

Hemlock Subtype: 10 stands were classified as a hemlock subtype of the chestnut oak forests. The stands range from sites along Wappinger Creek in which hemlock has an importance value of 7% to sites near the top of the Canoo Hills (e.g., plots 664) in which hemlock is present only as a distinctive layer of standing dead trees in understory and sapling size classes (Table 7). While hemlock is present in a number of stands classified in other forest types, the hemlock subtype is distinctive in the virtual absence of a number of the major deciduous species found in other subtypes of the chestnut oak forests: i.e., sugar maple, pignut hickory, white ash, and white oak (Table 7). The major canopy species of the hemlock subtype (with their mean importance values) are chestnut oak (31%), hemlock (26%), red oak (17%), and white pine (14%) (Table 12). Average total tree basal area is higher in this group of stands ($x = 28.3 \text{ m}^2/\text{ha}$) than in any other group (Table 16). However, the percent of the sky visible through the canopy cover is patchy (look at this - are the high values in stands where hemlocks have died recent - look at correlation between % sky and IV of hemlock). There is a distinct vertical differentiation of canopy trees in stands where hemlock is not the leading dominant with chestnut and red oak occupying the largest tree age classes and the canopy dominant and sub-canopy layers, while hemlock is present in a wide range of diameter size classes but most abundant in the understory layer (i.e., as stems $>10 \text{ cm DBH}$ but completely overtopped by adjacent trees). The herbaceous layer in forests of the hemlock subtype is low in both species diversity and total cover relative to other forest types within the Arboretum. Only 49 of herbaceous species were found in the hemlock subtype. Only two species (Mianthemum canadense and Mitchella repens) were encountered in the herb quadrats used to sample the cover of herbaceous species. Both species were encountered in only 2 stands and with average cover values of less than 2%. However, 7 of these 49 species encountered in the 10 stands: Aralia nudicaulis, Carex sp., M. canadense, Monotropa uniflora, Solidago sp., Solidago caesia and Polypodium vulgare, were at least present within 50-60% of the stands.

The sapling layer is also fairly distinctive in this subtype. Striped maple (Acer pennsylvanicum) and hemlock reach their greatest relative importance in sapling size classes in this subtype, while ironwood (Ostrya virginiana) is much less abundant than in the other two subtypes of the chestnut oak forests (Table 13). In stands where hemlock abundance is high in the canopy, the sapling size classes are also dominated by hemlock (e.g., plots 761, 808, 698, and 739). The remaining stands have a much more diverse sapling layer, with the highest relative abundance of white pine, red oak and black birch (Betula lenta) of any of the chestnut oak subtypes (Tables 8 & 13). The total density of stem in the sapling size classes, however, was only 32-42% as high as in the other forest type stands (Table 16).

As in all of the chestnut oak forests, maple-leaved viburnum is the overwhelmingly dominant shrub species (Table 14). Vaccinium angustifolium was the second most abundant shrub species in the subtype, contributing 28% of the total shrub cover. However, it was present in only 4 of the stands, and its high relative abundance is largely a reflection of the overall paucity of the shrub layer in this subtype. Total shrub cover in this group of stands ($x = 4.8\%$) was only one quarter to one half of the total shrub cover in the other groups. The seedling layer was dominated by red maple (47% of all seedlings) and striped maple (16%) (Table 15); however, total seedling density ($x = 2.35/\text{m}^2$) was the lowest of any of the groups (Table 16).

Hickory Subtype: Twenty percent of the upland forests were classified in the hickory subtype of the chestnut oak forests. Chestnut oak (IV = 23%) and red oak (IV = 18%) are the two leading dominants in this subtype, but 4 species are present as co-dominants: pignut hickory (IV = 14%), sugar maple (IV = 13%), hemlock (IV = 9%), and white oak (IV = 8%). The diagnostic species for the subtype is pignut hickory (*Carya glabra*), which is present in all of the stands and virtually absent from the other subtypes of chestnut oak forests. However, the presence of white oak and hemlock, each in a separate subset of stands within the subtype, is also a major difference between this subtype and the maple subtype. Sugar maple and hemlock were both most abundant in the under-story layer of tree-sized (i.e., >10 cm DBH) stems. Canopy structure in this subtype is very similar to the maple subtype. These two subtypes had the greatest mean canopy height (24-25m), lowest percent of the sky visible through the canopy (6.87-7.1%), and intermediate total tree basal area (22-25 m²/ha) (Table 16). Pignut hickory was represented in equal abundances in canopy, sub-canopy, and understory strata. Chestnut and red oak were both concentrated in the largest tree size classes and the canopy stratum.

The sapling layer of stands in the hickory subtype is dominated by ironwood (*Ostrya virginiana*) and sugar maple and shadbush (*Amelanchier* sp.). All three of these species reach higher relative abundance in this subtype than in any other forest type of the Arboretum. The oaks and hickories contribute only 4% of the total density of saplings in these stands. In addition, this subtype has the highest density of stems in the sapling size classes of all of the upland forest types (Table 16).

Maple-leaved viburnum (*Viburnum acerifolium*) contributed 71% of the total cover of shrubs in this forest type and was present in 86% of the stands. The only other major shrub species were *Vaccinium angustifolium* (present in 7 of 15 stands) and a combination of *Viburnum dentatum* or *V. rafenesquania* (present in 4 of 15 stands). Total shrub cover was intermediate (8.0%) relative to other subtypes of the chestnut oak forests (Table 13). The seedling layer in these stands is dominated by white ash, sugar maple, red maple, and *Amelanchier* spp. (Table 15).

The diversity of the herbaceous layer in the hickory subtype is over twice as high as in the hemlock subtype. One hundred and nine of the 157 herbaceous taxa found in the upland forests were present in at least one of the stands in the hickory subtype. Ten species were present in greater than 50% of the stands: *Carex* spp., *Dryopteris marginalis*, *Galium circaezans*, grass species, *Maianthemum canadense*, *Monotropa uniflora*, *Polygonatum pubescens*, *Solidago* spp., *S. caesia* and *Veronica officinalis*. Of these species, the sedges (*Carex* spp.) and *Maianthemum canadense* had the highest average cover measured in the herb quadrats.

Maple Subtype: Twenty-three percent of the upland forests were classified as a maple subtype of the chestnut oak forests. Average canopy dominance in these stands is shared almost equally by chestnut oak, red oak, and sugar maple (Table 12). Although the average importance value of red maple in these stands is low (6.3%), red maple reaches a higher frequency and average local abundance in this subtype than in the other two subtypes of the chestnut oak forests. Pignut hickory, white oak, and hemlock are each present in a few (3-4) of the stands in this subtype, but generally do not co-occur with each other. The three canopy dominants reach their greatest relative abundance in different

canopy strata: chestnut oak in canopy positions, red oak in sub-canopy positions, and sugar maple in the understory layer. This group of stands had the greatest mean canopy height, lowest percent of the sky visible through the canopy, and second highest basal area of any of the 5 groups.

The sapling stratum in the maple subtype is dominated by ironwood (Ostrya virginiana) (present in 82% of the stands) and sugar maple (present in 94% of the stands). Two other understory tree species (Hammamelis virginiana and Cornus florida) that are more characteristic of the understories of oak-hickory stands are also relatively common in stands of the maple subtype (Table 13). The presence of beech saplings in 8 of the 17 stands is perhaps the most distinctive feature of the sapling stratum in these forests. One-third of the oak-hickory stands have beech in the sapling layer, but at very low densities (Table 13), and beech is found in only one stand (and at low densities) in each of the 3 other forest types. Seedling density in stands of the maple subtype is low (Table 16), with a relatively even distribution of abundance among species such as red maple and Amelanchier spp. that are widely distributed throughout the upland forests (Table 9). Average shrub cover in the maple subtype was the highest of any of the chestnut oak types. Maple-leaved viburnum accounted for 74% of the total cover of shrubs in this group of stands. It was present in all of the stands, covering an average of 9.4% of each plot. Virginia creeper (Parthenocissus quinquefolia) contributed another 10% of total shrub cover, but solely through the effects of one stand (plot 859) that had virginia creeper covering 22% of the forest floor.

The herbaceous stratum of the maple subtype is comparable in species richness to the hickory subtype, with 110 of 157 taxa occurring in the maple subtypes. Nine species occurred in greater than half of the stands: Aralia nudicaulis, Arisaema triphyllum, Aster divaricatus, Carex spp., Carix platyphylla, Dryopteris marginalis, Monotropa uniflora, Polygala paucifolia and Solidago caesia. Two of these species (C. platyphylla and O. marginalis) are particularly abundant in this group relative to other forest types of the Arboretum (Table 11). D. marginalis was found in 14 of the 17 stands in the group; and C. platyphylla occurred in 10 of the stands but was present in only one stand in the oak-hickory and red maple forests (Table 11). Sedges as a group had the highest average cover of the herbaceous taxa encountered in the 0.5 m² quadrats.

Oak-Hickory Forests: Twenty-eight percent of the stands were classified as oak-hickory forests (Table 7). These stands are distinctive in the replacement of chestnut oak and red oak by black oak and white oak as the major oak species (Table 12). The other major canopy tree species are red maple and pignut hickory. Although its absolute abundance is low, shagbark hickory (Carya ovata) is present in 43% of the oak-hickory stands, and is largely absent from the other forest types. Stratification of species within the canopy is not as pronounced in the oak-hickory stands as it is in the chestnut oak stands (Table 20, Appendix C); however, the oaks are still concentrated in the canopy stratum while red maple is more abundant in sub-canopy and understory strata. The mean, total basal area of trees (and therefore, by inference, the total biomass of trees) in the oak-hickory forests is the lowest of any of the groups of stands; this figure, coupled with the high percentage of the sky visible through the canopy, reflects the relatively open canopy that appears to be a characteristic of these stands. The sapling layer is relatively dense, and dominated by witch hazel, flowering dogwood, sugar maple, musclewood, and red

maple (Table 13). the most distinctive features of the sapling layer are the rarity of ironwood (which is one of the most abundant species in the sapling layer of chestnut oak forests) and the abundance of musclewood (Table 13; and Table 21, Appendix C) relative to its virtual absence from the chestnut oak forests. Oak species are uncommon in the sapling layer. The seedling layer is intermediate in density and not strikingly different than in the other upland forest types (Table 15). In contrast, the shrub layer within the oak-hickory stands is relatively distinctive. Although mapled-leaved viburnum is still the most abundant shrub species, dominance is shared almost equally with virginia creeper (Parthenocissus quiquifolia) and Cornus racemosa. Neither of the latter two species is common in the chestnut oak stands. Total shrub cover is relatively high in the oak-hickory stands, averaging 12.8% (Table 14). One hundred and thirty herbaceous taxa (species or genera) were found in the 21 oak-hickory stands. Grasses, sedges and goldenrods were each present in more than half of the stands, however only two other taxa - Solidago caesia and Monotropa uniflora - were present in over half of the stands. Hypericum punctatum (24% of the stands) and Lysimachia quadrifolia (33%) were both relatively common in the oak-hickory stands but very rare in the chestnut-oak forests.

Red Maple Forests: The 12 stands classified as red maple forest represent a diverse collection of species and environmental conditions. The most distinctive features of the canopies of these stands are the overwhelming dominance of red maple (IV = 51%) and the rarity of all of the oak species (Table 12). Three of the stands (Plots 252, 476 & 707) have canopies of almost entirely red maple (with importance values >93%). The group includes the only stands with pitch pine (Pinus rigida) (in Plots 639 & 771) on southwest facing slopes, and the only stands with tulip tree (Liriodendron tulipifera) (in Plots 476 & 506) in two young stands on level terrain west of Cary Drive. The remainder of the stands have varying amounts of oak in the canopy, and represent compositions that are transitional to the other major forest types. Despite the youngest mean age of the largest trees in a plot of any of the forest types, these stands have intermediate total basal area.

Sapling density seedling density and shrub cover are all very high relative to the other forest types (Table 16). The sapling layer is dominated by red maple, ironwood, and sugar maple. Black birth (Bentula lenta) reaches its highest abundance (8.7% of total sapling density) in this group of stands. Red maple seedlings make up 38% of total seedling density (Table 15). The most distinctive shrub species are species of Rubus; otherwise the shrub layer is very similar to the oak-hickory communities.

Ninety-one taxa were present in the herb layers of the 12 stands. Eight of these were present in more than half of the stands: Aster divaricatus (9 stands), Carex spp. (8), grasses (7), Maianthemum canadense (6), Potentilla simplex (9), Solidago spp. (9), S. caesia (8), and Veronica officianalis (8).