

Paddy Expansion and Aggregation since the Mid-1950s in a Cold Region and Its Possible Causes

Fengqin Yan, Lingxue Yu, Chaobin Yang and Shuwen Zhang *

a. Formulas of related landscape indices

The related landscape indices including mean area (MA), largest patch index (LPI), patch density (PD), edge density (ED), cohesion index (COHESION), division index (DIVISION), splitting index (SPLIT), and aggregation index (AI) are calculated as follows (Equations (1)–(8)):

$$MA = \frac{\sum_{j=1}^n a_{ij}}{n_i}, \quad (1)$$

where a_{ij} is the area of patch ij (ha), and n_i is the number of patches of type i .

$$LPI = \frac{\max_{j=1}^n (a_{ij})}{A} \times (100), \quad (2)$$

where a_{ij} is the area of patch ij (m²), and A is the total landscape area (m²).

$$PD = \frac{N}{A}, \quad (3)$$

where A is the total patches areas of each cultivated land type (100 ha), and N is the number of patches of each cultivated land type.

$$ED = \frac{\sum_{k=1}^m (e_{ik})}{A} \quad (4)$$

where e_{ik} is the total patches length of type i , and A is the total patches areas of each cultivated land type (ha).

$$COHESION = \left[1 - \frac{\sum_{j=1}^n p_{ij}}{\sum_{j=1}^n p_{ij} \sqrt{a_{ij}}} \right] \times \left[1 - \frac{1}{\sqrt{Z}} \right] \times (100) \quad (5)$$

where p_{ij} is the perimeter of patch ij in terms of the number of cell surfaces. a_{ij} is the area of patch ij in terms of the number of cells, and Z is the total number of cells in the Landscape.

$$DIVISION = \left[1 - \sum_{j=1}^n \left(\frac{a_{ij}}{A} \right)^2 \right], \quad (6)$$

where a_{ij} = area (m²) of patch ij . and A is the total landscape area (m²).

$$SPLIT = \frac{A^2}{\sum_{i=1}^m \sum_{j=1}^n a_{ij}^2}, \quad (7)$$

where a_{ij} is the area (m^2) of patch ij . and A^2 is the total landscape area (m^2).

$$AI = \frac{m_{ii}}{\max m_{ii}} \quad (8)$$

where m_{ii} is the number of like adjacencies (joins) between pixels of patch type (class) i based on the single-count method. $\max m_{ii}$ is the maximum number of like adjacencies (joins) between pixels of patch type.

b. Tables

Table S1. Codes and percentages of one-step changes.

Code	Percentage (%)	Code	Percentage (%)
M→P→P→P→P	4.32	D→D→P→P→P	0.31
M→M→M→P→P	3.30	F→P→P→P→P	0.16
D→P→P→P→P	2.80	W→P→P→P→P	0.12
D→D→D→D→P	2.78	S→P→P→P→P	0.06
M→M→P→P→P	2.49	F→F→F→F→P	0.05
D→D→D→P→P	2.12	F→F→F→P→P	0.05
M→M→M→M→P	1.34	G→G→G→P→P	0.03
G→P→P→P→P	0.52	F→F→P→P→P	0.03
G→G→P→P→P	0.32		

Table S2. Codes and percentages of two-step changes (percentages > 0.1%).

Code	Percentage (%)	Code	Percentage (%)
M→D→D→P→P	10.17	F→D→D→D→P	0.61
M→D→D→D→P	8.70	F→D→D→P→P	0.50
M→M→D→D→P	6.36	G→D→P→P→P	0.47
M→M→D→P→P	6.05	M→G→P→P→P	0.36
G→D→D→P→P	3.13	G→M→M→P→P	0.33
G→D→D→D→P	3.04	G→M→P→P→P	0.30
M→M→M→D→P	2.70	F→F→F→D→P	0.27
M→M→G→P→P	1.77	M→M→F→P→P	0.23
M→M→M→G→P	1.31	P→P→D→P→P	0.18
M→D→P→P→P	1.14	F→F→D→P→P	0.17
M→M→G→G→P	0.90	W→D→D→P→P	0.16
G→G→D→P→P	0.90	D→M→P→P→P	0.16
G→G→D→D→P	0.77	P→M→P→P→P	0.13
F→F→D→D→P	0.74	M→G→G→P→P	0.10

Table S3. Codes and percentages of three-step changes (percentages > 0.1%).

Code	Percentage (%)	Code	Percentage (%)
M→P→D→P→P	1.99	D→D→P→D→P	0.27
M→G→D→D→P	1.57	G→P→D→P→P	0.26
M→G→D→P→P	1.31	M→M→F→G→P	0.25
D→P→D→P→P	1.29	F→P→D→P→P	0.22
G→M→D→P→P	1.23	M→M→P→M→P	0.21

M→M→P→D→P	0.83	M→P→G→P→P	0.20
M→M→F→D→P	0.80	D→M→D→P→P	0.18
M→M→G→D→P	0.66	M→G→G→D→P	0.18
M→M→D→M→P	0.64	M→M→P→G→P	0.16
M→M→D→G→P	0.62	M→F→D→D→P	0.16
G→M→G→P→P	0.58	D→G→D→P→P	0.15
M→D→M→P→P	0.58	M→G→M→P→P	0.15
M→M→F→M→P	0.49	F→M→D→D→P	0.14
M→P→M→P→P	0.44	G→G→P→D→P	0.14
G→M→D→D→P	0.32	F→G→D→P→P	0.12
M→M→G→M→P	0.31	M→F→G→P→P	0.12
F→F→G→D→P	0.28	F→G→D→D→P	0.12

Table S4. Codes and percentages of four-step changes (percentages > 0.1%).

Code	Percentage (%)	Code	Percentage (%)
M→D→P→D→P	0.51	M→G→P→D→P	0.18
M→D→M→D→P	0.36	M→D→G→D→P	0.14
M→G→M→G→P	0.30	M→G→D→G→P	0.13
M→G→F→D→P	0.27	M→D→F→D→P	0.13
M→D→G→P→P	0.27	G→D→P→D→P	0.13
M→G→M→D→P	0.24	G→M→G→D→P	0.12
F→M→D→P→P	0.23	M→F→G→D→P	0.10



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