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Estimation of the Net Primary Production in the Korean Peninsula

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韓半島의 純一次 生産量의 推定

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ABSTRACT

The net primary production in the Korean peninsula was estimated by Miami model, Montreal model and Kira's model, based on 148 meteorological data.

The modes in frequency distribution of the values calculated by Montreal and Miami model were found at 1,500g/m^2/yr. class and at one step high class in 100g. interval, while by Kira's madel at 1,700g/m^2/yr. class.

The relationships between values by Miami model(X) and those by Motreal model (Y_m) and Kira's model(Y_k) can be expressed as follows; $Y_m=0.365X+944.7$, $Y_k=0.462X+1006.9$ and $Y_k=1.282Y_m-211.5$. The total amount of the net primary production in 218,583.4 km^2, 98.9% of the whole area(220,951 km^2) of the Korean Peninsula, was estimated as 290,691,407 tons/yr. by Miami model, 310,751,566 tons/yr by Montreal model and 352,071,901 tons/yr by Kira's model. Therefore, it is reasonable that the organic substance over 300 million-tons is added yearly in the Korean Peninsula, because only 1.1% of the whole area no calculated. In addition, the net primary production amount of Han-river basin was estimated as ca. 38 million-tons, whether calculated with the meteorological data in level of the Korean Peninsula or with more detail data.

INTRODUCTION

During last a decade various models have been proposed by some investigators to estimate the net primary productivity(NPP) on the earth. Among them Miami model(Lieth, 1972, 1973), Montreal model(Lieth & Box, 1972) and Kira's model(Kira, 1976) are noticeable for this paper. On the other hand, the annual net primary production or phytomass on the earth was estimated by Whittaker & Likens(1973) and Kira(1976), based on the data from various vegetation types. However, to test the fittings of their models and to estimate the real net primary production in particular region, the much more field data in different regions on the earth would be demanded.

In the Korean Peninsula, even at present, there is no study on this problem except Yim

(1984) and no useful field data for it. Considering such a situation in the peninsula, the author estimated and discussed the potential net primary productivity in different localities of the Korean Peninsula by above mentioned Miami model, Montreal model and Kira's model.

MATERIALS AND METHODS

Data sources and calculation For the Miami model, monthly mean temperature and mean annual precipitation measured at 148 meteological stations over the Korean Peninsula were used(Central Meteorological Office, 1968, 1982).

For more details, in the Han-river basin as a sample area, 46 meteorological stations' data were used for the estimation.

The potential evapotranspiration rate(PE) for the Montreal model and the warm index (WI) for the Kira's model were based on the values obtained by Yim & Kira(1975, 1976), respectively.

The net primary productivities of different localities were calculated by three models as follows;

Miami model

$$y=\frac{3000}{1+e^{1.315-0.119x}} \quad \cdots\cdots (1)$$

where y: productivity level(g/m^2/yr)

x: mean annual temperature(°C)

e : natural log base

$$y=3000(1-e^{-0.000664x}) \quad \cdots\cdots (2)$$

where y: productivity level(g/m^2/yr)

x: precipitation(mm)

Lower values obtained by equation (1) or (2) were adopted.

Montreal model

$$P=3000(1-e^{-0.0009695(E-20)})$$

where P: annual net primary productivity(g/m^2/yr)

E: annual actual evapotranspiration(mm)

The E or PE by Yim & Kira(1975, 1976) were used.

Kira's model

$$P_n=0.0859WI+8.40$$

where P_n: net primary productivity including root system (ton/ha/yr)

WI: warmth index(°C·month)

The net primary production amounts of the particular regions were obtained by multiplying their areas(mesh area) with the mean value of the net primary productivity in different meshes.

Preparation of NPP maps The whole area was divided into 45km×45km meshes on the topographic map(1:1,000,000) published by the National Institute of Construction. The size of the mesh was sufficient for most of the cell to contain one or more meteorological stations. In Han-river basin, for the the detail study, 10km×10km meshes on the topographic map(1 : 250,000) and the data of 46 meteorological stations were adopted.

Based on the values obtained by three models, the isopleth lines were drawned on the topographic maps. For mean annual temperature, PE and WI in different localities, the values calculated by a mean temperature lapse rate of −0.55°C per 100m increasing in altitude were used after Yim & Kira(1975). Discontinuities at the border between neighboring cells were smoothed by free hand drawing.

RESULTS AND DISCUSSION

The net primary productivity in different localities calculated by three models(Miami model, Montreal model and Kira's model) was shown in Table 1. The variation ranges between different localities were 769~1850g/m²/yr in Miami model, 1,100~1,650g/m²/yr in Montreal model, and 1,200~1,950g/m²/yr in Kira's model. Their modes in the NPP-frequency curves showing normal curve were found in the class of 1,500~1,550g/m²/yr, 1,450~1,500g/m²/yr and 1,650~1,700g/m²/yr, respectively(Fig. 1).

And the positive linear correlations between the values by three models were found as follows;

$$Y_m = 0.365x + 944.725 \qquad (1)$$

where x: values by Miami model

Y_m: values by Montreal model

$$Y_k = 0.462x + 1006.881 \qquad (2)$$

where x: values by Miami model

Y_k: values by Kira's model

$$Y_k = 1.282x - 211.452 \qquad (3)$$

where x: values by Montreal model

Y_k: values by Kira's model

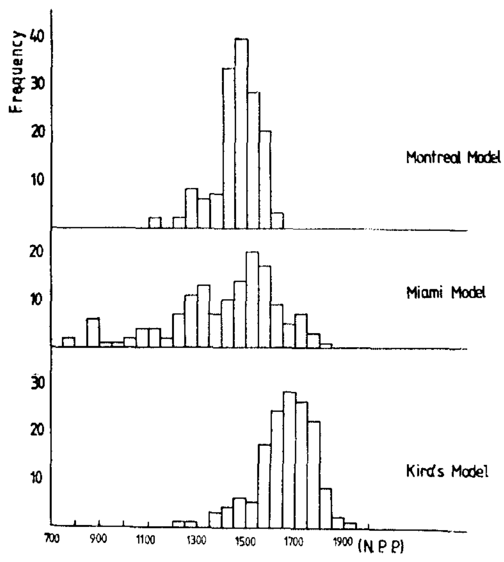

Fig. 1. Frequency distributions of net primary productivity of 148 localities in the Korean Peninsula.

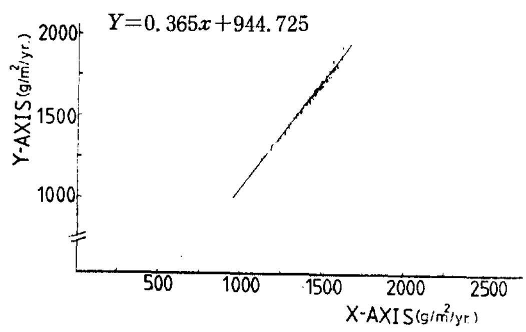

Fig. 2. The relationship between values by Miami model and by Montreal model. X axis: Miami model, Y axis: Montreal model.

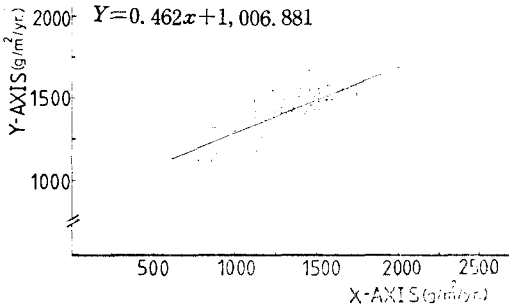

Fig. 3. The relationship between values by Miami model and by Kira's model. *X* axis: Montreal model, *Y* axis: Kira's model.

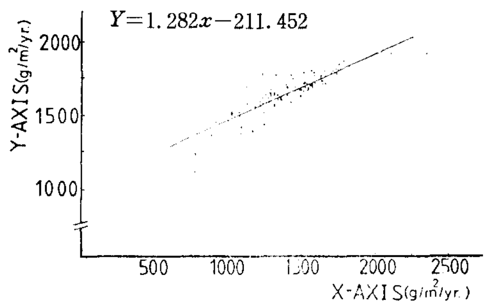

Fig. 4. The relationship between values by Montreal model and by Kira's model. *X* axis: Miami model, *Y* axis: Kira's model.

Table 1. The net primary productivity at 148 stations in the Korean peninsula. A and B: calculated by Miami Model (1) and (2), respectively. C: calculated by Montreal Model, D: calculated by Kira's Model.

Station No.	Locality	A ($g/m^2/year$)	B ($g/m^2/year$)	C ($g/m^2/year$)	D ($g/m^2/year$)
1	Gangneung	1,593.55	1,719.44	1,488.39	1,686.97
2	Seoul	1,504.42	1,699.82	1,483.99	1,677.53
3	Incheon	1,504.42	1,547.93	1,448.30	1,661.20
4	Ulreung-do	1,584.66	1,881.00	1,454.30	1,649.18
5	Chupungryeong	1,540.12	1,598.98	1,482.52	1,669.79
6	Pohang	1,673.22	1,483.98	1,511.66	1,736.80
7	Daegu	1,637.91	1,434.26	1,514.54	1,747.96
8	Jeonju	1,620.19	1,683.75	1,520.29	1,727.35
9	Ulsan	1,655.59	1,663.40	1,513.90	1,720.48
10	Gwangju	1,655.59	1,668.01	1,514.54	1,742.81
11	Busan	1,743.23	1,801.31	1,537.40	1,782.32
12	Mogpo	1,708.34	1,579.49	1,540.24	1,772.02
13	Yeosu	1,734.54	1,746.03	1,537.40	1,786.62
14	Jeju	1,820.70	1,846.83	1,562.71	1,838.16
15	Unggi	1,086.97	1,542.29	1,239.87	1,371.72
16	Cheongjin	1,162.24	1,613.36	1,265.28	1,396.63
17	Jungangjin	890.26	1,338.90	1,290.33	1,437.01
18	Seongjin	1,239.35	1,682.57	1,291.98	1,438.72
19	Sineuiju	1,291.58	1,727.47	1,422.51	1,584.75
20	Hamheung	1,326.70	1,756.81	1,368.07	1,528.06
21	Weonsan	1,424.16	1,834.71	1,407.14	1,590.77
22	Pyeongyang	1,353.17	1,778.47	1,439.25	1,613.10

Table 1. (continued)

Station No.	Locality	A (g/m²/year)	B (g/m²/year)	C (g/m²/year)	D (g/m²/year)
23	Jangjeon	1, 504. 42	1, 895. 19	1, 439. 25	1, 629. 42
24	Sinmag	1, 344. 34	1, 771. 28	1, 422. 51	1, 585. 61
25	Haeju	1, 459. 81	1, 861. 97	1, 445. 29	1, 643. 17
26	Suncheon	1, 751. 92	2, 062. 62	1, 609. 31	1, 851. 90
27	Gwangyang	1, 734. 54	2, 051. 74	1, 580. 71	1, 821. 84
28	Boseong	1, 637. 91	1, 988. 90	1, 488. 39	1, 722. 19
29	Goheung	1, 734. 54	1, 741. 53	1, 550. 11	1, 796. 93
30	Gurye	1, 708. 34	1, 747. 36	1, 580. 71	1, 803. 80
31	Jangseong	1, 637. 91	1, 731. 37	1, 547. 30	1, 743. 67
32	Yeonggwang	1, 682. 02	1, 624. 24	1, 548. 70	1, 775. 45
33	Naju	1, 690. 81	1, 687. 50	1, 561. 31	1, 788. 34
34	Haenam	1, 717. 09	1, 585. 99	1, 562. 71	1, 784. 90
35	Jindo	1, 743. 23	1, 574. 86	1, 557. 12	1, 792. 63
36	Wando	1, 751. 92	1, 653. 78	1, 559. 92	1, 803. 80
37	Seogwipo	2, 034. 40	2, 102. 20	1, 618. 72	1, 924. 06
38	Namweon	1, 655. 59	1, 657. 98	1, 548. 70	1, 769. 44
39	Seosu	1, 646. 75	1, 589. 83	1, 515. 98	1, 754. 84
40	Muju	1, 540. 12	1, 559. 35	1, 483. 99	1, 684. 40
41	Gunsan	1, 620. 19	1, 544. 35	1, 530. 30	1, 741. 95
42	Gimje	1, 760. 58	1, 525. 87	1, 537. 40	1, 742. 81
43	Gochang	1, 655. 59	1, 561. 74	1, 530. 30	1, 759. 99
44	Jeongub	1, 664. 41	1, 623. 32	1, 540. 24	1, 761. 71
45	Iri	1, 637. 91	1, 621. 13	1, 552. 92	1, 751. 40
46	Miryang	1, 734. 54	1, 569. 17	1, 584. 83	1, 829. 57
47	Changyeong	1, 682. 02	1, 508. 64	1, 561. 31	1, 791. 77
48	Habcheon	1, 699. 58	1, 564. 03	1, 583. 46	1, 808. 09
49	Geochang	1, 602. 44	1, 568. 51	1, 511. 66	1, 723. 05
50	Hamyang	1, 637. 91	1, 628. 25	1, 534. 57	1, 741. 95
51	Hadong	1, 743. 23	1, 920. 19	1, 573. 81	1, 815. 82
52	Jinju	1, 717. 09	1, 771. 58	1, 559. 92	1, 799. 50
53	Masan	1, 760. 58	1, 823. 70	1, 577. 92	1, 820. 98
54	Chungmu	1, 820. 70	1, 782. 22	1, 612. 01	1, 876. 81
55	Gyeongju	1, 699. 58	1, 453. 79	1, 552. 92	1, 793. 49
56	Donghae	1, 655. 59	1, 632. 43	1, 517. 42	1, 742. 81
57	Yeongdeog	1, 690. 81	1, 422. 26	1, 520. 29	1, 771. 16
58	Cheongsong	1, 495. 50	1, 281. 96	1, 457. 30	1, 646. 60
59	Yeongju	1, 549. 03	1, 449. 16	1, 497. 16	1, 699. 00
60	Mungyeong	1, 540. 12	1, 638. 14	1, 489. 85	1, 690. 41

Table 1. (continued)

Station No.	Locality	A (g/m²/year)	B (g/m²/year)	C (g/m²/year)	D (g/m²/year)
61	Seonsan	1,664.41	1,395.11	1,565.49	1,790.91
62	Gimcheon	1,664.41	1,449.99	1,562.71	1,789.20
63	Dongchon	1,655.59	1,227.73	1,552.92	1,778.89
64	Yeongcheon	1,655.59	1,320.65	1,548.70	1,768.58
65	Uljin	1,655.59	1,429.68	1,517.42	1,732.50
66	Nonsan	1,655.59	1,612.49	1,568.27	1,792.63
67	Gongju	1,584.66	1,759.20	1,518.85	1,728.21
68	Seonghwan	1,522.27	1,511.41	1,492.78	1,692.99
69	Onyang	1,566.86	1,586.36	1,495.70	1,711.03
70	Dangjin	1,531.20	1,630.16	1,458.79	1,675.81
71	Hongseong	1,557.95	1,617.64	1,486.92	1,706.73
72	Seosan	1,566.86	1,606.68	1,494.24	1,699.86
73	Daecheon	1,593.55	1,582.22	1,488.39	1,717.04
74	Geumsan	1,549.03	1,635.52	1,491.32	1,710.17
75	Boeun	1,513.35	1,618.01	1,430.14	1,625.99
76	Danyang	1,549.03	1,528.22	1,501.52	1,713.60
77	Jecheon	1,415.27	1,548.89	1,416.38	1,626.84
78	Jincheon	1,522.27	1,646.88	1,502.97	1,691.27
79	Yeongdong	1,566.86	1,467.69	1,488.39	1,711.03
80	Samcheog	1,637.91	1,558.11	1,494.24	1,723.05
81	Yangyang	1,611.32	1,584.86	1,492.78	1,726.49
82	Hoeyang	1,239.35	1,593.38	1,340.95	1,522.05
83	Inje	1,450.89	1,477.32	1,467.73	1,666.36
84	Hongcheon	1,504.42	1,594.04	1,498.61	1,717.04
85	Hoengseong	1,468.73	1,592.92	1,463.27	1,668.08
86	Weonju	1,477.65	1,621.03	1,486.92	1,676.67
87	Pyeongchang	1,433.07	1,537.09	1,437.73	1,628.56
88	Jeongseon	1,433.07	1,485.19	1,420.98	1,623.41
89	Yeongweol	1,477.65	1,458.40	1,464.76	1,665.50
90	Cheolweon	1,362.02	1,752.34	1,408.69	1,602.79
91	Geumhwa	1,353.17	1,673.40	1,416.38	1,604.51
92	Hwacheon	1,513.35	1,520.91	1,528.87	1,723.91
93	Pyeonggang	1,309.12	1,708.08	1,374.38	1,564.14
94	Icheon	1,326.70	1,697.57	1,417.92	1,599.92
95	Tongcheon	1,486.58	1,657.00	1,440.76	1,635.43
96	Goseong	1,522.27	1,581.75	1,445.29	1,652.61
97	Onjeongri	1,486.58	1,898.69	1,436.22	1,635.43
98	Suweon	1,630.18	1,689.59	1,464.76	1,671.51

Table 1. (continued)

Station No.	Locality	A (g/m²/year)	B (g/m²/year)	C (g/m²/year)	D (g/m²/year)
99	Pyeongtaeg	1, 549. 03	1, 505. 47	1, 511. 66	1, 718. 76
100	Yangpyeong	1, 486. 58	1, 682. 17	1, 491. 32	1, 685. 26
101	Gapyeong	1, 450. 89	1, 764. 62	1, 457. 30	1, 653. 47
102	Gaeseong	1, 441. 98	1, 694. 54	1, 448. 30	1, 644. 02
103	Ganghwa	1, 513. 35	1, 595. 53	1, 485. 46	1, 695. 56
104	Yeonan	1, 486. 58	1, 525. 48	1, 472. 18	1, 674. 09
105	Singye	1, 397. 49	1, 571. 55	1, 452. 80	1, 640. 59
106	Hwangju	1, 433. 07	1, 292. 76	1, 494. 24	1, 680. 96
107	Jaeryeong	1, 459. 81	1, 285. 49	1, 475. 14	1, 675. 81
108	Eunyul	1, 433. 07	1, 252. 62	1, 454. 30	1, 638. 01
109	Jangyeon	1, 450. 89	1, 349. 72	1, 449. 80	1, 653. 47
110	Ongjin	1, 468. 73	1, 331. 54	1, 454. 30	1, 644. 02
111	Gogsan	1, 335. 51	1, 691. 33	1, 414. 85	1, 609. 66
112	Seongcheon	1, 388. 61	1, 514. 77	1, 514. 54	1, 709. 31
113	Yangdeog	1, 265. 39	1, 470. 84	1, 414. 85	1, 621. 69
114	Yeongweon	1, 282. 84	1, 607. 88	1, 437. 73	1, 635. 43
115	Deogcheon	1, 230. 70	1, 595. 34	1, 428. 62	1, 621. 69
116	Suncheon	1, 397. 49	1, 421. 46	1, 486. 92	1, 690. 41
117	Anju	1, 309. 12	1, 540. 19	1, 461. 78	1, 655. 19
118	Gwangryangman	1, 459. 81	1, 131. 42	1, 482. 52	1, 680. 96
119	Nampo	1, 477. 65	1, 117. 22	1, 486. 92	1, 696. 42
120	Huchang	882. 83	1, 402. 12	1, 263. 60	1, 406. 08
121	Jaseong	1, 021. 88	1, 359. 77	1, 336. 11	1, 510. 02
122	Ganggye	1, 021. 88	1, 387. 95	1, 355. 76	1, 515. 17
123	Chosan	1, 120. 17	1, 365. 21	1, 382. 24	1, 567. 57
124	Huicheon	1, 213. 46	1, 670. 40	1, 397. 85	1, 577. 02
125	Unsan	1, 230. 70	1, 754. 08	1, 396. 30	1, 577. 02
126	Guseong	1, 274. 11	1, 745. 20	1, 407. 14	1, 588. 19
127	Euiju	1, 274. 11	1, 440. 69	1, 410. 23	1, 590. 77
128	Yongampo	1, 282. 84	1, 398. 19	1, 416. 38	1, 585. 61
129	Cheolsan	1, 335. 51	1, 398. 09	1, 434. 70	1, 619. 97
130	Namsi	1, 039. 12	1, 344. 34	1, 407. 14	1, 578. 74
131	Jeongju	1, 282. 84	1, 583. 17	1, 416. 38	1, 584. 75
132	Changseong	1, 213. 46	1, 390. 94	1, 414. 85	1, 598. 50
133	Yeongheung	1, 459. 81	1, 511. 22	1, 440. 80	1, 636. 29
134	Jubug	1, 388. 61	1, 338. 94	1, 419. 45	1, 589. 91
135	Sinheung	1, 433. 07	1, 308. 67	1, 457. 30	1, 640. 59

Table 1. (continued)

Station No.	Locality	A (g/m²/year)	B (g/m²/year)	C (g/m²/year)	D (g/m²/year)
136	Hongweon	1, 370. 87	1, 180. 39	1, 375. 96	1, 557. 27
137	Bugcheong	1, 388. 61	1, 124. 71	1, 417. 92	1, 579. 60
138	Dancheon	1, 344. 34	1, 071. 67	1, 363. 31	1, 520. 33
139	Samsu	769. 01	1, 023. 58	1, 118. 10	1, 278. 95
140	Gabsan	853. 47	875. 93	1, 224. 45	1, 352. 82
141	Pungsan	775. 83	1, 030. 52	1, 123. 56	1, 240. 29
142	Myeongcheon	1, 187. 76	1, 073. 59	1, 332. 88	1, 494. 56
143	Gyeongseong	1, 153. 78	1, 087. 48	1, 272. 00	1, 418. 97
144	Musan	1, 037. 98	899. 08	1, 287. 01	1, 452. 47
145	Gyeongweon	1, 037. 98	997. 55	1, 298. 59	1, 461. 92
146	Onseong	1, 054. 19	913. 95	1. 293. 64	1, 454. 19
147	Jongseong	982. 18	859. 94	1, 321. 53	1, 488. 55
148	Hoeryeong	1, 111. 83	874. 52	1, 319. 90	1, 488. 55

Considering three model combinations one another, the relationship between Montreal model and Miami model showed more closer connection than those of another combinations (Fig. 2~4). This is reasonable rationally, because these two models essentially stand on the same principle.

Two kind NPP maps by the Miami and Montreal model showed some differences between them, especially in southern Korea (Figs. 5 and 6). However, the difference is no essential one, because there is the linear relationship between them as shown in Figs. 2-4, and it undoubtedly originates from the mapping technique in dividing class interval of NPP series.

Sum area concerned for estimation of annual net primary production or phytomass cummulated, 218, 583km² including Is. Jeju and Is. Ulreung, was corresponding to 98. 9% of the whole area of the Korean Peninsula, 220, 951km² reported in geography. The net primary production per year in sum area was estimated as much as 290, 691, 407 tons/yr by Miami model, 310, 751, 566 tons/yr by Montreal model and 352, 071, 901 tons/yr by Kira's model.

Considering these results, the potential annual net primary production in the Korean Peninsula will be sure over about 300, 000, 000 tons/yr at least. In the Han-river basin the annual net primary production was estimated approximately 38, 000, 000 tons/yr, calculated with more detail meteorological data.

This value in Han-river basin coincides with the one calculated with the data of another region level in detail degree. Therefore, it seems that the data used for the estimation of net primary productivity or annual net primary production in the Korean Peninsula is almost sufficient for the aim of this paper.

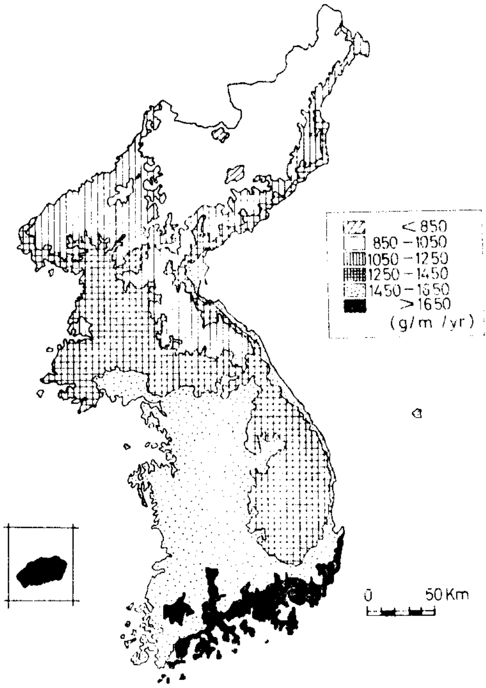

Fig. 5. The net primary productivity in the Korean Peninsula. By the Miami model (Lieth, 1972)

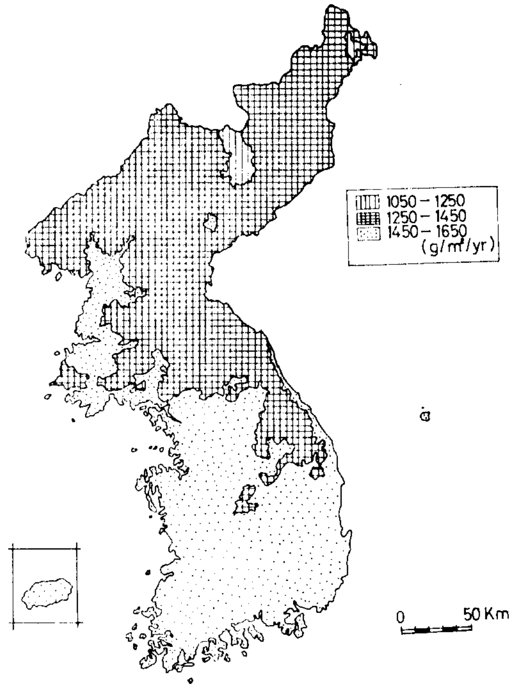

Fig. 6. The net primary productivity in the Korean Peninsula. By the Montreal model (Lieth, 1973)

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摘 要

中央氣象臺의 氣象資料(1968, 1982)를 써서 Miami model, Montreal model 및 Kira model에 의하여 韓半島의 148個地點의 年間純一次生產力(NPP)을 推定하고 이에 의거하여 年間純一次生產總量을 算出하였다.

前記 3 model에 의한 地點別 計算値의 頻度分布를 比較하여 보면 最頻値가 Miami model과 Montreal model에서는 各各 1,500～1,550g/m²/yr와 1,450～1,500g/m²/yr 區間에, Kira model에서는 1,650～1,700g/m²/yr 區間에 나타났다.

Miami model의 값(X)과 Montreal model의 값(Y_m)과의 關係는 $Y_m=0.365X+944.725$, X와 Kira model의 값(Y_k)과의 關係는 $Y_k=0.462X+1006.881$. Y_m과 Y_k과의 關係는 $Y_k=1.282Y_m-211.452$로 近似시킬 수 있었다.

韓半島 全體의 面積 220,951 km²의 약 98.9%인 218,583.4 km²를 計算하였는 바, 이 面積에서의 NPP 總量은 Miami model에 의하면 290,691,407 tons/yr, Montreal model에 의하면 310,751,566 tons/yr, Kira model에 의하면 352,071,901 tons/yr로 算出되었다. 그러므

로 韓半島의 年間 純一次生産總量은 적어도 약 3億 tons이 넘는 것으로 보인다.

또 같은 方法으로 推定된 漢江流域의 年間 純一次生産量은 약 3,800萬tons/yr이었으며, 韓半島 全體에 대하여 사용한 氣象資料水準에서 計算한 것과 漢江流域만을 좀더 仔細한 氣象資料를 써서 計算한 것과에 有意한 差異가 없었다. 그러므로 本硏究에 쓰인 氣象資料는 滿足할만 한 것이 었다고 보인다.

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