Exotic Plants Invasions in Southern Appalachian Forests

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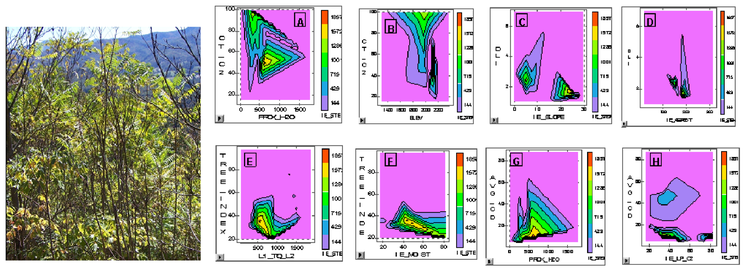
Introduction

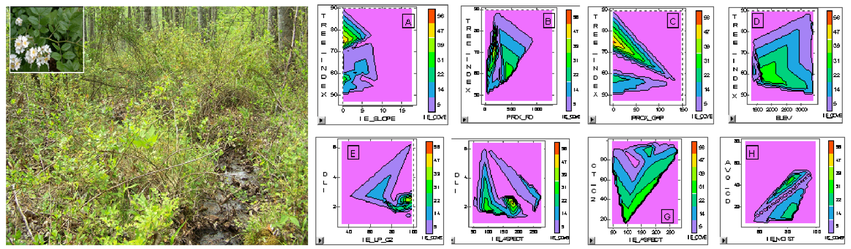
The USFS Southern Research Station; USFS National Forest Systems; Equinox Environmental™ (EE) and others received support from USFS Forest Health Monitoring's Evaluation Monitoring program to determine if invasive exotic (IE) plant species commonly found along right-of-ways (ROWs) in the Southern Appalachian mountains were able to expand from these ROWs into forest interiors. Right-of-ways are common points of introduction for exotic invasive plants that we called Level 1 (L1) monitoring. We developed stratified-random surveys based on the ecological characteristics of 20 of the most common IE species in Southern forests. We initiated these surveys from identified locations of IE species along ROWs into adjacent forest interiors. Any IE species found on these surveys were evaluated for a variety of factors to determine abundance and area of infestation. These sites containing one or more IE species were called Level 2 (L2) sites. At some L2 sites we established long-term fixed-area plot monitoring (using FIA protocols) to evaluate the effects of exotic species on native plant communities called Level 3 (L3) monitoring. This poster discusses some of the major results from three years of surveys in three different areas of the Southern Appalachians (Hot Springs, Mount Rogers, and Linville Gorge). This project was designed to evaluate a number of hypothesis regarding IE species primarily focused on the type and number of IE species that were able to invade forest interiors and whether biotic and abiotic factors measured at L2 sites could eventually be used to develop risk maps for IE species in the Southern Appalachians.

Ailanthus altissima (Tree of Heaven)



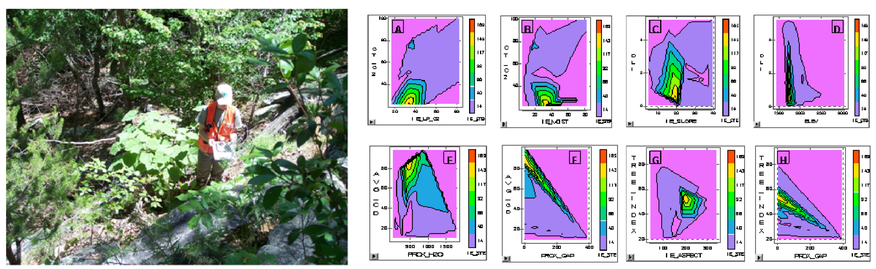
The greatest abundance (Z = IE number of stems) of ***Ailanthus altissima*** plants from 18 Level 2 survey sites (2005-2007) in 3 areas of the Southern Appalachian forests was found with the following abiotic (X) and biotic (Y) site factors: (A) moderately dry Community Types at > 500 feet from Water at about (B) 1900 feet elevation on (C) moderate 25 degree Slopes covered with relatively thin Duff and Litter cover (< 2 inches) on (D) southern Aspects at (E) L2 sites > 500 feet from L1 sites of introduction on ROWs. The (F) Soils were relatively dry (about 50%) at sites (G) about 500 feet from Water Sources and on (H) relatively dry Topographic locations (e.g., slopes). Generally this species was most abundant on drier slopes and soils with southern aspects and relatively open tree canopies at moderate elevations.

Rosa multiflora (Multiflora Rose)



The greatest abundance (Z=IE cover in ft²)of ***Rosa multiflora*** plants from 19 Level 2 surveys (2005-2007) in 3 areas of the Southern Appalachian forests was found with the following Abiotic (X) and Biotic (Y) Site Factors: (A) gentle to flat Slopes with mostly closed Canopies under larger Trees, (B) near forest Roads and very close or in Gaps at (D) around 2000 feet Elevation at (E) very mesic Topographic locations (e.g., coves) with (F) relatively low Duff + Litter on (G) southwest Aspects covering a broad range of forest communities with (H) moist soils. Generally this species was most abundant on relatively flat, open or edge type of conditions with mesic soils.

Paulownia tomentosa (Princess Tree)



The greatest abundance (Z= number of IE stems)of ***Paulownia tomentosa*** plants from 18 Level 2 survey sites (2005-2007) in 3 areas of the Southern Appalachian forests was found with the following abiotic (X) and biotic (Y) site factors: (A) relatively dry forest Community Types, Landscape Positions, and (B) Soil Moisture on (C) moderate Slopes (20 degrees) with low Duff + Litter (< 1.0 inches) and (D) low Elevations (1750 feet) near (E) open Water sources with high Canopy Density (>80 %) and (F) near or in Gaps on (G) southwestern Aspects in forest stands with moderate Tree Index values (about 55). In general this species was most abundant in stands with relatively small or young trees but with high canopy closure at lower elevations near Gaps on moderately steep southwestern-facing slopes with low soil moisture.

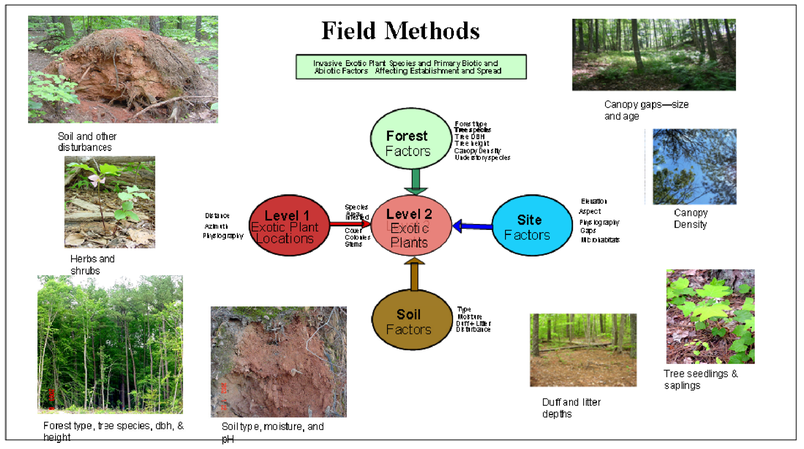
Acknowledgements

–USFS Forest Health Monitoring
–USFS Southern Research Station
–Southern Appalachian Man and Biosphere program
–Volunteer Citizen-Scientists in Southern Appalachian Communities

METHODS

Literature searches revealed important ecological characteristics related to habitat preferences, reproduction strategies, and other factors related to the establishment and spread of IE species. We developed stratified-random surveys based on these ecological characteristics that primarily consisted of evaluating the tops, slopes, and bottoms of ridges above and below roads and other ROWs where other studies had located the type and occurrence of IE species. Each point where an IE species was located became a L2 site, and the extent of the infestation was followed until no more exotic plants of any species were found in the area. This method often lead to finding other exotic species at the same L2 sites. Detailed data was taken at each L2 site and for each IE species at an L2 site that characterized the relative abundance of each species, numerous physical site characteristics that often related to water retention, soil factors related to the type of soil and disturbances, and biotic factors that related to the forest type, species present, overstory canopy, duff/litter accumulation, and other factors. We used descriptive statistics to evaluate the occurrence of species at L2 sites, and multivariate statistics with SAS 9.2 to evaluate the relationships among exotic species abundance and the physical and biological characteristics of each L2 site.

Field Methods



L2 ABUNDANCE RELATIONSHIPS

Table 1. Primary biotic and abiotic variables associated with 60 to 100% of abundance (z=s+ne+w, of stems, shrubs/herbs=cover) of each exotic invasive species in Level 2 (forest interior) surveys. Values determined by multivariate analyses.

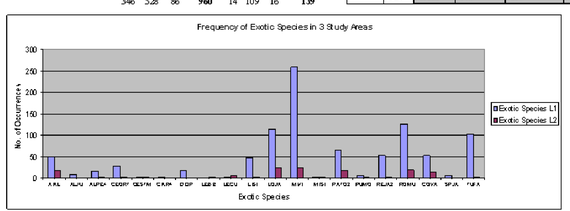
Primary Biotic & Abiotic Variables[1]	AIAL	LOJA	MIVI	ROMU	PATO2
L1-L2	500	400	1000	200	1000
LP	40	90	85	100	55
Soil Moisture	50	80	80	80	30
Aspect	190	250	220	100	210
Slope	25	5	5	5	20
Elevation	2100	1300	1600	1800	1800
Tree Index	40	60	40	75	55
Ave. CD	10	40	40	30	80
DLI	2.0	1.5	4.0	2.0	0.5
Prox. Water	500	50	400	200	400
Prox. Road	600	500	600	200	500
Prox. Gap	400		80	5	0NR
Community	40	90	100	50	10

[1] Approximate value associated with 60 to 100 percent of biomass of each species

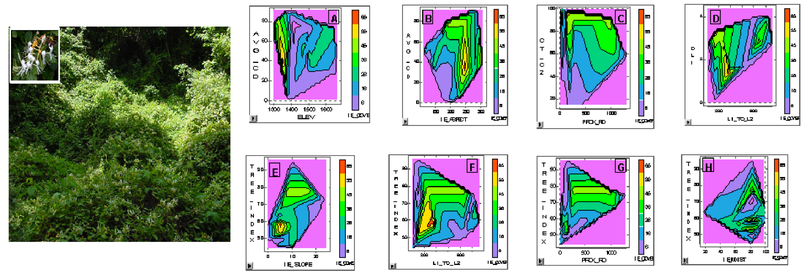
FREQUENCY OF L2 INVASIONS

Exotic Plant Species	USDA PLANTS Code	Frequency (Level I) MR	MS	LG	TOTAL L1	Frequency (Level II) MR	MS	LG	TOTAL L2
Ailanthus altissima	AIAL	2	34	13	49	0	15	3	18
Alliaria petiolata	ALPE4	15	0	0	15	1	0	0	1
Celastrus orbiculatus	CEOR7	0	28	0	28	0	2	0	2
Centaurea stoebe var. micranthos	CESTM	1	0	0	1	1	1	0	2
Cirsium arvense var. arvense	CIAR4	1	0	0	1	0	0	0	0
Dioscorea polystachya	DIOP	10	8	0	18	0	0	0	0
Lespedeza bicolor	LEBI2	0	0	0	0	0	3	0	3
Lespedeza cuneata	LECU	0	0	3	3	0	6	0	6
Ligustrum sp.	LIS1	13	35	0	48	0	2	0	2
Lonicera japonica	LOJA	8	106	0	114	0	24	0	24
Microstegium vimineum	MIVI	69	183	7	259	0	21	3	24
Miscanthus sinensis	MIS1	0	0	3	3	0	1	1	2
Paulownia tomentosa	PATO2	0	17	49	66	0	9	9	18
Pueraria montana var. lobata	PUMO	3	4	0	7	0	1	0	1
Rosa multiflora	ROMU	65	59	3	127	8	11	0	19
Sorghum vario	SOVA	52	0	0	52	2	12	0	14
Stenotaphrum secundatum	STSE	0	0	6	6	0	0	0	0
Tussilago farfara	TUFA	101	0	1	102	1	0	0	1
		346	528	86	960	14	109	16	139

		Site Factors: Elevation (ft)	Site Factors: Aspect (deg)	Forest Factors: Avg. canopy density (%)	Forest Factors: TCI	Forest Factors: DLI
AIAL	N	18	12	18	16	18
	Mean	1887.5	176.7	37.7	46.7	2.9
	S.D.	329.3	81.7	25.4	18.0	1.6
LOJA	N	24	13	24	22	21
	Mean	1446.4	168.5	51.6	59.2	2.5
	S.D.	113.8	53.7	24.4	10.7	1.0
MIVI	N	24	14	24	24	22
	Mean	1776.0	178.6	38.7	51.8	2.6
	S.D.	456.7	65.0	28.7	14.8	1.1
PATO	N	18	13	17	17	17
	Mean	2027.4	188.1	42.6	42.8	2.0
	S.D.	37.4	93.5	31.7	18.3	1.7
ROMU	N	19	5	11	11	19
	Mean	2093.3	145.0	47.2	64.3	2.4
	S.D.	1011.1	54.8	25.7	11.2	1.2

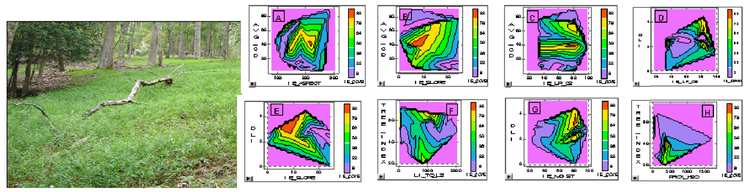


Lonicera japonica (Japanese Honeysuckle)



The greatest abundance (Z=IE cover in ft²)of ***Lonicera japonica*** plants from 24 Level 2 surveys (2005-2007) from 3 areas in the Southern Appalachian forests were found with the following abiotic (X) and biotic (Y) site factors: (A) 1350 feet elevation and mean canopy density of 40%; (B) 250 degrees aspect; (C) in mesic Community Types (CT) from 0 to 1000 feet from nearest road; (D) at L2 sites about 230 feet from nearest L1 points of introduction along common ROWs; (E, F, and G) on flat slope of 5 degrees under Tree Cover Index values of 55; (H) at sites with high soil moisture. Generally this species was most abundant at mesic sites in mesic plant communities near forest roads and urban ROWs on gently sloping terrain with a westerly aspect at 1350 feet elevation.

Microstegium vimineum (Japanese Stiltgrass)



The greatest abundance (Z=IE cover in ft²)of ***Microstegium vimineum*** plants from 24 Level 2 surveys (2005-2007) in 3 areas of the Southern Appalachian forests was found with the following abiotic (X) and biotic (Y) site factors: (A) 210 degrees Aspect under about 40% Canopy Density on (B) gentle 10 degree Slopes at (C) mesic topographic locations (e.g., coves) with (D and E) relatively deep Litter plus Duff depths (> 3.0 inches) at sites about 1000 feet from (F) Level 1 sources on common ROWs. Plants were most abundant also at sites with (G) high Soil Moisture under open and small tree canopies (Tree Canopy Index < 40) within 500 feet of a water source. Generally this species was most abundant in areas with gentle slopes facing southwest under open smaller tree stands in relatively mesic forest communities on mesic topographic sites with moist soils.

RESULTS

Frequency of Exotic Species: We considered L2 species occurrences the ability of IE species to become introduced and initially established in forest interiors. We found a great difference between the type and abundance of exotic species found at L1 and L2 sites. There were 139 documented invasive exotic plant occurrences in 73 Level 2 survey sites . Of these occurrences, 32% were herbs and grasses, 26% were trees, 23% were shrubs, and 19% were vines. Generally speaking, many species observed in L1 surveys were not documented in L2 surveys. This was true for MRNRA and LGWA where 54% and 55% of species found at L1 sites were absent from L2 surveys. Only 13% of species were absent in Hot Springs L2 surveys and, conversely, 31% of species observed in L2 surveys were not recorded in L1. In most cases, however, those species that occurred with the greatest frequency along roads and other ROWs (L1) were also the most frequently recorded species occurrences in L2 surveys. The most frequently occurring species documented in forest interiors were *Microstegium vimineum* (*N*=24), *Lonicera japonica* (*N*=24), *Rosa multiflora* (*N*=19), *Ailanthus altissima* (*N*=18), and *Paulownia tomentosa* (*N*=18). There was a significant difference among the project areas in terms of species presence and abundance. First, no species were recorded in all 3 project areas and of the 20 invasive exotics documented in L2 surveys, most (60%) occurred in only one area. These patterns are partly due to differences in sampling bias—nearly 70% of all L2 surveys occurred in Hot Springs.

Abundance of Exotic Species: We considered exotic species abundance with success of exotic species to spread in forest interiors, and thus an even bigger threat then the initial establishment within forests The abundance of exotic species was based on cover for shrub, herb, and vine species and number of stems for tree species. Several factors were consistently associated with IE abundance—the abiotic factors were slope, aspect, elevation, topographic position, soil type, and distance to roads, water, gaps, and from L1 to L2 sites. The biotic factors most commonly associated with the most biomass for each species were tree cover index (dbh, height, and canopy closure), forest type, canopy density, and depth of duff and litter. We found substantial differences in habitat preference, particularly between IE tree species and shrubs/herbs/vines. The former tended to prosper on warmer, drier sites with more open canopies, and the latter appeared to prefer moister sites with more canopy coverage. We have not yet examined if there are any apparent relationships between exotic species abundance and the type and abundance of associated native plant species. We expect there will be because of the success of exotic species in the more mesic forest types.