Bottomland Hardwoods

Bottomland hardwoods (BLH) are basically wet, floodplain forests that are subject to regular seasonal flooding events. Under the USFWS wetlands classification, BLH are in the palustrine system, forested class, and either the broad-leaved or needle-leaved deciduous subclasses (Cowardin et al, 1979). Like all wetland ecosystems, hydrology is the driving factor of a bottomland hardwood. The distribution of bottomland tree species across a site is determined by individual species' tolerance of certain hydrologic regimes (as defined by very small topographical changes in the landscape). Thus, a complete understanding of the hydrology (existing and/or target) is essential for species selection and individual seed/sapling placement across the site.

Due to these considerations, any bank approaching the MBRT with a potential BLH restoration must provide a detailed hydrologic study of the site. This study must have been conducted over a time period of at least one year and will preferably encompass two separate, but successive, flood seasons. Any plans to manipulate or maintain hydrology will be included in the Mitigation Bank Instrument (MBI).

The relatively slow growth rate of many hardwood trees means that it may take 70-100 years for a mature BLH to fully develop. While some species (cottonwood, sycamore) may reach 30' or more in height in 5 years, others (oak, hickory) may only reach 5'-7' in the same time. In addition, the average age of reproductive maturity of most BLH tree species is 20-25 years. For these reasons it is necessary to hold the bank for a relatively long period of time to assure success before final credit release. However, it is impractical (and impossible) to hold the bank until functional maturity, and is probably unnecessary to hold it until reproductive viability. While preferring a minimum of 15 years before release, we recognize the difficulty this time period presents the banker and will work towards a 10-year full credit release schedule. However, credit releases are based on reaching specific success criteria and will not be granted on a per annum or time demarcated basis. Thus, the years a bank has been in development in no way reflects the amounts of credits released.

Note: While reference sites are necessary and will be helpful in setting overall goals for the restoration project, choosing appropriate species for the project should not be based upon reference site conditions, but upon the final target hydrology of the site being restored . This may not necessarily match historic conditions on the site, but will provide for the highest probability of success. (See **Target Forest Type - TFT**)

Bottomland Hardwood Success Criteria – 10 year

1. Site preparation

- Removal of exotics/invasives, and/or inappropriate or competing species
- Elimination of impediments to desired hydrology* (removal of roads or berms, filling of ditches, ruts, etc.).
- Establishment/acceptance of Target Forest Type (TFT) (modified from White et al. 1990)

2. Development of hydrology* (continuation of site preparation)

- Construction of final earthworks (establishment of micro-topography)
- Installation of monitoring wells/piezometers/flood gages

3. Tree planting

- Should be initiated after desired hydrology has been attained*, i.e. – after annual flooding regime has been observed (species placement should be based upon micro-topographical and edaphic habitat preference) (Bledsoe & Shear 2000)
- Tree species will be planted to achieve overall composition of 10-15 species per acre (Clewell pers. comm.) from Table 1
- Planted to achieve a final coverage of 200-300 stems/acre, 85% canopy coverage, and a basal area of 250-325 ft^2/acre at maturity (Allen et al. 2001)

4. Introduction of shrub and herbaceous layer (if not naturally recruited)

- Should be initiated a minimum of three years after successful establishment of target tree species (Allen et al. 2001), if natural recruitment is not sufficient
- Shrubs must be from Table 2, a minimum of three species, with target cover 20-60%
- Herbaceous layer: ≥ 50% of species present are from Table 3, with appropriate coverage[§] as compared to TFT. If necessary, plantings will be made if colonization has not occurred.

[§] Typical herbaceous coverage in mature BLH may range from 5% (Ezell pers. comm.) to near 100% in situations with high seasonal variability (Allen et al. 2001). Thus, target coverage of herbs needs to be determined according to TFT prior to project initiation and goals to attain this target value need to be established at the time of TFT submittal.

Monitoring:

Monitoring plots should include a specific number of set plots monitored during each period and for final credit release. There should also be an equal number of randomly placed plots to show site variation, with a minimum of 1 set and 1 random plot for each 75 acres of contiguous project area.

- Hydrology*: well/gage reports, evidence of sediment deposits, drift lines, high water marks, etc.
- Vegetation: target speciation, positive growth of root collar, height, cover, basal area, etc.
- Exotics: <1% cover at all times (no seed bearing plants at any time)

* Hydrologic manipulations and monitoring may not be applicable on all sites. The MBRT will determine the necessity and feasibility of such endeavors during the MBI review process, according to the specific site information available for individual sites.

Bottomland Hardwood Restoration – credit release schedule

20% - Initial release for conservation easement and financial assurance

15% - Upon completion of site preparation and hydrology work (criteria 1 & 2)
- Removal of exotics, invasives, or inappropriate species
- All earthwork on site completed
- TFT established and accepted
- Monitoring equipment installed*
- Must show that target hydrology has been attained before trees are planted* (minimum 1 year hydrologic monitoring)

15% - Post-planting of trees (criterion 3)
- Target species planted to achieve overall composition of 10-15 species per acre, with no greater than 25% coverage of a single species.
- Minimum of 400 trees per acre, post-planting (White et al 1990)

15% - Post-planting of trees (after 1 year positive growth)
- Visual evidence of species (and individual seedling) placement in relation to appropriate topographic/hydrologic habitat
- Plantings show positive growth of root collar, diameter, and/or height

15% - Post-planting of shrubs and herbaceous layer (criterion 4)
- A minimum of three years positive growth of planted tree species is required before shrubs and herbs are planted
- Visual evidence of appropriate shrubs and herbs, planted sparingly or naturally recruited, in small groupings across site (Clewell pers. comm., Allen et al. 2001)

20% - Final credit release (approximately year 10)
- A minimum of nine years positive growth of planted tree species
- Visual and monitored* hydrology show positive correlation with the target hydrology for the site
- Minimum of 10 target tree species and coverage of 200-300 stems per acre, with all plantings showing positive growth of root collar, diameter, and height with a minimum of 10 trees per acre of each target species (White et al 1990)
- Average height of planted canopy a minimum 7'-10' (excluding fast growing species such as *Platanus* and *Populus*)
- 50% of herbaceous species from Table 3, appropriate cover as related to TFT
- 50% of shrub species from Table 2, 20-60% cover
- <1% cover by exotics

* Hydrologic manipulations and monitoring may not be applicable on all sites. The MBRT will determine the necessity and feasibility of such endeavors during the MBI review process, according to the specific site information available for individual sites.

(Though not based on years into the project, credit releases subsequent to the initial release should roughly work out to be in years 1, 2, 3, 5, and 10)

Bottomland Hardwood Enhancement – credit release schedule

20% - Initial release for conservation easement and financial assurance

10% - Upon completion of site preparation and hydrology work (criteria 1 & 2)
- Removal of exotics, invasives, or inappropriate species
- All earthwork on entire site completed
- TFT established and accepted
- Monitoring equipment installed*
- Must show that target hydrology has been attained before trees are planted* (minimum 1 year hydrologic monitoring)

10% - Post-planting of trees (criterion 3)
- Target species planted to achieve overall composition of 10-15 species per acre, with no greater than 25% coverage of a single species.
- Minimum of 400 trees per acre, post-planting (White et al 1990)

15% - Post-planting of trees (after 1 year positive growth)
- Visual evidence of species (and individual seedling) placement in relation to appropriate topographic/hydrologic habitat
- Plantings show positive growth of root collar, diameter, and/or height

15% - Post-planting of shrubs and herbaceous layer (criterion 4)
- A minimum of three years positive growth of planted tree species is required before shrubs and herbs are planted
- Visual evidence of appropriate shrubs and herbs, planted sparingly or naturally recruited, in small groupings across site (Clewell pers. comm., Allen et al. 2001)

10% - Post-planting of all vegetation
- A minimum of 6 years positive growth of planted tree species, with all plantings showing positive growth of root collar, diameter, and height
- Visual evidence of suitable shrubs with not greater than 60% cover, and herbs with appropriate cover as related to TFT

20% - Final credit release (approximately year 10)
- A minimum of nine years positive growth of planted tree species
- Minimum of 10 target tree species and coverage of 200-300 stems per acre, with all plantings showing positive growth of root collar, diameter, and height with a minimum of 10 trees per acre of each target species (White et al 1990)
- Visual and monitored* hydrology show positive correlation with the target hydrology for the site
- Average height of planted canopy a minimum 7'-10' (excluding fast growing species such as *Platanus* and *Populus*)
- 50% of herbaceous species from Table 3, appropriate cover as related to TFT
- 50% of shrub species from Table 2, a minimum 3 species, with 20-60% cover
- <1% cover by exotics

* Hydrologic manipulations and monitoring may not be applicable on all sites. The MBRT will determine the necessity and feasibility of such endeavors during the MBI review process, according to the specific site information available for individual sites.

(Though not based on years into the project, credit releases subsequent to the initial release should roughly work out to be in years 1, 2, 4, 7, and 10)

Table 1. Appropriate bottomland hardwood tree species (subcanopy and canopy) for restoration work in Mobile District (modified from Clewell 1986).

Acer negundo	*Halesia diptera*	*Populus deltoides*
Acer rubrum	*Hamamelis virginiana*	*Populus heterophylla**
Alnus serrulata	*Ilex cassine*	*Quercus falcata* var. *pagodifolia*
*Betula nigra**	*Ilex decidua*	*Quercus laurifolia*
*Carpinus caroliniana**	*Ilex opaca*	*Quercus lyrata*
Carya aquatica	*Juniperus silicola*	*Quercus nigra*
Celtis laevigata	*Liquidambar styraciflua*	*Quercus michauxii*
Chamaecyparis thyoides	*Liriodendron tulipifera*	*Quercus phellos*
Chionanthus virginicus	*Magnolia virginiana*	*Quercus virginiana*
Cornus foemina	*Morus rubra*	*Salix nigra*
Crataegus crus-galli	*Nyssa aquatica*	*Symplocos tinctoria*
Crataegus marshalli	*Nyssa biflora*	*Taxodium ascendens*
Crataegus spathulata	*Ostrya virginiana*	*Taxodium distichum*
Crataegus viridis	*Persea borbonia*	*Ulmus alata**
Cyrilla racemiflora	*Persea palustris*	*Ulmus americana*
Diospyros virginiana	*Pinus ellottii*	*Viburnum dentatum*
Fraxinus caroliniana	*Planera aquatica*	*Viburnum nudum*
Fraxinus pennsylvanica	*Platanus occidentalis*	

** Species only marginally appropriate, as the Mobile district is at the extreme edge of historical distribution.*

Table 2. Appropriate bottomland hardwood shrub species for restoration work in Mobile District (modified from Clewell 1986).

Alnus serrulata	*Forestiera acuminata*	*Lyonia lucida*
Arundinaria gigantea	*Hypericum galioides*	*Myrica cerifera*
Baccharis glomeruliflora	*Ilex amelanchier*	*Osmanthus americanus*
Callicarpa americana	*Ilex coriacea*	*Sabal palmetto*
Cephalanthus occidentalis	*Ilex glabra*	*Sabal minor*
Cornus amomum	*Illicium floridanum*	*Styrax americana*
Cornus foemina	*Itea virginica*	*Styrax grandifolia**
Crataegus aestivalis	*Leucothoe racemosa*	

** Species only marginally appropriate, as the Mobile district is at the extreme southern edge of historical distribution.*

Table 3. Appropriate herb species for bottomland hardwood restoration work in Mobile District (Allen et al. 2001 - *A Guide to Bottomland Hardwood Restoration*)

Category 1:

Aquatic milkweed	*Asclepias perennis*
Small-spike falsenettle	*Boehmeria cylindrica*
Millet beakrush	*Rhynchospora miliacea*
Water pimpernel	*Samolus valerandi* spp. *parviflorus*
Swamplily	*Crinum americanum*
Bugleweed	*Lycopus* spp.
Lizard's tail	*Saururus cernuus*
Ferns	*Osmunda*, *Woodwardia*, *Thelypteris* spp.

Category 2:

Small-fruit beggartick,	*Bidens mitis*
Mexican water-hemlock	*Cicuta maculata*
Hairlike mock bishop-weed	*Ptilimnium capillacium*
Pickerel weed	*Pontederia cordata*
Smartweed spp.	*Polygonum* spp.
Bur-reed spp.	*Sparganium* spp.

Target Forest Type (TFT) (modified from White et al. 1990)

The Target Forest Type (TFT) includes the selection of an actual reference site (either offsite or potentially onsite outside of the restoration area), but recognizes that bottomland hardwood (BLH) site hydrology and species composition, even among sites within the same watershed, may differ greatly due to edaphic and micro-topographical variations onsite. Thus, the TFT is an amalgam of reference site conditions and suitable species for the particular BLH being restored, created, or enhanced.

The TFT is to be established by the banker, and is basically a reference site with a supplemental species list. An appropriate reference site needs to be selected in order to establish a target for determining the successful attainment of suitable soils, hydrology, and vegetative cover on the restoration site. However, it should be recognized that species composition and diversity are higher for young forests, and using only the species found on a mature reference site is not appropriate for restoration success. So, as part of the site preparation, a list of the 10-15 tree species that will be planted should be provided to the IRT as a supplement to the selected reference site. The species should be chosen based on the hydrology of the site after all earthwork has been completed, inclusive of reference site species and additional suitable species. Thus, final micro-topography and hydrology can be considered in choosing appropriate species to augment those found on the reference site.

It is the applicant's responsibility to characterize the Target Forest Type (reference site and species list) to the satisfaction of the IRT.

Possible criteria for determining whether or not a site is appropriate for enhancement or restoration. All factors were modified from a study by White et al. 1990. Restoration requires functional lift to hydrology and vegetation, enhancement can involve lift to vegetation only.

Restoration	**Enhancement**
Soils:	**Soils:**
>12” of soil disturbed, or losses of >50% of top 12”	<12” of soil disturbed, or losses of <50% of top 12”
Hydrology:	**Hydrology:**
>50% deviation in frequency and duration of hydrologic conditions as related to TFT	0-50% deviation in frequency and duration of hydrologic conditions as related to TFT
Vegetation:	**Vegetation:**
>90% losses of either: - tree canopy - canopy species composition - understory cover - understory species composition	50-90% losses of either: - tree canopy - canopy species composition - understory cover - understory species composition

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Bey, C.F. "*Ulmus americana* L. – American Elm"
Filer, Jr. T.H. "*Quercus nuttallii* Palmer – Nuttall Oak"
Grelen, H.E. "*Betula nigra* L. – River Birch"
Johnson, R.L. "*Nyssa aquatica* L. – Water Tupelo"
Kennedy, Jr., H.E. "*Fraxinus pennsylvanica* Marsh. – Green Ash"
Kormanik, P.P. "*Liquidambar styraciflua* L. – Sweetgum"
McGee, C.E. "*Nyssa sylvatica* Marsh. – Black Tupelo"
McReynolds, R.D., and E.A. Hebb. "*Quercus laurifolia* Michx. – Laurel Oak"
Pitcher, J.A., and J.S. McKnight. "*Salix nigra* Marsh. – Black Willow"
Rogers, R. "*Quercus alba* L. - White Oak"
Sclaegel, B.E. "*Quercus phellos* L. – Willow Oak"
Smith, H.C. "*Carya cordiformis* (Wangenh.) K. Koch – Bitternut Hickory"
Solomon, J.D. "*Quercus lyrata* Walt. – Overcup Oak"
Vozzo, J.A. "*Quercus nigra* L. – Water Oak"
Walters, R.S., and H.W. Yawney. "*Acer rubrum* L. – Red Maple"
Wells, O.O., and R.C. Schmidtling. "*Platanus occidentalis* L. – Sycamore"
"*Populus deltoides* Bartr. Ex Marsh. – Eastern Cottonwood"
"*Quercus falcata* var. *pagodifolia* Ell. – Cherrybark Oak"

The following articles concerning specific tree species characteristics may be found through the "USDA Forest Service Silvics Manual" at http://www.na.fs.fed.us/spfo/pubs/silvics_manual/Volume_1:

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Wilhite, L.P., and J.R. Toliver. "*Taxodium distichum* (L.) Rich. – Baldcypress"

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Reed, M.R., K.T. Barnett, and K.W. McLeod. "Competition control necessary for bottomland hardwood restoration?"

McLeod, K.W., M.R. Reed, V.H. Parrish, and T.G. Ciravolo. "Bottomland restoration in the Southeastern coastal plain."

And articles from USDA NRCS Wetland Restoration Series at http://www.pwrc.usgs.gov/wli/:

Melvin, N.C. "Vegetation restoration recommendations – bottomland hardwood

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Melvin, N.C. "Evaluation of reforestation in the Lower Mississippi River alluvial valley."