PIEDMONT AND COASTAL PLAIN OAK FORESTS

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PIEDMONT AND COASTAL PLAIN OAK FORESTS THEME

Concept: Piedmont and Coastal Plain Oak Forests are common upland communities dominated by various species of *Quercus*, with or without *Carya*, and lacking *Castanea dentata* and most of the characteristic flora that distinguish Mountain Oak Forests. They are the predominant natural forests of the Piedmont, with the exception of the foothills area, and are limited in extent but widespread in dissected lands in the Coastal Plain.

Distinguishing Features: Most Piedmont and Coastal Plain Oak Forests may be easily distinguished from Mountain Oak Forests by their geographic location. Only Mountain Oak Forests occur west of the Blue Ridge escarpment, while no Montane Oak Forests occur in most of the Piedmont. In the foothills east of the escarpment, and in a few large monadnock areas such as Hanging Rock and the Kings Mountains, both Piedmont and Coastal Plain Oak Forests and Mountain Oak Forests occur. They are distinguished by their flora. A large pool of species is typical of the Blue Ridge and these species act as indicators of Montane Oak Forests. They are scarce, or more often absent, in the Piedmont and Coastal Plain Oak Forests of North Carolina. *Castanea dentata*, still present as root sprouts in many occurrences, was once the most important distinguishing species. *Rhododendron maximum, Rhododendron catawbiense, Rhododendron calendulaceum, Gaylussacia baccata, Pyrularia pubera, Pinus strobus*, *Magnolia fraseri, Tsuga caroliniana, Tsuga canadensis, Magnolia acuminata*, *Acer pensylvanicum*, *Pinus pungens*, and *Pinus rigida* are additional species sometimes in Mountain Oak Forests but rarely present in Piedmont communities. *Quercus falcata, Quercus stellata*, and *Pinus echinata* are typical Piedmont species that are usually absent in Mountain Oak Forests but may be present in particular communities.

Piedmont and Coastal Plain Oak Forests are distinguished from Piedmont and Coastal Plain Mesic Forests by the absence of *Fagus grandifolia* and by an abundance of oaks more drought tolerant than *Quercus rubra*. *Quercus rubra* may be codominant or locally dominant in either, and these communities will need to be distinguished on the basis of associated trees. A well-developed forest canopy under natural conditions distinguishes Piedmont and Coastal Plain Oak Forests from Piedmont and Mountain Glades and Barrens, Low Elevation Cliffs and Rock Outcrops, and other nonforested themes.

Synonyms:

Sites: In the Piedmont, oak forests occur on most upland sites, from warm lower slopes to upland ridge tops. In the Coastal Plain, oak forests are restricted to areas with natural sheltering from too-frequent fire. These include bluffs and dissected lands, and occasional isolated ridges surrounded by nonflammable wetlands. Oak Forests become more extensive and occupy more sites in the northernmost Coastal Plain.

Soils: Oak Forests may occur on almost any upland soil in the Piedmont, and on a wide variety of Coastal Plain upland soils that are not excessively sandy. Most are Hapludults or Kankhapludults.

Hydrology: Piedmont and Coastal Plain Oak Forests occur in all but moist or the most extremely dry upland conditions. Most sites are well drained, but a few may have somewhat restricted drainage.

Vegetation: Piedmont and Coastal Plain Oak Forests are almost always dominated, at least weakly, by some combination of *Quercus alba, Quercus rubra, Quercus velutina, Quercus falcata, Quercus stellata*, and *Quercus montana*. Various species of *Carya* are usually present and sometimes codominant. *Pinus echinata* often is a minority component, probably more often under more natural conditions, and *Pinus taeda* or *Pinus virginiana* may sometimes be present. These pines, plus *Liriodendron tulipifera*, *Liquidambar styraciflua*, and *Acer rubrum,* often are increased in abundance in the canopy by logging. *Fraxinus americana* may be abundant in some examples with less acidic soil. The understory typically includes some combination of *Cornus florida, Nyssa sylvatica, Oxydendrum arboreum*, and *Acer rubrum*, though a number of additional species may be present in the Coastal Plain, in more mesic sites, and in areas with less acidic soil. Shrub layers tend to be open, with species of *Vaccinium* the most typical dominants. Herb layers usually are sparse under present conditions and are limited in diversity. Under past conditions of regular fire, they are believed to have been denser, more diverse, and more dominated by grasses.

Dynamics: Under natural conditions, Piedmont and Coastal Plain Oak Forests are uneven-aged, with numerous old trees present but with trees of a broad range of ages intermixed at a fine scale. No unlogged forests remain in these regions, as they do in the Mountain region. Remnants wood lots that were never clearcut, inaccessible slopes, and the oldest second-growth forests, suggest similar stand dynamics. The newer understandings of the role of fire in these communities, discussed below, do not change this impression. The dominant oaks are among the most long-lived tree species in North Carolina, with maximum life spans of 400-600 years, 300 years for associated hickories (literature summarized in Loehle 1987). Successful regeneration of canopy trees occurs primarily in small canopy gaps caused by the death of one or a few trees. Trees produce irregular seed crops, with mast years resulting in large numbers of seedlings that survive for several years beneath the canopy. The oaks that establish in canopy gaps generally are from this pool of advanced regeneration.

Ongoing processes such as lightning and severe thunderstorms create individual gaps. Occasional extensive disturbances such as hurricanes create many gaps throughout a stand at one time, but most of the individual gaps are small openings the size of one or a few trees. At a stand scale, old-growth is expected over the vast majority of the landscape, while at a fine scale there is dynamic equilibrium of gaps in different stages of succession. Skeen, Carter, and Ragsdale (1980) argued that even the shade-intolerant *Liriodendron* could reproduce enough in the larger gaps in old-growth forest to persist in the climax Piedmont forests; the same would appear to be true of the pines.

Following severe canopy disturbance such as clearcutting, and even more where land was cleared and farmed, examples tend to regenerate as even-aged successional forests dominated by more ruderal, shade-intolerant species such as *Pinus* spp., *Liriodendron tulipifera*, or *Liquidambar styraciflua*. Various oaks often are present, but in much smaller numbers. In the past, *Pinus echinata* was often the dominant successional tree, but in more recent decades, *Pinus taeda* and hardwoods have become the predominant successional trees.

There is renewed interest in the dynamics of oak forests in general in recent years, and numerous studies have been published in the 2000s and 2010s. Much new information has been added on the role of fire as an important ecological driver in these communities. It is increasingly being recognized that it likely is a crucial process, and that the near-universal removal of fire is altering forests. Fire in the past presumably led to lower understory density, longer persistence times for canopy gaps, and denser herb layers than we see at present. Longer persistence of gaps would create a more open canopy across stands, allowing shade-intolerant species to be more abundant and more diverse. *Pinus echinata*, the longest-lived and most fire-tolerant of the pines that occur in these communities, was more abundant. The natural, or presettlement, fire regime for these communities is not fully known. Few old trees and fire-scarred logs remain to support fire history studies comparable to those done in the Appalachians. Fire was more frequent than in the Mountain region, but less frequent than prevailed in flatter Coastal Plain uplands. This is in keeping with the intermediate size fire compartments and lightning rates in the Piedmont, and with the occurrence of Coastal Plain examples in areas with some shelter from fire. Likely these forests burned around every 10 years, an interval that, persisting over a long time, would favor oaks over competing species but would be long enough to allow oak regeneration.

It is also difficult to tell how much the presettlement fire regime was human-caused versus natural. Earlier historical explorers reported that Native Americans ignited forests regularly. Such travelers tended to follow Indian paths and stay in Indian villages, giving them a severely biased view of how much human influence there was on the land, but it is clear that human-caused fires were common at least in those areas. Less clear is how much their ignition merely preempted fires that would have happened anyway and how much it changed the frequency, intensity, and seasonality of fire. Though data are sparse, Lafon et al. (2017) did not find evidence that fire frequencies were greater in areas with dense prehistoric human populations than in sparsely populated areas in the Blue Ridge and farther west, nor did frequencies greatly decline in the period after Native American populations were decimated by European diseases but before settlers arrived. The same may have been true in the Piedmont. In any case, increasing the amount of fire by prescribed burning and by allowing naturally ignited fires to burn where possible can be expected to be beneficial to oak forests. It may be noted that burning tends to favor more drought-tolerant species, and that burning is likely to make forests better adapted to future climatic warming and drying.

Most natural and human-caused fires were, and are, low to moderate in intensity. Because the dominant canopy trees are tolerant of such fires, fire likely was not a major cause of canopy gaps. Instead, as suggested by McEwan et al. (2013) for an old-growth oak forest in Kentucky, and generalized by Lafon et al. (2017), fire's primary role was as a filter of the pool of young trees that is present when canopy gaps are formed by wind, lightning, or other natural disturbance. Fire determined what species could regenerate, while the time and location of regeneration of individuals was determined by formation of canopy gaps by wind, lighting, ice, and occasional hotter fires. The dominant oak species tolerate fire better than the associated hardwoods as seedlings and saplings as well as mature trees. Allocation of resources to roots makes them better able to sprout repeatedly if burned, giving them an advantage over most trees.

Frequent burning in the past led to much lower understory density, longer persistence times for canopy gaps, resulting more open canopies, and denser herb layers than can thrive in the present

shady conditions. Forests therefore could support more abundant and diverse shade-intolerant species. These characteristics would make for easier fire spread in these forests. This feedback may have been an important aspect of fire behavior in the past, and this possibility makes it harder to determine natural fire regimes based on the present. The effects of decades of removal of fire are not quickly reversed, because the most important effects are the result of a chronic fire regime. The expected higher diversity consists mostly of conservative species adapted to that regime, species that are slow to colonize and that now have reduced populations. A single burn often has little effect. More severe prescribed fires and wild fires, or fires accompanied by canopy removal, generally result in the appearance of a few ruderal species in large numbers. These are sometimes mistakenly interpreted as successful restoration of fire-tolerant lower strata, if species are not distinguished or if their ecology is not considered.

There has been growing concern in recent decades that oaks are failing to regenerate, both in North Carolina and throughout the eastern deciduous forest region (Loftis and McGee 1993; Rodewald 2003; Knott et al. 2019). While this phenomenon is widespread in the region, details in these sources show substantial variation, including local areas where it does not appear to be occurring. Because the detection of this pattern is at a broad scale, much of the area affected is influenced by ongoing timber management and variation in logging practices as well as other factors. However, it can readily be observed in many Piedmont and Coastal Plain Oak Forests that oaks are scarce or absent in the understory and that other species are gradually replacing them in the canopy. Oak seedlings are abundant after mast years, but saplings and understory trees are scarce. Various shade-tolerant understory trees have increased in cover. Once a dense understory is established, the forest floor is too shady for oak seedlings to grow to saplings, and the established shade-tolerant trees capture most of the canopy gaps.

The term mesophication has been applied to this process (Nowacki and Abrams 2008), because the tree species that are increasing in most of the eastern United States are regarded as more mesophytic than the oaks. This process is generally blamed on lack of fire. The species that have increased, especially *Acer rubrum* and, in other regions, *Acer saccharum*, and most other mesophytic species, are not well adapted to fire. *Acer rubrum* stems can be observed to be killed by fires that do not kill oaks of similar size, across a wide range of sizes. Though these species sprout vigorously, so that a single fire would cause little long term change, chronic repeated fire would reduce them drastically. Establishment of mesophytic species is believed to also change the environment within the forest, with humidity increased beneath a dense understory and a thicker duff layer developing. The thin leaves of mesophytic trees pack down on the ground surface more than oak leaves do and hold moisture more effectively. This reduces the flammability of the forest litter, making the forests less able to burn. The higher humidity and thicker duff themselves may also favor mesophytic species; however, given the increased root competition with denser vegetation and the lower water use efficiency of most mesophytic species, moisture may not actually be more available to seedlings.

Though mesophication is believed to result from lack of fire, there are views that subtle climate changes could be contributing. McEwan et al. (2013) and Nowacki and Abrams (2015) cite statistics indicating that the overall region of eastern oak forests was wetter after 1970 than in the earlier 1900s, coinciding with the period of rapid maple increase, and that there were more droughts in the several centuries before 1900. It is very difficult to sort the effects of fire

suppression and rainfall shifts from other phenomena, including changes in land use practices and increasing deer populations. Israel (2011) found a widespread decrease in cover in all lower strata, among shade-tolerant and intolerant species, across a wide range of site conditions and successional ages. This study was in Duke Forest, near Durham, an area with very high deer populations.

Not generally noted in mesophication literature, the understory species with the greatest increase in our area, *Acer rubrum*, actually has a very broad moisture tolerance, and does well in dry sites. More mesophytic species, such as *Fagus grandifolia*, can be seen in the understory of oak forests, but in much smaller numbers and over less of the landscape. Other shade-tolerant understory species that have increased are not particularly associated with mesic sites, including *Nyssa sylvatica* and *Oxydendrum arboreum*. These species only occasionally reach the canopy, but they contribute to shade in the understory and thus could help exclude oak saplings. At the same time, one of the most abundant shade-tolerant understory species, *Cornus florida*, has drastically declined due to disease since the 1980s.

Also generally not noted is that *Acer rubrum*, though shade-tolerant, has ruderal characteristics such as prolific seeding, widespread seed dispersal, and rapid seedling growth in high light. Other species with these characteristics, *Pinus taeda, Liriodendron tulipifera*, and *Liquidambar styraciflua*, have also drastically increased in Piedmont and Coastal Plain forests, and appear to be the species preventing successful oak regeneration after severe disturbances such as logging in many places. The increase in severe disturbance and drastic canopy opening since European settlement, and the proliferation of permanent artificial forest edges with ongoing settlement and fragmentation, have favored all of these species at the expense of oaks in the landscape. The dramatic increase in seed rain of these species, including *Acer rubrum,* could be regarded as the primary driver of current oak forest dynamics. Nevertheless, these species would not have become abundant in a landscape with regular fire.

Much attention has been devoted in recent years to shortleaf pine forests. Because *Pinus echinata* was, until recent decades, the primary successional species in abandoned fields and other cleared lands in substantial parts of the Piedmont, much of this loss is due to the loss of these successional stands to harvest, aging, and conversion to other land uses. The displacement of *Pinus echinata* by *Pinus taeda* in successional stands on more recently abandoned cleared land has further contributed to this decline, but such successional stands are additionally much less extensive than after the mass abandonment of farmland in the 1860s and 1930s.

The question of the role of *Pinus echinata* in the prevailing natural communities of the Piedmont is more controversial. It is difficult to determine because the species likely first increased due to logging and other human disturbances, then decreased due to fire suppression and competition with other pines and hardwoods. There has been much belief, but less careful argument for, the existence of widespread shortleaf pine savannas in the Piedmont analogous to the longleaf pine savannas of the Coastal Plain. There has been a zone recognized in the eastern Piedmont where shortleaf pine is the prevailing pine, but this recognition too was based at least substantially on successional stands. It leaves unanswered the question of how much of the never-cultivated landscape was dominated by pine in comparison with oak forests. Pinchot and Ashe (1897) are often cited as a source for widespread abundance of the species. It is worth noting that, at that time,

when abandoned farm land and successional forests were widespread on the landscape and fire remained frequent, they stated: "at the present time [ca. 1895], on account of the general distribution of groves of seed-bearing short-leaf pine, this species quickly forms a stand in abandoned fields, ... yet in many [other] portions ..., the short-leaf pine does not rapidly take old fields, from five to ten years or even more being required for a thick stand to be naturally secured." The term "groves" is not generally used for the dominant landscape cover nor for extensive patches. If these groves were sufficient to rapidly seed in abandoned fields in some places, the fact that this did not occur in other places suggests that shortleaf pine seed sources must have been much sparser there. The fact that no other successional species filled old fields before 5-10 years indicates how much less seed rain there was at that time for all early successional tree species. By the 1930s, pines, sometimes *Pinus echinata*, sometimes *Pinus taeda*, filled abandoned fields much more rapidly (Crafton and Wells 1934, Billings 1938, Keever 1950).

The likely natural occurrence of *Pinus echinata* in Piedmont and Coastal Plain Oak Forests is as a fairly constant minority species occurring as scattered individuals and small groves. This pattern can be observed in some examples of mature oak forests, suggesting establishment of a clump when a medium size canopy gap coincided with favorable conditions for their seedlings. Such groves likely were more abundant, and scattered individuals likely more frequent between them. How much more abundant they were before European settlement is difficult to judge, because they can be expected to have increased when European settlers began cutting trees in large numbers.

Like the upland oaks, *Pinus echinata* is well suited to fire at moderate frequencies. Its ecology is very similar to that of the oaks it co-occurs with. Mature trees survive fire well and, unlike most pines, seedlings retain buds near ground level that allow them to sprout if top-killed by fire. The structure of regularly burned forests, with little understory and higher levels of light on the ground, would allow this species to regularly reproduce in canopy gaps. It is not clear under what circumstances it would be able to supplant oaks as the dominant tree over large areas, and unclear that this happened in North Carolina in typical upland sites.

Comments: The name "oak-hickory forest" is used for most of the communities in this theme, primarily because it is the name in widespread use for these communities. Ware (1992) raised the question of why this name is used when oaks clearly dominate and other genera may be more abundant than hickories. It should be noted that the name applies to a wide range of forests over a broad region, with hickories more abundant in some than others. It may also be noted that maples and mesophytic genera were not as abundant in the past when the name originated. The genus *Carya* is prominent in species lists. Five species are common in the species pool for Piedmont oak–hickory forests, more than any genus other than oak, and at least two species are present in most large stands.

References:

Billings, W.D. 1938. The structure and development of old field shortleaf pine stands and certain associated physical properties of the soil. Ecological Monographs 16:88-208.

Crafton, W.M. and. B.W. Wells. 1934. The old field pre-sere: An ecological study. Journal of the Elisha Mitchell Scientific Society 49:225-246.

Israel, K.A. 2011. Vegetation change in Duke Forest, 1977-2010. M.S. Thesis, University of North Carolina, Chapel Hill.

Keever, C. 1950. Causes of succession on old fields of the Piedmont, North Carolina. Ecological Monographs 20:231-250.

Knott, J.A., J.M. Desprez, C.M. Oswalt, and S. Fei. 2019. Shifts in forest composition in the eastern United States. Forest Ecology and Management 433:176-183.

Lafon, C.W., A.T. Naito, H.D. Grissino-Mayer, S.P. Horn, and T.A. Waldrop. 2017. Fire history of the Appalachian region: a review and synthesis. USDA Forest Service Southern Research Station General Technical Report SRS-219.

Loehle, C. 1987. Tree life history strategies: the role of defenses. Canadian Journal of Forest Research 18:209-222.

Loftis, D.L. and C.E. McGee (eds.). 1993. Oak Regeneration: serious problems, practical recommendations. (Symposium Proceedings). Gen. Tech. Rep. SE-84. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station. 319 p.

McDonald, R.I., R.K. Peet and D.L. Urban. 2003. Spatial pattern of Quercus regeneration limitation and *Acer rubrum* invasion in a Piedmont forest. Journal of Vegetation Science 14:441-450.

McEwan, R.W., N. Pederson, A. Cooper, J. Taylor, R. Watts, and A. Hruska. 2013. Fire and gap dynamics over 300 years in an old-growth temperate forest. Applied Vegetation Science 17:312-322.

Nowacki, G.J. and M.D. Abrams. 2008. The demise of fire and "mesophication" of forests in the eastern United States. Bioscience 58:123-138.

Nowacki, G.J. and M.D. Abrams. 2015. Is climate an important driver of post-European vegetation change in the Eastern United States? Glob. Change Biol. 21:314–334.

Oosting, H.J. 1942. An ecological analysis of the plant communities of Piedmont, N.C. American Midland Naturalist 28:1-126.

Peet, R.K. and N.L. Christensen. 1980. Hardwood forest vegetation of the North Carolina Piedmont. Veroeff. Geobot. Inst. ETH, Stiftung Rubel, Zurich. 69. Heft:14-39.

Pinchot, G. and W.W. Ashe. 1897. Timber trees and forests of North Carolina. North Carolina Geological Survey Bulletin No. 6.

Rodewald, A.D. 2003. Decline of oak forests and implications for forest wildlife conservation. Natural Areas Journal 23:368-371.

Skeen, J.N., M.E. Carter, and H.L. Ragsdale. 1980. Yellow-poplar: the Piedmont case. Bull. Torrey Bot. Club 107:1-6.

Ware, S. 1992. Where are all the hickories in the Piedmont oak-hickory forest? Castanea 57:4-12.

Xi, W., R.K. Peet, M.L. Lee and D.L. Urban. 2019. Hurricane disturbances, tree diversity, and succession in North Carolina Piedmont forests, USA. Journal of Forestry Research 30:219-231.

KEY TO PIEDMONT AND COASTAL PLAIN OAK FORESTS

1. Forest dominated by *Quercus montana* (but lacking montane species such as *Castanea dentata* and *Rhododendron calendulaceum* that would fit better with Chestnut Oak Forest or Montane Oak–Hickory Forest); forest on an isolated erosional remnant hill or hill group (monadnock) or in the Uwharrie Mountains.
   2. Forest dominated by *Quercus montana* without a significant minority of *Pinus echinata* and without more than scattered *Kalmia latifolia*.....**Piedmont Monadnock Forest (Typic Subtype)**
   2. Forest with at least significant minority of *Pinus echinata* or with a shrub layer dominated by *Kalmia latifolia.*
      3. Forest with shrub layer dominated by *Kalmia latifolia*; generally on upper north-facing sides on monadnocks; (mesophytic trees absent or nearly so). **Piedmont Monadnock Forest (Heath Subtype)**
      3. Forest with little or no *Kalmia latifolia*; *Pinus echinata* 5% or more of the canopy, likely more in the past.....**Piedmont Monadnock Forest (Pine Subtype)**

1. Forest not dominated by *Quercus montana*; if the species is present, *Quercus alba* exceeds it in abundance.
   4. Forest consisting of varying combinations of *Quercus hemispherica, Pinus taeda, Quercus nigra,* and *Quercus virginiana*; *Quercus alba* generally absent; often containing *Cartrema americana*; community in the Coastal Plain, on upland ridges surrounded by wetlands. ..... **Swamp Island Evergreen Forest**
   4. Forest not containing appreciable, if any, *Quercus hemispherica, Quercus virginiana*, or *Cartrema americana*; generally containing abundant *Quercus alba*; if in the Coastal Plain, generally on upland slopes or dissected bluffs, not on upland ridges surrounded by wetlands.
      5. Forest dominated by *Quercus alba*, alone or in combination with other species.
         6. Forest containing a substantial amount of both *Quercus phellos* and *Quercus stellata*; evidence of ponded water in low microsites is generally present; some wetland herbs or shrubs are generally present locally. ..... **Mixed Moisture Hardpan Forest**
         6. Forest not containing more than incidental *Quercus phellos*; ponded microsites and wetland herbs or shrubs are absent or only incidentally present.
            7. Forest basic, containing multiple species associated with soils with higher base saturation and pH, such as *Fraxinus americana, Fraxinus biltmoreana, Carya cordiformis, Carya ovata, Lindera benzoin, Frangula caroliniana, Symphoricarpos orbiculatus, Rhus aromatica*, *Elymus hystrix, Elymus virginicus*, and *Chasmanthium latifolium*; generally also containing greater abundance of additional species such as *Cercis canadensis,* Carya sp., Acer *floridanum, Acer leucoderme, Ostrya virginiana*, *Ulmus alata*, and *Carya carolinae-septentrionalis*; *Vaccinium* generally less abundant than *Viburnum* or other shrubs, though it may be present.
               8. Forest dry-mesic in composition, with *Quercus rubra*, or rarely, *Quercus michauxii* or other mesophytic oaks, generally codominant or at least more abundant than the combination of *Quercus stellata, Quercus falcata*, and *Quercus marilandica*.
                  9. Forest in the Piedmont, on a substrate of crystalline rock, generally diabase, gabbro, amphibolite, or rarely calcareous sedimentary rock; species indicative of the Coastal Plain, such as *Persea palustris, Ilex glabra, Clethra alnifolia*, and *Symplocos tinctoria* absent or rare; *Quercus rubra* almost always abundant..... .....**Dry-Mesic Basic Oak–Hickory Forest (Piedmont Subtype)**
                  9. Forest in the Coastal Plain, on a substrate of unconsolidated sediment; containing species indicative of the Coastal Plain, such as *Persea palustris, Ilex glabra, Clethra alnifolia*, or *Symplocos tinctoria*; *Quercus rubra* rarely present, *Quercus michauxii* much more likely; very rare community..... .....**Dry-Mesic Basic Oak–Hickory Forest (Coastal Plain Subtype)**

8. Forest dry in composition, with *Quercus falcata* or *Quercus stellata* abundant in the canopy or at least predominating over *Quercus rubra* ..... **Dry Basic Oak–Hickory Forest**

7. Forest not basic, containing few, if any, *Fraxinus americana, Fraxinus biltmoreana, Carya cordiformis, Lindera benzoin, Frangula caroliniana, Symphoricarpos orbiculatus, Rhus aromatica*, *Elymus hystrix, Elymus virginicus*, *Chasmanthium latifolium*, or other indicators of high base status soils; *Vaccinium* spp. generally the predominant shrubs.

10. Forest dry-mesic in composition, with *Quercus rubra*, or rarely, *Quercus michauxii* or other mesophytic oaks, generally codominant or at least more abundant than the combination of *Quercus stellata, Quercus falcata*, and *Quercus marilandica*.

11. Forest in the Coastal Plain, on a substrate of unconsolidated or semi-consolidated sedimentary rock; if geographic location ambiguous, community containing species widespread in the Coastal Plain and not in the Piedmont, such as *Persea palustris, Quercus nigra, Ilex glabra, Clethra alnifolia*, and *Symplocos tinctoria*..... **Dry-Mesic Oak–Hickory Forest (Coastal Plain Subtype)**

11. Forest in the Piedmont, on a substrate of crystalline rock or sedimentary rock older than Cretaceous age; if geographic location ambiguous, community lacking species widespread in the Coastal Plain and scarce in the Piedmont. ..... **Dry-Mesic Oak–Hickory Forest (Piedmont Subtype)**

10. Forest dry in composition, with *Quercus falcata* or *Quercus stellata* abundant in the canopy or at least predominating over *Quercus rubra* and *Quercus michauxii*.

12. Forest in the Coastal Plain, on a substrate of unconsolidated or semi-consolidated sedimentary rock; if geographic location ambiguous, community containing species widespread in the Coastal Plain and not in the Piedmont, such as *Persea palustris, Ilex glabra, Clethra alnifolia*, and *Symplocos tinctoria*. ..... **Dry Oak–Hickory Forest (Coastal Plain Subtype)**

12. Forest in the Piedmont, on a substrate of crystalline rock or sedimentary rock older than Cretaceous age; if geographic location ambiguous, community lacking species widespread in the Coastal Plain and scarce in the Piedmont. ..... **Dry Oak–Hickory Forest (Piedmont Subtype)**

DRY-MESIC OAK–HICKORY FOREST (PIEDMONT SUBTYPE)

Concept: Dry-Mesic Oak–Hickory Forests are common Piedmont and Coastal Plain upland hardwood forests of acidic soils, occurring in environments intermediate between the mesic sites of sheltered slopes and the driest sites on ridge tops and upper slopes. They cover the moisture range between that where *Fagus* becomes a significant component and that where *Quercus falcata, Quercus stellata, Quercus marilandica*, or *Quercus montana* become significant components. The Piedmont Subtype covers the extensive examples of the Piedmont region, which lack characteristic Coastal Plain species and lack montane species.

Distinguishing Features: Because the overall moisture level is not easy to determine, upland hardwood forests are most easily distinguished by the canopy composition, and the overall flora. *Quercus stellata, Quercus falcata, Quercus marilandica*, and *Quercus montana* are scarce or absent in Dry-Mesic Oak–Hickory Forest, while *Quercus rubra* is largely absent from Dry Oak–Hickory Forest. Dry-Mesic Oak–Hickory Forest is distinguished from Mesic Mixed Hardwood Forest by the absence of more mesic species, particularly *Fagus grandifolia* (though such species may establish in the understory in the absence of fire). It is distinguished from Montane Oak–Hickory Forest by the absence of characteristically montane flora, such as *Castanea dentata, Magnolia fraseri, Acer pensylvanicum, Rhododendron calendulaceum*, *Gaylussacia frondosa*, *Gaylussacia baccata*, and *Rhododendron maximum*. Additionally, some species, such as *Kalmia latifolia* and *Hamamelis virginiana*, are widespread in Montane Oak–Hickory Forests but are restricted to more mesic communities in the Piedmont and Coastal Plain.

Dry-Mesic Oak–Hickory Forests are distinguished from Dry-Mesic Basic Oak–Hickory Forests and other basic oak forests by the absence or scarcity of a suite of species indicating high base status, such as *Fraxinus americana, Fraxinus biltmoreana, Cercis canadensis, Brachyelytrum erectum*, *Dichanthelium boscii*, *Symphoricarpos orbiculatus, Frangula caroliniana*, and *Celtis* spp. Basic indicators also include a set of species that are characteristic of more mesic or floodplain communities but that occur in dry sites with basic soils. These include *Acer floridanum, Carya ovata, Elymus hystrix, Elymus virginicus, Phryma leptostachya*, and *Phegopteris hexagonoptera*. Characteristic species of acidic soils, such as *Oxydendrum arboreum, Vaccinium stamineum, Vaccinium pallidum, Vaccinium tenellum, Gaylussacia frondosa*, and *Chimaphila maculata* may be present in basic communities, but predominate in Dry-Mesic Oak–Hickory Forest.

The Piedmont Subtype is distinguished from the Coastal Plain Subtype by floristic differences. *Quercus rubra* is largely restricted to the Piedmont Subtype. *Quercus nigra, Gaylussacia frondosa, Morella cerifera*, and *Arundinaria tecta* are largely restricted to the Coastal Plain Subtype. The Coastal Plain Subtype also tends to have at some least some plants more typical of wetter habitats, such as *Ilex glabra, Osmundastrum cinnamomeum*, and *Lorinseria (Woodwardia) areolata*, presumably associated with very small seepage patches.

Synonyms: *Quercus alba - Quercus rubra - Carya alba / Cornus florida / Vaccinium stamineum / Desmodium nudiflorum* Piedmont Forest (CEGL008475).
Ecological Systems: Southern Piedmont Dry Oak-(Pine) Forest (CES202.339).
Mesic Mesotrophic and Dry-Mesic Mesotrophic Forest (Peet and Christensen 1980).
White Oak-Red Oak-Black Oak (Oosting 1942).

SAF 52: White Oak-Black Oak-Northern Red Oak.

Sites: Dry-Mesic Oak–Hickory Forests in the Piedmont occupy most mid slopes and low ridges, and sometimes occur on lower or upper slopes, upland flats, or other places where moisture conditions are dry mesic. They occur on most substrates, including felsic igneous and metamorphic rocks, most metasedimentary rocks, and most Triassic sediments.

Soils: The Piedmont Subtype occurs on a wide variety of acidic upland soils, most commonly Typic Hapludults and Typic Kanhapludults. The most common map units are Cecil, Pacolet, Georgeville, Tatum, Appling, Madison, and Badin, but 30 or more additional series are associated with occurrences. A few examples are mapped as Alfisols such as Enon and Wilkes, but perhaps represent inclusions or examples where the series is not well developed.

Hydrology: Dry-Mesic Oak–Hickory Forests are well drained and are intermediate between the driest typical upland conditions and the moist conditions of mesic forests.

Vegetation: The Piedmont Subtype has a well-developed forest canopy with *Quercus alba* generally the most abundant species. *Quercus rubra* is common. Other species frequently present include *Quercus velutina, Carya tomentosa, Carya glabra*, *Carya ovalis*, *Pinus echinata*, *Acer rubrum*, and in the eastern Piedmont, *Pinus taeda*. Examples that have had substantial logging often have more pines and *Acer rubrum*, and *Liquidambar styraciflua* and *Liriodendron tulipifera* may also become abundant in the canopy. The understory most typically consists of *Acer rubrum*, *Oxydendrum arboreum*, *Cornus florida*, and *Nyssa sylvatica*, but may include abundant *Ilex opaca*, *Prunus serotina*, *Liquidambar styraciflua*, and small numbers of other species, as well as canopy species. *Fagus grandifolia* may be present in the understory but not in the canopy. The most characteristic shrubs are *Vaccinium stamineum, Vaccinium pallidum*, and *Euonymus americanus*. *Viburnum rafinesqueanum* or *Vaccinium tenellum* may be abundant in parts of the Piedmont. Trailing *Muscadinia rotundifolia* var. *rotundifolia* sometimes may cover significant patches of ground. The herb layer tends to be sparse. Common and frequent species include *Chimaphila maculata*, *Goodyera pubescens*, *Hexastylis arifolia*, *Tipularia discolor*, *Hylodesmum nudiflorum*, *Danthonia spicata*, *Dichanthelium* spp., *Carex* spp., and *Uvularia puberula*. Several other species are frequent in microsites where leaf litter does not persist, such as tip up mounds, small convex areas of slope, and edges of trails. These include *Houstonia pusilla*, *Hieracium venosum*, and several mosses such as *Dicranum scoparium*, *Leucobryum albidum*, and *Bryoandersonia illecebra*.

These forests generally have a closed or nearly closed canopy where not broken by gaps, a moderate-density understory, and a patchy sparse to moderate shrub layer. Canopy gaps are generally present in any sizeable stand and are an important part of the structure. Under past conditions of moderate fire frequency, canopies would have been more open, though still more forest than savanna, and would have had less *Acer rubrum* and more *Pinus echinata*. The forests would have had sparser understory and more cover and diversity of herbs, especially of grasses.

Range and Abundance: Ranked G4G5. Dry-Mesic Oak–Hickory Forest occurs throughout the Piedmont, except in the foothill ranges and possibly near the Blue Ridge escarpment. It is one of the most common communities throughout this range. The equivalent association ranges from Georgia to Maryland. Though it is confined to the Piedmont in North Carolina and presumably southward, in northern Virginia the same community composition extends across the Coastal Plain. *Quercus coccinea* becomes a more important component in Virginia.

Associations and Patterns: Dry-Mesic Oak–Hickory Forest (Piedmont Subtype) is a matrix community, making up much of the typical landscape mosaic in most of the Piedmont. In the topographic moisture gradient, Dry-Mesic Oak–Hickory Forest occurs between Dry Oak–Hickory Forest and Mesic Mixed Hardwoods, often with a very gradual transition. It may also adjoin patches of Piedmont/Coastal Plain Acidic Cliff, Piedmont/Coastal Plain Heath Bluff, Piedmont Monadnock Forest, other upland communities, or floodplain communities. It may be associated with Dry-Mesic Basic Oak–Hickory Forest or other basic communities, sometimes with a sharp boundary at a geologic contact.

Variation: No variants are recognized. Examples vary as expected, with the transition to other communities. Examples transitional to Dry-Mesic Basic Oak–Hickory Forest may have few Ericaceae but lack any definitive species of basic soils.

Dynamics: Dynamics are similar to those of the Piedmont members of this theme in general.

There have been several studies in Duke Forest where Dry-Mesic Oak–Hickory Forest itself has been a major focus. Israel (2011) looked at changes in long-term permanent plots. She found ongoing changes, some of which have accelerated in recent years, even in forests that were considered to be in the climax stage. Xi, et al. (2019) examined the complexity of natural disturbance by a severe storm. McDonald, Peet and Urban (2003) looked at spatial patterns that suggest that oak regeneration is indeed less abundant near maple understory, but at scales that go beyond simple light competition. Besides the ongoing questions of altered fire regimes and storm damage, very high populations of deer appear to be an important driver of recent changes, which span all successional stages and a wide range of communities (Israel 2011).

More subtle changes have also occurred. One notable result of a student data analysis project using the CVS plot database for Piedmont oak forests was identification of a distinct community similar to other Dry-Mesic Oak–Hickory Forests but confined to Duke Forest. This cluster consisted solely of the older plots from Duke Forest. More recent plots from Duke Forest were similar to other Piedmont plots, all of more recent age. The most striking difference was abundant *Cornus florida* in the understory. *Cornus florida* was often the most abundant understory tree species in Dry-Mesic Oak–Hickory Forest and Mesic Mixed Hardwood Forests in the author's memory, into the 1980s. The introduced dogwood anthracnose fungus (*Discula destructiva*) has reduced it to a minor component and one that is concentrated in a drier part of the moisture gradient than where it once had its peak abundance.

Comments: Befitting its abundance in the landscape near major universities, and especially in university research forests, Dry-Mesic Oak–Hickory Forest has been the subject of many published studies, including several versions of vegetation classification. Most influential for this document

has been Peet and Christensen (1980), but numerous others have contributed to the general understanding of this community, including Oosting (1942), Glazier (1967), Nehmeth (1968), Ohmann (1980), and Wells (1974).

Rare Species:
Vascular plants: *Helianthemum propinquum, Orbexilum pedunculatum* var. *pedunculatum, Gillenia stipulata, Prunus alabamensis, Pyrola americana, Quercus prinoides,* and *Smilax hugeri.*

References:

Glazier, D.C. 1967. An analysis of the vegetation and soil of upland hardwood stands in the Piedmont and Coastal Plain of Moore Co., North Carolina. M.S. Thesis, N.C. State University.

Israel, K.A. 2011. Vegetation change in Duke Forest, 1977-2010. M.S. Thesis, University of North Carolina, Chapel Hill.

McDonald, R.I., R.K. Peet and D.L. Urban. 2003. Spatial pattern of Quercus regeneration limitation and *Acer rubrum* invasion in a Piedmont forest. Journal of Vegetation Science 14:441-450.

Nehmeth, J.C. 1968. The hardwood vegetation and soils of Hill Demonstration Forest, Durham Co., N.C. Journal of the Elisha Mitchell Scientific Society 84:482-491.

Ohmann, J.L. 1980. Unique communities and rare plant species in Duke Forest: An applied methodology for their location and protective management. M.F. Thesis, Duke University, Durham, NC.

Oosting, H.J. 1942. An ecological analysis of the plant communities of Piedmont, N.C. American Midland Naturalist 28:1-126.

Peet, R.K., and N.L. Christensen. 1980. Hardwood forest vegetation of the North Carolina Piedmont. Veroeff. Geobot. Inst. ETH, Stiftung Rubel, Zurich. 69. Heft:14-39.

Sechrest, C.G., and A. Cooper. 1970. An analysis of the vegetation and soils of upland hardwood stands in the Piedmont and Coastal Plain of Moore Co., N.C. Castanea 35:26-57.

Wells, E.F. 1974. A vascular flora of the Uwharrie Wildlife Management Area. Castanea 39:39-57.

Xi, W., R.K. Peet, M.L. Lee and D.L. Urban. 2019. Hurricane disturbances, tree diversity, and succession in North Carolina Piedmont forests, USA. Journal of Forestry Research 30:219-231.

DRY-MESIC OAK–HICKORY FOREST (COASTAL PLAIN SUBTYPE)

Concept: Dry-Mesic Oak–Hickory Forests are common Piedmont and Coastal Plain upland hardwood forests of acidic soils, occurring in environments intermediate between the mesic sites of sheltered slopes and the driest sites on ridge tops and upper slopes. They cover the moisture range between that where *Fagus* becomes a significant component and that where *Quercus falcata, Quercus stellata, Quercus marilandica*, or *Quercus montana* become significant components. The Coastal Plain Subtype occurs in the Coastal Plain region and contains some species generally present in the Piedmont.

Distinguishing Features: Dry-Mesic Oak–Hickory Forests are distinguished by natural dominance of a mix of oaks, with or without hickories, in which *Quercus alba* is prominent and more drought tolerant oaks (*Quercus montana, Quercus marilandica, Quercus stellata,* and *Quercus falcata*) are scarce or are outweighed by trees more mesophytic than *Quercus alba*. They are distinguished from Mesic Mixed Hardwood Forest by the absence of more mesic species, particularly *Fagus grandifolia* and *Quercus michauxii* (though such species may establish in the understory in the absence of fire). The flora in all strata is limited to species tolerant of acidic soils, with species such as *Oxydendrum arboreum*, *Nyssa sylvatica*, *Cornus florida*, and *Vaccinium* spp. common, and species such as *Cercis canadensis*, *Fraxinus americana*, *Ostrya virginiana*, and most mesophytic herbs absent or scarce.

The Coastal Plain Subtype is distinguished from the Piedmont Subtype by floristic differences, most prominent in the lower strata. No species of very high constancy distinguish the subtypes, but a suite of species that are present in one but lacking in the other is generally represented. Species of the Coastal Plain Subtype include *Gaylussacia frondosa*, *Symplocos tinctoria*, and various wetland species such as *Persea palustris*, *Magnolia virginiana*, *Clethra alnifolia*, *Ilex glabra*, *Vaccinium elliottii, Arundinaria tecta*, *Lorinseria areolata*, *Osmundastrum cinnamomeum*, and *Chasmanthium laxum*. Other species sometimes present in the Coastal Plain Subtype but seldom in the Piedmont Subtype include *Morella cerifera* and *Callicarpa americana*. Species frequently found in the Piedmont Subtype but rarely or never in the Coastal Plain Subtype include *Quercus rubra*, *Quercus coccinea*, *Quercus montana*, *Vaccinium pallidum*, *Viburnum rafinesqueanum*, *Viburnum prunifolium*, *Viburnum acerifolium, Corylus cornuta*, *Carya carolinae-septentrionalis*, and *Chionanthus virginicus.* Herbs are scarce in both subtypes. *Chasmanthium laxum* and *Mitchella repens* are among the most frequent herb layer species in the Coastal Plain Subtype but scarce in the Piedmont, while *Hieracium venosum* is frequent in the Piedmont Subtype but largely absent in the Coastal Plain. The Coastal Plain Subtype often has a greater mixture of plants of different moisture tolerance than the Piedmont Subtype.

Synonyms: Synonyms: *Quercus alba - Carya alba / Oxydendrum arboreum - Ilex opaca / Gaylussacia frondosa - Symplocos tinctoria - Vaccinium stamineum* Coastal Plain Forest (CEGL004321).
Ecological Systems: Atlantic Coastal Plain Dry and Dry-Mesic Oak Forest (CES203.241).
SAF 52: White Oak-Black Oak-Northern Red Oak.

Sites: Dry-Mesic Oak–Hickory Forests in the Coastal Plain occupy upper to lower slopes and other dry-mesic areas that are naturally sheltered from fire. Most sites occur on bluffs or dissected areas,

but a few may occur on high river terraces where they are surrounded by wetter communities. Soil texture and drainage as well as topography contributes to where this community occurs.

Soils: Soils apparently are extremely variable or perhaps poorly characterized. In 39 occurrences with soil mapping recorded, 23 series are represented, primarily Ultisols but including Entisols and Inceptisols. The most frequently mapped series are Winton (Aquic Hapludult), Roanoke (Typic Enodaquult), and Baymeade (Arenic Hapludult). Because most occurrences are in dissected topography, their soils may represent small inclusions in other map units.

Hydrology: Dry-Mesic Oak–Hickory Forests are well drained and are intermediate between the driest typical upland conditions and the moist conditions of mesic forests. Local areas with wetland species may represent small seepage areas where ground water is a short distance below but does not show on the surface.

Vegetation: The Coastal Plain Subtype has a typical forest canopy dominated by *Quercus alba*, in combination with a variety of species that include *Pinus taeda*, *Carya tomentosa*, *Carya pallida*, and *Quercus velutina*. Species shared with wetter or drier communities are present at lower frequency or abundance, including *Quercus falcata*, *Quercus michauxii*, and *Pinus echinata*. The understory frequently includes abundant *Ilex opaca, Cornus florida*, *Oxydendrum arboreum*, *Acer rubrum*, *Nyssa sylvatica*, *Carpinus caroliniana*, and *Liquidambar styraciflua*. Less frequent but sometimes abundant species include *Magnolia virginiana*, *Stewartia malacodendron*, *Ostrya virginiana*, and *Magnolia tripetala*. Shrubs and ground level vines may be sparse to moderate in cover. *Muscadinia rotundifolia, Symplocos tinctoria*, and *Vaccinium fuscatum* are frequent and abundant, and *Euonymus americanus*, *Vaccinium arboreum, Sassafras albidum*, *Callicarpa americana*, *Smilax rotundifolia*, *Smilax bona-nox*, and *Bignonia capreolata* are also frequent. Less frequent but sometimes abundant species include *Asimina parviflora*, *Clethra alnifolia*, *Styrax grandifolius*, *Vaccinium stamineum*, *Vaccinium tenellum*, *Gaylussacia frondosa*, *Castanea pumila*, *Morella cerifera*, *Ilex glabra*, *Eubotrys racemosus*, and *Arundinaria tecta*. Herbs are sparse to moderate in cover but are generally not diverse. *Mitchella repens* or *Chasmanthium laxum* are frequent and often abundant, and *Polystichum acrostichoides*, *Lorinseria areolata, Osmundastrum cinnamomeum*, and *Chasmanthium sessilifolium* may be abundant in some examples.

Range and Abundance: Ranked G3G4 but more likely G3. Dry-Mesic Oak–Hickory Forests occur throughout the Coastal Plain, from the Sandhills Region to bluffs along tidewater rivers and creeks, but they are largely confined to small areas of dissected topography. They did not dominate large parts of the landscape in the past as the Piedmont Subtype did, though they may have been extensive in the northernmost part of the Coastal Plain. The corresponding NVC association is attributed only questionably to South Carolina and Georgia. It might be expected to range through these states, but a different association might be recognized there. A different comparable association, which shares more Piedmont species, is recognized in Virginia.

Associations and Patterns: The Coastal Plain Subtype appears to naturally be a large patch community. It is common in the small areas of dissected topography but is absent in the prevailing landscapes of the Coastal Plain. It may grade to Dry Oak–Hickory Forest uphill and to Mesic Mixed Hardwood Forest or Piedmont/Coastal Plain Heath Bluff downhill, but patches may be

small enough that these communities may not be distinguishable. It may sometimes border floodplain or other wetland communities and less often grades directly to longleaf pine communities.

Variation: No variants are recognized. Examples vary with latitude, with northern examples less sharply differentiated from the Piedmont Subtype. Investigation is needed to determine if some northern examples may be more similar to the association recognized in Virginia. Examples also vary with gradation to other communities, including Mesic Mixed Hardwood Forest, Dry Oak–Hickory Forest, and Dry-Mesic Basic Oak–Hickory Forest.

Dynamics: Dynamics of naturally occurring examples presumably are similar to those of the Piedmont and Coastal Plain Oak Forests theme in general and to the Piedmont Subtype. However, the proximity to the coast means more disturbance by hurricanes, with a corresponding greater frequency of gap formation, and this may contribute to the greater abundance of pines, while the greater natural fire frequency of the Coastal Plain probably once meant more frequent and intense burning, even in sites with topographic sheltering. This too may contribute to the greater occurrence of pines. Pines, especially *Pinus taeda*, seem to become more abundant in hardwood communities of slopes as one goes southward and also westward across the Gulf Coastal Plain. In the presettlement forests of the Big Thicket of Texas, pines were generally codominant in analogous communities (Schafale and Harcombe 1983).

Comments: The transition from the Coastal Plain subtype to Mesic Mixed Hardwood Forest or Dry Oak–Hickory Forest appears to be more gradual than the comparable transition in the Piedmont. This may be a result of greater disruption of natural fire regimes or may be a result of the nature of Coastal Plain soils. The presence of wetland species even in these dry upland communities is presumably related to small areas of seepage.

Though the oak-hickory forests of the Coastal Plain have received less study than those of the Piedmont, Glazier (1967) and Sechrest and Cooper (1970) are two studies that contributed to earlier understanding of this community.

The NVC contains 3 associations comparable to this subtype. *Quercus alba - Carya glabra* / Mixed Herbs Coastal Plain Forest (CEGL007226), formerly attributed to North Carolina, has been clarified as an association of the Gulf Coast. *Quercus alba - Quercus nigra - Quercus falcata / Ilex opaca / Clethra alnifolia - Arundinaria gigantea ssp. tecta* Forest (CEGL007862), and *Quercus alba - Carya alba / Vaccinium elliottii* Forest [Provisional] (CEGL007224) are related associations that may overlap this subtype.

Rare Plant Species:

References:

Glazier, D.C. 1967. An analysis of the vegetation and soil of upland hardwood stands in the Piedmont and Coastal Plain of Moore Co., North Carolina. M.S. Thesis, N.C. State University, Raleigh.

Schafale, M.P., and P.A. Harcombe. 1983. Presettlement vegetation of Hardin County, Texas. American Midland Naturalist 109:355-366.

Sechrest, C.G., and A. Cooper. 1970. An analysis of the vegetation and soils of upland hardwood stands in the Piedmont and Coastal Plain of Moore Co., N.C. Castanea 35:26-57.

DRY OAK–HICKORY FOREST (PIEDMONT SUBTYPE)

Concept: Dry Oak–Hickory Forests are common Piedmont or Coastal Plain upland hardwood forests of acidic soils occurring in the driest typical topographic positions, on south slopes and ridge tops; where *Quercus alba, Q. stellata*, and *Q. falcata* predominate in the canopy. They are the driest sites in typical Piedmont landscapes but are less xeric than some communities of specialized settings such as montmorillonitic soils or shallow rock. They contain acid-tolerant flora such as *Oxydendrum arboreum, Nyssa sylvatica, Vaccinium stamineum, Vaccinium pallidum*, and *Vaccinium arboreum*, and lack more base-loving plants. The Piedmont Subtype covers typical examples of the Piedmont, which lack significant Coastal Plain flora.

Distinguishing Features: Dry Oak–Hickory Forests are distinguished from Dry-mesic Oak–Hickory Forests by having *Quercus stellata, Q. falcata*, and other trees more drought tolerant than *Quercus alba* predominating over *Quercus rubra* and other trees less drought tolerant than *Quercus alba*. They are distinguished from Xeric Hardpan Forests by a canopy that contains significant *Quercus alba* and other trees that are less xerophytic than *Quercus stellata*.

Dry Oak–Hickory Forests are distinguished from Dry Basic Oak–Hickory Forests by having acid-tolerant plants predominating and by lacking more base-loving plants. Characteristic species in basic communities and typically lacking in acidic communities include *Fraxinus americana, Cercis canadensis, Acer leucoderme*, *Rosa carolina, Clematis ochroleuca*, *Viburnum* spp., and in more strongly basic sites, *Frangula caroliniana, Symphoricarpos orbiculatus*, or *Rhus aromatica*. Several additional species are more widely distributed but are more abundant in basic communities, including *Carya carolinae-septentrionalis, Ulmus alata*, and *Acer floridanum*. Acid-tolerant species such as *Oxydendrum arboreum, Vaccinium pallidum, Vaccinium tenellum*, and *Chimaphila maculata* may be present in both communities but predominate in their stratum in Dry Oak–Hickory Forest.

The Piedmont Subtype is distinguished from the Coastal Plain Subtype by floristic differences, though the dominant species may be the same. Species indicative of the Coastal Plain Subtype include species shared with dry sandy communities, such as *Quercus margarettiae, Quercus incana, Cnidoscolus stimulosus*, or *Gaylussacia dumosa*, as well as species of wetter communities, such as *Quercus nigra, Gaylussacia frondosa, Morella cerifera*, and *Arundinaria tecta*.

Synonyms: Quercus falcata - Quercus alba - Carya alba / Oxydendrum arboreum / Vaccinium stamineum Forest (CEGL007244).
Ecological Systems: Southern Piedmont Dry Oak-(Pine) Forest (CES202.339).
Oligotrophic Forest, Dry Eutrophic Forest (Peet and Christensen 1980).
White Oak, White Oak-Post Oak (Oosting 1942).
Type IV (Nehmeth 1968).
SAF 53: White Oak.

Sites: Dry Oak–Hickory Forests occur on ridgetops, upper slopes, steep south-facing slopes, and other relatively dry upland areas on acidic soils. They occasionally occur on upland flats with somewhat restricted rooting depth, which makes them seasonally dry.

Soils: The Piedmont Subtype may occur on most upland soils. The most common map units are Cecil, Pacolet, Georgeville, Tatum, Appling, Madison, and Badin (all Typic Kanhapludults or Typic Hapludults), but 30 or more additional series are associated with occurrences. A few examples mapped as Alfisols, such as Enon and Wilkes, or Inceptisols, such as Misenheimer, may represent inclusions or incomplete development of these series.

Hydrology: Dry Oak–Hickory Forests occur in the driest environments produced by normal Piedmont topography. Conditions are dry because of runoff from high topographic positions, though a few examples may also have restricted rooting depth.

Vegetation: The Piedmont Subtype forests are dominated by *Quercus alba* in combination with oaks of drier sites, generally *Quercus falcata*, *Quercus stellata*, sometimes *Quercus montana*. *Pinus echinata* may be abundant, sometimes codominant or locally dominant in small groves. Other frequent canopy species include *Carya tomentosa*, *Carya glabra*, *Quercus velutina*, *Quercus coccinea*, *Pinus virginiana*, and, in the eastern part of the range, *Pinus taeda*. Examples that have had substantial logging often have more pines and *Acer rubrum*, and *Liquidambar styraciflua* or *Liriodendron tulipifera* may become abundant in the canopy. Typical understory species are *Oxydendrum arboreum, Acer rubrum, Nyssa sylvatica, Cornus florida*, and *Vaccinium arboreum*. Shrubs range from sparse to dense. The most characteristic shrubs are *Vaccinium stamineum, Vaccinium pallidum*, and *Euonymus americanus*. *Viburnum rafinesqueanum* or *Vaccinium tenellum* may be abundant in parts of the Piedmont. Trailing *Muscadinia rotundifolia* var. *rotundifolia* may sometimes cover significant patches of ground. The herb layer tends to be sparse. Abundant and frequent species include *Chimaphila maculata*, *Goodyera pubescens*, *Hexastylis arifolia*, *Tipularia discolor*, *Hylodesmum nudiflorum*, *Danthonia spicata*, *Piptochaetium avenaceum*, *Coreopsis major*, *Dichanthelium* spp., *Carex* spp., and *Schizachyrium scoparium*. Several other species are frequent in microsites where leaf litter does not persist, such as tip up mounds, small convex areas of slope, and edges of trails. These include *Houstonia pusilla*, *Hieracium venosum*, and several mosses such as *Dicranum scoparium*, *Leucobryum albidum*, and *Bryoandersonia illecebra*.

Range and Abundance: Ranked G4G5. This community occurs throughout the Piedmont, except in the foothill ranges and possibly near the Blue Ridge escarpment. It may once have been the most extensive in the Piedmont, but because much of its extent is on flat uplands, land use has removed a greater proportion than most other common communities.

The corresponding NVC association is very broad and not precisely defined, extending to Mississippi and Kentucky. It apparently excludes the Atlantic Coastal Plain. It apparently does not occur in Virginia, where drier sites are occupied by an oak/heath forest of more northerly affinities. This concept is almost certainly inappropriately broad. There is no reason to believe this community should have a range so different from the similar Dry Mesic Oak–Hickory Forest.

Associations and Patterns: This is the driest community in the typical topographic moisture gradient. It grades to Dry Mesic Oak–Hickory Forest in less dry sites downhill or on different slope aspects. It may be associated with Dry Basic Oak–Hickory Forest or other basic communities, if there is a change in geologic substrate. This transition can sometimes be very gradual but may be

abrupt. It is less often associated with Piedmont Monadnock Forest, Xeric Hardpan Forest (Acidic Hardpan Subtype) or Mixed Moisture Hardpan Forest.

Variation: Four variants are recognized:
1. Typic Variant: Most widespread and most precisely fitting the description above.
2. Hardpan Variant: Occurring on soils with montmorillonitic clay but not extreme enough to support Xeric Hardpan Forest or Mixed Moisture Hardpan Forest. They have an admixture of plants suggestive of local or periodic wetness, such as *Quercus phellos*, *Vaccinium corymbosum*, and *Chasmanthium laxum*.
3. Shale Slope Variant: Occurring on steep slopes with channery soils, where slate, shale, or other rock breaks up into small flat fragments. The accumulation of rock fragments makes these slopes better drained and somewhat unstable. They tend to have more *Pinus virginiana* or *Pinus echinata* in them, and often have some unusual species, such as *Rhus aromatica*, along with more typical acid-tolerant species.
4. Chestnut Oak Variant: Occurring on rocky ridges. This variant is transitional to Piedmont Monadnock Forest and is the only variant to have appreciable *Quercus montana*.

Dynamics: Dynamics are similar to those discussed for the Piedmont members of this theme in general and to those of Dry Mesic Oak–Hickory Forests.

Comments: As in Dry Mesic Oak–Hickory Forest, a number of early studies recognized this community. Peet and Christensen (1980) were particularly influential in the current classification.

Pinus echinata - Quercus alba / Vaccinium pallidum / Hexastylis arifolia - Chimaphila maculata Forest (CEGL008427) and *Pinus taeda - Quercus (alba, falcata, stellata)* Successional Coastal Plain Forest (CEGL004766) are widespread associations that appear to overlap this. While pines of several species may be present in natural examples in North Carolina, codominant or dominant pines suggests a successional version of this community type. *Pinus taeda - Quercus falcata / Vaccinium pallidum / Hexastylis arifolia* Forest (CEGL006033) has been defined in Virginia and not attributed to North Carolina. It is unclear how it relates to this.

Rare Plant Species:
Vascular plants: *Corallorhiza wisteriana, Nestronia umbellula, Onosmodium virginianum, Gillenia stipulata, Prunus umbellata, Rhus michauxii, Thermopsis mollis var. mollis,* and *Yucca flaccida.*

References:
Nehmeth, J.C. 1968. The hardwood vegetation and soils of Hill Demonstration Forest, Durham Co., N.C. Journal of the Elisha Mitchell Scientific Society 84: 482-491.

Oosting, H.J. 1942. An ecological analysis of the plant communities of Piedmont, N.C. American Midland Naturalist 28:1-126.

Peet, R.K., and N.L. Christensen. 1980. Hardwood forest vegetation of the North Carolina Piedmont. Veroeff. Geobot. Inst. ETH, Stiftung Rubel, Zurich. 69. Heft: 14-39.

DRY OAK–HICKORY FOREST (COASTAL PLAIN SUBTYPE)

Concept: Dry Oak–Hickory Forests are common Piedmont or Coastal Plain upland hardwood forests of acidic soils occurring in the driest typical topographic positions, on south slopes and ridge tops; where *Quercus alba, Q. stellata*, and *Q. falcata* predominate in the canopy. The Coastal Plain Subtype covers Coastal Plain examples, which have a distinct component of Coastal Plain flora.

Distinguishing Features: Dry Oak–Hickory Forests are distinguished from Dry-Mesic Oak–Hickory Forests by canopy composition, which has *Quercus stellata, Q. falcata*, and other trees more drought tolerant than *Quercus alba* predominating over trees less drought tolerant than *Quercus alba*. *Quercus alba* tends to be dominant or most abundant in both, though some examples of the Coastal Plain Subtype are more strongly dominated by *Quercus falcata*. Dry Oak–Hickory Forests are distinguished from various sandhill communities by having a closed canopy and lacking the scrub oak understory and characteristic herb layer of longleaf pine communities.

It may be difficult to tell true primary Dry Oak–Hickory Forest from sandhill communities degraded by fire exclusion, since many characteristic hardwoods and shrubs will invade sandhills in the absence of fire. It is unclear how readily *Pinus palustris* would cooccur in these hardwood forests, but a substantial presence presumably indicates that the site was naturally a sandhill community. The presence of abundant scrub oaks (*Quercus margaretiae, Quercus incana*, and *Quercus marilandica*) or of *Aristida stricta* indicates a former sandhill. The location can also be indicative; fire was frequent on the uplands, and only some kind of natural mitigation of fire frequency or intensity is likely to have allowed the occurrence of oak-hickory forest.

The Coastal Plain Subtype is distinguished from the Piedmont Subtype by geography and substrate and by the presence of characteristic Coastal Plain species. *Quercus falcata* and pines are more common, *Quercus coccinea* virtually absent. In the lower strata, characteristic or predominantly Coastal Plain species such as *Gaylussacia frondosa*, *Ilex glabra*, *Persea palustris*, and various scrub oaks tend to be present in at last small numbers.

Synonyms: *Quercus falcata - Quercus stellata - Carya alba / Vaccinium* spp. Coastal Plain Forest (CEGL007246).
Ecological Systems: Atlantic Coastal Plain Dry and Dry-Mesic Oak Forest (CES203.241).

Sites: Coastal Plain Dry Oak–Hickory Forests occur on upper slopes and other dry areas that are naturally sheltered from fire. They are usually on bluffs or dissected areas but occur occasionally on high river terraces. Good soil drainage is needed, but the most excessively drained soils support sandhill communities. Soil texture and drainage as well as topography thus contribute to where this community occurs.

Soils: Soils apparently are extremely variable or perhaps poorly characterized. In 21 occurrences with soil mapping recorded, 19 series are represented, primarily Ultisols but including Entisols and Inceptisols. Because most occurrences are in dissected topography, their soils may represent small inclusions in other map units.

Hydrology: Sites are terrestrial and are dry but not excessively drained. Local areas with wetland species may represent small seepage areas where ground water is a short distance below but does not show on the surface.

Vegetation: The Coastal Plain Subtype is a forest generally dominated by *Quercus falcata* and *Quercus alba*, often with abundant *Pinus taeda*, *Quercus stellata*, *Carya tomentosa*, and less frequently *Pinus echinata*, *Pinus palustris*, and *Quercus velutina*. The understory typically includes *Oxydendrum arboreum*, *Cornus florida*, *Acer rubrum*, *Liquidambar styraciflua*, *Nyssa sylvatica*, and less often, *Ilex opaca*, *Persea palustris*, *Prunus serotina*, or *Diospyros virginiana*. The shrub layer may be sparse to dense. *Vaccinium arboreum, Symplocos tinctoria*, and *Gaylussacia frondosa* are frequent. Other shrubs may include *Asimina parviflora*, *Castanea pumila*, *Vaccinium stamineum*, and *Vaccinium tenellum*. Sprawling vines often have substantial cover, especially *Muscadinia rotundifolia*, *Smilax rotundifolia*, *Smilax bona-nox*, and *Gelsemium sempervirens*. Herbs tend to be sparse, though patches dominated by *Chasmanthium laxum* occur in some examples. Few other herbs have been recorded in examples, none with high constancy. CVS vegetation plots help characterize this community but don't represent the range of composition recorded in other examples.

Range and Abundance: Ranked G4?. In North Carolina, this community occurs throughout the Coastal Plain, from the Sandhills Region to bluffs along tidewater rivers and creeks, but it is largely confined to small areas of dissected topography. It did not dominate large parts of the landscape as the Piedmont Subtype did. The corresponding NVC association ranges to Georgia, Louisiana, and Tennessee, but may be too broadly defined compared to other associations with more limited range. This community can at least be expected to range through South Carolina into Georgia. A different community which shares more Piedmont species occurs in Virginia.

Associations and Patterns: Dry Oak–Hickory Forests usually grade downhill to Dry-Mesic Oak–Hickory Forest and Mesic Mixed Hardwood Forest on slopes and dissected areas and may occasionally border floodplain communities more directly. Few examples of intact uphill boundaries remain, but this community presumably bordered sandhill or Mesic Pine Savanna communities, though it is unsure if the natural boundary would be sharp or gradual.

Variation: No variants are recognized. Examples vary with latitude, with northern examples less sharply differentiated from the Piedmont Subtype. Substantial variation in the amount of species more characteristic of longleaf pine communities may or may not be natural.

Dynamics: Dynamics of naturally occurring examples presumably are similar to those of the Piedmont Subtype and to the dynamics discussed for the theme as a whole. However, the proximity to the coast means more disturbance by hurricanes, with a corresponding greater frequency of gap formation, and this may contribute to the greater abundance of pines. In addition, the greater natural fire frequency of the Coastal Plain probably means more frequent and intense burning, even in sites with topographic sheltering. This too may contribute to the greater occurrence of pines. Unlike in the Piedmont, more frequently burned communities typically occur nearby, and it is possible that climatic cycles that affect fire frequency would cause boundaries of communities to shift over time. Certainly, present fire suppression has allowed vegetation resembling Dry Oak–Hickory Forest to spread farther into flat uplands in some areas.

Comments: *Quercus alba - Quercus falcata - (Carya pallida) / Gaylussacia frondosa* Forest (CEGL006269) is a more northerly Coastal Plain dry oak-hickory forest association that ranges from NJ to VA. It has been questionably attributed to NC but no distinctive northern version of Dry Oak–Hickory Forest that would warrant recognition has been found.

Rare species:

References:

DRY-MESIC BASIC OAK–HICKORY FOREST (PIEDMONT SUBTYPE)

Concept: Dry-Mesic Basic Oak–Hickory Forests are uncommon Piedmont and Coastal Plain forests that occur on less acidic and more fertile soils than typical, with moisture regimes comparable to Dry-Mesic Oak–Hickory Forests. They fall between Basic Mesic Forest and Dry Basic Oak–Hickory Forest on appropriate substrates. The Piedmont Subtype covers examples in the Piedmont, which lack characteristic Coastal Plain species and lack montane species.

Distinguishing Features: DryaMesic Basic Oak–Hickory Forests are distinguished from Basic Mesic Forest by a canopy is dominated by *Quercus alba*, along with other oaks and hickories. There is essentially no *Fagus grandifolia* in the canopy, and *Liriodendron* is scarce in natural occurrences. Dry-Mesic Basic Oak–Hickory Forests are distinguished from Dry Basic Oak–Hickory Forests by a more mesic flora. The more drought-tolerant oaks such as *Quercus stellata, Quercus marilandica*, and *Quercus falcata* are scarce or absent, and *Quercus rubra* often is abundant.

Dry-Mesic Basic Oak–Hickory Forests are distinguished from Dry-Mesic Oak–Hickory Forests by occurrence of flora indicative of unusually high pH and base saturation. Species of basic soils include *Fraxinus americana, Cercis canadensis, Celtis* spp., *Symphoricarpos orbiculatus, Frangula caroliniana, Brachyelytrum erectum*, and *Dichanthelium boscii*. Basic indicators also include a set of species that are characteristic of more mesic or floodplain communities but that occur in dry sites that are less acidic. These include *Acer floridanum, Carya ovata, Elymus hystrix, Elymus virginicus, Phryma leptostachya*, and *Phegopteris hexagonoptera*. Characteristic species of acidic soils, such as *Oxydendrum arboreum, Vaccinium stamineum, Vaccinium pallidum, Vaccinium tenellum, Gaylussacia frondosa*, and *Chimaphila maculata,* may be present, but don't predominate as they do in Dry-Mesic Oak–Hickory Forest.

The Piedmont Subtype is distinguished from the Coastal Plain Subtype by floristic differences. *Quercus rubra* is largely restricted to the Piedmont Subtype. *Quercus nigra, Gaylussacia frondosa, Morella cerifera*, and *Arundinaria tecta* are largely restricted to the Coastal Plain Subtype. The Coastal Plain Subtype also tends to have at some least some plants more typical of wetter habitats, such as *Ilex glabra, Osmundastrum cinnamomeum*, and *Woodwardia areolata*, presumably associated with very small seepage patches.

Synonyms: *Quercus alba - Quercus rubra - Carya (ovata, carolinae-septentrionalis) / Cercis canadensis* Forest (CEGL007232).
Ecological Systems: Southern Piedmont Dry Oak-(Pine) Forest (CES202.339).

Sites: Dry-Mesic Basic Oak–Hickory Forests in the Piedmont occupy most mid slopes and low ridges, and sometimes occur on lower or upper slopes, upland flats, or other places where moisture conditions are dry-mesic.

Soils: The Piedmont Subtype occurs on a variety of upland soils that have high base saturation and less acidic pH than most Piedmont soils. The most common series mapped are Enon and Iredell, both Alfisols, with fewer mapped as Mecklenburg, Orange, and Wilkes, also Alfisols. Examples are also mapped on Pacolet and a wide variety of other Ultisols but may represent inclusions in

these map units. Though such soils are commonly called basic, it has been noted that few have pH above neutral and some are fairly acidic. Base saturation and availability of individual cations may be more important, and examples have higher values than Dry-Mesic Oak–Hickory Forest.

Hydrology: Sites are well drained and are intermediate between the driest typical upland conditions and the moist conditions of mesic forests.

Vegetation: The Piedmont Subtype forests are dominated by combinations of *Quercus alba, Quercus rubra*, *Carya tomentosa*, *Carya glabra*, *Carya carolinae-septentrionalis, Fraxinus americana*, and *Fraxinus biltmoreana*. Other species that may be present include *Quercus velutina*, *Liriodendron tulipifera*, *Carya ovalis*, *Carya ovata*, *Acer floridanum*, and *Juglans nigra*. In examples altered by logging, *Liriodendron tulipifera*, *Pinus taeda*, or *Liquidambar styraciflua* may be abundant or even dominant in the canopy. The understory may be dominated by *Acer floridanum*, *Ulmus alata*, *Acer leucoderme*, *Ostrya virginiana*, *Cornus florida*, or other species. Other frequent or abundant species include *Juniperus virginiana*, *Carpinus caroliniana*, *Acer rubrum*, *Liquidambar styraciflua*, *Ulmus rubra*, *Ilex opaca*, and *Oxydendrum arboreum*. Shrubs are generally low in density. *Viburnum prunifolium* or *Viburnum rafinesqueanum* may be dense, or there may be a low density mix of shrubs that includes *Symphoricarpos orbiculatus*, *Euonymus americanus*, *Celtis tenuifolia*, *Rosa carolina*, and *Frangula caroliniana*. *Vaccinium* species may be present in small numbers but often are absent. Shrubs of floodplains, such as *Aesculus sylvatica* and *Lindera benzoin*, occasionally are present in small numbers. Vines may form significant cover on the ground, including *Muscadinia rotundifolia*, *Toxicodendron radicans*, *Parthenocissus quinquefolius*, *Lonicera sempervirens*, and, often, the exotic *Lonicera japonica*. Herbs generally are sparse under present conditions, though *Piptochaetium avenaceum* may dominate patches. Frequent herbs include *Asplenium platyneuron*, *Galium circaezans*, *Endodeca serpentaria*, *Maianthemum racemosum*, and *Hylodesmum nudiflorum*. Widespread species of uplands, such as *Hexastylis arifolia*, *Goodyera pubescens*, and *Danthonia spicata* may be present. Other herbs that may be present include *Dichanthelium boscii*, *Brachyelytrum erectum*, *Phegopteris hexagonoptera*, *Actaea racemosa*, *Melica mutica*, *Viola palmata*, *Botrypus virginianus*, *Agrimonia pubescens*, *Phryma leptostachya*, *Polygonatum biflorum* var. *biflorum*, and *Nabalus latissimus.* Several other species are frequent in microsites where leaf litter does not persist, such as tip up mounds, small convex areas of slope, and edges of trails. These include *Houstonia pusilla*, *Hieracium venosum*, and several mosses such as *Dicranum scoparium*, *Leucobryum albidum*, and *Bryoandersonia illecebra*.

Dynamics: Dynamics are similar to those of Dry-Mesic Oak–Hickory Forest (Piedmont Subtype) and to the theme as a whole. Gap phase regeneration and uneven-aged tree population structure are the natural state, and fire of low to moderate intensity and of moderate frequency is important. Current examples without recent fire sometimes have more grass cover and diversity than their acidic counterparts; it remains to be seen if this will be true of burned examples. If it is, this could lead to somewhat more open canopies, as stands burn more readily.

Range and Abundance: Ranked G3G4. This community occurs throughout the Piedmont, except in the foothill ranges and near the Blue Ridge escarpment. The corresponding NVC association ranges to Alabama and into Virginia.

Associations and Patterns: Dry-Mesic Basic Oak–Hickory Forest (Piedmont Subtype) is a large patch community. It is abundant in many areas of mafic rock substrate but does not form a regularly repeating part of the typical Piedmont landscape. In the topographic moisture gradient, Dry-Mesic Basic Oak–Hickory Forest occurs between Dry Basic Oak–Hickory Forest and Basic Mesic Hardwoods, often with a very gradual transition. It may also adjoin patches of Piedmont/Coastal Plain Acidic Cliff, Piedmont/Coastal Plain Heath Bluff, other upland communities, or floodplain communities. It may be associated with Dry-Mesic Oak–Hickory Forest or other acidic communities, if there is a change in geologic substrate. This transition can sometimes be gradual but may be abrupt.

Variation: Two variants are recognized, though the boundary between them will be difficult to define:
1. Typic Variant is the most frequent variant, containing plants of basic soils but lacking the species confined to more strongly basic soils.
2. Strongly Basic Variant contains plants associated only with the most strongly basic soils and has a greater diversity and abundance of plants of richer soils. Examples may have *Juglans nigra*, *Tilia americana* var. *caroliniana*, *Frangula caroliniana*, and possibly *Quercus muhlenbergii*. It is much less common than the Typic Variant.

Comments: The effect of base-rich soils in producing distinctive communities was recognized by Peet and Christensen (1980) and Oosting (1942). The 3rd Approximation recognized only a single Basic Oak–Hickory Forest community, which spanned the dry and dry-mesic moisture range. The reasoning for the broader moisture range was the that the basic-rich soils confused assessment of moisture conditions based on the plants present. As noted, species typical of more mesic sites can be found in drier sites with basic soils, including a number of species considered typical of floodplain in Dry-Mesic Basic Oak–Hickory Forest. However, additional experience has clarified that the dominant trees reflect the moisture gradient in ways similar to acidic soils.

Quercus alba - Quercus rubra - Quercus prinus - Tilia americana var. caroliniana / Ostrya virginiana Forest (CEGL004542) is an association defined by analysis of Uwharrie Mountains CVS data but is not recognized here. Five plots were attributed to it (2-151, 2-165, 3-167, 3-168, and 6-151). The plots share a common feature of abundant *Tilia americana* var. *caroliniana*, but vary drastically in canopy dominants and even setting, with one apparently occurring on an alluvial terrace. For the upland sites, it is unclear how they would be distinguished from other Dry-Mesic Basic Oak–Hickory Forests, other than by the abundance of *Tilia*, one of a suite of basic indicators but a stronger basic indicator than most. The distinctness of this association needs to be assessed against a broader data set of basic communities, and field relations need to be determined. It is possible that it could represent the Strongly Basic Variant.

Rare species:
Vascular plants: *Acmispon helleri, Agastache nepetoides, Baptisia aberrans, Berberis canadensis, Buchnera americana, Cirsium carolinianum, Hexalectris spicata, Oligoneuron album, Polygala senega, Gillenia stipulata, Ruellia purshiana, Silphium terebinthinaceum,* and *Smilax lasioneura.*

References:

Oosting, H.J. 1942. An ecological analysis of the plant communities of Piedmont, N.C. American Midland Naturalist 28:1-126.

Peet, R.K., and N.L. Christensen. 1980. Hardwood forest vegetation of the North Carolina Piedmont. Veroeff. Geobot. Inst. ETH, Stiftung Rubel, Zurich. 69. Heft:14-39.

DRY-MESIC BASIC OAK–HICKORY FOREST (COASTAL PLAIN SUBTYPE)

Concept: Dry-Mesic Basic Oak–Hickory Forests are uncommon Piedmont and Coastal Plain forests that occur on less acidic and more fertile soils than typical, with moisture regimes comparable to Dry-Mesic Oak–Hickory Forests. They fall between Basic Mesic Forest and Dry Basic Oak–Hickory Forest on appropriate substrates. The Coastal Plain Subtype covers the rare Coastal Plain examples, containing flora characteristic of the Coastal Plain in addition to widespread flora of the type.

Distinguishing Features: Dry-Mesic Basic Oak–Hickory Forests are distinguished from Basic Mesic Forests by a canopy that is dominated by *Quercus alba*, along with other oaks and hickories. There is essentially no *Fagus grandifolia* in the canopy, and *Liriodendron* is scarce in natural occurrences. They are distinguished from Dry-Mesic Oak–Hickory Forests by occurrence of more base-loving flora in association with less acidic substrate. Heaths, at least the more acid-loving ones such as *Oxydendrum arboreum, Vaccinium pallidum*, and *Vaccinium tenellum*, are absent or scarce. *Fraxinus americana, Acer floridanum, Ostrya virginiana, Cercis canadensis*, and *Viburnum* spp. may be abundant. A few examples have distinctive base-loving herbs, but most are more readily distinguished by the woody strata.

The Coastal Plain Subtype often has a greater mixture of plants of different moisture tolerance than the Piedmont Subtype. *Quercus falcata* is a common component, even as characteristic wetland species are often present in small numbers.

Synonyms: *Quercus alba - Carya glabra - Carya alba / Aesculus pavia* Forest (CEGL007225). Ecological Systems: Atlantic Coastal Plain Dry and Dry-Mesic Oak Forest (CES203.241).

Sites: Dry-Mesic Basic Oak—Hickory Forest (Coastal Plain Subtype) communities occur on upper to lower slopes and other dry-mesic areas that are naturally sheltered from fire and that apparently have calcareous material in the soil. Most sites occur on bluffs or dissected areas, but a few may occur on high river terraces. Soil texture and drainage as well as topography contributes to where this community occurs.

Soils: Soils in this community are not well known. Vegetation suggests they are high in base saturation. As with many Coastal Plain Basic Mesic Forests, they may be derived from alluvial terrace material. Soil mapping treats most as Winton (Aquic Hapludult), with one example on Suffolk (Typic Hapludult) and one on Wahee (Aeric Endoaquult).

Hydrology: Dry-Mesic Basic Oak–Hickory Forests are well drained and are intermediate between the driest typical upland conditions and the moist conditions of mesic forests. Local areas with wetland species may represent small seepage areas where ground water is a short distance below but does not show on the surface.

Vegetation: The Coastal Plain Subtype is dominated by a mix of species of dry-mesic, mesic, and high base conditions, including *Quercus alba, Quercus michauxii, Quercus shumardii, Carya cordiformis, Carya tomentosa, Carya glabra*, and *Fraxinus* sp. *Acer floridanum* is highly constant and often dominant in the understory. Other frequent understory species in CVS plots include

Cornus florida, Morus rubra, Carpinus caroliniana, Cercis canadensis, Asimina triloba, Acer rubrum, Ilex opaca, Ulmus rubra, Nyssa sylvatica, Quercus nigra, and *Diospyros virginiana.* Shrubs are generally sparse, with *Euonymus americana* and *Callicarpa americana* most constant. A number of vines are constant or frequent, including *Bignonia capreolata, Muscadinia rotundifolia, Parthenocissus quinquefolia, Toxicodendron radicans, Smilax rotundifolia, Smilax bona-nox, Smilax glauca, Campsis radicans, Lonicera sempervirens*, and the exotic *Lonicera japonica*. The herb layer is moderate to dense. *Polystichum acrostichoides, Chasmanthium laxum*, or *Mitchella repens* may dominate patches. Other frequent species include *Dichanthelium boscii, Podophyllum peltatum, Brachyelytrum erectum, Asplenium platyneuron, Botrypus virginianus, Athyrium asplenioides, Circaea canadensis (lutetiana*), *Carex blanda, Carex laxiflora, Carex grayi, Festuca subverticillata, Galium circaezans, Passiflora lutea, Sanicula canadensis, Scleria oligantha, Viola sororia, Polygonatum biflorum, Gonolobus suberosus, Endodeca serpentaria*, and epiphytic *Tillandsia usneoides*. Other herb species in site descriptions include *Melica mutica, Oxalis violacea, Lysimachia quadrifolia,* and *Maianthemum racemosum*.

Dynamics: Dynamics of naturally occurring examples presumably are similar to those of the Piedmont and Coastal Plain Oak Forests theme in general and to the Piedmont Subtype. However, the proximity to the coast means more disturbance by hurricanes, with a corresponding greater frequency of gap formation, and this may contribute to the greater abundance of pines, while the greater natural fire frequency of the Coastal Plain probably once meant more frequent and intense burning, even in sites with topographic sheltering.

Range and Abundance: Ranked G4? but perhaps rarer. In North Carolina only a handful of occurrences are known, all of them small. Most are on bluffs near the Roanoke River but a couple are widely disjunct. Though not known there, examples may be found along the Cape Fear River. Dry-Mesic Basic Oak–Hickory Forest appears to be even rarer than Basic Mesic Forest in the Coastal Plain. The NVC association ranges southward to Georgia and then westward to Mississippi and Tennessee. This is probably too broadly defined, when the analogous acidic Dry-Mesic Basic Oak–Hickory Forest association ranges only to Georgia at the most and perhaps more narrowly.

Associations and Patterns: The Coastal Plain Subtype appears to be a small patch community. The full extent of occurrences is unclear, but all appear to be only a few acres in size. It is unclear if they might have once extended into the flat uplands above the bluffs, areas now occupied by fields, but this seems unlikely, as the calcareous material probably did not extend beyond the slope. Examples probably were naturally bordered by longleaf pine communities above. Below, they may be bordered by Basic Mesic Forest or by floodplain communities.

Variation: Nothing is known of the natural variation.

Comments: The related NVC association is unclearly defined, and it may not fit our examples well. It probably also is too broadly defined relative to other associations.

No Dry Basic Oak–Hickory Forest community is known in the Coastal Plain. Dry mesic conditions appear to prevail up to the top of the bluff in all known examples.

Rare species:

References:

DRY BASIC OAK–HICKORY FOREST

Concept: Dry Basic Oak–Hickory Forests are uncommon Piedmont forests that occur on less acidic and more fertile soils than typical, with moisture regimes comparable to Dry Oak–Hickory Forests. They occur in the driest typical topographic positions such as ridge tops and upper slopes but not with more the extreme dry conditions created by edaphic situations such as clay hardpans, shallow rock, or excessive drainage.

Distinguishing Features: Dry Basic Oak–Hickory Forests are distinguished from Dry-Mesic Basic Oak–Hickory Forests by having flora and dominant vegetation indicating drier conditions. As in Dry Oak–Hickory Forest, while *Quercus alba* is usually the most abundant tree species, *Quercus stellata* or *Quercus falcata* are more abundant than *Quercus rubra*. Xeric Hardpan Forests and Xeric Piedmont Slope Woodlands generally are dominated by *Quercus stellata* but have little or no *Quercus alba*, indicating conditions drier than those in typical Piedmont landscapes. Mixed Moisture Hardpan Forests may also have abundant *Quercus stellata* and sometimes *Quercus alba* but combine them with appreciable amounts of *Quercus phellos* along with some wetland species in lower strata.

Dry Basic Oak–Hickory Forests are distinguished from Dry Oak–Hickory Forests by a suite of plants indicative of high base saturation. *Cercis canadensis, Fraxinus americana, Fraxinus biltmoreana, Acer leucoderme*, and *Viburnum* spp. are generally abundant in Dry Basic Oak–Hickory Forest and scarce in Dry Oak–Hickory Forest, and stronger basic indicators such as *Frangula caroliniana, Symphoricarpos orbiculatus*, or *Rhus aromatica* are often present. *Carya* spp. and *Juniperus virginiana* are more abundant than in Dry Mesic Basic Oak–Hickory Forest, though less confined to it. As in the dry-mesic forests, species more typical of floodplains or mesic sites may occur in the basic type, but these are less common. More acid-tolerant species such as *Oxydendrum arboreum, Vaccinium pallidum, Vaccinium tenellum*, and *Chimaphila maculata* may be present in Dry Basic Oak–Hickory Forest but are less abundant than in Dry Oak–Hickory Forest.

Synonyms: *Quercus alba - Quercus stellata - Carya carolinae-septentrionalis / Acer leucoderme - Cercis canadensis* Forest (CEGL007773).
Ecological Systems: Southern Piedmont Dry Oak-(Pine) Forest (CES202.339).
Dry Eutrophic (Peet and Christensen 1980).

Sites: Dry Basic Oak–Hickory Forests occur on ridgetops, upper slopes, south-facing slopes, and other dry topographic settings. They are generally on a substrate of mafic rock but may occur on sedimentary or meta-sedimentary rocks with similar chemistry. They may occasionally occur on upland flats where restricted rooting depth or montmorillonitic soils make them seasonally dry but where conditions are not extreme enough to support Xeric Hardpan Forest.

Soils: Dry Basic Oak–Hickory Forests are supported by a variety of upland soils that are circumneutral or high in base saturation. The most common series mapped are Enon and Iredell, both Alfisols, with fewer mapped as Mecklenburg and Wilkes, also Alfisols. Examples are also mapped on Wynott, Georgeville, and other Ultisols, and occasionally on Goldston, a rocky Inceptisols, and Picture, one of the few Mollisols in North Carolina. Though such soils are

commonly called basic, it has been noted that few have pH above neutral and some are fairly acidic. Base saturation and availability of individual cations may be more important, and examples have higher values than Dry Mesic Oak–Hickory Forest.

Hydrology: Dry Basic Oak–Hickory Forests occur in the driest environments produced by normal Piedmont topography. Conditions are dry because of runoff from high topographic positions, though a few examples may also have restricted rooting depth.

Vegetation: Dry Basic Oak–Hickory Forests are dominated by *Quercus alba* in combination with oaks of drier sites. *Quercus stellata* or *Quercus falcata* are usually abundant, and one may codominate. Hickories, including *Carya carolinae-septentrionalis*, *Carya tomentosa*, *Carya glabra*, and *Carya ovalis*, are generally also abundant, sometimes codominant, as are *Fraxinus americana* and *Fraxinus biltmoreana. Pinus echinata* may be abundant in some examples, sometimes codominating or dominating in small groves. Other species that may be present in the most basic sites include *Juglans nigra* and *Quercus muhlenbergii*. Examples that have been logged may have increased amounts of *Pinus taeda*, *Liriodendron tulipifera*, or *Liquidambar styraciflua*. The understory is variable and may include a diversity of species. *Acer leuocoderme*, *Ulmus alata*, or *Acer floridanum* may be dense. *Cornus florida*, *Cercis canadensis*, *Juniperus virginiana*, *Morus rubra*, or less often *Ostrya virginiana* are fairly frequent and may have high cover. Shrubs are general sparse. Species may include *Euonyumus americanus*, *Viburnum rafinesqueanum*, *Viburnum prunifolium*, *Viburnum rufidulum*, *Viburnum acerifolium*, *Symphoricarpos orbiculatus*, *Celtis tenuifolia*, *Rhus aromatica*, *Frangula caroliniana*, *Rosa carolina*, and sometimes species of mesic forests such as *Aesculus sylvatica* or *Lindera benzoin*. *Vaccinium* spp. may be present in small numbers but often are absent. Herbs are often sparse, but *Piptochaetium avenaceum*, *Scleria oligantha*, or *Danthonia spicata* may form denser patches. Other frequent or abundant species include *Endodeca serpentaria, Dichanthelium boscii, Asplenium platryneuron, Galium circaezans*, and *Ruellia caroliniana*. With a more natural fire regime, it is likely a number of other herbs would be present, including grasses such as *Andropogon gerardii* and *Sorghastrum nutan*, and potentially species shared with Xeric Hardpan Forest such as *Tragia urticifolia, Parthenium integrifolium*, and *Clematis ochroleuca*.

Dynamics: Dynamics are similar to those of the theme as a whole and to Dry Oak–Hickory Forest (Piedmont Subtype). The drier sites, often in less dissected topography, likely led to natural fires that were more intense and more extensive. This would produce a more open canopy under natural conditions, though still more forest than savanna in general. Current examples without recent fire sometimes have more grass cover and diversity than their acidic counterparts; it remains to be seen if this will be true of burned examples. If it is, this could lead to somewhat more open canopies, as stands burn more readily.

With more fire, it is possible that the boundaries between Dry Basic Oak–Hickory Forest and Xeric Hardpan Forest would shift. It is possible that some former Xeric Hardpan Forests have become indistinguishable from Dry Basic Oak–Hickory Forests. A dendrochronology at Picture Creek Diabase Barrens found an abrupt and complete shift from regeneration of *Quercus stellata* and *Pinus echinata* to regeneration of *Quercus alba* and *Pinus taeda* in the site, corresponding to a change in ownership that presumably brought an end to burning (Sigmon-Chatham 2015).

Range and Abundance: Ranked G2G3. This community occurs throughout the Piedmont, except

in the foothill ranges and near the Blue Ridge escarpment. The corresponding NVC association ranges through South Carolina and Georgia, possibly into Alabama. It is replaced by a different association in Virginia.

Associations and Patterns: Dry Basic Oak–Hickory Forest (Piedmont Subtype) is a large patch community. It is abundant in many areas of mafic rock substrate but does not form a regularly repeating part of the typical Piedmont landscape. This is the driest community in the typical topographic moisture gradient. It grades to Dry Mesic Basic Oak–Hickory Forest in less dry sites downhill or on different slope aspects. It may be associated with Dry Oak–Hickory Forest or other basic communities, if there is a change in geologic substrate. This transition can sometimes be gradual but may be abrupt. This community also often is associated with Xeric Hardpan Forest or Mixed Moisture Hardpan Forest.

Variation: Four variants are recognized, though the boundary between them will be difficult to define.
1. Typic Variant is the most frequent variant, containing plants of basic soils but lacking the species confined to more strongly basic soils.
2. Strongly Basic Variant is a rarer variant containing plants associated only with the most strongly basic soils and having a greater diversity and abundance of plants of basic soils. Examples may have *Juglans nigra*, *Tilia americana* var. *caroliniana*, *Frangula caroliniana*, and possibly *Quercus muhlenbergii*.
3. Hardpan Variant occurs on soils with montmorillonitic clay but not extreme enough to support Xeric Hardpan Forest or Mixed Moisture Hardpan Forest. They have an admixture of plants suggestive of local or periodic wetness, such as *Quercus phellos*, *Vaccinium corymbosum*, and *Chasmanthium laxum*, though not much as in Mixed Moisture Hardpan Forest.
4. Boulderfield Variant occurs in areas with a high cover of large boulders, which leads to a high cover by woody vines and reduced cover by herbs. Earlier drafts of the 4th Approximation recognized it as a provisional subtype, based on an NVC association defined based on several CVS plots: *Quercus alba - Carya glabra - Fraxinus americana / Acer leucoderme / Vitis rotundifolia* Forest (CEGL004541). However, some examples of all Piedmont oak forest communities are rocky and others have high cover of vines. It is unclear that these areas are that distinctive.

The Shale Slope Variant of Dry Oak–Hickory Forest has some species characteristic of basic soils in it, so that it might fit almost as well as a variant of Dry Basic Oak–Hickory Forest.

Comments: No examples of Dry Basic Oak–Hickory Forest are known in the Coastal Plain; if any are found, they would be covered by this type but probably would warrant a new subtype.

Rare species:
Vascular plants: *Agastache nepetoides, Baptisia aberrans, Berberis canadensis, Buchnera americana, Cirsium carolinianum, Hexalectris spicata, Acmispon helleri, Polygala senega, Gillenia stipulata, Ruellia purshiana, Silphium terebinthinaceum, Smilax lasioneura,* and *Oligoneuron album.*

References:

Peet, R.K., and N.L. Christensen. 1980. Hardwood forest vegetation of the North Carolina Piedmont. Veroeff. Geobot. Inst. ETH, Stiftung Rubel, Zurich. 69. Heft:14-39.

Sigmon-Chatham, L.L. 2015. Historic forest structure and composition of the Dry-Mesic Basic Oak-Hickory Forest and Xeric Hardpan Forest community types of the Picture Creek Diabase Barrens: Insights from dendrochronology. M.S. thesis, N.C. State University.

PIEDMONT MONADNOCK FOREST (PINE SUBTYPE)

Concept: Piedmont Monadnock Forests are *Quercus montana*-dominated forests of very rocky isolated erosional remnant hills in the eastern and central Piedmont. The Pine Subtype covers examples where *Pinus echinata* is naturally present in more than small numbers, though it may not codominate. The Pine Subtype occurs primarily in the Uwharrie area and occasionally on monadnocks elsewhere.

Distinguishing Features: Piedmont Monadnock Forests may be distinguished from most communities by the dominance of *Quercus montana*. They are distinguished from Chestnut Oak Forests by a more limited flora that lacks many characteristic montane species, such as *Castanea dentata, Rhododendron calendulaceum, Pyrularia pubera, Gaylussacia ursina, Magnolia fraseri, Carex pensylvanica*, and *Maianthemum racemosum*. The Pine Subtype is distinguished from the Typic Subtype by having an apparently natural, persistent significant component of *Pinus echinata* (greater than 10 percent).

Synonyms: *Quercus prinus - Pinus echinata / Vaccinium pallidum* Piedmont Monadnock Forest (CEGL004148).
Ecological Systems: Southern Piedmont Dry Oak-(Pine) Forest (CES202.339).

Sites: Piedmont Monadnock Forests generally occur on isolated erosional remnant hills composed of weathering-resistant rock. The Pine Subtype usually occurs on west- or east-facing slopes of the hills.

Soils: Soils are similar to those of the Typic Subtype and are very rocky, well drained, and generally extremely acidic.

Hydrology: Sites are dry to xeric due to high topographic position. The high rock content in the soil may contribute to dry conditions.

Vegetation: The Pine Subtype is dominated by *Quercus montana*, similarly to the other subtypes. *Pinus echinata* may be codominant or may be a minority component but naturally makes up at least 10% of the canopy. *Quercus velutina, Quercus alba, Carya glabra, Carya tomentosa*, *Quercus coccinea*, *Quercus stellata*, and *Quercus falcata* are often present in small numbers. The understory generally includes abundant *Nyssa sylvatica, Oxydendrum arboreum,* and *Acer rubrum*, and smaller numbers of *Diospyros virginiana*, *Prunus serotina*, and other species. The shrub layer is sparse to moderate and usually is dominated by *Vaccinium pallidum*. *Vaccinium stamineum* is frequent, and *Vaccinium arboreum, Vaccinium tenellum*, and other species occur occasionally. *Muscadinia rotundifolia* may cover large areas on the ground, and *Smilax glauca* and *Smilax rotundifolia* are frequent. The herb layer is sparse. *Chimaphila maculata* is the only highly constant species. Other species that are frequent in the few CVS plots in this subtype include *Tephrosia virginiana, Pteridium latiusculum, Danthonia sericea, Hieracium venosum, Schizachyrium scoparium, Piptochaetium avenaceum, Dichanthelium commutation, Scleria oligantha*, and *Clitoria mariana*.

Range and Abundance: Ranked G2. This subtype appears to be much less common in North Carolina than the Typic Subtype but it may be overlooked, or examples may have lost their characteristic *Pinus echinata*. This community may occur in South Carolina and Georgia but is not confirmed.

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Associations and Patterns: The Pine Subtype occurs as small patches. It tends to occur on the west slopes of monadnocks, sometimes on the east and south slopes, with the Typic Subtype on the top, but it is absent from many isolated monadnocks. It tends to give way to the Heath Subtype on north slopes, and sometimes to the Xeric Piedmont Slope Woodland or Piedmont Acidic Glade on south slopes. Examples grade downhill to Dry Oak–Hickory Forest or sometimes directly to more mesic forests.

Variation: Details of variation are not known.

Dynamics: The dynamics of Piedmont Monadnock Forests are similar to those of Piedmont oak forests as a whole, and the Pine Subtype is similar to the Typic Subtype in dynamics. The steeper slopes in the Pine Subtype may make fires more intense in it, and this may support the persistence of *Pinus echinata*. If pine is present in appreciable amounts, the greater flammability may also contribute to greater fire intensity.

Comments: The Pine Subtype is much less well documented than other subtypes. While the vegetation description above is based on CVS plot data, only a handful of plots have been sampled. The impression of constancy and of minor species present could change substantially with more data.

The Pine Subtype is one of the least distinct of communities in the Fourth Approximation, and further study may suggest it should be merged with the Typic Subtype. *Pinus echinata* is naturally a frequent but minority component of most Piedmont oak forests, occasionally dominating local groves. No other oak forests have a recognized subtype, or even a variant, based on its presence or absence. The abundance of *Pinus echinata* appears to have been modified more than for most trees, sometimes reduced by the removal of fire, sometimes increased by logging or land clearing. It is generally impossible to know if the presence, absence, or particular abundance of this species in a given oak forest is natural. The argument for recognizing the Pine Subtype of Piedmont Monadnock Forest is that the presence of pine appears to be less modified in it, that it distinctly is present in some examples and not others, and that its presence appears tied to a distinctive landscape position.

Rare species:

References:

PIEDMONT MONADNOCK FOREST (TYPIC SUBTYPE)

Concept: Piedmont Monadnock Forests are very rocky, acidic forests of isolated erosional remnant hills, occasionally of bluffs, in the eastern and central Piedmont. They are dominated by *Quercus montana*, occasionally codominated by *Quercus coccinea*, but lack dominated characteristic montane species of Chestnut Oak Forests. The Typic Subtype covers the most common examples, which lack an appreciable component of either *Pinus echinata* or *Kalmia latifolia*.

Distinguishing Features: Piedmont Monadnock Forests may be distinguished from most communities by the dominance of *Quercus montana*. Some Dry Oak–Hickory Forests that are transitional to this type may have abundant *Quercus montana*, but it does not dominate. Piedmont Monadnock Forests may be distinguished from Chestnut Oak Forests by a more limited flora that lacks many characteristic montane species, such as *Castanea dentata, Rhododendron calendulaceum, Pyrularia pubera, Gaylussacia ursina, Magnolia fraseri, Carex pensylvanica*, and *Maianthemum racemosum*. Piedmont species such as *Quercus falcata* and *Quercus stellata* are often present.

The Typic Subtype is distinguished by the absence of a significant admixture of pines, more xerophytic oaks, or *Kalmia latifolia*.

Synonyms: *Quercus prinus - Quercus alba / Oxydendrum arboreum / Vitis rotundifolia* Forest (CEGL006281).
Ecological Systems: Southern Piedmont Dry Oak-(Pine) Forest (CES202.339).

Sites: Piedmont Monadnock Forests usually occur on isolated erosional remnant hills, known as inselbergs or monadnocks. The substrate usually is dacite, rhyolite, quartzite, pyrophyllite or other highly weathering-resistant rocks. A few examples occur on bluff tops where there is an abundance of quartz veins.

Soils: Soils are very rocky, well-drained, and generally extremely acidic. Peet and Christensen (1980) suggested that aluminum toxicity might be an important factor at the pH values they measured. The most frequently mapped soil series are Georgeville (Typic Kanhapludult), Tatum, and Uwharrie (Typic Hapludults). Other frequent series include Herndon and Badin (Typic Kanhapludults) and Goldston (Typic Dystruept), but a wide variety of other Typic Hapludults and Typic Kanhapludults also are mapped.

Hydrology: Sites are dry to xeric due to high topographic position. The high rock content in the soil may contribute to dry conditions.

Vegetation: The Typic Subtype forest is strongly dominated by *Quercus montana*. *Quercus alba, Quercus velutina, Quercus coccinea, Carya glabra*, and *Carya tomentosa* occur with high constancy in CVS plots but in small numbers. *Quercus falcata* and *Quercus stellata* are less frequent, as are small numbers of *Pinus echinata* or *Pinus virginiana*. The understory is generally dominated by *Oxydendrum arboreum*, and *Nyssa sylvatica a*nd *Acer rubrum* are usually present. Also highly constant, though in small numbers, are *Diospyros virginiana, Sassafras albidum, Prunus serotina*, and *Cornus florida*. The shrub layer may be sparse to moderate in density.

Vaccinium pallidum usually dominates, and *Vaccinium stamineum* is high constant and often abundant. Other frequent shrubs are *Vaccinium tenellum* and *Vaccinium arboreum*. *Gaylussacia baccata*, in a disjunct population, dominates the shrub layer of one well-known example. *Muscadinia rotundifolia* often covers large areas on the ground, and *Smilax glauca* and *Smilax rotundifolia* are frequent. The herb layer is very sparse. *Chimaphila maculata* is the only highly constant species in CVS plots. Other characteristic species, less frequent in plot data but often observed, include *Danthonia spicata, Hieracium venosum, Clitoria mariana, Schizachyrium scoparaium*, *Goodyear pubescens*, *Hylodesmum nudiflorum*, *Pteridium aquilinum* and *Tephrosia virginiana*. Though not found in plots, the additional herb species listed for the Pine Subtype likely occur occasionally and would be more frequent if examples were burned regularly.

Range and Abundance: Ranked G3G4. Piedmont Monadnock Forests occur throughout the Piedmont, except in the foothills, and are most abundant in the Uwharrie area. They are rare in the northeastern Piedmont. The equivalent association ranges to Georgia and Alabama.

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Associations and Patterns: Piedmont Monadnock Forests usually occur as large, sometimes small, patches. They usually grade downhill to Dry Oak–Hickory Forest, sometimes directly to more mesic communities. In the Uwharrie area, where Piedmont Monadnock Forests are the most extensive and diverse, the Heath Subtype occurs on north-facing slopes of the hills, the Pine Subtype on west, east, and sometimes south slopes, and the Typic Subtype on the tops. Xeric Piedmont Slope Woodland or Piedmont Acidic Glade often occurs on the south slopes. Where the felsic volcanic rocks give way to mafic volcanic rocks, Dry Basic Oak–Hickory Forest replaces these communities.

Variation: The low diversity makes for less variation than is present in many community types. The few examples that occur on mafic rock monadnocks should be examined for differences that could be recognized as a variant.

Dynamics: The dynamics of Piedmont Monadnock Forests are similar to those of Piedmont oak forests as a whole. The exposure of monadnocks makes them particularly susceptible to lightning and wind. They are also particularly susceptible to fires spreading uphill, which produces increased intensity, though they may also be the starting point for more lightning fires than most places. Nevertheless, tree dynamics appear to be dominated by small to medium size canopy gaps, and forests naturally exist as old-growth, multi-aged stands. The abundance of both small rock outcrops and loose rock in these forests may disrupt fire behavior. As with other Piedmont oak forests, it is presumed that more regular fire would once have supported more grass cover and more herb diversity. The high cover of *Muscadinia rotundifolia* that occurs in many examples might be less with more frequent fire, but this species is capable of quickly recovering its cover.

Comments: Peet and Christensen (1980) recognized monadnock forests as distinct in their analysis of Piedmont vegetation, and they appear to have originated the name. They suggested aluminum toxicity, related to the extremely acidic soils, might be responsible along with dryness for creating these distinctive forests. Not all high hills support Piedmont Monadnock Forest, and a few examples occur in sites other than monadnocks. A few examples also occur on monadnocks composed of mafic rock, which presumably do not have highly acidic soils. It thus is possible that

abundance of rock itself may be an important driver of the abundance of *Quercus montana* and the distinctive character of this community.

Piedmont Monadnock Forest was tentatively treated as a subtype of Chestnut Oak Forest in earlier versions of the 4th Approximation guide. The recognition of several subtypes within it suggests it would be better treated as a distinct type. While floristically depauperate, it appears to be as distinct from montane Chestnut Oak Forest as Montane Oak–Hickory Forest is from Piedmont oak-hickory forests.

This community type is generally quite distinctive in the eastern Piedmont where it reaches its best development near the summits of monadnocks. Farther west, where erosional remnants are larger, it appears to become less distinct, as *Quercus montana* becomes more common in the Dry Oak–Hickory Forest.

Piedmont Monadnock Forests are generally very low in plant diversity. Peet and Christensen (1980) suggest a combination of elevation, dryness, and acidic, nutrient poor soil. Because many examples stand only a few hundred feet above surrounding lands and less than 1000 feet above sea level, elevation is unlikely to be significant. While dryness is clearly important, the subordinate role of *Quercus stellata* and *Q. marilandica* and the absence of *Q. montana* on other dry sites suggests that other factors are important. The low soil pH, infertility, and rockiness are likely factors.

Except in the Uwharrie Mountains and Blue Ridge foothills, monadnocks represent a small portion of the Piedmont landscape. However, since they are usually too rocky and steep to farm and are less accessible than most areas for wood cutting, many examples have escaped total destruction in the past. While cutting and livestock foraging has been universal, a number remain in good condition.

Rare species: Vascular – Amorpha schwerinii, Fothergilla major, Monotropsis odorata, Smilax biltmoreana, Thermopsis mollis var. mollis.

References:

Peet, R.K., and N.L. Christensen. 1980. Hardwood forest vegetation of the North Carolina Piedmont. Veroeff. Geobot. Inst. ETH, Stiftung Rubel, Zurich. 69. Heft: 14-39.

PIEDMONT MONADNOCK FOREST (HEATH SUBTYPE)

Concept: Piedmont Monadnock Forests are *Quercus montana*-dominated forests of very rocky isolated erosional remnant hills in the eastern and central Piedmont. The Heath Subtype covers examples with a dense shrub layer of *Kalmia latifolia*, generally occurring on north-facing side slopes.

Distinguishing Features: The combination of *Quercus montana*-dominated canopy, without mesophytic trees, along with dense *Kalmia latifolia* shrub layer, occurring in the eastern or central Piedmont, distinguishes this subtype from all other communities. Communities with only sparse *Kalmia latifolia* should not be classified as this subtype. In the western Piedmont and Blue Ridge, Chestnut Oak Forest (Dry Heath Subtype) may be locally dominated by the same combination of species but typically is more diverse and contains other characteristic montane species such as *Gaylussacia baccata, Gaylussacia ursina, Rhododendron calendulaceum*, or *Castanea dentata*. This subtype sometimes grades into Piedmont/Coastal Plain Heath Bluff on lower slopes, where more mesic canopy appears over the dense *Kalmia* shrub layer. However, in most places the Heath Subtype and Heath Bluff do not co-occur.

Synonyms: *Quercus prinus - Quercus alba / Oxydendrum arboreum / Kalmia latifolia* Forest (CEGL004415)
Ecological Systems: Southern Piedmont Dry Oak-(Pine) Forest (CES202.339).

Sites: Piedmont Monadnock Forests generally occur on isolated erosional remnant hills composed of weathering-resistant rock. The Heath Subtype occurs on north-facing slopes of monadnocks.

Soils: Soils are similar to those of the Typic Subtype and are very rocky, well drained, and presumably extremely acidic.

Hydrology: Sites are well drained and dry but are cooler and more moist than other Piedmont Monadnock Forests because of the northerly slope aspect.

Vegetation: The Heath Subtype, like other Piedmont Monadnock Forests, has a canopy strongly dominated by *Quercus montana*. *Quercus alba, Quercus velutina*, *Quercus coccinea*, *Carya tomentosa*, and other species are often present in small numbers. The understory is generally dominated by *Oxydendrum arboreum*, and *Nyssa sylvatica, Acer rubrum, Ilex opaca*, *Diospyros virginiana, Sassafras albidum*, *Amelanchier arborea*, and *Cornus florida* are frequent. The shrub layer is dense and is dominated by *Kalmia latifolia*. *Vaccinium stamineum* and *Vaccinium pallidum* have high constancy. Other frequent shrubs include *Symplocos tinctoria*, and *Vaccinium arboreum*, and a few examples have *Hamamelis virginiana* or *Fothergilla major*. *Smilax rotundifolia* is frequent. The herb layer is sparse. *Chimaphila maculata* is the only high constancy species. Other species noted include *Epigaea repens, Uvularia sessilifolia, Danthonia spicata, Polygonatum biflorum*, and *Galax urceolata*.

Range and Abundance: Ranked G3. In North Carolina, this subtype occurs primarily in the Uwharrie area. The equivalent association ranges southward to Alabama. Unless it is more abundant in some other state, its rank probably should be G2.

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Associations and Patterns: The Heath Subtype often exists in association with other subtypes. It occurs on the north slopes of monadnocks, with the Typic Subtype uphill of it and on top, and the Pine Subtype occurs on west and east slopes. The Heath Subtype sometimes grades downhill to Piedmont/Coastal Plain Heath Bluff on more mesic slopes but more often gives way to Mesic Mixed Hardwood Forest or is bordered below by a floodplain community.

Variation: No pattern of variation is known.

Dynamics: Dynamics of the Heath Subtype probably are intermediate between the typical dynamics of Piedmont oak forests and of mesic forests. The north-facing slopes likely lead to lower fire intensity and frequency, but the exposed upper slope position still allows fire to occur. The prevalence of *Kalmia latifolia* suggests reduced fire frequency and intensity compared to most oak forests, but some fire probably is necessary for *Quercus montana* to remain dominant in the long run.

Comments: This subtype may be largely confined to the Uwharrie Mountains. It is compositionally related to the oak-heath forests of the Virginia Piedmont, which cover large expanses of the landscape, as well as to the Chestnut Oak Forests of the mountains. *Symplocos tinctoria* can be an important shrub component.

Rare species: Vascular plants – *Fothergilla major*.

References:

MIXED MOISTURE HARDPAN FOREST

Concept: Mixed Moisture Hardpan Forest is a community with a mixture of tree species typical of hydric and xeric conditions, occurring on sites with clay-rich soils that have restricted internal drainage or shrink-swell properties. Typically, *Quercus phellos* is mixed with *Quercus alba, Quercus stellata*, or *Carya carolinae-septentrionalis* as the predominant canopy.

Distinguishing Features: Mixed Moisture Hardpan Forest is distinguished by the co-occurrence of wetland and upland oak and hickory species, generally including both *Quercus phellos* and *Quercus stellata* in significant numbers, without segregation into distinct Xeric Hardpan Forest and Upland Depression Swamp communities. *Quercus alba* and other dry-mesic species are also generally abundant but may be scarce. The site generally shows evidence of shallow ponding of water but not of water flow.

Synonyms: *Quercus phellos - Quercus (alba, stellata) - Carya carolinae-septentrionalis* Hardpan Forest (CEGL004037).
Ecological Systems: Piedmont Hardpan Woodland and Forest (CES202.268).

Sites: Mixed Moisture Hardpan Forests occur on unusually flat upland areas of the Piedmont, generally associated with diabase, gabbro, or other mafic rock but potentially with clay-rich metasedimentary rocks.

Soils: This community occurs on montmorillonitic or other clay-rich soils that restrict water penetration and interfere with roots through their density or shrink-swell behavior. The most common soil series mapped in occurrences is Iredell (Vertic Hapludalf), with some mapped as Enon (Ultic Hapludalf) or Lignum (Aquic Hapludult) and a few as Orange (Albaquic Hapludalf), Misenheimer (Aquic Dystrudept), or other series.

Hydrology: Sites appear to be alternately wet and dry, with water pooled on part of the ground surface at times but dry most of the time. Moisture conditions are not comparable to any position on the normal upland moisture gradient. However, dry and wet conditions apparently are more moderate than in Xeric Hardpan Forest or Upland Depression Swamp Forest respectively.

Vegetation: Mixed Moisture Hardpan Forest has a canopy with a mix of trees that includes species of wet, mesic, and dry sites. *Quercus phellos* and *Quercus stellata* co-occur. Other highly constant species in CVS plots include *Carya glabra, Liquidambar styraciflua, Ulmus alata, Quercus alba, Quercus falcata, Carya tomentosa*, and *Fraxinus americana*. *Carya ovata, Ulmus americana, Quercus velutina, Pinus echinata*, and *Pinus virginiana* also are frequent. The understory includes *Acer rubrum, Nyssa sylvatica, Cornus florida, Prunus serotina, Juniperus virginiana, Ilex opaca*, and *Diospyros virginiana*, as well as canopy species. Also frequent are *Oxydendrum arboreum, Crataegus marshallii*, and *Morus rubra*. The shrub layer is sparse to moderate in density. *Ilex decidua, Viburnum prunifolium, Vaccinium pallidum, Rosa carolina,* and *Hypericum hypericoides* occur with high constancy in plots. Other frequent shrubs include *Vaccinium stamineum* and *Vaccinium fuscatum*. Additional species noted in whole-site surveys include *Eubotrys racemosa* and *Vaccinium tenellum,*

Vines are prominent in portions. *Smilax rotundifolia* may form tangles, and *Muscadinia rotundifolia* may have substantial cover on the ground. *Parthenocissus quinquefolia, Toxicodendron radicans, Lonicera sempervirens, Campsis radicans*, and the introduced *Lonicera japonica* are highly constant, and *Smilax bona-nox* is frequent. The herb layer is sparse to moderate and often is very patchy. *Danthonia spicata* is in all plots and may have moderate cover. Other high constancy or frequent species in plots include *Dichanthelium laxiflorum, Scutellaria integrifolia, Stylosanthes biflora, Endodeca serpentaria, Potentilla canadensis, Asplenium platyneuron, Eupatorium rotundifolia, Euphorbia pubentissima, Galium circaezans, Lespedeza repens, Lespedeza virginica*, and *Clematis ochroleuca*, along with collectively frequent *Carex* spp. Additional notable species reported in site surveys include *Chasmanthium laxum, Hexastylis lewisii, Coreopsis major, Cunila origanoides, Iris verna,* and *Sericocarpus linifolius*.

Range and Abundance: Ranked G2?, but possibly G3. Examples are scattered through the central and eastern Piedmont, with one anomalous possible occurrence in the Coastal Plain. The equivalent association occurs in Virginia and possibly South Carolina.

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Associations and Patterns: Mixed Moisture Hardpan Forests occur as large to small patches. Occurrences may be associated with Upland Depression Swamp Forest or Xeric Hardpan Forest, but more often are surrounded by oak–hickory forests.

Variation: Variation is not well known, but two variants are recognized to encourage further investigation of differences.

1. Basic Variant occurs over mafic rock and presumably has soil with relatively high pH and base saturation. *Fraxinus americana*, *Clematis ochroleuca*, *Rosa carolina* and other species more typical of higher pH soil are likely to be present.
2. Acidic Variant occurs on other substrates which produce more typically acidic soils with lower base saturation. The above species are likely to be absent, and *Oxydendrum arboreum*, *Vaccinium pallidum*, *Chimaphila maculata*, and other acid tolerant species are more likely to be present. This variant is less common than the Basic Variant.

Dynamics: The natural dynamics of Mixed Moisture Hardpan Forest are expected to be fairly similar to other Piedmont oak-hickory forests. The difficult rooting environment may make the trees more susceptible to wind throw, but most canopy gaps still appear to be small. This community would naturally be exposed to fire as frequently as the surrounding upland matrix. It would likely burn almost as frequently, but occasional fires might occur during times of wet ground and thave little effect on the community. Like the various oak-hickory forests, it probably would be more grassy and more open with regular burning but less so than in oak-hickory forests and much less than in Xeric Hardpan Forest.

It is not known if seasonal or ephemeral aquatic animal communities are present in the small pools of Mixed Moisture Hardpan Forests, but they should be sought.

Comments: There has been uncertainty about the recognition of this community. Mixed Moisture Hardpan Forest appears to be conceptually transitional between Xeric Hardpan Forest and Upland Depression Swamp, in a way that may or may not reflect an important conservation target of its own. Arguments for its recognition include that it often occurs in patches of several acres and that

it often occurs without one or both of the communities it is intermediate between. Though not well known, its dynamics may be distinct and not intermediate. This community type is more narrowly defined than other oak forests, perhaps more comparable to a subtype, but there is no type that it reasonably can be nested within. It can be difficult to recognize Mixed Moisture Hardpan Forests in secondary sources. The combination of closely associated patches of Xeric Hardpan Forest and Upland Depression Swamp Forest will sound similar if mixed together in a site description.

Communities with comparable unusual mixtures of wet and dry soil conditions and of wetland and xerophytic plants are known in other parts of the Southeast and are sometimes known by the term "xerohydric." The piedmont gabbro upland depression forest in Georgia described by Sewell and Zomlefer (2014) is a similar hardpan setting. The overall species list suggests a similarly mixed, but much more diverse, community, containing *Quercus michauxii, Quercus shumardii*, and *Quercus oglethorpensis*. However, passing mention of "dry phase" or "wet phase" suggests the presence of segregated communities that are not distinguished. It is unclear if mixed xerohydric community is also present.

No published literature is known that addresses North Carolina's Mixed Moisture Hardpan Forests, though they may be implicit in some of the limited literature on Xeric Hardpan Forest. They were initially described in several Natural Heritage Program county and regional inventory reports, under the name of "mesic hardpan forest." The combination of xerophytic and wetland vegetation "averages" mesophytic, but mesophytic species are scarcer than those of either extreme. The vegetation description above is based primarily on CVS plot data, but only five plots represent this community. The constancy values therefore may be of limited accuracy.

Rare species:

References:

Sewell, S.Y.S., and W.B. Zomlefer. 2014. Floristics of Piedmont gabbro upland depression forests in Jasper County, Georgia. Castanea 79: 195-220

SWAMP ISLAND EVERGREEN FOREST

Concept: Swamp Island Evergreen Forests are evergreen hardwood or mixed communities occurring on sandy upland islands surrounded by swamps. They are dominated by *Quercus hemisphaerica* and *Pinus taeda,* sometimes *Quercus nigra*, and contain several species otherwise found in North Carolina only in maritime and coastal fringe forests. Natural isolation from fire is thought to be an important determinant of these communities.

Distinguishing Features: Swamp Island Evergreen Forests are distinguished from the various oak-hickory forest types, as well as from Mesic Mixed Hardwood Forest and other inland communities, by the abundant presence of hardwoods more typical of the coastal fringe in North Carolina, most commonly *Quercus hemisphaerica* and *Cartrema americana*, but sometimes including *Quercus virginiana, Quercus geminata*, and other species. They are distinguished from Coastal Fringe Evergreen Forest and Maritime Evergreen Forests by their inland location, and also by the lack of certain characteristic maritime species, such as *Ilex vomitoria*. Swamp Island Evergreen Forests sometimes grade into Pine/Scrub Oak Sandhill, from which they are distinguished by a denser canopy, lack of evidence of present or past abundance of *Pinus palustris*, and scarcity of shade-intolerant species. This distinction may become blurred by logging and long absence of fire.

Synonyms: *Quercus hemisphaerica - Pinus taeda - (Quercus nigra) / Osmanthus americanus var. americanus / Ilex glabra* Forest (CEGL007022). Coastal Fringe Evergreen Forest (Third Approximation).
Ecological Systems: Atlantic Coastal Plain Dry and Dry-Mesic Oak Forest (CES203.241).

Sites: Swamp Island Evergreen Forests occur on locally high areas on floodplain terraces, surrounded by wetter floodplain communities. All known examples are associated with medium to large blackwater rivers.

Soils: Soils in all known examples are sandy and well drained. A few are mapped as Aquic Paleudults (Foreston, Johns) or Aquic Quartzipsamments (Pactolus), and many are not distinguished from the map units of the surrounding floodplain, such as Johnston (Cumulic Humaquept) and Dorovan (Typic Haplosaprist).

Hydrology: Moisture levels are generally dry-mesic to dry. The sites are not flooded, though exceptional floods might inundate them briefly. Soils are well drained, but the water table presumably is not deep.

Vegetation: The canopy may be dense or somewhat open. *Quercus hemispherica* or *Pinus taeda* dominate or codominate. *Quercus nigra* may be abundant, occasionally codominant. No other large trees occur with high frequency, but *Fagus grandifolia, Acer rubrum, Liquidambar styraciflua*, and *Quercus virginiana* occur in some examples. The understory is often dominated by *Quercus hemispherica* or *Cartrema americana*. *Ilex opaca, Acer rubrum*, and *Persea palustris* are frequent in occurrences. Both wetland species such as *Carpinus caroliniana* and upland species such as *Sassafras albidum* may occur occasionally. The shrub layer is highly variable among examples, and often includes a mix of species typical of both dry and wet habitats. Most

frequent in occurrences are *Gaylussacia frondosa, Ilex glabra, Lyonia lucida*, *Vaccinium arboreum*, and *Clethra alnifolia*. Less frequent but notable species include *Asimina parviflora* and *Ilex coriacea*. No vine species appear to be frequent in site descriptions, but *Muscadinia rotundifolia, Parthenocissus quinquefola*, *Toxicodendron radicans*, and *Smilax* spp. may be present. Herb diversity generally is very low. *Pteridium aquilinum* and *Mitchella repens* are most frequent and are sometimes mentioned as dominant. *Hexastylis arifolia* is present in multiple sites.

Range and Abundance: Ranked G2G3. In North Carolina, this community is known only in the southern part, associated with the Lumber, Waccamaw, and Northeast Cape Fear rivers and their large tributaries such as Juniper Creek and Big Swamp. The equivalent association is attributed to South Carolina and Georgia. Because the characteristic species are more widespread farther south, and because there are larger rivers, this community may be more abundant in those states.
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Associations and Patterns: Swamp Island Evergreen Forests occur as small, occasionally large, patches. They usually are in the highest locations, and grade downhill to Blackwater Bottomland Hardwoods or Cypress–Gum Swamp.

Variation: No variants are recognized. Examples vary with elevation but often are heterogeneous. Nevertheless, some have more wetland species while others appear very dry and seem transitional to sandhills.

Dynamics: The dynamics of this community have not been studied. It occurs in locations that are sheltered from fire spread by wet, nonflammable vegetation, and this presumably is crucial to their distinctive character. Comparable soils in better connected uplands would support longleaf pine communities. Nevertheless, they may naturally burn occasionally, and this may be important to their dynamics. The coexistence of shade-tolerant *Quercus hemispherica* and shade-intolerant *Pinus taeda* may depend on periodic disturbance. It is possible that some examples may be unrecognized former longleaf pine communities, occurring in places where natural fire was barely adequate to maintain their dominance in the past, or possibly where anthropogenic fire was frequent and consistent enough to support them in the past.

The sandy soils also suggest the possibility of excess drainage and drought stress as a source of natural disturbance and contributor to coexistence of species.

Comments: No published literature is apparent on this rare community type. It was recognized in natural heritage site surveys over the last several decades and was only more recently distinguished from Coastal Fringe Evergreen Forest. Besides containing species that are otherwise found only near the coast in North Carolina, Swamp Island Evergreen Forests also share with maritime communities a tendency to contain an unusual mix of species of wet and dry sites, though the dominant species have broad moisture tolerance.

Beyond sheltering from fire, the cause of the distinctive character of the community is not clear. It is unclear why species that are otherwise confined to within a few miles of the coast in North Carolina are able to persist in disjunct inland populations in these sites. Their sites are all in the southernmost part of the state, which is also the only part with large blackwater river floodplains.

Rare species:

References: