한국환경생태학회지 14(2) : 154~161, 2000
Kor. J. Env. Eco. 14(2) : 154~161, 2000

Changes of Land Use Pattern due to Urbanization in Taejon, Korea[1]

Shin-Ho Kang[2], Nobukazu Nakagoshi[3], Sung-Chul Ko[4]

도시화에 따른 대전시 토지이용의 변화[1]

강신호[2] · 中越信和[3] · 고성철[4]

ABSTRACT

The objectives of this study were to determine how land use pattern in Taejon, the sixth largest city in Korea has changed with urbanization. Degree of green naturalness (DGN) was used to analyze land use pattern from 1990 to 1998. Number of 1km × 1km grids, numbers of statistical land use data and compared rate of population increase quantified land use patterns.

The rate of population increase of Taejon was 27.8%, from 1990 to 1998. Eight degrees of DGN were identified with secondary forest(grade 7) occupied the largest area(203 grids: 37.5%) of the total 541 grids in 1998. The changes in land use were compared among 1990, 1994 and 1998. Grade 1 increased by 9 grids while grade 2 decreased by 6 grids. Likewise paddy field decreased by 10km^2 from 62 to 52km^2, dry field and forest also decreased by 4km^2 and 1km^2, respectively, while residence and factories increased by 10km^2 and 0.5km^2, respectively. The green space was mostly distributed in a national park and greenbelts in the outer zone of the city. As a result, paddy and dry fields in central area of the city have been changed to residential and industrial areas. The city environment in term of DGN reduced its quality and quantity.

KEY WORDS : DGN, LAND USE PATTERN, URBANIZATION

요 약

본 연구는 한국의 여섯 번째 대도시인 대전을 대상으로 시간의 경과와 도시화에 따른 토지이용 변화 조사를 그 목적으로 하였다. 1990년부터 1998년까지의 녹지자연도 비교를 통하여 조사하였고 같은 기간 인구증가율은 27.8%이었다. 1998년에 조사된 녹지자연도는 총 8개 등급, 541개 격자로 구성되었다. 2차림인 7등급이 203개 격자(37.5%)로 가장 많았고, 개발지역인 1등급이 137개 격자(25.3%)인 반면 경작지인 2등급은 81개 격

1 Received on May 31, 2000
2 Graduate School for International Development and Cooperation, Hiroshima University, Higashi-Hiroshima 739-8529, Japan(shkang@hiroshima-u.ac.jp)
3 Graduate School for International Development and Cooperation, Hiroshima University, Higashi-Hiroshima 739-8529, Japan(nobu@hiroshima-u.ac.jp)
4 Dept. of Biology, HanNam University, Taejon 306-791, Korea(kscaaa@eve.hannam.ac.kr)

자(12.7%), 조림지는 84개 격자(15.5%)의 순으로 나타났다. 1990년부터 1998년까지 녹지자연도의 비교에서 1등급이 9개 격자가 증가한 반면, 2등급이 6개 격자가 감소한 것을 알 수 있었다. 이는 논이 62km2에서 52km^{2}로의 10km^{2}가, 밭과 산림지역이 각각 4km^2 및 1km^{2}가 감소한 반면, 대지와 공장용지가 각각 10km^2 및 0.5km^{2}가 증가한 것으로 녹지자연도 비교의 결과와 같게 나타났다. 대전시 녹지 대부분이 도시외곽의 국립공원에 분포하여 결과적으로 도시 중심부의 경작지가 개발지역으로 변화되었다. 개발제한구역이 설정되어 있기는 하나 녹지자연도로 본 대전시의 녹지는 질적, 양적으로 감소되었다.

주요어 : 녹지자연도, 토지이용변화, 도시화

INTRODUCTION

The pattern of landscape development in time and space results from complex interaction of physical, biological and social forces (Risser *et al.*, 1984; Urban *et al.*, 1987). Human land use has influenced most landscape, resulting in a landscape mosaic of natural and human-managed patches that vary in size, shape and arrangement(Forman and Godron, 1986; Krummel *et al.*, 1987). Quantifying relationship between changing landscape patterns and functional processes would be particularly informative and provide a more complete understanding of landscape dynamics(Turner and Ruscher, 1988).

Today, natural ecosystem of Korea is under destruction stress. There is strong pressure towards urbanization. After the 1960s, Korea's economy has grown rapidly as a result from government policy to convert the country from agro-silvo-pastral based on modern industrialized. Large-area industrial complex, residential area, and highways were constructed according to the plan of this period. People, therefore, came into and crowding cities where they created more pollution and destroyed more environments than before.

Taejon is located in the central area of South Korea, and is a center for traffic development. The central downtown was constructed on flat plain of level land on 60m above the sea level near the Kum-Kang River, which flows through downtown from north to south. The leisure area, Yusung Hot Spring, is in the western part, Taeduk Science Complex and Toonsan New Town locates in northeastern part of the city. In the northern part, there are four industrial complexes, which will be expanded according to the plan of Korean Government.

Population of Taejon will be 1.65 millions in the year 2001 and the Third Government Complex was established in Taejon. They will be more needs for larger scale residential area and the city has a plan to do so(Ko, 1998). Therefore, urban green space will be further destroyed and citizen will expect a higher level of life and sound man-made environment.

Meanwhile, the degree of green naturalness (DGN), in Korea, was conducted by ministry of Environment for systematical conservation and management of natural ecosystem such as lakes, marshes, coastal and terrestrial regions from 1986 to 1990 through grid map (Ministry of Environment, 1991). The grid map technique was developed in geography. Grid map can show both continuously varying attributes without boundaries(e.g. gradients, physiognomy, and temperature), and discontinuously attributes with boundaries(e.g. vegetation, soil, and land use) in the same unit. Before more advanced computing systems such as geographic information system(GIS) became popular, data for grid maps could be easily computerized and analyzed statistically(Driese *et al.*, 1997).

The purpose of this study is to examine the changes of land use type with urbanization through degree of green naturalness(DGN) and present counterparts for the conservation

Table 1. Population increases from 1990 to 1998 (except foreigners) in Taejon

Year	Household	Population			Population density (person/km²)	Area (km²)
		Total	Male	Female		
1990	262,348	1,049,578	530,189	519,389	1,954	537.19
1991	277,923	1,091,200	550,290	540,910	2,031	537.27
1992	327,049	1,136,621	573,057	563,564	2,116	537.13
1993	348,619	1,191,378	600,435	590,753	2,219	536.86
1994	365,412	1,235,378	621,850	613,528	2,288	539.85
1995	379,121	1,268,432	638,471	629,961	2,350	539.87
1996	394,869	1,297,884	653,571	644,313	2,404	539.89
1997	411,867	1,318,212	663,060	655,152	2,451	539.89
1998	417,523	1,341,413	674,563	666,850	2,492	539.89

of green space.

METHODS

1. Study area

The study was conducted in Taejon(127° 14′ ~127° 33′ E, 36° 10′ ~36° 29′ N) which is the sixth largest city in Korea. It is encompassed by the several counties and cities, Okchon, Boeun, Kongju, Yonki, Nonsan and Kumsan in the central region of South Korea. Its central area is a basin surrounded by mountains on all sides with some of the mountains namely, Mts. Shikjang, Kyeryong, Bomoon and Kyejok belong to Noryong mountain range. Annual mean temperature and precipitation of this city are 12.6℃ and 1,170mm(KLASS, 1998), respectively.

The rock of study area consists of granite gneiss, crystalline schist and granite. The soil of the city was not fertile. Crystalline schist was distributed in southern mountain area. Granite and granite gneiss were distributed in eastern and western part of the city(Office of Rural Development, 1974).

The rate of population increase from 1990(1,049,578) to 1998(1,341,413) in Taejon was 27.87%(KLASS, 1998; Table 1) and population will more rapidly increase within the year 2001(Ko, 1998). Residential area and central downtown were constructed on level land to group densely near a tributary to the Kum-Kang River, namely, Kapchon, Yoodungchon and Taejonchon. Population density was higher than the registered value, 2,492 per km².

2. Land use types

For DGN mapping all territory of Taejon, 539.89km², was divided into 1km × 1km grids(541 grids) on 1:50,000 map. The DGN map was based on satellite photo and topographic map. Grids in administration boundary, if which belong to more than a half the city which were included. Grade of grid was decided by land use type that occupied the largest area. The DGN maps were from the year 1990, 1994 and 1998, then were compared to each other. The grid size of 1km × 1km was already tested and its efficacy and limit were reported in Korea(Kim and Lee, 1997) and Japan(Nakagoshi *et al.*, 1998).

Eleven land use categories were used as the classification based on the methods of Ministry of Environment 1988 and 1989.

As for maps from 1990(Ministry of Environment, 1991), and 1994(Taejon City, 1994), the legend of topographic map 1:25,000 was introduced to identify grades. Field surveys were conducted from 1995 to 1998, and especially pacing emphasis on the areas which were developed and has development project.

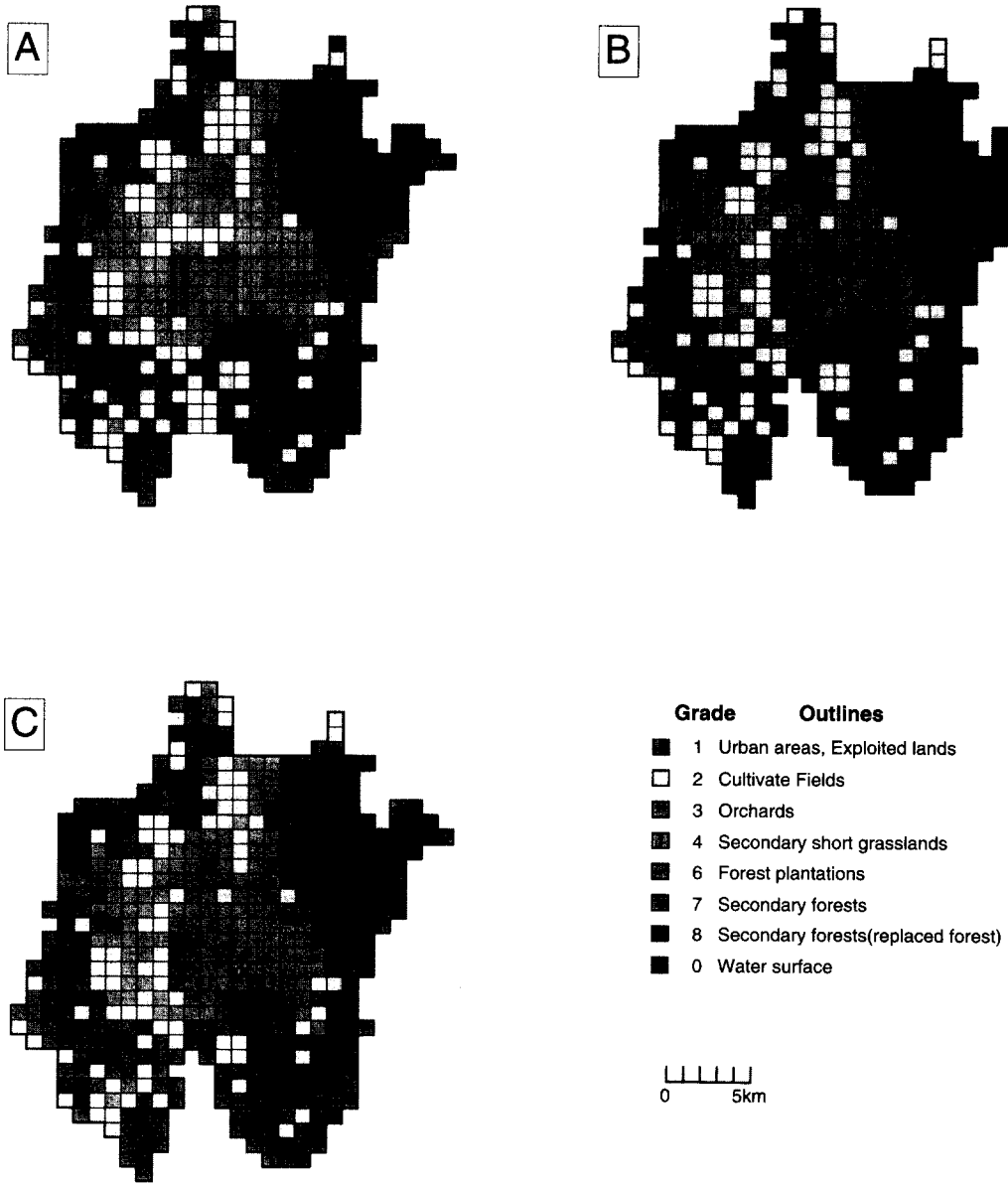

Figure 1. Grid maps of land use change from 1990 to 1998 in Taejon, Korea(A: 1990, B: 1994, C: 1998)

RESULTS

The DGN map(Figure 1) expressed the current state of land use in the city. The area of Taejon is 539.89km^2, while the numbers of 1km × 1km grids are 541 grids on the map. The results of the DGN could be identified into eight grades that are, 1, 2, 3, 4, 6, 7, 8 and 0. There were no grids of grades 5, 9 and 10. Secondary forest consisting of *Quercus serrata* - *Q. acutissima* forest(grade 7) occupied 203 grids(37.5%). Build-up area(grade 1) covered 137 grids(25.3%). Cropland(paddy field and dry field), or grade 2, covered 81 grids(15.0%),

and plantations(grade 6) covered 84 grids(15.5%). The species of plantation are mainly *Pinus rigida, and some Robinia pseudoacacia, Larix leptolepis and Juniperus chinensis*. Grade 1 increased by 9 grids, while grade 2 decreased by 6 grids(Table 3).

Several land use types were changed by construction of residential area, towns, highways, dam and manufacturing districts. Paddy field has decreased by 10km^2 from 62 to 52km^2, dry field and forest land also have decreased by 4km^2 and 1km^2, respectively, while residents and factories increased in area by 9km^2 and 0.5km^2, respectively(Table 2). Since 1989, the paddy field and dry field had decreased annually, the former by 1.2% and the latter by 1.3%. Decreasing of cultivated area, especially paddy field, lead to loss of several ecosystem functions such as flood control, fostering of underground water, cooling of hot air in summer, protection for soil surface, purification of air and water pollution.

Moreover, the area of forest also decreased by 168ha(0.5%) from 30,949ha to 30,781ha(KLASS, 1998; Table 4), due to the because of increase in population and industry. The most urgent meters to do are to conserve and secure green space for citizens in order to provide delightfulness lives. The percentage of forest area, or grades 6, 7 and 8 was 54.3% in Taejon. It was the highest among the six largest cities that of Seoul(25.3%), Pusan(36.6%), Taegu(50.7%), Inchon(24.1%) and Kwangju (38.4%), but it was still lower than Korean average.

DISCUSSION

Like many other developed countries,

Table 2. The yearly composition of the DGN in Taejon. Explanation of grades are shown in Figure 1. Grades 5, 9 and 10 were null

Year	Grade 1	Grade 2	Grade 3	Grade 4	Grade 6	Grade 7	Grade 8	Grade 0	Total
1990	132	92	1	1	74	214	0	27	541
(%)	24.4	17.0	0.2	0.2	13.7	39.6	0.0	5.0	100
1994	136	84	1	4	72	213	7	24	541
(%)	25.1	15.5	0.2	0.7	13.3	39.4	1.3	4.4	100
1998	137	81	1	4	84	203	7	24	541
(%)	25.3	15.0	0.2	0.7	15.5	37.5	1.3	4.4	100

Table 3. The yearly change of Land use type (Unit: %)

Year	Dry field	Paddy field	Orchard	Pasture land	Forest	Buildings
1990	7.82	11.62	0.47	0.03	55.62	9.45
1994	7.13	10.35	0.49	0.03	55.26	11.20
1998	7.00	9.44	0.51	0.04	54.83	12.19

Table 3. (Continued)

Year	Road	River	Park	Cemetery	Miscellaneous	Total
1990	4.11	9.44	0.34	0.24	0.84	100.00
1994	4.80	9.26	0.63	0.24	0.62	100.00
1998	5.15	9.19	0.75	0.23	0.67	100.00

Modified from Korean Local Administration Statistics System (1998).

Korea is suffering from environmental degradation caused by urbanization and industrialization(Nakagoshi and Rim, 1988). Urbanization is a big problem not only in developed countries but also developing countries. For much of recorded history, we have viewed the natural environment as a resource to be exploited. However, our attitude towards nature has began to shift profoundly as the negative effects of our industrialized economy have become clearer and more catastrophic(Rockwood, 1995). In an urban environment, green space within a city is indispensable for the well being of citizens. Moreover, animals exist not only in natural and rural landscapes but also in urban landscape(Gilbert, 1989; Nakagoshi and Moriguchi, 1999). The abundance and distribution of wildlife species might also vary with changing spatial patterns in the landscape (Turner and Ruscher, 1988). Internal fragmentation of reserves by road, fences, farming, logging and other human activities should be avoided as much as possible because the many negative effects fragmentation can have on species and populations (Primack, 1995).

At first, we discuss the protection system of green such as greenbelt in Taejon, which is the highest percentage among the metropolitan cities in Korea. The greenbelts, where construction of new buildings, roads and other technical facilities is strictly controlled by law, aim at controlling both disorganized urban sprawl and population migration from rural areas to urban cities, and at conserving natural landscapes(Nakagoshi and Rim, 1988). Taejon has large greenbelts, 316.82 km^2 in its outer zone, which is higher than other cities about numerical greenness. However, the most green area in greenbelts was distributed in outer zone, the environmental condition of central area has been affected by population increase. There are no proper grids to convert from natural forest (grade 9) and natural grassland(grade 10), to grades 6 and 7, which are not, designed for greenbelts to conservation area and to grades 1 and 2 in greenbelts to build-up area.

To make a comparison with Taegu City, which is very similar city based on greenbelts composition. The population of Taegu City was 2,517,203 in 1999. It was increased by 12,588 during 1998. The composition of forests, totally 49,657ha was mixed forest 46%, conifers 42% and others. Almost of these forest is private(Taegu City, 2000). There was 418.875km^2 of greenbelts, even though, 47.3% of its area in 1995, and 75% of greenbelts was made-up of forest(Park and Nakagoshi, 1998), but the impression of greenness was higher than Taejon, because of its even broad distribution. There are 417 parks and greenery space in Taegu City 125,997km^2 in 1999. In Japan, the land use type is residential area 1,354ha(30.6%), commercial area 1,227ha(27.8%), industrial area 1,068ha(24.2%) and others 768.7ha(17.4%) in delta zone of Hiroshima (Moriguchi, 2000).

Table 4. Comparative change of forest area in Taejon (Unit : ha)

Year	Conifers	Deciduous	Mixed	Others	Total
1991	12,505	9,938	8,236	270	30,949
1992	12,504	9,921	8,223	270	30,918
1993	12,499	9,905	8,212	279	30,895
1994	12,484	9,897	8,192	288	30,859
1995	12,411	9,851	8,134	371	30,797
1996	12,387	9,822	8,116	456	30,781
1997	12,411	9,822	8,066	407	30,706
1998	12,406	9,822	8,059	391	30,678

Secondly, the problems of landscape management are insufficient of green space caused by population increase and its concentration in the city, as well as some ecological issues. The area of parks in Taejon was 44.9km^2 (204 locations), 7.6% of the total area and 34.6m^2 per person. Almost all of green areas consisting of some mountains are located in the outer zone of the city. Citizen cannot enjoy forest easily, because there are no green space in main residential area or downtown area, except green space of universities and small vicinity parks. Kyeryongsan National Park occupied 15.2% of the total park area, and other parks, Mt. Bomoon, Mt. Shikjang, Mt. Kyejok and Mt. Koobong are also located in the outer zone of the city. Likewise, ecological exchange between green areas in the outer zone was cut off by industrial development. Roadsides and streamside are not functioning as ecological corridors. The long-term plan to construct green stations has to be improved to connect the green spaces, between outer zone and central area. It is possible to plant with following species(Taejon City, 1994), in the urban green patches. *Zelkova serrata*, *Carpinus laxiflora*, *Carpinus tschonoskii*, *Acer palmatum*, *Quercus serrata*, *Quercus aliena*, *Quercus acutissima*, *Styrax japonica*(tree layer), *Rhododendron mucronulatum*, *Ligustrum obtusifolium*, *Symplocos chinensis* for. *pilosa*(shrub layer), *Carex siderosticta*, *Carex lanceolata* and *Sasa borealis*(herb layer) for roadsides in the urban green patches, respectively. For streamside, *Zelkova serrata*, Celtis *sinensis*, *Ulmus davidiana* var. *japonica*, *Salix koreensis*, *Populus davidiana*(tree layer), *Cleodendron trichotomum*, *Rhus chinensis*, *Viburnum sargentii*, *Forsythia ovata*(shrub layer), *Phalaris arundinacea*, *Phragmites communis*, *Miscanthus sinensis*(herb layer) were also recommended, respectively. Ecological parks with some institutions, such as natural history museum, zoo and botanical garden will be needed for citizen education.

In conclusion, the changes of land use type with urbanization could be investigated in this paper. Urbanization of the city leads to changes of all area into build-up area except for forest in the greenbelts. It was difficult to find green space in the main residential area, and the population density has been increasing. The native forest that has a local character should be conserved and long-term plans, both for environmental conservation and sustainable use, have to be improved for ecological lives of citizen.

LITERATURE CITED

Drises, K. L., W. A. Reinners, E. H. Merrill and K. G. Gerow(1997) A digital land cover map of Wyoming, USA: A tool for vegetation analysis. J. Veg. Sci. 8: 133-146.

Forman, R. T. T. and M. Godron(1986) Landscape Ecology. John Wiley and Sons, New York. 619pp.

Gilbert, O. L.(1989) The ecology of urban habitats. Champman and Hall, London. 369pp.

Lee, W. S., K. H. Cho, S. J. Rhim(1998) Status, protection, and management of bird community in Mt. Nam area. Korean. J. Ecol. 21: 665-673(in Korean with English abstract).

Kim, J. W and E. J. Lee(1997) Multicriterion matrix technique of vegetation assessment - A new evaluation technique on the vegetation naturalness and its application. Korean J. Ecol. 20: 303-313(in Korean with English abstract).

Ko, S. C.(1998) Present conditions and improve counterpart of green space in Taejon, In Jang, J. H and K. W. Hahn(eds.), Preservation and Management of Urban Ecosystem. Proceedings of International Symposium HanNam University, Taejon, pp. 14-50(in Korean).

KLASS(1998) National Statistics Combination, Korea Local Administration Statistics System. Seoul, pp. 1008-1074(in Korean).

Krummel, J. R., R. H. Gardner, G. Sugihara and R. V. O' Neill(1987) Landscape patterns in a disturbed environment. Oikos 48: 321-324.

Ministry of Environment(1991) Survey for Natural

Ecosystem '90(The Fifth years - Land utilization of Chungnam). Korean Government, pp. 15-63(in Korean).

Moriguchi T.(2000) Land use pattern of urban greenery space and its ecological appraisement. Hiroshima University, Master thesis, 23pp(in Japanese).

Nakagoshi, N. and Y. D. Rim(1988) Landscape ecology in the greenbelts area in Korea. Münster Geogr. Arbeiten 29: 247-250.

Nakagoshi, N., M. Hikasa, M. Koarai, T. Goda and I. Sakai(1998) Grid map analysis and its application for detecting vegetation changes in Japan. Appl. Veg. Sci. 1: 219-224.

Nakagoshi, N. and T. Moriguchi(1999) Ecosystem and biodiversity conservation planning in Hiroshima City, Japan. J. Environ. Sci. 11: 149-154.

Office of Rural Development(1974) Detailed Soil MapDaejeon Si and Daedeog Gun. - Institute of Agricultural Science, Office of Rural Development, 117pp. + maps(in Korean).

Park, J.H. and N. Nakagoshi(1998) Current use of GIS and its application in building database to landscape ecology in Korea. Journal of International Development and Cooperation, 4: 153-164.

Primack, R. B. 1995. A Primer of Conservation Biology. Sinauer, Massachusetts, 277pp.

Risser, P. G., J. R. Karr and R. T. T. Forman(1984) Landscape Ecology: Directions and Approaches. Illinois Natural History Survey Special Publication No. 2. Champaign, Illinois, 18pp.

Rockwood, P.(1995) Landscape planning for biodiversity. Landscape and Urban Planning 31: 379-385.

Taegu City(2000) Hwakyungbaekso. Taegu City. Taegu 350pp(in Korean).

Taejon City(1994) Green Plan 2003. Taejon City, Taejon 295pp(in Korean).

Turner, M. G. and C. L. Ruscher(1988) Changes in landscape patterns in Georgia, USA. Landscape Ecol. 1: 241-251.

Urban, D. L., R. V. O' Neill and H. H. Shugart(1987) Landscape ecology, a hierarchical perspective. BioScience 37: 119-127