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Windbreak Plant Species for Odor Management around Poultry Production Facilities

Introduction

The U.S. poultry industry is the world's largest producer and second largest exporter of poultry meat. U.S. consumption of poultry meat (broilers, other chicken, and turkey) is considerably higher than beef or pork. Considering overall animal production in the U.S., the total number of chickens per farm has increased considerably. This national trend of producing more chickens on fewer farms is especially evident in the state of Maryland. From 1974 to 2002, while the number of broiler chicken farms decreased by 37 percent, the number of birds produced increased by 86 percent (National Agricultural Statistical Service). While poultry producers are increasing the efficiency of their operations Maryland has been losing farmland, in most cases to development. Maryland has lost 7.3 percent of the state's farmland during the last eight years, and in 2005 alone, the state lost 10,000 acres of farmland according to USDA's Maryland agriculture statistics office. This trend of farmland loss is at a rate almost four times that of the nation as a whole. The encroachment of houses on Maryland's farmland, combined with the trend toward more concentrated poultry, points to a much greater need for vegetative buffers.

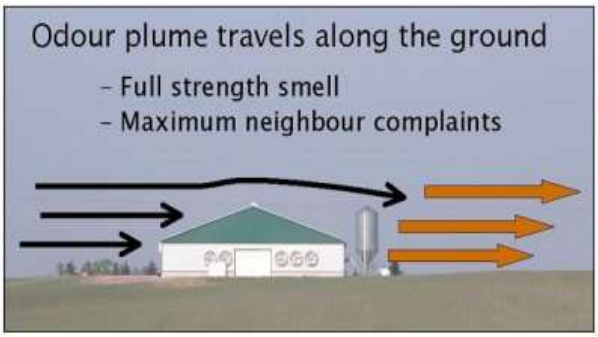
A windbreak will significantly improve the visual appearance of the farm and foster good neighbor relations. Photo by George Malone.

Benefits of Windbreak/Buffers

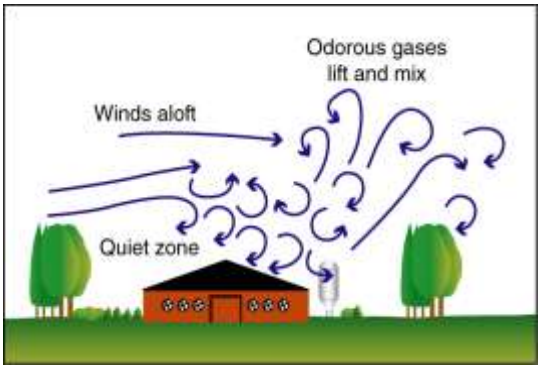
Handling of Odor and Dust Particles

Tree and shrub buffers absorb gaseous ammonia, precipitate out dust by slowing the air speed from exhaust fans, and deflect the odor plume into the atmosphere above the buffer, all in a very cost-effective way. With odor management, the buffer becomes part of the overall management of the farm operation. Odor from poultry houses typically travels downwind, along the ground,

in a concentrated plume. By planting trees and shrubs around poultry houses farmers can disrupt the plume and mix it with the prevailing winds to dilute odor.
Ammonia is the gas of greatest concern to the poultry industry. Evidence shows that ammonia is absorbed by plants. Moreover, the additional source of nitrogen can actually stimulate additional growth in some plants. Plants have the ability to absorb aerial ammonia (Yin et al., 1998). Plants located in front of exhaust fans, were found to have higher amounts of nitrogen and dry matter weights compared to control plants (Patterson 2005). Plant growth is increased with the right amount of ammonia; however there is a critical threshold where too much ammonia will cause tissue necrosis, reduced growth, and greater frost sensitivity (Van deer Eerden et al 1998). During the summer, trees reduced air velocity by 99%, dust by 49% and ammonia by 46% downwind of the trees (Malone 2006). The direction of the wind strongly influenced these results; wind blowing toward the fans "increased" the efficacy of the buffer while wind blowing in the opposite direction "decreased" this efficacy (Malone 2006).



Without windbreaks and without wind management the odor plumes are picked up by passing air masses and travel near the ground with little or no dilution or filtration. Diagram by Todd Leuty.



Windbreaks located upwind and downwind of poultry farms will reduce and manipulate air flow around the facility to reduce the spread of odors. Overhead winds can lift particles and gases into the lower atmosphere to help dilute and disperse odors. Also, more clean air diverts up and over the source of odor. Diagram by Todd Leuty.

Visual and Noise Barriers

The primary benefit from plant buffers installed near the poultry production facility is the improved visual perception of the facility, but they also can reduce noise and dust by up to 50%. This is extremely important to good neighbor relations where current single family housing exists near to poultry farms. These benefits are especially important in the mid-Atlantic, with its booming housing market.

This photo shows the problem and the solution. Housing is increasingly encroaching on typically agricultural lands. The austree hybid plants and Norway spruces will absorb gaseous ammonia and odors, and hide the poultry operations from their neighbors. Photo by PA NRCS.

Other benefits

Windbreaks/buffers may also reduce the spread of specific infectious diseases by blocking, intercepting or diverting wind-borne infectious organisms away from buildings. However, use care to select windbreak plants

that do not produce large or prodigious amounts of seed that attract birds, which may spread these diseases. You can avoid this by using male cultivars of dioecious plants (i.e. hollies) or fruitless cultivars.

Windbreaks help filter and capture nutrients from runoff and ground water through root absorption of up to an estimated 80% of the nitrogen and phosphorus in certain environments. This will then keep those nutrients from entering adjacent water courses.

Windbreak/Buffer Design and Maintenance

Plant selection will vary depending on the site. Select plants based on the following factors:

- mature height and spread of the plant
- soil type
- drainage
- wind conditions
- precipitation
- USDA hardiness range of each tree and shrub species
- growth rate
- whether it is a native or introduced species
- location and distance from exhaust fans
- farm layout (location of roads and neighbors)

To maximize particulate trapping, select plants based on the following factors:

- high leaf surface roughness (plants with leaf hairs, leaf veins, and small leaf size)
- complex leaf shapes
- large leaf circumference to area ratios and medium to rapid growth rates

Windbreak Design

It is usually best to select several different species of trees and shrubs for use in windbreaks. This is to prevent the loss or destruction of the entire windbreak if attacking insect pests or tree diseases occur on certain species. Having diversity also offers a better chance for tree survival during alternating seasons of drought and or wet soil conditions. Finally, to provide an effective windbreak, a combination of plant growth rates should be used. Faster growing plants, which provide quick visual screening, generally are short lived.

When possible due to space constraints, windbreaks should consist of three or more rows of deciduous and evergreen species of plants. Additional rows of plants may be needed near the tunnel ventilation fans as those plants will be growing in a more stressful environment and plant death will be more frequent. Deciduous shrubs are generally planted in the outside or inside rows, followed by deciduous trees towards the middle or along the downwind side where they can grow more efficiently. Deciduous plants planted near the tunnel ventilation fans will accumulate dust particles during the growing season when the fans are operating. Those leaves will then drop off in the autumn when the fans are not being used. The plants will then leaf out in the spring repeating this process. Tree varieties and placement for the windbreak should be managed to maximize odor interception and dilution of air, and reduce odor leaving the source.

Where site conditions allow, place plantings around the entire perimeter of the odor source. The closer the windbreak is positioned to the poultry house the better the odor, dust and ammonia will be trapped and dispersed (Lin et al 2006). However the windbreak should not be placed so close to the ventilation fans that it causes the plants to be desiccated from the higher wind speed. Keeps the inner row of windbreak planting from all buildings and waste storage areas at least 10 times the exhaust fan diameter. For example, if the tunnel ventilation fan has a diameter of 4 feet then the first line of plants should be planted 40 feet away. In those cases where multiple fans are used in one location, this planting distance formula will need to be modified; consider mounding soil behind the fans with plants located on top of the mound. In using evergreen plants consider that winter snows will be heavily deposited down wind at a distance of 10 times the total height of the plants. Be sure that roads or other buildings are not located in this area where additional snow will be deposited.

Use wide "between row spacing" to increase particle surface area contact and foliage light levels. Tree rows should be spaced wide enough apart to allow access by a small tractor for mechanized management of vegetation.

Windbreak Maintenance

Irrigation is very important during the first five years of plant establishment. Plant survival and the overall health of the plants will benefit from using drip irrigation. Either an emitter placed in the area of the plant or tubing with regularly spaced holes will work. Irrigation is especially important for those plants located in front of the fans which will have additional stresses from the desiccating high winds, ammonia and dust.

Weed control is also extremely important to the establishment and longevity of the windbreak. By using plastic weed barrier, with organic mulch, competition from weeds will be limited, retaining soil moisture, and maximizing plant growth. Pre and post emergent herbicides may need to be used where the weed pressure is high. It is extremely important to follow all label directions and state pesticide guidelines. Weed management (especially grass control) is extremely important until the young plants have out grown the weeds.

Proven Plants for Windbreaks/Buffers on Poultry Production Farms

The following table represents plants which have been planted as buffers around poultry farms in the Mid-Atlantic U.S. and have proven to be effective in passive ammonia absorption.

Botanical Name/Cultivar	Common Name	Family	Hard. Zone	Size (H x W)	Growth Rate*	Native Range
Ilex cornuta x aquifolium 'Nellie Stevens'	Nellie Stevens holly	Aquifoliceae	6 - 9	20' x 15'	fast	Asia, Europe
Ilex crenata 'Steeds'	Japanese holly	Aquifoliceae	6 - 9	8' x 4'	moderate	Japan, Korea, China
Ilex opaca	American holly	Aquifoliceae	5 - 9	40' x 20'	slow to moderate	Mass to Fl to TX
Juniperus virginiana	Eastern red cedar	Cupressaceae	3b - 9	40' x 20'	moderate	MA to FL to TX
Thuja plicata x standishii 'Green Giant'	arborvitae	Cupressaceae	5 - 7	60' x 20'	fast	hybrid
x Cupressocyparis leylandii	Leyland cypress	Cupressaceae	6 - 10	100' x 20'	very fast	hybrid
Gleditsia triacanthos var. inermis	honeylocust	Fabaceae	4 - 9	50' x 50'	fast	PA to NE to TX/MS
Picea abies	Norway spruce	Pinaceae	3b - 7	50' x 25'	moderate to fast	north-central Europe
Populus deltoides x nigra 'Spike'	hybrid poplar	Salicaceae	4 - 7	70' x 30'	fast	sterile hybrid
Salix matsudana x alba	Austree hybrid willow	Salicaceae	4 - 8	60' x 15'	very fast	Am/Asian hybrid (male)
Salix purpurea 'Streamco'	purpleosier willow	Salicaceae	4 - 7	15' x 15'	fast	Europe
Taxodium distichum	bald cypress	Taxodiaceae	5 - 9	70' x 20'	slow to moderate	DE to FL to LA

* Growth rates – slow = less than 1'/year, moderate = 1' – 2'/year, fast = 2' - 3'/year, very fast = over 3'/year

Cultural Requirements of Proven Plants for Windbreaks/Buffers on Poultry Production Farms

For best results, always chose a plant species that meets your site conditions.

Botanical Name/Cultivar	Moisture Requirements				Light Requirements			Notes
	Dry	Med	Moist	Wet	Sun	Part Shade	Shade	
Ilex cornuta x aquifolium 'Nellie Stevens'		X	X		X	X		Fruitless without a male pollinator
Ilex crenata 'Steeds'		X	X		X	X		Excellent for high emission loading areas
Ilex opaca		X	X		X	X		Consider using 'Jersey Male', a fruitless cultivar
Juniperus virginiana	X	X			X	X		
Thuja plicata x standishii 'Green Giant'	X	X			X	X		
x Cupressocyparis leylandii	X	X			X	X		fungal canker and insects can be problematic, 'Green Giant' arborvitae is the preferred alternative
Gleditsia triacanthos var. inermis	X	X	X		X	X		
Picea abies		X	X		X			
Populus deltoides x nigra 'Spike'		X	X		X	X		
Salix matsudana x alba	X	X	X	X	X	X		Due to it's fast growth, it provides a visual screen within 1 – 2 years
Salix purpurea 'Streamco'		X	X	X	X	X		
Taxodium distichum	X	X	X	X	X			

Potential Plants for Windbreaks/Buffers of Poultry Production Farms

This table represents plants which have been planted as street trees and shrubs. In urban environments tolerance to pollutants such as ozone and sulfur dioxide, salt, heat, drought, and soil compaction are necessary. While these plants have not yet been tested for use around poultry facilities due to their tolerance of inhospitable urban environments they should be considered for use and further evaluation. White and loblolly pines have been used with very poor results and are not tolerant to high levels of ammonia. Therefore Pines are not recommended for planting in areas opposite ventilation fans, but may be an option for use in non-discharge areas.

Botanical Name	Common Name	Family	Cultivar	Hardiness Zone	Size (H x W)	Growth Rate*	Native Range
Acer buergerianum	trident maple	Aceraceae		5 - 8	20' x 30'	slow-mod.	China
Acer campestre	hedge maple	Aceraceae	Queen Elizabeth	5 - 8	25' x 35'	slow	Europe
Acer negundo	boxelder	Aceraceae	Baron	3 - 9	30' x 50'	fast	Canada to Mexico
Acer rubrum	red maple	Aceraceae	Brandywine	4 - 8	12' x 25'	moderate to fast	eastern US
Acer rubrum x saccharinum	Freeman maple	Aceraceae	Autumn Blaze	4 - 8	40' x 50'	fast	eastern US
Acer truncatum hybrid	purpleblow maple	Aceraceae	Norwegian Sunset, Pacific Sunset	4 - 8	25' x 35'	slow	northern China, Russia
Alnus rugosa	speckled alder	Betulaceae		3 - 6	15' x 20'	moderate	Canada to ND and VA
Alnus serrulata	hazel alder	Betulaceae		5 - 9	15' x 15'	moderate	ME to FL and LA
Amorpha fruticosa	false indigo	Fabaceae		4 - 9	10' x 15'	moderate	CT to MN and LA to FL
Caragana arborescens	Siberian pea shrub	Fabaceae		2 - 7	15' x 15'	moderate to fast	Siberia and Mongolia
Celtis laevigata	sugar hackberry	Celastraceae	All Seasons, Magnifica	4 - 8	25' x 40'	moderate to fast	IN to TX to FL

Botanical Name	Common Name	Family	Cultivar	Hardiness Zone	Size (H x W)	Growth Rate*	Native Range
Celtis occidentalis	common hackberry	Celastraceae		3 - 9	50' x 50'	moderate to fast	Canada to New Mexico
Cercis canadensis	redbud	Fabaceae		3 - 9	25' x 25'	moderate	NJ to FL to TX
Ginkgo biloba	ginkgo	Ginkgoaceae	Autumn Gold, Lakeview, Palo Alto, President	4 - 8	30' x 70'	slow to moderate	Eastern China
Gymnocladus dioicus	Kentucky coffeetree	Fabaceae		3b - 8	40' x 60'	slow to moderate	NY to NE to TN
Ilex decidua	possumhaw holly	Aquifoliceae	Red Escort (male)	5 - 9	10' x 15'	slow to moderate	MD to FL to TX
Ilex glabra	inkberry holly	Aquifoliceae	Compacta, Densa, Nordic, Cape Cod	5 - 9	8' x 10'	slow	Canada to FL w to MO and TX
Ilex vomitoria	yaupon holly	Aquifoliceae		7 - 10	15' x 20'	moderate to fast	se VA to FL & TX
Maackia amurensis	Amur maackia	Fabaceae		4 - 7	25' x 30'	slow	Manchuria
Maclura pomifera	osage orange	Moraceae	White Shield	4 - 9	30 x 30	fast	AR/OK to TX
Metasequoia glyptostroboides	dawn redwood	Taxodiaceae		5 - 8	25' x 80'	fast	China
Nyssa sylvatica	black tupelo	Nyssaceae		4 - 9	25' x 40'	slow-mod.	ME to MI to TX
Ostrya carpinifolia	hop hornbeam	Betulaceae		3 - 9	25' x 35'	slow	Eastern US
Picea pungens	Colorado spruce	Pinaceae		3 - 7	15' x 50'	slow to moderate	SW America
Platanus occidentalis	Sycamore	Platanaceae		4 - 9	90' x 90'	moderate to fast	ME to MN to FL to TX
Platanus x acerifolia	London planetree	Platanaceae	Columbia, Liberty	5 - 8	70' x 100'	moderate	American and Asian hybrid
Quercus acutissima	sawtooth oak	Fagaceae		6 - 9	50' x 50'	moderate	Asia
Quercus bicolor	swamp white oak	Fagaceae		4 - 8	50' x 50'	slow to moderate	Quebec to MI to GA

Botanical Name	Common Name	Family	Cultivar	Hardiness Zone	Size (H x W)	Growth Rate*	Native Range
Quercus macrocarpa	bur oak	Fagaceae		3 - 8	70' x 70'	slow	Can. to PA to TX
Quercus nuttallii	nuttall oak	Fagaceae		5 - 9	40' x 50'	fast	AL to TX to MO
Quercus phellos	willow oak	Fagaceae		5 - 9	35' x 50'	moderate	NY to FL to MO/TX
Quercus prinus	chestnut oak	Fagaceae		4 - 8	90' x 90'	moderate	Ontario/ME to SC/AL to TX
Quercus rubra	Northern red oak	Fagaceae		3 - 7	60' x 60'	fast	Nova Scotia to PA to IA
Quercus shumardii	shumard oak	Fagaceae		5 - 9	45' x 60'	moderate to fast	KS to MI to FL
Robinia pseudoacacia	black locust	Fabaceae		4 - 8	30' x 40'	fast	PA to GA to OK
Sophora japonica	scholar tree	Fabaceae		4 - 7	60' x 60'	moderate to fast	China and Korea
Thuja plicata	giant arborvitae	Cupressaceae		4 - 8	20' x 60'	moderate	AK to N. CA to MT
Tilia cordata	littleleaf linden	Tiliaceae		3b - 7	40' x 60'	moderate	Europe
Tilia tomentosa	silver linden	Tiliaceae		4 - 7	40' x 60'	moderate	Europe, W. Asia
Ulmus americana	American elm	Ulmaceae	Valley Forge, Jefferson, Princeton, New Harmony	3 - 9	40' x 70'	moderate to fast	Canada to FL to Rockies
Ulmus carpinifolia	smoothleaf elm	Ulmaceae	Elsmo, Patriot, Homestead, Prospector	5 - 7	40' x 70'	fast	Europe, N Africa
Zelkova serrata	Japanese zelkova	Ulmaceae		5 - 8	40' x 60'	moderate to fast	Asia

* Growth rates – slow = less than 1’/year, moderate = 1’ – 2’/year, fast = 2’ - 3’/year, very fast = over 3’/year

Cultural Conditions of Potential Plants for Windbreaks/Buffers of Poultry Production Farms

For best results, always chose a plant species that meets your site conditions.

Botanical Name	Moisture Requirements				Light Requirements			Notes
	Dry	Med	Moist	Wet	Sun	Part Shade	Shade	
Acer buergerianum	X	X	X		X	X		used as a street tree in Japan
Acer campestre	X	X			X	X		'Queen Elizabeth' is faster growing and tolerant of soil compaction
Acer negundo	X	X	X	X	X	X		'Baron' is a seedless cultivar
Acer rubrum	X	X	X	X	X	X		'Brandywine' is a male (seedless) cultivar
Acer rubrum x saccharinum	X	X	X	X	X	X		
Acer truncatum hybrid	X	X	X		X	X		
Alnus rugosa	X	X	X	X	X			fixes atmospheric nitrogen
Alnus serrulata	X	X	X	X	X			fixes atmospheric nitrogen
Amorpha fruticosa	X	X			X			pH adaptable, saline tolerant, fruit is banned in CT, fixes atmospheric nitrogen
Caragana arborescens	X	X	X		X	X		fixes atmospheric nitrogen
Celtis laevigata	X	X	X	X	X			
Celtis occidentalis	X	X	X		X			
Cercis canadensis	X	X	X		X	X		
Ginko biloba	X	X	X		X			use male (fruitless) cultivars
Gymnocladus diocus	X	X	X		X			
Ilex decidua		X	X	X	X	X		*I. opaca* can serve as a pollinator; 'Escort' is a seedless cultivar.
Ilex glabra		X	X	X	X	X	X	plants sucker to form thickets
Ilex vomitoria	X	X	X	X	X	X		
Maackia amurensis	X	X	X	X	X	X	X	fixes atmospheric nitrogen

Botanical Name	Moisture Requirements				Light Requirements			Notes
	Dry	Med	Moist	Wet	Sun	Part Shade	Shade	
Maclura pomifera	X	X	X	X	X			'White Shield' is thorn free and male (fruitless)
Metasequoia glyptostroboides	X	X	X	X	X			
Nyssa sylvatica	X	X	X	X	X	X		tap rooted species, transplant in the Spring
Ostrya carpinifolia	X	X	X		X	X		slow to reestablish after transplanting, obtain locally grown plants
Picea pungens	X	X	X		X			
Platanus occidentalis	X	X	X	X	X	X		
Platanus x acerifolia	X	X	X	X	X	X		
Quercus acutissima		X	X	X	X	X		fastest growing oak
Quercus bicolor	X	X	X	X	X	X		
Quercus macrocarpa	X	X	X		X	X		difficult to transplant due to taproot
Quercus nuttallii	X	X	X	X	X			very good for Southern areas, transplants well
Quercus phellos	X	X	X		X	X		transplants well
Quercus prinus	X	X	X		X	X		transplants well
Quercus rubra		X	X		X	X		transplants well
Quercus shumardii	X	X	X		X			slow growth after transplanting
Robinia pseudoacacia	X	X	X		X	X		
Sophora japonica	X	X	X		X			
Thuja occidentalis		X	X		X	X		
Thuja plicata		X	X		X	X		
Tilia cordata		X	X		X			
Tilia tomentosa	X	X	X		X			
Ulmus americana	X	X	X	X	X			use new Dutch Elm Disease tolerant cultivars
Ulmus carpinifolia	X	X	X		X			
Zelkova serrata	X	X	X		X			

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