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Study of Understory Vegetation at The University of Mississippi Field Station in North Mississippi

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ABSTRACT The University of Mississippi Field Station is a 300-hectare area located in the Eocene Hills of the interior coastal plain of the southeastern US. Twenty long-term monitoring plots were established in 1996 following a major ice storm. Plots were sampled for understory (vegetation less than 1.5 m height) vegetation from 1996 to 2008 to study the changes in vegetation due to natural disturbance and to study the spread of invasive species. Species richness, total percent foliar cover, total percent open space and importance values (based on frequency and cover) were determined. Results indicate that there are 345 vascular plant species belonging to 90 families at the University of Mississippi Field Station (UMFS). Poaceae was the most abundant family followed by Asteraceae and Fabaceae. Understory species richness increased from 73 in 1996 to 195 in 2008. Mean percent foliar cover decreased from 58% in 1996 to 32% in 2008. Importance values for the invasive species *Microstegium vimineum* and *Lonicera japonica* decreased in 2008. Native species such as *Andropogon virginicus* and *Vitis rotundifolia* became dominant in 2008. Thus, there was a shift in vegetation with native species becoming more prevalent and displacing invasive species.

Key words: Disturbance, *Lonicera japonica*, *Microstegium vimineum*, Mississippi, understory vegetation.

INTRODUCTION Disturbance is important for maintaining species diversity within communities and at a landscape level, but it is also recognized to have undesirable effects such as community invasion by invasive species (Johnstone 1986). Native plant species abundance changes in response to disturbances, for example, in areas where there is little human activity there is less chance of invasion by invasive species (Herman et al. 2006). Native plant communities respond to natural disturbances in to particular environments; a notable shift in the pattern of vegetation composition is usually associated with human influence (Magee et al. 1999).

The University of Mississippi Field Station (UMFS) is a 300-hectare research facility of the University of Mississippi (UM) located within the headwaters of the Little Tallahatchie River, which flows into the Yazoo River, then into the Mississippi River, and finally into the Gulf of Mexico. Floristically, the Yazoo-Mississippi delta region is one of the poorest known areas in Mississippi (Carter et al. 1990). UMFS is located near Abbeville in Lafayette County in north Mississippi (34°25′N, 89°23′W). The area that can be described as loess covered hills that drain into small valleys where perennial first order streams form. The hilltops, side slopes and ''bottoms'' were devastated by clearing and poor agricultural practices after European settlement began in 1832 (Faulkner and Holland 2005). This is reflected in the presence of surface sandy soils, which were originally covered with loess, and a meter or more of postsettlement alluvium in valley floors (Holland and Cooper 1999). Habitat structure includes grasslands, wetlands, and closed canopy forests (mainly oak and pine). Soil type is mainly sandy and loamy soils (Holland and Cooper 1999).

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UMFS was previously known as the University of Mississippi Biological Field Station. UMFS was formerly a 66-hectare spring-fed swampy area converted to a fish farm called Ole Miss Fisheries Inc. (later known as Minnows, Inc.). In the early 1980s, the farm was sold to Weyerhaeuser Co., who owned the forestland adjoining the fish farm. Before the UMFS was established, the area lay fallow for two to three years, and during this time most of the open land area (which included numerous fish ponds) became filled with vegetation through secondary succession. Most of the ponds, levees, and access areas were reclaimed for research purposes after the UMFS was established in 1985. Currently, UMFS consists of pine and mixed hardwood forest, bottomland forest, open fields, wetlands (including eight constructed wetlands), ponds, and springs, as well as 200 constructed small ponds (Knight 1996, UMFS 2010).

Two catastrophic events impacted species dynamics at UMFS. A severe ice storm occurred in February 1994 causing many tree trunks to snap under the weight of the ice. In 1995 UMFS experienced a pine bark beetle (*Dendroctonus frontalis*) infestation, which required harvest of numerous trees for control purposes. Prior to this harvest, there was no comprehensive annotated checklist of the vascular flora of UMFS, and therefore, there are no records of the vegetation that existed prior to the clearing. In order to have a clear floristic record prior to any additional disturbances, long term monitoring plots were established in 1996 at UMFS to survey the vascular plants and to facilitate observations of changes in vegetation over time (especially since the 1995 harvesting). The main objective of this study is to compile the data from 1996 to 2008 to assess the changes in understory vegetation following disturbance and to document the spread of invasive species.

MATERIALS AND METHODS Long-term monitoring plots were established using a geographic information system (GIS) map in 1996 (Figure 1). A 100 × 100 m coordinate system was set up to identify locations on the property and 20 Long-Term Monitoring Plots (LTMPs) were established. The locations for the plots were selected randomly from the GIS coordinate system. The grids falling inside UMFS were numbered from 1 to 302. A random number table was then obtained and three digits were chosen. A number was randomly chosen and the corresponding grid was listed as a long term monitoring plot (Holland et al. 1997). Each grid was then labeled with letters running horizontally and numbers running vertically. Each LTMP plot was labeled by combining the letter and the number of the corresponding grid (Holland et al. 1997). Each plot is 20 × 20 m square. The edges and center of each plot were marked with orange stakes for relocation purposes. These plots were selected from 302 possible plot-sampling sites on the property (Faulkner and Holland 2005). Upon completion of new building construction in 2001, two additional plots (O7 and Q4) were added to study the disturbance caused by human activities at these "urban" sites (Faulkner and Holland 2005). Therefore, 22 plots were the basis for this study. Plots H8, K3, and U10 are undisturbed plots. No trees were cut in these plots due to disturbances caused by pine bark beetle infestation or the ice storm in 1994. The LTMP sites were sampled for overstory and understory vegetation since their establishment in 1996 for a total of five times, but this study addresses the understory only (1996, 1998, 2001, 2004, and 2008). Since we assume heterogeneity within the overall 20 × 20 m plot, the 1-meter plots are different plots in each measurement period.

Understory vegetation was assessed by randomly choosing a 1 × 1 m quadrat in each of the four quadrants of the plot. This gave a total of 88 1-meter quadrats for the 22 plots sampled. Sampling was conducted in September every year and the quadrats were chosen randomly within each plot each year. The percent foliar cover was estimated visually (Daubenmire 1968) and each species (up to 1.5 m in height) within the quadrat was identified (Radford et al. 1968, Cronquist 1980, Isley 1990, Frodin 2001, Jones 2005, USDA 2008, McCook and Kartesz 2010). The individual plants collected were checked by at least one graduate student and one professor specializing in botany. Species richness, foliar cover, frequency, relative values, and importance values were calculated for the total data

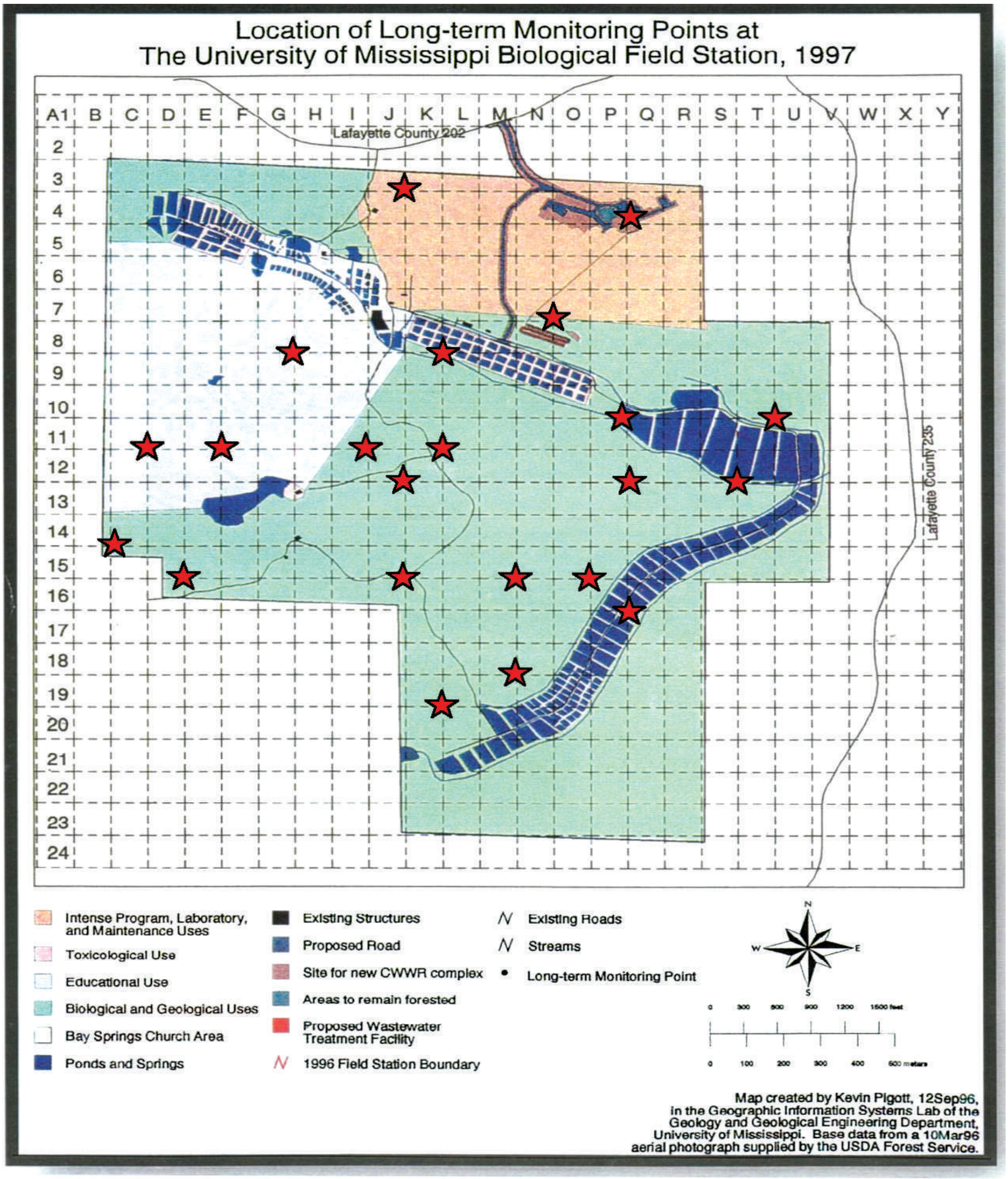

Figure 1. GIS map of The University of Mississippi Field Station, Lafayette County, North Mississippi. Red stars indicate the long term monitoring plots (total 22 plots).

set including all the plots using the following (Barbour et al. 1987, Holland and Burk 1990):

- Species Richness = Total number of species recorded for 22 plots
- Foliar Cover = Total area covered with vegetation and total cover occupied by each species within each quadrat
- Frequency = Percentage of plots in which a species occurred
- Relative values = Value for each species divided by total values for all species, multiplied by 100%
- Importance value = Relative % cover + Relative frequency divided by two.

Table 1. Plant species list (herbaceous and woody) over five sampling periods (cumulative) of The University of Mississippi Field Station, Lafayette County, North Mississippi

Aceraceae*
Acer barbatum
Acer negundo
Acer rubrum
Acer saccharinum

Alismataceae
Alisma triviale
Sagittaria latifolia

Alliaceae
Allium canadense

Amaranthaceae
Alternanthera philoxeroides

Anacardiaceae
Rhus copallina
Rhus glabra
Toxicodendron radicans

Apiaceae
Daucus carota
Hydrocotyle umbellata
Ptilimnium capillaceum
Sanicula canadensis

Aquifoliaceae
Ilex glabra
Ilex opaca
Ilex verticillata
Ilex virginiana

Aristolochiaceae
Aristolochia serpentaria

Asclepiadaceae
Asclepias tuberosa

Aspidiaceae
Asplenium platyneuron
Onoclea sensibilis

Asteraceae
Ambrosia artemisiifolia
Aster dumosus
Aster patens
Aster pilosus
Aster vimineus
Bidens discoidea
Bidens frondosa
Cirsium discolor
Cirsium horridulum
Elephantopus carolinianus
Elephantopus tomentosus
Erechtites hieracifolia
Erigeron annuus
Erigeron canadensis
Erigeron philadelphicus
Erigeron pulchellus
Erigeron strigosus
Eupatorium coelestinum
Eupatorium perfoliatum
Eupatorium pubescens
Eupatorium serotinum
Gnaphalium purpureum
Hieracium aurantiacum
Helenium amarum
Helenium arborum
Helenium tenuifolium
Helianthus angustifolius
Krigia dandelion
Krigia virginica
Lactuca canadensis
Mikania scandens
Solidago altissima
Solidago gigantea
Solidago nemoralis
Taraxacum officinale
Verbesina helianthoides
Xanthium strumarium

Azollaceae
Azolla caroliniana

Balsaminaceae
Impatiens capensis
Impatiens pallida

Berberidaceae
Podophyllum peltatum

Betulaceae
Alnus crispa
Alnus serrulata
Carpinus caroliniana
Ostrya virginiana

Bignoniaceae
Bignonia capreolata

Blechnaceae
Woodwardia areolata

Brassicaceae
Arabidopsis thaliana
Cardamine hirsuta

Cactaceae
Opuntia humifusa

Callitrichiaceae
Callitriche heterophylla

Campanulaceae
Lobelia appendiculata
Lobelia spicata

Caprifoliaceae
Lonicera japonica
Sambucus canadensis

Caryophyllaceae
Cerastium glomeratum
Stellaria media

Commelinaceae
Tradescantia hirsutiflora

Convolvulaceae
Ipomoea coccinea
Ipomoea purpurea

Cornaceae
Cornus florida
Cornus foemina
Cornus racemosa
Cornus rugosa

Cupressaceae
Juniperus virginiana

Cyperaceae
Carex annectens
Carex atlantica
Carex cherokeensis
Carex lurida
Carex retroflexa
Carex tribuloides
Carex vulpinoidea
Cyperus haspan
Cyperus ovularis
Cyperus pseudovegetus
Cyperus strigosus
Dulichium arundinaceum
Eleocharis obtusa
Eleocharis quadrangulata
Fuirena squarrosa
Rhynchospora glomerata
Scirpus cyperinus

Dennstaedtiaceae
Pteridium aquilinum

Dryopteridaceae
Athyrium filix-femina ssp. *asplenioides*
Polystichum acrostichoides

Ebenaceae
Diospyros virginiana

Ericaceae
Oxydendrum arboreum

Euphorbiaceae
Croton capitatus

Fabaceae
Albizia julibrissin
Apios americana
Cassia fasiculata
Chamaecrista fasciculata
Clitoria mariana
Desmanthus illinoensis
Desmodium canescens
Desmodium ciliata
Desmodium paniculatum
Desmodium pauciflorum
Desmodium rigidum
Desmodium rotundifolium
Desmodium viridiflorum
Desmodium tortuosum
Erythrina herbacea
Lathyrus hirsutus
Lespedeza cuneata
Lespedeza frutescens
Lespedeza hirta
Lespedeza nuttalli
Lespedeza procumbens
Lespedeza repens
Lespedeza striata
Lespedeza virginica
Trifolium campestre
Trifolium dubium
Trifolium hirtum
Trifolium hybridum
Vicia sativa ssp. *nigra*

Fagaceae
Fagus grandifolia
Quercus alba
Quercus coccinea
Quercus falcata
Quercus laurifolia
Quercus lobata
Quercus lyrata
Quercus marilandica
Quercus michauxii
Quercus nigra
Quercus palustris
Quercus phellos
Quercus rubra
Quercus stellata
Quercus velutina

Geraniaceae
Geranium carolinianum
Vaccinium arboreum
Vaccinium fuscatum

Halagoraceae
Myriophyllum aquatium

Hamamelidaceae
Liquidambar styraciflua

Hydrangeaceae
Decumaria barbara

Hydrocharitaceae
Vallisneria americana

Hypericaceae
Hypericum crux-andreae
Hypericum drummondii
Hypericum hypericoides
Hypericum mutilum
Hypericum punctatum

Iridaceae
Belamcanda chinensis
Sisyrinchium albidum
Sisyrinchium angustifolium

Juglandaceae
Carya aquatica
Carya cordiformis
Carya glabra
Carya ovalis
Carya ovata
Carya pallida
Carya tomentosa

Table 1. Continued

Juncaceae
Juncus acuminatus
Juncus coriaceus
Juncus diffusissimus
Juncus effusus
Juncus polycephalus
Juncus tenuis
Juncus validus
Luzula bulbosa
Luzula echinata

Lamiaceae
Lamium amplexicaule
Lamium purpureum
Salvia lyrata
Scutellaria elliptica
Lycopus virginius

Lauraceae
Sassafras albidum

Lemnaceae
Lemna minor

Lentibulariaceae
Utricularia macrorhiza

Liliaceae
Smilax bona-nox
Smilax glauca
Smilax hispida
Smilax laurifolia
Smilax rotundifolia
Smilax tamnifolia

Lythraceae
Ammannia coccinea

Magnoliaceae
Liriodendron tulipifera
Magnolia virginiana

Melastomataceae
Rhexia alifanus
Rhexia mariana

Monotropaceae
Monotropa uniflora

Moraceae
Broussonetia papyrifera
Morus rubra

Nyssaceae
Nyssa aquatica
Nyssa sylvatica

Oleaceae
Fraxinus americana
Fraxinus pennsylvanica
Ligustrum sinense
Ligustrum vulgare

Onagraceae
Ludwigia alternifolia
Ludwigia peploides
Oenothera laciniata

Ophioglossaceae
Botrychium dissectum

Orchidaceae
Listera australis
Spiranthes cernua

Orobanchaceae
Epifagus virginiana

Osmundaceae
Osmunda cinnamomea
Osmunda regalis

Oxalidaceae
Oxalis stricta

Passifloraceae
Passiflora incarnata

Pinaceae
Pinus echinata
Pinus palustris
Pinus taeda
Pinus virginiana

Plantaginaceae
Plantago aristata
Plantago heterophylla
Plantago virginica

Platanaceae
Platanus occidentalis

Poaceae
Andropogon scoparius
Andropogon virginicus
Aristida dichotoma
Aristida longespica
Arthraxon hispidus var. *cryptatherus*
Arundinaria gigantea
Briza minor
Bromus arvensis
Bromus japonicas
Cynodon dactylon
Dichanthelium scoparium
Digitaria ischaemum
Digitaria sanguinalis
Echinochloa muricata
Eleusine indica
Eragrostis cilianensis
Eragrostis capillaries
Eremochloa ophiuroides
Erianthus contortus
Festuca elatior
Hordeum pusillum
Leersia oryzoides
Leersia virginica
Microstegium vimineum
Panicum agrostoides
Panicum anceps
Panicum boscii
Panicum depauperatum
Panicum hemitomon
Panicum lanuginosum var. *lindheimeri*
Panicum laxiflorum
Panicum lindheimeri
Panicum microcarpon
Panicum rigidulum
Panicum scoparium
Panicum sphaerocarpon
Paspalum distichum
Paspalum urvillei
Phragmites australis
Phalaris canariensis
Phleum pretense
Poa annua
Poa trivialis
Secale cereale
Sporobolus poiretii
Tridens flavus
Uniola laxa
Uniola sessiliflora

Polygonaceae
Polygonum amphibium
Polygonum hydropiperoides
Polygonum persicaria
Polygonum punctatum
Polygonum sagittatum
Polygonum setaceum
Rumex acetosella
Rumex pulcher
Tovara virginiana

Polypodiaceae
Pleopeltis polypodioides

Pontederiaceae
Pontederia cordata

Potamogetonaceae
Potamogeton natans

Ranunculaceae
Delphinium tricorne
Ranunculus hispidus
Ranunculus macranthus
Ranunculus pusillus

Rhamnaceae
Berchemia scandens

Rosaceae
Amelanchier arborea
Duchesnea indica
Geum canadense
Prunus americana
Prunus serotina
Rosa multiflora
Rosa palustris
Rubus allegheniensis
Rubus argutus
Rubus hispidus

Rubiaceae
Cephalanthus occidentalis
Diodia teres
Diodia virginica
Galium tinctorium
Houstonia caerulea
Houstonia pusilla
Setaria geniculata
Setaria pumila
Sorghum halepense

Salicaceae
Salix nigra

Saururaceae
Saururus cernuus

Saxifragaceae
Itea virginica

Scrophulariaceae
Agalinis fasciculata
Agalinis tenuifolia
Gratiola virginiana
Linaria canadensis
Nuttallanthus canadensis
Paulownia tomentosa

Solanaceae
Solanum carolinense

Sparganiaceae
Sparganium americanum

Typhaceae
Typha angustifolia
Typha latifolia

Ulmaceae
Celtis laevigata
Celtis occidentalis
Planera aquatic
Ulmus alata
Ulmus americana
Ulmus parvifolia
Ulmus rubra

Urticaceae
Boehmeria cylindrica
Pilea pumila
Urtica dioica

Valerianaceae
Valerianella locusta
Valerianella radiata

Verbenaceae
Callicarpa americana
Verbena brasiliensis

Violaceae
Viola bicolor
Viola macloskeyi
Viola palmata
Viola primulifolia
Viola sagittata
Viola striata

Vitaceae
Parthenocissus quinquefolia
Vitis aestivalis
Vitis rotundifolia

Xyridaceae
Xyris caroliniana
Xyris jupicae

*Nomenclature follows USDA PLANTS database.

RESULTS AND DISCUSSION A total of 345 vascular plants species belonging to 90 families were found (cumulative from all the sampling periods), including saplings and seedlings found in the understory (Table 1). Poaceae was the most numerous family (44 species), followed by Asteraceae (37 species) and Fabaceae (28 species). The total number of UMFS understory species changed from 73 in 1996, 103 in 1998, 92 in 2001, 115 in 2005, and 195 in 2008. Mean percent foliar cover decreased to 32% in 2008 from 58% in 1996. Mean percent foliar cover was 60% in 1998, 44% in 2001, and 48% for 2005 sampling. The total foliar cover was highest in 1998 and decreased in the following years. This is most likely due to the increased shading by overstory vegetation (Holland, unpublished data).

Many herbaceous plants (including species of *Juncus*, *Polygonum*, *Scirpus*, *Typha*, etc.) were found in the wetlands of UMFS (Davis and Holland 1997). Wetlands in north and central Mississippi are found to be dominated by graminoid species (Herman et al. 2006). Two invasive species, *Lonicera japonica* and *Microstegium vimineum*, were first found in the UMFS plots in the 1996 and 2003 samplings, respectively. The importance value of *L. japonica* decreased gradually from 13 in 1996, 11 in 1998, 6.5 in 2005, and to 5 in 2008. In north Mississippi (forest and grasslands), high species richness and a high proportion of herbs are associated with low *L. japonica* cover (Surrette and Brewer 2008). The importance value for *M. vimineum* decreased from 5 in 2003 to 2 in 2008. *Microstegium vimineum* was not encountered before 2003. However, no statistical analysis was used to test the significance since *Microstegium* was not encountered prior to 2003, and we had only two importance values in total. No human efforts have been made to control these invasive species, and the results from the study indicate a natural decline in their populations. For the first time since 1996 sampling, *Cynodon dactylon* was found to be one among the five species with highest importance values in 2008 (Importance value = 5). *Cynodon dactylon*, a designated noxious weed in Arkansas, California, and Utah (USDA 2008), has increased in dominance at the UMFS plots.

Disturbance is considered a key factor leading to increased likelihood of invasive species invasion (Bergelson et al. 1993, Hobbs and Humphries 1995). Changes due to the presence of introduced species may alter the photosynthetic rates or alter microbial activity within a community (Surrette and Brewer 2008). Decreased human disturbance in the UMFS plots over the years along with overstory development might be the reasons for the importance value decreases for these invasive species, except for *C. dactylon*. In a survey of north Mississippi wetlands, it was found that 52 of the 53 wetlands surveyed were occupied by at least one nonnative plant species. Therefore, there is a clear indication that a potential threat exists for native species to be replaced and for native ecosystems to be impacted as those species considered to be highly invasive expand their ranges throughout Mississippi (Ervin and Linville 2006). However, our results indicate that the population of invasive species (except for *C. dactylon*) declined naturally over the years, and native plant species increased in dominance, displacing the population of invasive species without any management efforts.

The top five species having the highest importance values in UMFS plots has changed from 1996 to 2008 (Figure 2). The minimum importance value for choosing the top five species was 4%. In 1996 sampling, the top five species were *L. japonica* (13%), *Digitaria sanguinalis* (7%), *Eleocharis obtusa* (5%), *Panicum anceps* (4%), and *Galium tinctorium* (4%). The top five species with high importance values during the most recent sampling were *Andropogon virginicus* (6%), *Vitis rotundifolia* (6%), *C. dactylon* (5%), *L. japonica* (5%), and *Chasmanthium laxum* (4%). The change in the top five species in 2008 may be because of the inclusion of two new plots O7 and Q4 in 2001. *Vitis rotundifolia* (a native species) has increased in importance value over the 12-year sampling period. The importance values of *D. sanguinalis*, *E. obtusa*, *P. anceps*, and *G. tinctorium* have decreased over the years.

Overall, there was an increase in the UMFS understory species richness. Both overall species richness and foliar cover showed similar trends; both were highest in 1998, and then

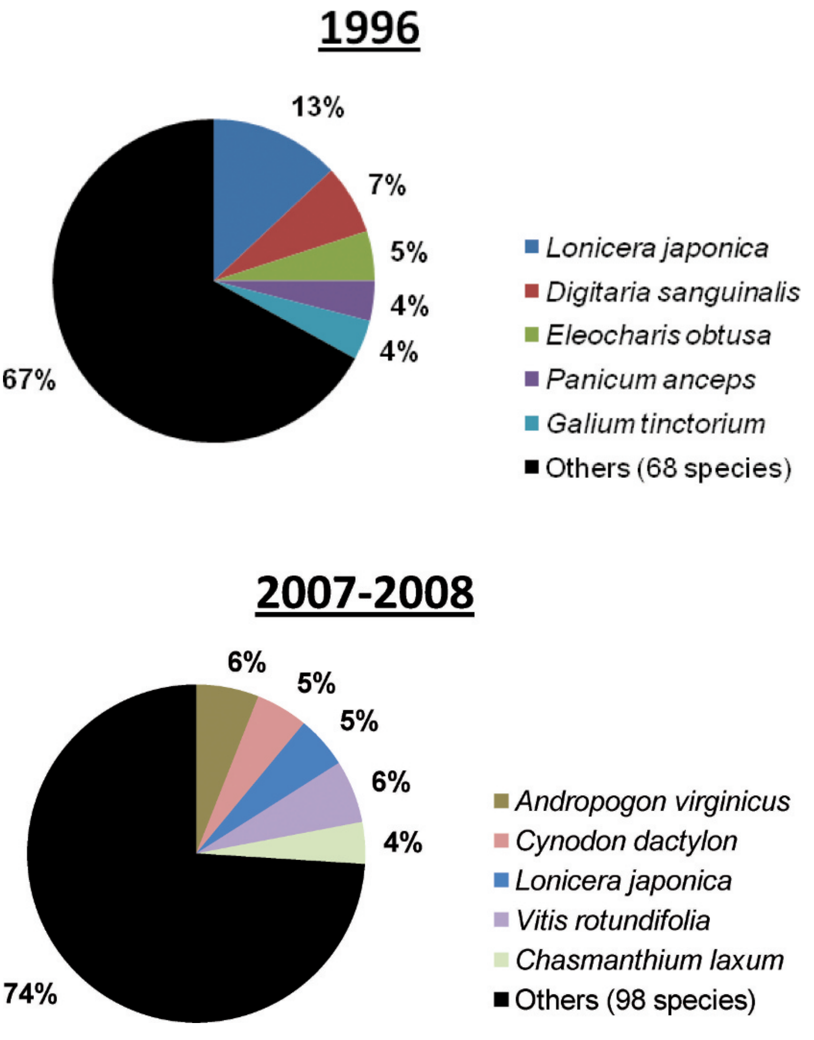

Figure 2. Changes in importance values for understory vegetation from 1996 to 2008 at The University of Mississippi Field Station.

showed a decrease in 2001. The 1998 increase in species richness could be due to recolonization following the 1995 harvesting, which could also explain the initial increase in foliar cover. In the 2000–2001 sampling, species richness and foliar cover decreased, which could be the result of shading of understory species as the overstory became more fully developed. Removal of overstory vegetation is known to affect the understory abundance by increasing the light availability (Thomas et al. 1999). Overall cover and understory biomass is known to increase with canopy openness (Ehrenreich and Crosby 1960, Halls and Schuster 1965, Stone and Wolfe 1996). Plot P16 is a wetland plot and in 1996, it was open and had high species dominance of *E. obtusa.* Over the years, more seedlings of overstory species have invaded plot P16 and the total cover of *E. obtusa* has decreased. This may be because of the decreased moisture in the pond available to *E. obtusa.* Over the study period, there was a decrease in the abundance of species that prefer open habitats (for example, *E. obtusa*). Thus, our observations indicate that the canopy is becoming closed, resulting in the increase of shade-preferring species like *C. laxum*. The decrease in the importance value of *L. japonica* could also be attributed to decrease in overstory canopy openness. *Lonicera* is shade tolerant but needs full to partial sunlight to grow successfully (ISSG 2006).

We suggest that monitoring of these plots continues for at least another decade in order to monitor the vegetation changes and also to document any spread of invasive species, such as *L. japonica* and *M. vimineum*. To record any changes in vegetation and for restoration purposes, it is important to document what is initially present. However, we lack the vegetation data prior to the disturbance caused by pine bark beetle infestation and, hence, cannot compare pre- and postdisturbance changes in vegetation. In conclusion, our results document an increase in understory species richness and change in vegetation with mostly native species becoming more prevalent and displacing the invasive species 15 yr after a major ice storm and subsequent clearing of damaged timber.

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