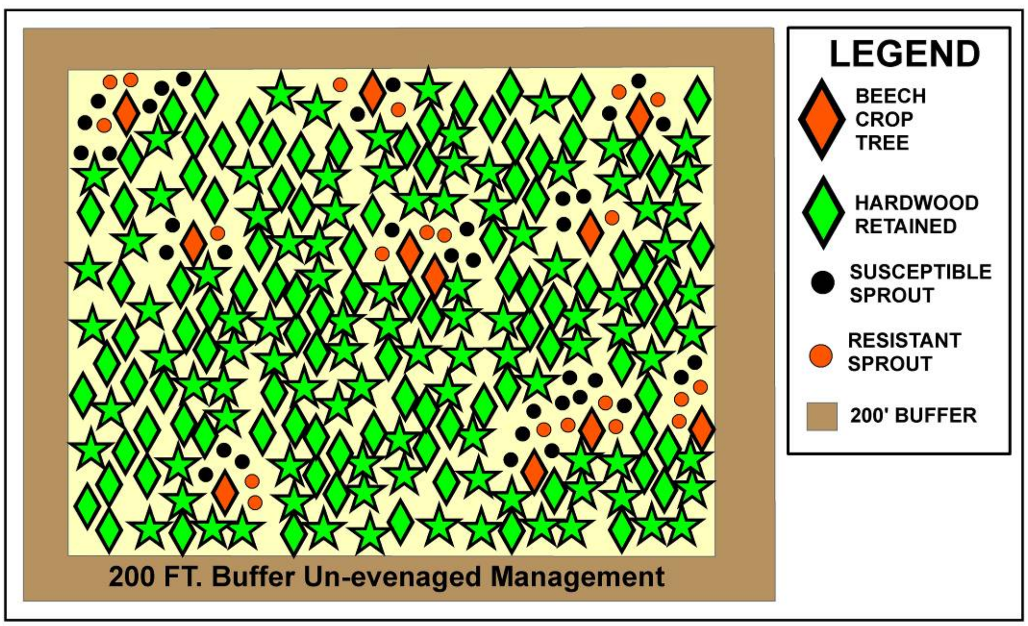

Figure 10. BBD susceptible, resistant, and tolerant trees produce sprouts.

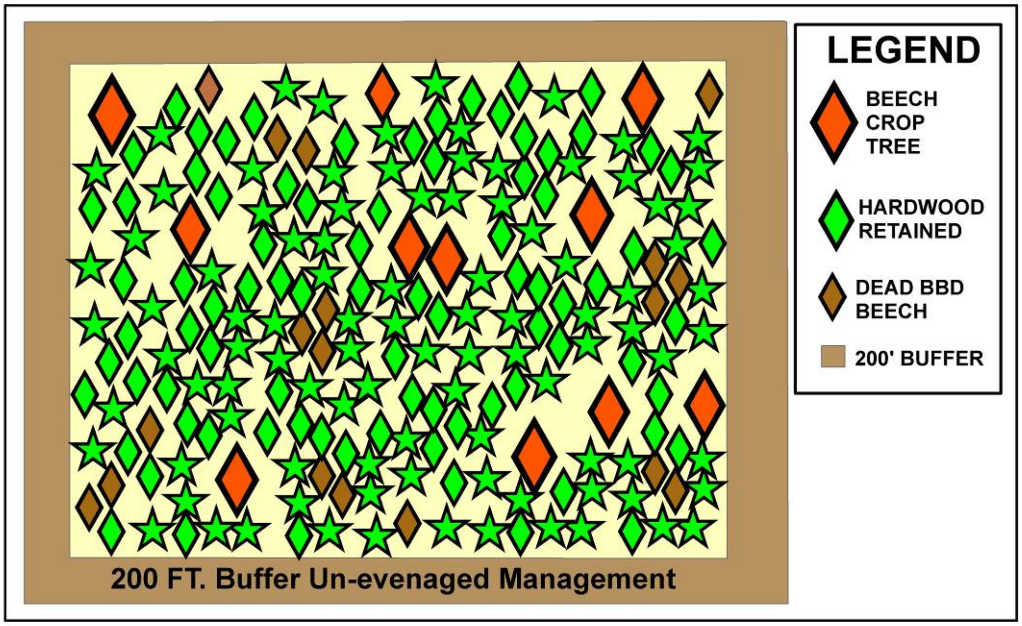

Figure 11. Mature BBD trees die, creating new canopy gaps.

E. Revisit BMPA every 10-15 years to identify Crop Trees exhibiting signs of excessive BBD, and identify new crop tree recruits > 6” to < 10” dbh.

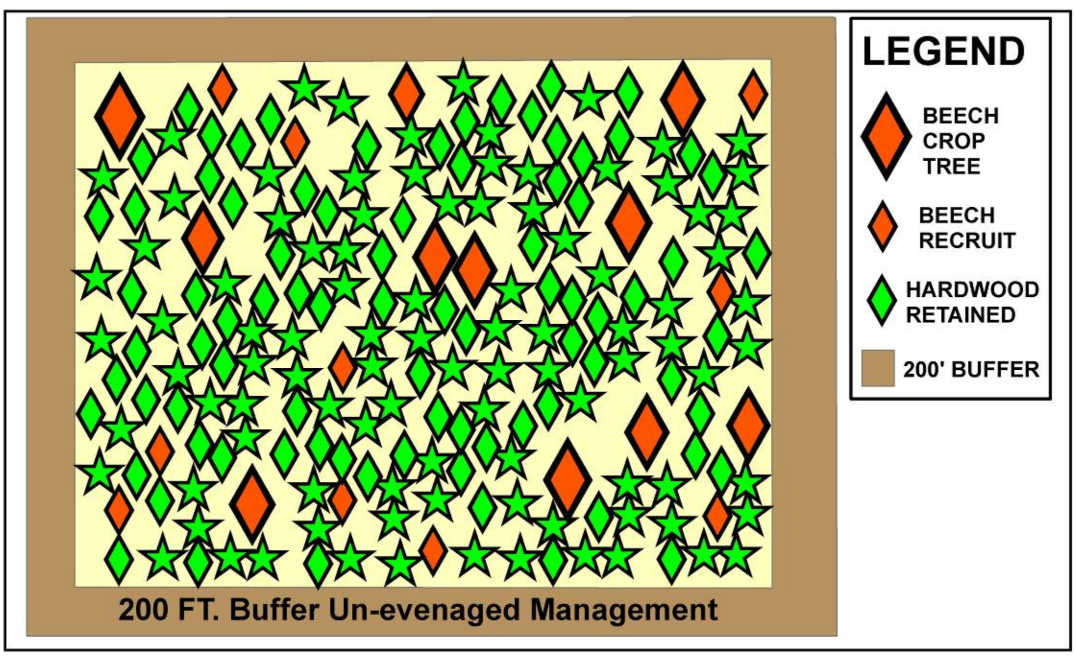

Figure12. Identify new crop tree recruits (small ) every 10-15 years.

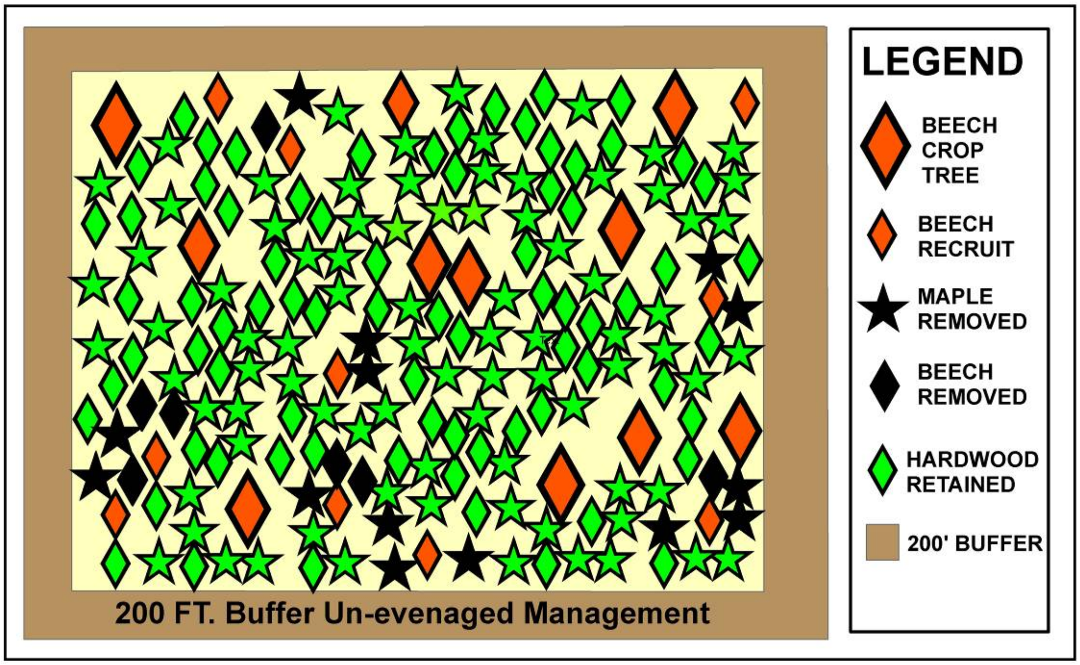

Figure13. Apply crop tree criteria to release new recruits.

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Appendix A. Visual Evidence of Beech Bark Disease

Figure 1. On dying trees, leaves that emerge in the spring may not mature, giving the crowns a thin, open appearance, OR the leaves may turn bright yellow in mid- summer. **Trees with > 10% yellow- or recently dead crown are at higher risk of mortality, > 50% is BBD Susceptible.** US Forest Service (USFS) Photo.

Figure 2. Extensive areas of bark reddened by Nectria fruiting bodies. Recently infested trees may not have other bark symptoms. Trees may be BBD **Susceptible or Tolerant.** USFS Photo.

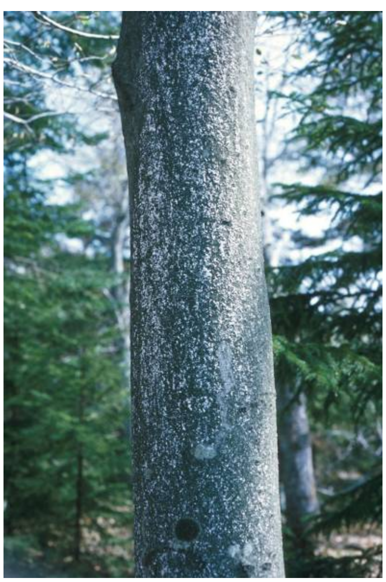

Figure 3. Heavy infestations of beech scale can cover tree boles with white wax. Recently infested trees may not have other bark symptoms. Trees may be BBD **Susceptible or Tolerant.** Ron Kelly-VTANR Photo.

Figure 4. Sexual fruiting bodies (perithecia) of *Nectria coccinea var. faginata* appear in the fall. (magnified) USFS Photo.

Figure 5**. "Wind snap"** occurs when wind breaks off the tree where wood borers and decay fungi weaken the wood beneath scale-Nectria-killed bark. Joseph O'Brien, USDA Forest Service, Bugwood.org.

Figure 6. **Dead bark** and decay are obvious BBD indicators that the tree is **Susceptible**. USFS Photo.

Figure 7. **Blocky bark** indicates that Nectria was walled off before the cambium could be infected. Trees with extensive blocky bark (above) may be considered BBD **Tolerant** if < 10% of the crown is yellow or recently dead. Barbara Burns-VTANR photo.

Figure 8. Wool-like white wax on beech scale insects in crevices and rough areas. Trees with scattered raised lesions and a healthy crown are considered **Tolerant**. Ron Kelly-VTANR Photo.

Figure 9. Beech scales first become established on rough areas of the bark, such as old branch stubs. At this stage, ***smooth- barked*** trees ≤ 10" dbh with minor infestations may be Tolerant or Susceptible. MI State Univ. Ext. photo.

Figure 10. Heavy infestation of beech scale insects, covered with wool-like wax. Bark defects are absent because the infestation is recent. Natural Resources Canada photo.

Figure 11. **Raised lesions** typical of Nectria infestation. Trees with only raised lesions are considered **Tolerant.** Ron Kelly-VTANR Photo

Figure 12. **Sunken lesions** appear as holes into the cambium. Nearly 100% of the circumference visible from this face is affected. Tree is BBD **Susceptible**. Ron Kelly-VTANR Photo

Appendix B. Visual Indicators of BBD Susceptibility and Mast Production

Figure 1. BBD **S**usceptible (sunken lesions) **P**oor **M**ast producing beech **(S-PM)**.

Figure 2. BBD **Tolerant** (raised lesions and blocky bark) **G**ood **M**ast producer **(T-GM). Crop Tree**

Figure 3. BBD **T**olerant (scattered raised lesions) **P**oor **M**ast producer (**T-PM).**

Figure 4. BBD **T**olerant (smooth bark, very few, small raised lesions – most "dots" are individual *claw scars*) **G**ood **M**ast producer = **(T-GM). Crop Tree.**

Figure 5. BBD **R**esistant **G**ood **M**ast producer; note small bear claw "dot scars" in box, not to be confused with BBD raised lesions **(R-GM). Crop Tree**.

Figure 6. BBD **R**esistant **P**oor **M**ast producer **(R-PM). Crop Tree.**

Figure 7. **R**esistance and **M**ast **U**nknown   6" to <10" dbh healthy beech **(RU-MU). Crop Tree.**

Figure 8. Defect indicates decay, increasing beech susceptibility to "wind snap".

Figure 9. Sun scald caused bark mortality on south side of exposed beech. Avoid exposing beech crop trees to south sun exposure.
Photo: Joseph O'Brien, USDA Forest Service, Bugwood.org

Photos by Paul Hamelin, VT Fish & Wildlife Department except as noted.