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Some observations on weed communities in the city of Durham, North Carolina, U.S.A.

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Introduction

For two reasons it may be of interest to present occasional observations on weed plant communities, made during a six months stay in summer 1973 in the city of Durham, North Carolina:
1) In American ruderal plant communities grow many plants of European origin, but little is known about their ecology in the new world.
2) The vegetation in the vicinity of Durham has been studied thoroughly by OOSTING 1942, including the succession on abandoned fields. The causes for the first years of old field succession have been investigated by KEEVER 1950. But the major cities provide many habitats, which by no means are to be regarded as "old fields"

Area of study

Durham (elevation 90–130 m) is situated in the Piedmont of North Carolina, within the foothills of the Appalachian mountains. The major soils have been developed from triassic sediments, interrupted by small areas of granitic rock. There is a mosaic of soil types with a sudden change from sand to clay. The p_H is exclusively acidic, mostly 5–6. This holds true even within the city with very few exceptions (see p. 2), as I found in tests using phydrion papers.
The data from the Raleigh Durham Airport meteorological station (fig. 1)) indicate a warm, moist climate (type V 1 b according to WALTER & LIETH 1967) with strong and especially immediate changes of temperature. There is no European counterpart for this type of climate, but there is a similarity to the climate of the coastal region of NW Yougoslavia. The year of investigation was 0.4 °C cooler than the average, and was extremely humid (fig. 1).
The climax vegetation is a summergreen decidous forest of oak – hickory type (OOSTING 1942), oak – hickory – pine type (KÜCHLER 1964) resp. südöstliche Eichen – Hickory – Wälder (KNAPP 1965), or more precisely a Caryo – Quercetum falcatae KORNAS 1965 within the class Querco – Fagetea grandifoliae KNAPP 1957 (see also WHIGHAM 1971).

Plant communities

The city vegetation in general is characterized by large trees on roadsides and lawns around buildings. There are older lawns and apparently newer ones, sown with a large variety of *Festuca pratensis*. The truly ruderal communities are concentrated in the more than 50 year old parts of downtown Durham. Even here it is not easy to find older perennial stands. Almost every patch of vegetation, of annual, perennial or liana dominated types, is at least once a year mowed as a "lawn"
Vegetation analyses (releves) of the typical ruderal stands are presented in tables 1 and 2. Notes to the releves are given in table 3. The plant names agree with the names in RADFORD, AH-

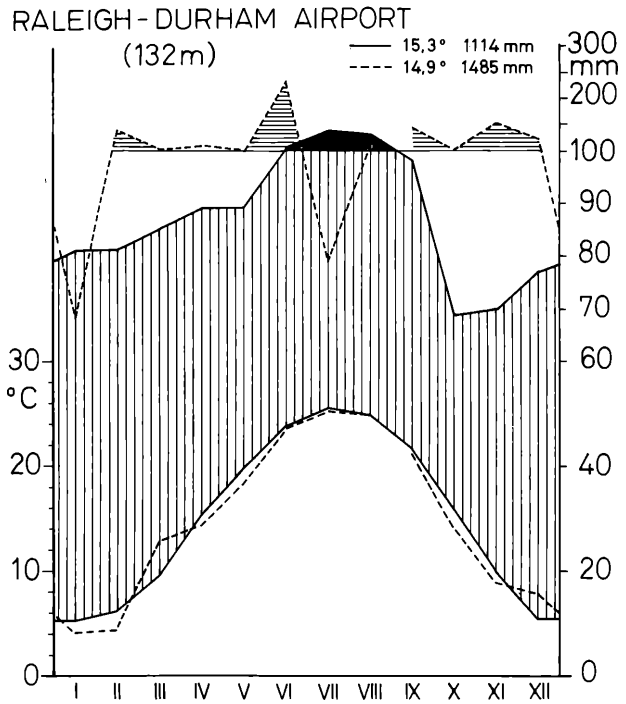

Fig. 1: Climatic diagram Raleigh Durham Airport.
solid line: longtime standard.
broken line: current year from Sept. 1972 to August 1973.

LES & BELL 1968. The figures indicate plant cover according to a modified BRAUN-BLANQUET scale:

5	75–100%	(calculated as 87,5%)
4	50– 75%	(62,5%)
3	25– 50%	(37,5%)
2	15– 25%	(20,0%)
2	5– 15%	(10,0%)
1	1– 5%	(2,5%)
+	<1%	(,, 1,0%)

(+) present in stand but outside sampling plot (calculated as 1,0%).

A. The *Stellaria media – Lamium amplexicaule* community has been found in gardens and gardenlike fields on sandy soil, rich in humus, probably fertilized (A_1, table 1 releves 1–3). A modification *(Scleranthus* subcommunity, A_2) on not fertilized, acidic sandy slopes is represented by rel. 4. The best development is in early spring; later in summer there is a spread of perennials. Succession is stopped due to spading and weeding.
B. The *Cerastium glomeratum* community (table 1 rel. 5) has been found on extremely eroded, dense, dry soil. In later spring or summer there is no vegetation at all. Succession is stopped due to trampling and water erosion rather than mowing.

Tab. 1: Releves of weed plant communities in Durham, N.C., part I.

Plant communities A - F see text.
Lf = life form: a = annuals; b = biennials; p = perennials;
l = lianas; w = woody plants (shrubs and trees).
Or = origin: A = N-American; E = Europaean; As = Asian.

	plant community	A	A	A	A	B	C	C	C	D	D	D	D	E	E	E	F		
	releve number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Lf	Or
A	Stellaria media	3	2	+	(+)													a	E
	Cardamine hirsuta	2!	1	+														a	E
	Viola rafinesquii	1			+													a	A
	Trifolium dubium	2!			1													a	E
	Lamium amplexicaule	2		+														a	E
	Veronica arvensis		+	+	(+)													a	E
A_2	Scleranthus annuus				2!													a	E
	Houstonia pusilla				2													a	A
	Plantago virginica				2!													a	A
	Plantago heterophylla				1													a	A
B	Cerastium glomeratum			+	1	1												a	E
	Holosteum umbellatum					1												a	E
	Draba verna					(+)												a	E
C	Helenium amarum						2	4	1									a	A
	Vulpia myuros						2											a	E
	Plantago aristata						2											a	A
	Microstegium vimineum							2!					+					a	A
	Chaenorrhinum minus								2									a	E
D	Chenopodium album									3	2	4	2					a	E
	Chenopodium ambrosioides									2!								a	trop A
	Solanum americanum									2	1							a	A
	Datura stramonium										2							a	A
	Physalis virginiana										+							p	A
	Sonchus asper										(+)	+	+					a	E
E	Euphorbia supina								+					2	+	1		a	A
	Paspalum setaceum										+	+	1	+	2			p	A
	Cyperus compressus								+							1		a	A
	Mollugo verticillata										+					1		a	A
F	Lolium perenne														+		1	p	E
	Plantago major															+	2!	p	E
	Trifolium repens			+													2!	p	E
	Polygonum aviculare																2	a	E
	Other annuals:																		
	Poa annua	+				1												a	E
	Oxalis stricta	+	+	+														a	A
	Lespedeza stipulacea						+				+							a	As
	Tridens flavus							+						1				a	A
	Digitaria ischaemum									3	1		+					a	E
	Ambrosia artemisiaefolia									+	1							a	A
	Digitaria sanguinalis										1				1		1	a	E
	Eragrostis pilosa										+		+	2				a	E
	Lespedeza striata													+	1			a	As
	Other perennials:																		
	Allium vineale	1	+	+														p	E
	Plantago lanceolata	2!					+	1						+				p	E
	Cynodon dactylon	+		+		+			+		2		+	2	2!	1		p	E
	Aster pilosus							+	+									p	A
	Duchesnea indica		+	(+)														p	As

Recorded only once: Rel.1 Geranium carolinianum 2, aA; Cerastium holosteoides 1, p E; Alchemilla microcarpa 1, aE; Vicia angustifolia (+), aE; Poa pratensis +, pE. Rel. 2 Taraxacum officinale 1, pE; Lolium multiflorum +, pE Rel. 3 Ranunculus parviflorus +, aE. Rel. 4 Veronica serpyllifolia 2!, pE. Rel. 7 Panicum spec +; Sphenopholis obtusata +, pA. Rel. 8 Setaria viridis +, aE; Aristida oligantha +, aA; Lespedeza virginica +, pA; Eragrostis spectabilis +, pA; Parthenocissus quinquefolia +, lA. Rel. 9 Amaranthus hybridus 3, aE; Bidens bipinnata +, aA; Artemisia vulgaris +, pE. Rel. 10 Polygonum pennsylvanicum +, aA; Vitus agnus-castus +, wE; Sorghum halepense 1, pE; Phytolacca americana +, pA; Ipomaea purpurea +, a trop A; Solanum carolinense 1, pA; Cyperus strigosus +, pA; Cassia nictitans +, aA; Acalypha rhomboidea +, aA. Rel. 12 Erigeron canadensis +, aA; Croton glandulosus 1, aA Panicum dichotomiflorum +, aA. Rel. 14 Paspalum dilatatum +, pA.

C. The *Plantago aristata – Vulpia myuros* community (table 1 rel. 6–8) has been found on sandy or gravelly soil around parking areas or other places extensively used by cars. In spite of heavy immission of road dust p_H is still acidic. Succession is stopped by driving and trampling.
D. The *Chenopodium album – Solanum americanum* community (table 1 rel. 9–12) is the truly ruderal annual plant community. It occurs in ruins of abandoned houses and in the urban renewal zone. It is only here as a result of concrete in the soil, that the p_H reaches values of 7–8. Succession is stopped by frequent perturbations of the substrate and partly by trampling.

Tab. 2: Releves of weed plant communities in Durham, N.C., part II

Plant communities G - L see text.
Lf = life form: a annuals; b = biennials; p = perennials;
l = lianas; w = woody plants (shrubs and trees).
Or = origin: A = N-American; E = European; As = Asian.

	plant community	G	G	G	G	G	G	G	H	H	H	H	H	I	I	K	K	K	K	L	L	L		
	releve number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	Lf	Or
G	Erigeron canadensis	+	+	2	+		1	+				+		+					+				a	A
	Solanum carolinense	3				1		2!			+		+		+								p	A
	Ambrosia artemisiaefolia		2!	+	1	+	2	2!			+(+)	+	2!		2	+							a	A
	Croton glandulosus		1					+															a	A
	Oenothera biennis		+					1															b	A
	Melilotus alba						+	2!															b	E
	Melilotus officinalis						1																b	E
	Lactuca serriola						+	1															b	E
	Daucus carota							2!		+													p	E
	Diodia teres							1															a	A
H	Eupatcrium capillifolium				1				4					+						1			p	A
	Solidago altissima								+	2	1	1	1									1	p	A
	Lactuca canadensis								+		(+)		1			+	+						b	A
	Aster pilosus						+	+		4	1	2	4	1		+			+				p	A
	Ipomaea lacunosa										+		1										a	A
	- purpurea										+		(+)										a	trop A
	Sorghum halepense										5												p	E
	Artemisia vulgaris											2	1										p	E
	Paspalum dilatatum											4	2									1	p	A
I	Lespedeza virginica			+			+					+		4	4								p	A
	- striata	+		+										2!	4								a	As
	Festuca pratensis													2!	1								p	E
K	Lonicera japonica	+			1			1		1	2					5	3	1	2		2!		l	As
	Rhus radicans															1				+			l	A
	Campsis radicans					+				2!							4	+	1	+	1		l	A
K_2	Pueraria lobata																2	5	5				l	As
L	Ailanthus glandulosa							+												3	5	2	w	As
	Ulmus alata															+				2	1	3	w	A
	Quercus phellos												(+)							+		+	w	A
L_1	Catalpa speciosa							+				1								3		+	w	A
	Quercus falcata																			+			w	A
	Albizzia julibrissin																				2!		w	As
	Gleditsia triacanthos									+											+		w	A
L_2	Platanus occidentalis				+											+						3	w	A
	Morus rubra																					+	w	A

plant community	G	G	G	G	G	G	G	H	H	H	H	H	I	I	K	K	K	K	L	L	L		
releve number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	Lf	Or
Other annuals:																							
Oxalis stricta	1										+											a	A
Digitaria ischaemum	2!		+			+	3					3					1					a	E
Panicum dichotomiflorum		+	2			+																a	A
Bidens aristosa				1		+							(+)	+								a	A
Bidens bipinnata				+	+												+					a	A
Acalypha rhomboidea					1							+							+			a	A
Cassia nictitans							+						+	+								a	A
Tridens flavus													+					+				a	A
Panicum spec.													+	+		+							
Other perennials:																							
Plantago lanceolata	1						+				1											p	E
Asparagus officinalis	+								+													p	E
Cynadon dactylon		1			+																	p	E
Paspalum setaceum		+						+														p	A
Solidago nemoralis				+			+															p	A
Commelina communis					+					(+)		1				1		+			2	p	As
Setaria geniculata					+				+		+											p	A
Trifolium pratense									+		+		1									p	E
Holcus lanatus									+												+	p	E
Phytolacca americana										+		+		1				+			+	p	A
Cyperus strigosus											+	+										p	A
Cichorium intybus												(+)					+					p	E
Others lianas and shrubs:																							
Ligustrum vulgare	+																			±		w	E
Liquidambar styraciflua		+		+															±			w	A
Fraxinus americana									+							+					±	w	A
Rubus flagellaris										2					+	2		+		2!	+	w	A
Robinia pseudo-acacia													+	+								w	A
Acer rubrum														+							±	w	A
Parthenocissus quinquefolia															+					1		l	A

Recorded only once: Rel. 1 Vulpia myuros +, aE; Rhus glabra +, wA; Leontodon nudicaulis +,pE. Rel. 2 Lespedeza stipulacea 1, aAs. Rel. 3 Aster dumosus +, pA; Eragrostis pilosa 1,aE. Rel.4 Liriodendron tulipifera+, wA; Juniperus virginiana +, wA. Rel. 5 Apocynum cannabinum 1, p A. Rel.6 Helenium amarum +, aA; Hedera helix +, lE; Chenopodium ambrosioides 1, a trop.A; Digitaria sanguinalis 1, aE. Rel. 7 Andropogon elliottii 1, pA; Desmodium glabellum +, pA. Rel. 9 Allium canadense +, pA; Mikania scandens +, p(1) A. Rel. 13 Dactylis glomerata 2, pE; Cyperus ovularis +, pA. Rel. 17 Helianthus spec. +; Euphorbia corollata +, pA. Rel.18 Ulmus americana 1, wA. Rel. 21 Carya tomentosa ±, wA; Bidens discoidea +, aA.

E. The *Euphorbia supina* community (table 1 rel. 13–15) has been found on highly trampled places along roads or at footpaths. Succession is stopped due to trampling and driving.
F. The *Lolium perenne –Plantago major* community (table 1 rel. 16) has been found only at a few places. The habitat exhibits an eroded, clayy soil, heavily shadowed by buildings; water is covering the surface for weeks even in summer, Succession is stopped by trampling.
G. The *Erigeron canadensis – Solanum carolinense* community (table 2 rel. 1–7) occurs in a great variety of habitats. It is characterized by a number of biennials, which need at least two winters of undisturbed development. Thus it is the second phase of succession, following the communities of annuals. The cover is 30% in average (table 3).
H. The *Aster pilosus* community (table 2 rel. 8–12) is the next phase of succession. According to habitat and history of the individual stand, different plant species may be dominating *(Eupatorium capillifolium* in rel. 8, *Sorghum halepense* in rel. 10, *Aster pilosus* in rel. 9 + 12, *Aster* and *Artemisia vulgaris* in rel. 11). The cover is 90% in average (table 3).
One releve from a railroad bed is very near to H, but shows several indicators of soil moisture: Small ditch at a railroad; sandy; area 16 m^2; cover 40%; affected by herbicides. *Setaria geniculata* 3, *Cyperus haspan* 1, *Ludwigia palustris* 1, *Cynodon dactylon* 1, *Taraxacum officinale* +, *Lonicera japonica* +, *Bidens discoidea* +, *Solidago altissima* +.
I. The *Lespedeza virginica* community (table 2 rel. 13 + 14) has been found on the new highway banks. It is probably sown. Succession is stopped due to mowing.
K. In many places lianas enter the herbaceous vegetation, forming the *Lonicera japonica* community (table 2 rel. 15–18). In the typical subcommunity (K_1) *Lonicera* is the dominating species. It can compete with the herbaceous vegetation by forming mats, but can climb more

Table 3. Notes to the phytosociological releves.

Rel. number		locality	date	area cover m^2	%	remarks x)
t.1	1	Norton Str.	15.3./18.5.	2	100	
	2	W Campus, Phytotron	15.3./18.5.	1	10	gravel
	3	W Campus, Phytotron	15.3./18.5.	1,5	5	gravel
	4	E Campus	20.4.	0,4	50	
	5	W Campus, Physics Bldg.	23.3.	0,5	4	
	6	Washington Str./Foster Str.	23.7.	6	20	
	7	near Pettigrew Str.	6.9.	1	70	parking area
	8	Liggett & Myers	6.9.	30	10	railroad track
	9	urban renewal zone	11.9.	5	100	pH 7
	10	" " "	11.9.	25	30	incl. 5° N
	11	near Corcoran Str.	11.9.	25	60	pioneers on ruins
	12	" " "	11.9.	25	20	" " " more trampled
	13	near Pettigrew Str.	6.9.	4	25	parking area
	14	W Campus, Biology Bldg.	12.9.	1	40	
	15	Dollar Ave.	30.6.	1	5	curb
	16	W Campus, Biology Bldg.	12.9.	1	50	
t.2	1	Main Str./Ninth Str.	25.9.	1,5	60	
	2	Washington Str. (backs.)	11.9.	16	25	coal heap
	3	urban renewal zone	11.9.	16	25	sandy-gravelly
	4	Chapel Hill Rd., block 45	11.9.	16	10	abandoned house
	5	near Buchanan Bvd.	6.9.	2,5	10	railroad track
	6	near Corcoran Str.	11.9.	4	15	broken walls, incl. 45° S
	7	Washington Str. (backs.)	11.9.	9	80	coal-sand
	8	Main Str.	6.9.	2,5	60	3 m high
	9	near Buchanan Bvd.	6.9.	4	100	railroad track
	10	near Buchanan Bvd.	6.9.	12	100	railroad bank, incl. 30°N
	11	Liggett & Myers	6.9.	15	90	
	12	urban renwal zone	11.9.	24	100	
	13	Cornwallis Rd./US 501	6.9.	25	60	incl. 15° SW
	14	bankof US 501, near 13	6.9.	25	100	incl. 5° NO
	15	Chapel Hill Rd., block 45	11.9.	25	90	abandoned house, pH 8
	16	near Buchanan Bvd.	6.9.	15	100	railroad bank
	17	Hunt Str.	6.9.	30	100	15° O
	18	Chapel Hill Rd., New Hope Valley	11.9.	12	100	
	19	Washington Str.	11.9.	3	100	3 m high
	20	Hunt Str.	6.9.	10	100	incl. 30° N, 8 m high
	21	near Buchanan Bvd.	6.9.	10	100	5 m high

x) Soil surface is level, if not indicated otherwise.

than 10 meters high. The *Pueraria lobata* (kudzu) subcommunity (K_2) is favoured by the more recent perturbations and high light intensities. Under these conditions kudzu is a much stronger competition than *Lonicera* is.

L. *Ailanthus glandulosa* community (table 2 rel. 19–21). Along buildings, walls or fences, in road ditches and banks shrub vegetation can establish itself. The typical ruderal shrub *(Catalpa* subcommunity, L_1) is dominated by *Ailanthus* and characterized by *Catalpa speciosa* and *Albizzia julibrissin.* Rel. 21 represents the moister type, characterized by sycamore *(Platanus* subcommunity, L_2). Both subcommunities are widespread in Durham and other cities as well. I was not able to find any special vegetation in wall fissures, which is so important in European cities. On several broken walls *Acalypha rhomboidea* was the most characteristic species. The following releve gives one example: Wall base; area 1,5 m^2; cover 30%. *Acalypha rhomboidea* 2, *Lagerstroemia indica* 2, *Hedera helix* 1, *Ipomaea purpurea* +.

Correlations between the communities.

For all pairs of plant communities I have calculated the "coefficient of community" (Gemeinschaftskoeffizient) as according to JACCARD 1928. The calculation was based on the mean cover of every species in the releves of one community. The results are presented in fig. 2. As a rule the greater the number of species in a community is, the higher the coefficient is. Only a slight similarity exists between the annual vegetation types. The trampled vegetation (E) has several species in common with other communities, where trampling occurs. The vegetation types of perennials, lianas and shrubs are closely related. The line of succession on the truly ruderal habitats is marked by high coefficients: D – G – H – K_1 – L_1.

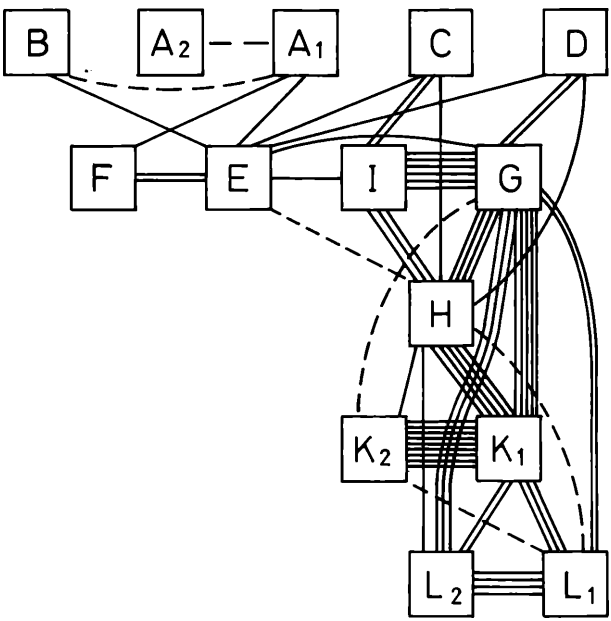

Fig. 2: Interrelationships between the plant communities:
"Coefficient of community" = Gemeinschaftskoeffizient according to JACCARD 1928.
Broken line >5%; one solid line >10%; two solid lines >20% etc.

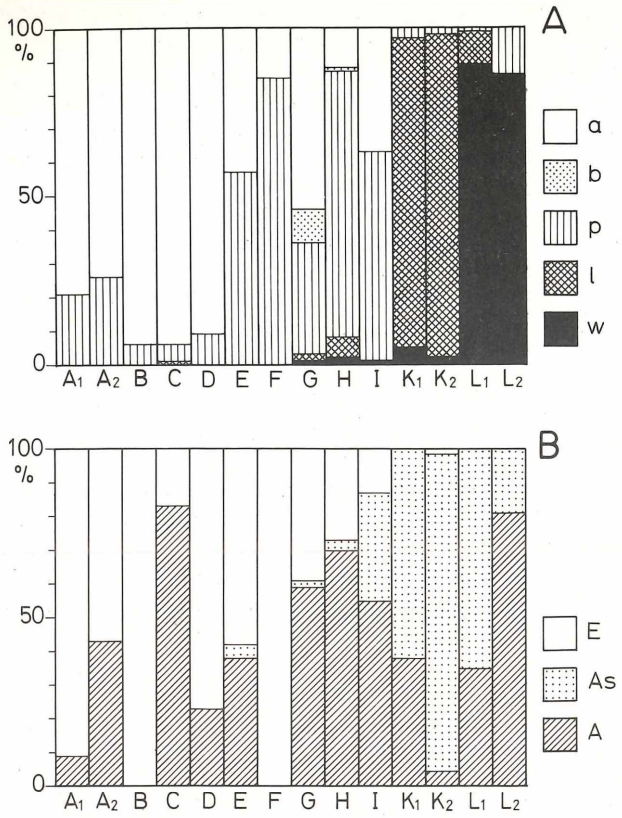

Fig. 3: Life form spectrum. a annuals, b biennials, p perennials, l Lianas, w other woody plants (shrubs and young trees). B. Plant geographic spectrum. A American, As Asian, E European origin.

Life forms

As is to be seen in fig. 3 A the plant communities A_1, A_2, B, C and D are completely dominated by annuals. Only a few perennials and nearly no woody plants occur. From the vegetation types most affected by trampling E contains almost as many annuals as perennials, while F is dominated by perennials. G still exhibits 50% annuals; the amount of biennials is relatively high. H already has about 80% perennials and 8% woody plants. I is intermediate between G and H. K is dominated by lianas, L by shrubs and young trees. There is a continuous shift in the life forms during the ruderal succession D – G – H – K_1 – L_1.

Plant geographic character

There are striking differences in the origin of the dominating plants within the different plant communities (fig. 3 B). A_1, B and F are almost pure European communities; strong European contributions have been found in A_2, D and E. Before the white settlement habitats like gardens, ruined houses, larger roads and railroads did not exist in America. So no plants had to adapt to these conditions. In the herbaceous vegetation on eroded and not too frequently perturbated soil (types C, G. H) American species dominate. In the ruderal woody vegetation

(K_1, K_2, L_1) Asian plants are better competitors than American ones, except on moist places (L_2). Here the succession is more directly aimed toward the climax forest.

Discussion

There is still much work to be done in defining the ruderal plant associations and in finding out their characteristic species. In this paper only at a very local level have several plant communities been discerned. Some of them, containing European species, are closely related to their European counterparts. This relationship should be worked out more in detail in the future. As in Europe the highest diversity at the community level has been found in the annual vegetation.

Regarding the species composition, habitat, life form and plant geographic character of the vegetation the most likely trend of succession on ruderal habitats is: $D - G - H - K_1 - L_1$. On abandoned fields (OOSTING 1942; KEEVER 1950) there are three major steps of succession: 1) in the first year *Digitaria sanguinalis* and *Erigeron canadense* are dominant; *Eragrostis pilosa* is characteristic in this case. 2) In the second year *Aster pilosus* and *Ambrosia artemisiaefolia* are dominant. Characteristic are: *Solanum carolinense, Ipomaea lacunosa, Daucus carota, Oxalis stricta, Lactuca canadensis, Croton glandulosus* and *Diodia teres.* 3) In the third year several species of *Andropogon* are dominant. Characteristic are *Campsis radicans* and *Eupatorium capillifolium.*

If we compare the old field vegetation with city vegetation, the differences especially in the first year are evident. As already mentioned above the city shows a variety of annual plant communities, none of them dominated by *Digitaria sanguinalis.* OOSTING 1942 mentions *Plantago aristata* and *Diodia teres* as indicators of soil erosion. As for the second year in the city the differentiation has been made between the vegetation growing at least two winters (G) and the vegetation growing at least two years (H). *Andropogon* dominance has not been observed in the city. Several species of *Andropogon* occur inside the city, but on places with only occasional perturbations or trampling. Thus the next succession stage already is dominated by lianas or summergreen shrubs. This may be invaded by plants from the climax forest. This type of succession is very different from the old field succession, where the woody phase starts with coniferous plants like *Pinus taeda, echinata, virginiana* and *Juniperus virginiana.*

Summary

Inside the city of Durham, North Carolina, there have been described annual, perennial und woody ruderal plant communities. They have been characterized by indicator plants, life forms and plant geographic character. The succession on ruderal habitats has been compared with the old field succession.

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