Dynamic Analysis of Landscape on Forest Resources

Li Changsheng

School of Humanities and Social Sciences, Harbin Institute of Technology, 150001, P. R. China.
E-mail: lichangsheng100@163.com

Abstract To study the landscape change of natural forest resource, FRAGSTATS package of landscape space pattern was used. Landscape shape Index, Mean shape index, Area-weighted mean shape index, Double log fragile dimension, Mean patch fragile dimension, Area-weighted mean patch fragile dimension, Shannon's diversity index, Shannon's evenness index, Simpson's diversity index, Simpson's evenness index, Modified Simpson's evenness index and Modified Simpson's diversity index are calculated. The results showed that Area-weighted mean shape index, Double log fragile dimension and Mean patch fragile dimension decreased slightly, i.e. the Shape of patches (sub compartments) didn't change a lot. The change of forest landscape was later than that of forest resource. The change of diversity index of patches was not obvious. But Relative patch richness and Patch richness density increased rapidly.
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In addition to the sustainable use of forest resources, sustainable forest management also includes changes of ecological landscape of forest resources (WU, 2000; GUO, et al, 2003). Studies on landscape of forest resources are very important (YANG ea al., 2003;HE, 2008). In order to study the landscape changes in forest resources of natural forest, in this paper, the landscape spatial pattern analysis software FRAGSTATS is used, which can analyze the landscape spatial pattern, for different size. FRAGSTATS for ArcView, which is a new version, as an integration extension of ArcView module, analysis of landscape spatial pattern, helping landscape ecologists and experts in natural resources analysis and demonstrate the natural landscape vegetation conditions(RIPPLE, et al, 1991).

1 Overviews of Study Area

Mangui forestry bureau is located at the northern part of western slope in Daxing'an Mountain, at Eerguna city and Genhe City in Hulunbeier League of the Inner Mongolia Autonomous Region, with 120 km long from east to west, and north-south width of 20 km. The total area of which is 390577 hm^2. The low hills below 1000 m account for 90.1% of the industry area. The highest elevation is 1409 m, and the minimum altitude is 507 m. in Green forest Whitewater River estuary. In the territory, the terrain is flat. Gentle slopes and valley areas account for 70%. It is a hilly slope terrain on the overall terrain and topography. The main river is Jiliu River, belonging to the Heilongjiang River as a tributary of the Eerguna River. Mangui forest belongs to cold temperate zone continental monsoon climate. Brown Coniferous forest soil is the zonal soil in this forest. Forest vegetation consists of the flora of Mongolia and the flora of East Siberia. The main forest types include Dahurian larch forest, Scotch pine forest, Asian white birch forest and poplar forest.

2 Research Methods

Three kinds of scales can be calculated by FRAGSTATS for ArcView(GARIGA，et al, 1994). As a limited patches mosaic landscape, FRAGSTATS for ArcView can calculate several landscape indexes, including 1 inlaid patch, Each kind of inlaid patches and the whole landscape. Consequently, the output results of FRAGSTATS for ArcView is settled as three kinds of files: Patch, Class and Land, formatted as dBase (.dbf).

Nearly 40 kinds of landscape index could be calculated by FRAGSTATS.（1）When the landscape index on the patch type level is interpreted, 8 indexes are chosen including type area, patch area, perimeter, type, the proportion of area, landscape similarity index, margin ratio, fragile dimension;（2）When the landscape index is interpreted on the Class type level, 14 indexes are chosen, including Patch area, Patch number, Average area of patches, Average shape index, Average patch fragile dimension, Patch area standard deviation, Proportion of landscape area accounted by patches, Total area of landscape, Largest patch index, Patch density, Variation coefficient of patch area, Average shape index weighted by area, Double log fragile dimension, Average patch fragile dimension weighted by area;

（3）When the landscape index is interpreted on landscape level, 22 indexes are chosen, including Patch numbers, Average area of patches, Average shape index, Average patch fragile dimension, Patch area standard deviation, Landscape type proportion, Proportion of landscape area accounted by patches, Total area, Largest patch index, Patch density, Variation coefficient of patch area, Average shape index weighted by area, Double log fragile dimension, Average patch fragile dimension weighted by area, Shannon diversity index, Simpson diversity index, Modified Simpson diversity index, Simpson's evenness index, Modified Simpson's evenness index, Patch richness, Patch richness density, Relative patch richness.

The following index is applied mainly in the paper:

Landscape Shape Index:

$$LSI = \frac{E}{2\sqrt{\pi - A}} \qquad (1)$$

Where A is the total area, E is the total length of the whole landscape.

Mean Shape Index:

$$MSI = \frac{\sum_{i=1}^{m}\sum_{j=1}^{n}\left(\frac{p_{ij}}{2\sqrt{\pi - a_{ij}}}\right)}{N} \qquad (2)$$

Where is the amount of patch types from 1 to m of the landscape, j is the amount of patches from 1 to n of the landscape, p_{ij} is perimeter of the $patch_{ij}$, a_{ij} is the area of $patch_{ij}$, n is the amount of patches in the whole landscape, m is the amount of patch types.

Area-Weighted Mean Shape Index:

$$AWMSI = \sum_{i=1}^{m}\sum_{j=1}^{n}\left[\left(\frac{p_{ij}}{2\sqrt{\pi - a_{ij}}}\right)\left(\frac{a_{ij}}{A}\right)\right] \qquad (3)$$

In this equation, the marks represent the same meanings with the ones in（2）.

Double Log Fragile dimension:

$$DLFD = \frac{2}{\left[n_i\sum_{i=1}^{m}\sum_{j=1}^{n}(\ln p_{ij} - \ln a_{ij})\right] - \left[\left(\sum_{i=1}^{m}\sum_{j=1}^{n}\ln p_{ij}\right)\left(\sum_{i=1}^{m}\sum_{j=1}^{n}\ln a_{ij}\right)\right]}{\left(n_i\sum_{i=1}^{m}\sum_{j=1}^{n}\ln p_{ij}^{\,2}\right) - \left(\sum_{i=1}^{m}\sum_{j=1}^{n}\ln p_{ij}\right)^2} \qquad (4)$$

In this equation, the marks represent the same meanings with the ones in（2）.

Mean Patch Fragile dimension:

$$MPFD = \frac{\sum_{i=1}^{m}\sum_{j=1}^{n}\left(\frac{2\ln p_{ij}}{\ln a_{ij}}\right)}{n_i} \qquad (5)$$

In this equation, the marks represent the same meanings with the ones in（2）.

Area-Weighted Mean Patch Fragile dimension:

$$MPFD = \sum_{i=1}^{m}\sum_{j=1}^{n}\left[\left(\frac{2\ln p_{ij}}{\ln a_{ij}}\right)\left(\frac{a_{ij}}{A}\right)\right] \qquad (6)$$

In this equation, the marks represent the same meanings with the ones in (1),(2).

Shannon's Diversity Index:

$$SHDI = -\sum_{j=1}^{m}(P_i - \ln P_i) \qquad (7)$$

Where P_i is the proportion that patch type accounted for the whole landscape, m is the patch type amount of the whole landscape.

Shannon's Evenness Index:

$$SHEI = \frac{-\sum_{i=1}^{m}(P_i - \ln P_i)}{\ln m} \qquad (8)$$

In this equation, the marks represent the same meanings with the ones in（7）.

Simpson's Diversity Index:

$$SIDI = 1 - \sum_{i=1}^{m}P_i^2 \qquad (9)$$

In this equation, the marks represent the same meanings with the ones in（7）.

Simpson's Evenness Index:

$$SIEI = \frac{1 - \sum_{i=1}^{m}P_i^2}{1 - \left(\frac{1}{m}\right)} \qquad (10)$$

Where P_i is the proportion that patch type

accounted for the whole landscape, m is the patch type amount of the whole landscape.

Modified Simpson's Evenness Index:

$$MSIEI = \frac{-\ln \sum_{i=1}^{m} P_i^2}{\ln m} \qquad (11)$$

In this equation, the marks represent the same meanings with the ones in（10）.

Modified Simpson's Diversity Index:

$$MSIDI = -\ln \sum_{i=1}^{m} P_i^2 \qquad (12)$$

In this equation, the marks represent the same meanings with the ones in（10）.

3 Results and Analysis

Landscape type = soil type + (the origin of forest territory × forest type × age group). According to forest investigational plan in 1996, soil type has been divided into 19 types, in which the origin of forest territory has been included, forest type has been divided into 11 types and age group in 5 levels, so the maximum amount of landscape types in this area=18+2×11×5=128.

3.1 Landscape index of different landscape types in 1967

Landscape index of different landscape types in 1967 are showed in table 1.

Table 1 Landscape index of different landscape types in 1967

Lands-cape type	Patch area (hm^2)	Patch num-bers	Average patch area (hm^2)	Average shape index	Average patch fragile dimension	proportion of landscape area (%)	Largest patch index	Patch density	Average shape index weighted by area	Double Log Fractal Dimens-ion	Average patch fragile dimension weighed by area
Young L. G.	28413	851	33	1.78018	1.29799	8.50876	.08684	.25484	2.10169	1.29889	1.29536
Middle L. G.	42656	969	44	1.77220	1.28888	12.77400	.11978	.29017	1.98713	1.28944	1.28401
Near-mature L. G.	12856	286	44	1.74608	1.28465	3.85001	.07786	.08564	1.92372	1.28765	1.28168
Mature L. G.	90236	2190	41	1.85736	1.29624	27.02254	.13475	.65582	2.03483	1.29616	1.28982
Over-mature L. G.	723810	1054	68	1.78992	1.28067	21.67565	.14673	.31563	1.95485	1.28101	1.27509
Young P. S. M.	363	18	20	1.70122	1.29798	.10886	.02485	.00539	1.75511	1.35409	1.28946
Middle P. S. M.	1553	38	40	1.69002	1.28404	.46533	.08384	.01137	1.90280	1.30978	1.28195
Near-mature P. S. M	958	40	23	1.54518	1.28529	.28709	.02186	.01197	1.62091	1.30822	1.27264
Mature P. S. M.	5608	199	28	1.57214	1.28064	1.67946	.06588	.05959	1.73362	1.28495	1.27617
Over-mature P. S. M	3953	86	45	1.57441	1.26862	1.18396	.05989	.02575	1.70678	1.27923	1.26345
Young B. P.	11664	381	30	1.64378	1.29123	3.49312	.09582	.11409	1.84218	1.29259	1.27996
Middle B. P	16814	423	39	1.70270	1.28500	5.03545	.11080	.12667	1.89296	1.28703	1.28112
Near-mature B. P.	1503	30	50	1.74335	1.28165	.45016	.05989	.00898	1.95790	1.31487	1.28013
Mature B. P.	3211	55	58	1.55664	1.25926	.96157	.05390	.01647	1.61311	1.27651	1.25601
Over-mature B. P.	226	4	56	1.41667	1.24549	.06767	.02844	.00119	1.37072	1.55827	1.23638
Middle P. D.	30	1	30	2.06373	1.31559	.00898	.00898	.00029	2.06373	.00000	1.31559
Middle P. H.	63	5	12	1.74064	1.31053	.01909	.00748	.00149	1.79761	1.55277	1.31046
Near-mature P. H.	117	6	19	1.47495	1.27582	.03504	.01527	.00179	1.68492	1.46536	1.28001
Mature P. H.	619	16	38	1.58707	1.27314	.18536	.02994	.00479	1.68206	1.33659	1.26953
Open forest	62	1	62	2.34372	1.31749	.01856	.01856	.00029	2.34372	.00000	1.31749
Shrub	2	1	2	1.47052	1.32544	.00076	.00076	.00029	1.47052	.00000	1.32544
Wasteland	7409	210	35	1.74685	1.29304	2.21884	.09283	.06288	2.08685	1.29752	1.29337
Cutting blank	290	5	58	1.92029	1.29792	.08684	.04192	.00149	1.94663	1.54476	1.28378
Fire slash	6042	84	71	1.68618	1.28134	1.80951	.16170	.02515	1.91894	1.29189	1.26173
Farm land	1122	9	124	1.49727	1.24549	.33599	.10181	.00269	1.51341	1.36419	1.23275
Water	1255	5	251	8.04230	1.42977	.37582	.29047	.00149	13.7719	1.72864	1.48826
Swamp	23922	360	66	1.95783	1.29885	7.16391	.12277	.10780	2.16682	1.30066	1.28771
Building	408	47	8	1.60557	1.31534	.12220	.01407	.01407	1.78078	1.33555	1.30878
others	185	4	46	1.30251	1.25391	.05541	.04791	.00119	1.19902	1.56161	1.20935

Where: L. G= *Larix gmelini*; P. S. M. = *Pinus sylvestris var. monglica*; B. P. = *Betula platyphlla*; P. D. = *Populus davidiana*; P. H. = *Populus hsinganica.*

3.2 Landscape index of different landscape types in 1996

Landscape index of different andscape types in 1996 are showed in table 2.

Table 2 Landscape index of different landscape types in 1996

Landscape type	Patch area(hm^2)	Patch numbers	Average patch area (hm^2)	Average shape index	Average patch fragile dimension	Proportion of landscape area (%)	Llargest patch index	the patch densty	Average shape index weighted by area	Double log fragile dimension	Average patch fragile dimension weighted by area
Young L. G.	15491	393	39	1.76066	1.29043	3.92907	.07101	.09967	1.83667	1.29203	1.27674
Middle L. G.	74637	1652	45	1.66506	1.27683	18.93009	.08369	.41899	1.66949	1.27582	1.26318
Near-mature L. G.	27671	555	49	1.59818	1.26771	7.01830	.05326	.14076	1.55179	1.26780	1.25122
Mature L. G.	110091	2478	44	1.61068	1.27110	27.92223	.07101	.62848	1.60677	1.27026	1.25804
Over-mature L. G.	36158	752	48	1.65241	1.27374	9.17083.	.11159	.19072	1.64737	1.27380	1.25929
L. G. Plantation	1640	67	24	1.68115	1.29672	41604	.05072	.01699	1.91555	1.31101	1.29163
Young P. S. M.	430	16	26	1.61441	1.28223	.10910	.03297	.00405	1.69729	1.34629	1.27589
Middle P. S. M.	2474	87	28	1.57291	1.28011	.62755	.03297	.02206	1.68547	1.29054	1.27326
Near-mature P. S. M	1993	43	46	1.54883	1.26489	.50558	.04311	.01090	1.59586	1.28688	1.25452
Mature P. S. M.	4207	140	30	1.51395	1.27066	1.06703	.05326	.03550	1.57419	1.27681	1.26321
Over-mature P. S. M	1249	39	32	1.50195	1.27132	.31686	.03550	.00989	1.50446	1.29492	1.25731
Young B. P.	1746	53	32	1.65341	1.28556	.44305	.04058	.01344	1.74429	1.30263	1.27080
Middle B. P	24430	482	50	1.59405	1.26614	6.19625	.06847	.12224	1.59835	1.26722	1.25520
Near-mature B. P.	19986	377	53	1.54088	1.25978	5.06909	.04818	.09561	1.56745	1.26146	1.25209
Mature B. P.	287225	566	50	1.54225	1.26102	7.28493	.05579	.14355	1.55612	1.26184	1.25268
Over-mature B. P.	6692	155	43	1.56474	1.26708	1.69750	.05579	.03931	1.58826	1.27247	1.25776
Young P. D.	195	7	27	1.68068	1.29050	.04966	.01927	.00177	1.62499	1.44959	1.26908
Middle P. D.	2672	93	28	1.56924	1.28047	.67788	.05833	.02358	1.69280	1.29019	1.27001
Near-mature P. D.	1637	57	28	1.45489	1.26793	.41543	.03804	.01445	1.52560	1.28395	1.25935
Mature P. D.	1448	57	25	1.44335	1.26785	.36734	.02536	.01445	1.50773	1.28405	1.26021
Over-mature P.D.	331	15	22	1.39660	1.26592	.08409	.01648	.00380	1.37922	1.33166	1.25225
Middle P. H.	79	3	26	1.54112	1.26880	.02003	.00836	.00076	1.56852	1.74334	1.27122
Near-mature P. H.	130	3	43	2.14260	1.30636	.03297	.01750	.00076	2.42398	1.80702	1.31727
Mature P. H.	158	5	31	1.84933	1.29605	.04007	.01293	.00126	1.97307	1.54217	1.30297
Over-mature P.H.	250	7	35	1.84841	1.29432	.06351	.02054	.00177	1.93204	1.45807	1.29355
Young S. S.	11	1	11	1.37461	1.27285	.00278	.00278	.00025	1.37461	.00000	1.27285
Middle S. S.	270	10	27	2.66247	1.34918	.06868	.01648	.00253	2.98825	1.46374	1.35073
Near-mature S. S.	197	9	21	2.68489	1.36099	.05017	.01217	.00228	2.90421	1.49180	1.36465
Mature S. S.	105	5	21	2.57290	1.34490	.02663	.01014	.00126	3.03735	1.60236	1.36898
Middle broad-leaved forest	23	1	23	1.90994	1.30983	.00583	.00583	.00025	1.90994	.00000	1.30983
Over-mature broad-leaved forest	580	1	58	1.22752	1.22162	.01471	.01471	.00025	1.22752	.00000	1.22162
Open forest	2300	67	34	1.75273	1.29558	.58342	.07608	.01699	1.95500	1.30972	1.28842
Shrub	1537	44	34	1.65205	1.27750	.38992	.03297	.01115	1.82197	1.30012	1.27931
Afforestation	3990	185	21	1.74242	1.30036	1.01206	.03297	.04692	2.04062	1.30562	1.29836
Nursery	14	1	14	1.14474	1.23642	.00355	.00355	.00025	1.14474	.00000	1.23642
Wasteland	689	65	10	1.54498	1.30372	.17484	.01623	.01648	1.74761	1.31794	1.29512
Cutting blank	1066	78	13	1.80425	1.31780	.27037	.04058	.01978	2.22738	1.33081	1.32338
Fire slash	1197	37	32	1.60141	1.28375	.30382	.03804	.00938	1.77580	1.30915	1.27650
Farm land	56	3	18	1.51499	1.28179	.01426	.00634	.00076	1.51080	1.75617	1.27376
Pastureland	217	9	24	1.97054	1.31763	.05519	.01369	.00228	2.29362	1.44291	1.32688
Water	285	30	9	1.80920	1.33845	.07230	.01065	.00760	2.16342	1.37112	1.32728
Swamp	15612	554	28	1.80729	1.30980	3.95975	.10145	.14050	2.08504	1.31057	1.29557
Building	1683	48	35	1.74109	1.31768	.42708	.15724	.01217	1.86187	1.33691	1.25651
Others	56	5	11	1.51006	1.29860	.01431	.00938	.00126	1.35854	1.53216	1.26033

Where: L. G= *Larix gmelini*; P. S. M. = *Pinus sylvestris var. monglica*; B. P. = *Betula platyphlla*; P. D. = *Populus davidiana*; P. H. = *Populus hsinganica*; S. S. = *Salix subfragiles*.

3.3 Change of landscape index of main landscape types

Change of landscape index of main landscape types from 1967 to 1996 is showed in table 3.

Table 3 Change of landscape index of main landscape types from 1967 to 1996

Year	Patch numbers	Average area of patches	Average shape index	Average patch fragile dimension	Proportion of landscape area accounted by patches (%)	Largest patch index	Patch density	Average shape index weighted by area	Double log fragile dimension
1967	7378	45	1.78732	1.29062	.29047	2.20943	120	1.29012	1.28414
1996	9333	42	1.63627	1.27681	.15724	2.36711	92	1.27534	1.26174

Year	Average patch fragile dimension weighted by area	Shannon diversity index	Simpson diversity index	Modified Simpson diversity index	Simpson's evenness index	Modified Simpson's evenness index	Patch richness	Patch richness density	Relative patch richness
1967	2.21804	.84464	1.86207	.65870	.87481	.55298	29.0000	.00868	100.0000
1996	2.39221	.85725	1.94667	.62842	.87673	.51138	45.0000	.01141	97.82609

3.4 Some images of landscape index in 1996

Some images of landscape index in 1996 are showed in Fig.1—Fig. 4.

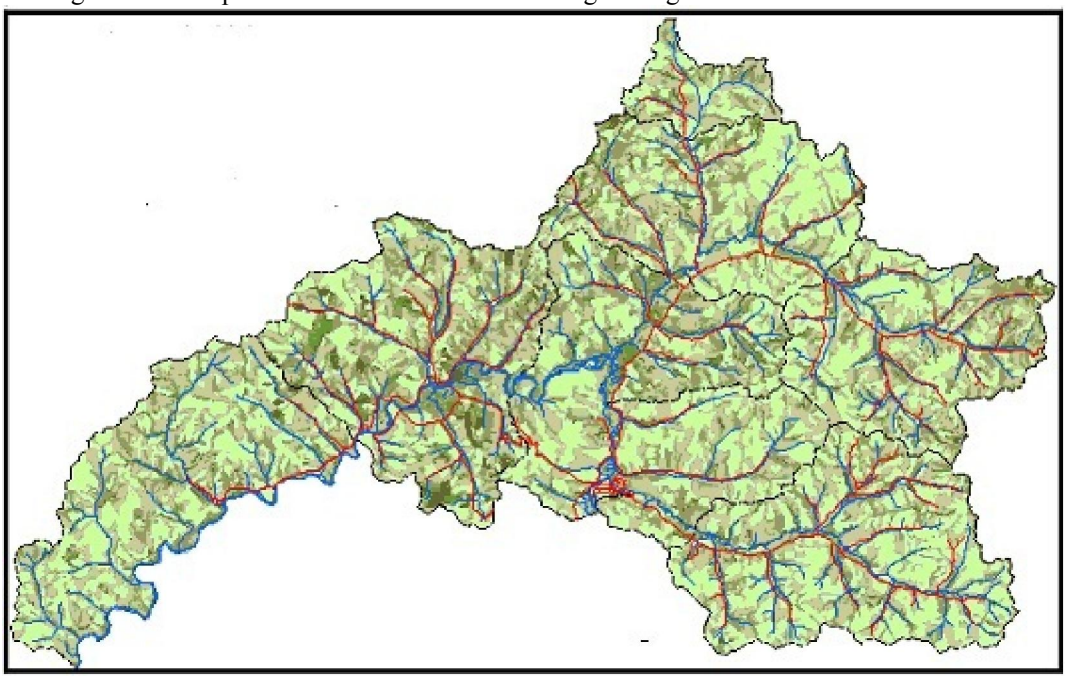

Fig. 1 Fragile dimension distribution image

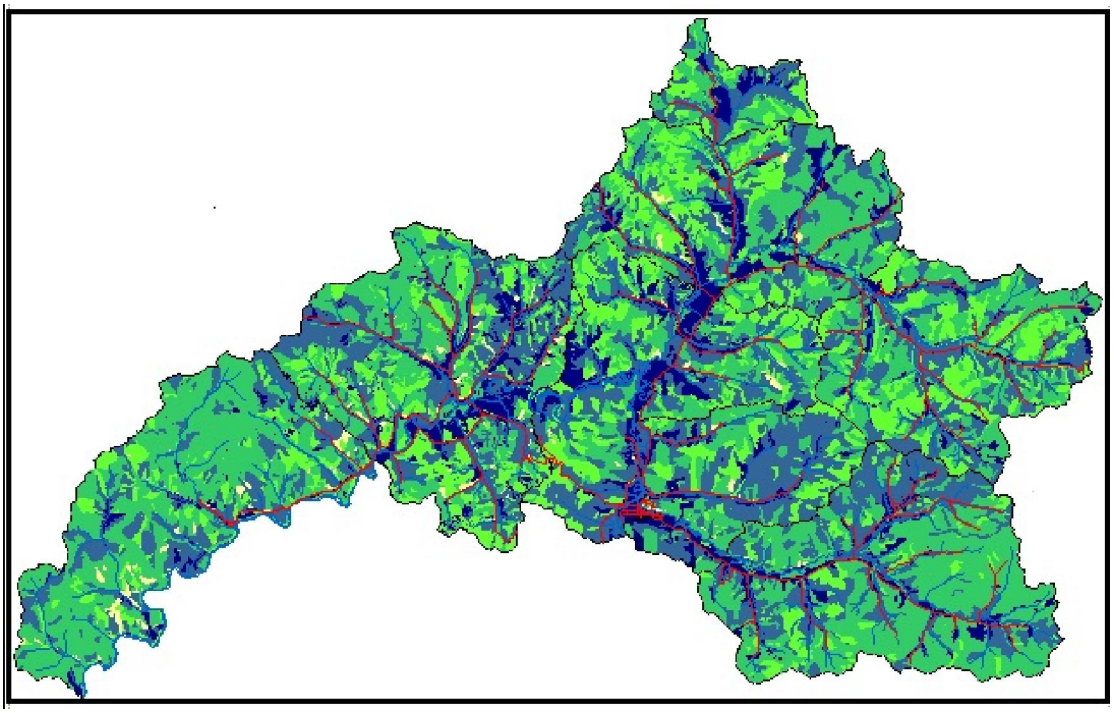

Fig. 2 Shape index distribution image

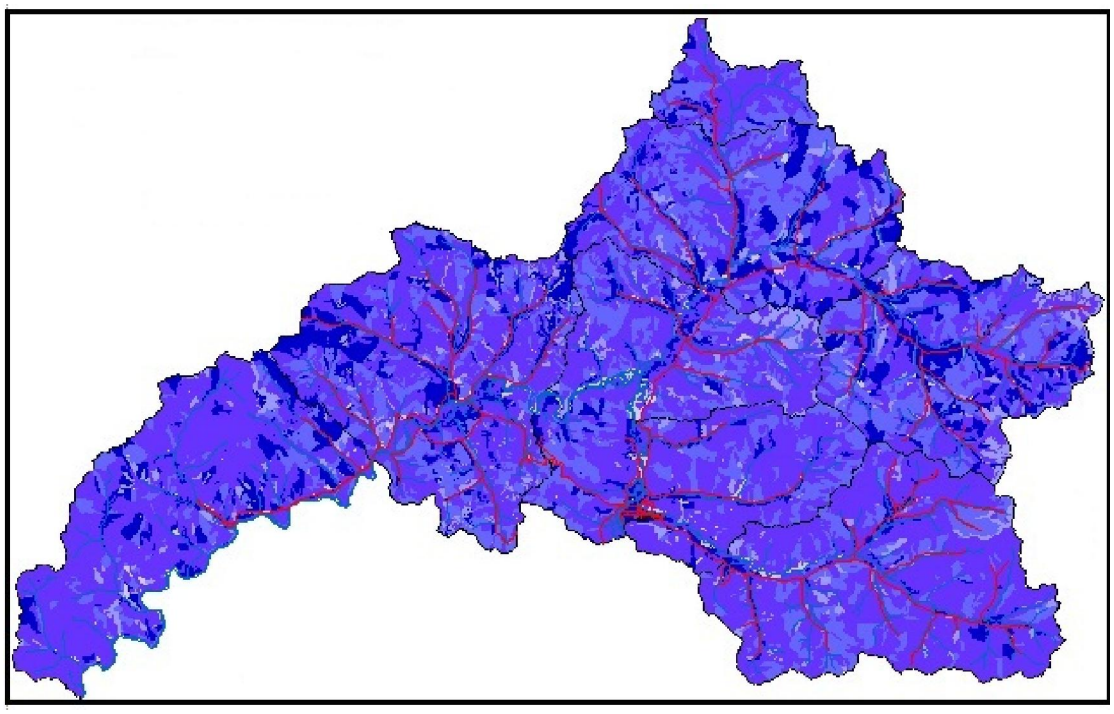

Fig. 3 Largest patch index distribution image

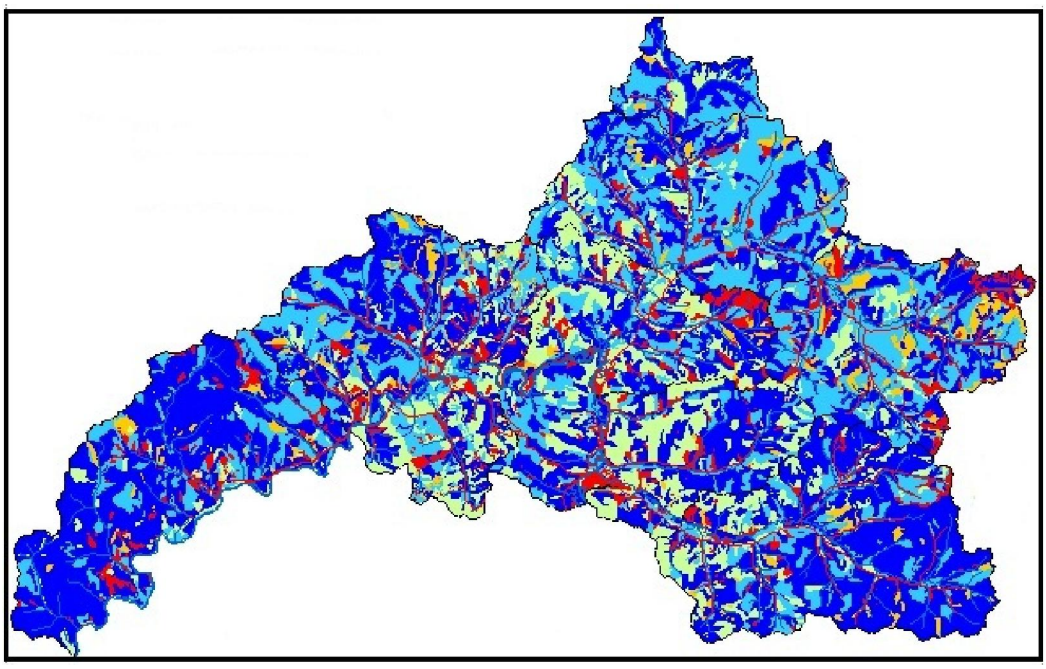

Fig. 4 Patch density distribution image

4 Conclusions

The territory that belongs to Mangui Forestry Bureau used to be primeval forest landscape in 1967. Because of the exploitation that has lasted for 40 years, a series of obvious difference had occurred in 1996. Following conclusions can be concluded by researching:

1) It is feasible to describe landscape on forest resources spatial data by Landscape shape index, Mean shape index, Area-weighted mean shape index, Double log fragile dimension, Mean patch fragile dimension, Area-weighted mean patch fragile dimension, Shannon's diversity index, Shannon's evenness index, Simpson's diversity index, Simpson's evenness index, Modified Simpson's evenness index and Modified Simpson's diversity Index.

2) Area-weighted mean shape index, Double log fragile dimension and Mean patch fragile dimension have decreased slightly for 40 years, reflecting that patch didn't change a lot. The diversity index has not changed a lot. It can be concluded as the changes of forest landscape appear later than the changes of forest resources.

3) Landscape types have increased from 29 in 1967 to 44 in 1996, with the patch richness and the patch richness density having increased greatly for 40 years.

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References:

1. Guo J P, ZHANG Y X. 2003. Advances and perspective of forest landscape ecology in China [J] (in Chinese). World Forestry Research, 16(5):46～49
2. HE H S. 2008. Forest landscape models: Definitions, characterization, and classification [J]. Forest Ecology and Managements. 254:284-294
3. Mc GARIGA L K，MARKS B. 1994. FRAGSTATS: Spatial pattern analysis program for quantifying landscape structure, Reference manual [M]. Oregon State University, Corvallis Oregon
4. RIPPLE W J, BRADSHAW G A, SPIES T A. 1991. Measuring forest landscape patterns in the Cascade Range of Oregon, USA [J]. Biological Conservation, 57:73-88
5. WU J G. 2000. Landscape ecology [M] (in Chinese). Beijing: Higher Education Press
6. YANG G J, XIAO D N. 2003. Forest landscape pattern and fragmentation: a case study on Xishui Natural Reserve in Qilian Mountain [J] (in Chinese). Journal of Ecology, 22(5):56～61.

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