МІЖНАРОДНЕ СПІВРОБІТНИЦТВО: СУСПІЛЬНО-ГЕОГРАФІЧНІ ТА ПОЛІТИКО-ПРАВОВІ АСПЕКТИ ОСВОЄННЯ АНТАРКТИКИ

УКРАЇНСЬКИЙ АНТАРКТИЧНИЙ ЖУРНАЛ

УАЖ, №14, 256—260 (2015)

УДК 911.9:502(99)

DEVELOPMENT OF ANTARCTIC PROTECTED AREAS: MATHEMATICAL FORECAST FOR 2020

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Розвиток природоохоронних районів Антарктики: математичний прогноз на 2020 рік.
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Реферат. У статті аналізується динамічне зростання кількості та загальної площі Антарктичних районів, які особливо охороняються (АРОО) та Антарктичних районів, які особливо управляються (АРОУ), що є відображенням стійкого природоохоронного імперативу у спектрі національних інтересів Сторін Договору про Антарктику. Зазначена динаміка проаналізована за допомогою моделі Річардсона, яка була застосована Томасом Сааті для аналізу динаміки гонки озброєнь у XX столітті. Використання зазначеної моделі дало змогу спрогнозувати кількість та загальну площу АРОО та АРОУ у найближчому десятилітті. Так, у 2020 році згідно з результатами моделювання очікується, що загальна площа АРОО та АРОУ складатиме 103 700 км^2 (співмірно з площею Ісландії). Обговорюється питання підвищення точності моделі, що використовується, і точності отриманих кількісних характеристик. Отримані кількісні характеристики нададуть політикам і керівникам національних антарктичних програм додаткові аргументи для вироблення рішень щодо подальшого управління людською діяльністю та охороною природи в Антарктиці. Серед широкої громадськості отримані кількісні характеристики сприятимуть кращому розумінню тенденцій розвитку міжнародно-правового режиму Антарктики.

Развитие природоохраняемых районов Антарктики: математический прогноз на 2020 год.
О. В. Кузько, А. П. Федчук, В. В. Савченко

Реферат. В статье анализируется возрастающая динамика увеличения количества и общей площади особо охраняемых районов Антарктики (ООРА) и особо управляемых районов Антарктики (ОУРА), что является отражением устойчивого природоохранного императива в спектре национальных интересов Сторон Договора в Антарктике. Указанная динамика анализируется с помощью модели Ричардсона, которая была применена Томасом Саати для анализа динамики гонки вооружений в XX столетии. Использование указанной модели дало возможность спрогнозировать количество и площадь ООРА и ОУРА в ближайшем десятилетии. Так, к 2020 г. ожидается, что общая площадь ООРА и ОУРА увеличится и составит 103 700 км^2 (что сопоставимо с площадью Исландии). Обсуждается вопрос повышения точности используемой модели и точности полученных количественных характеристик. Полученные количественные характеристики предоставят политикам и руководителям национальных антарктических программ дополнительные аргументы для выработки решений по дальнейшему управлению человеческой деятельностью и по охране окружающей среды в Антарктике. Среди широкой общественности полученные количественные характеристики будут способствовать лучшему пониманию тенденций развития международно-правового режима Антарктики.

Summary. This paper discusses the growing dynamics of the increasing of the amount and especially the Antarctic Specially Protected Areas (ASPA) and the Antarctic Specially Managed Areas (ASMA). This dynamics is a reflection of the sustainable environmental imperative in the national interests of the Antarctic Treaty Parties. This dynamics is analyzed using the Richardson's model, which was used by Thomas L. Saaty for the analysis of the arms race dynamics in the twentieth century. Using this model made it possible to estimate the expected of the ASPA and ASMA amount and areas in the near future. So in 2020 it is expected to increase the total areas of ASPA and ASMA up to 103,700 km^2 (which is comparable to the Iceland area). The question of the accuracy increasing of the used model and the accuracy of the quantitative characteristics is discussed. The obtained quantitative characteristics will provide the policy makers and national Antarctic program managers by the additional arguments for decision-making on the further management of the human activities and nature conservation in the Antarctic. Among the general public obtained characteristics will contribute to the better understanding of the development trends of the international legal regime of the Antarctic.

Key words: Antarctic Specially Protected Areas, Antarctic Specially Managed Areas, Richardson's model, mathematical forecast

1. Introduction. Problem formulation

Organizational and legal bases on the creation of a network of areas with special regime of conservation and management of human activities in Antarctica were laid in a special international act – Conciliation Measures for the Conservation of Antarctic Fauna and Flora, which were adopted by the Consultative Parties in 1964. Two years later, in 1966, the first 15 protected areas were defined with total area of 225.16 km^2. In the subsequent decades the approval of new areas occurred unevenly (Fig. 1). So, the next block of five areas (total area - 424.86 km^2) has been adopted only in ten years - in 1975. Most notable in Fig. 1 is a large block of 15 areas (total area - 342.42 km^2), approved in 1985 - in the most dynamic period of development of the international legal regime in the region and which was characterized by the simultaneous development of two contradictory trends: on the one hand – aggravation of debate between the Consultative Parties on developing a future regime of mineral resources in the Antarctic region; and on the other – an unprecedented promotion of the concept of maximum environmental protection of Antarctica by international environmental organizations (Fedchuk, 2011-2012).

Later on, in the late 1980s and early 1990s, protected areas were created not in such large numbers but on a relatively regular basis – average three areas on the results of each Antarctic Treaty Consultative Meeting (ATCM) and eventually their area had substantially increased and began including not only upland areas and the coastal strip, but also the adjacent marine area.

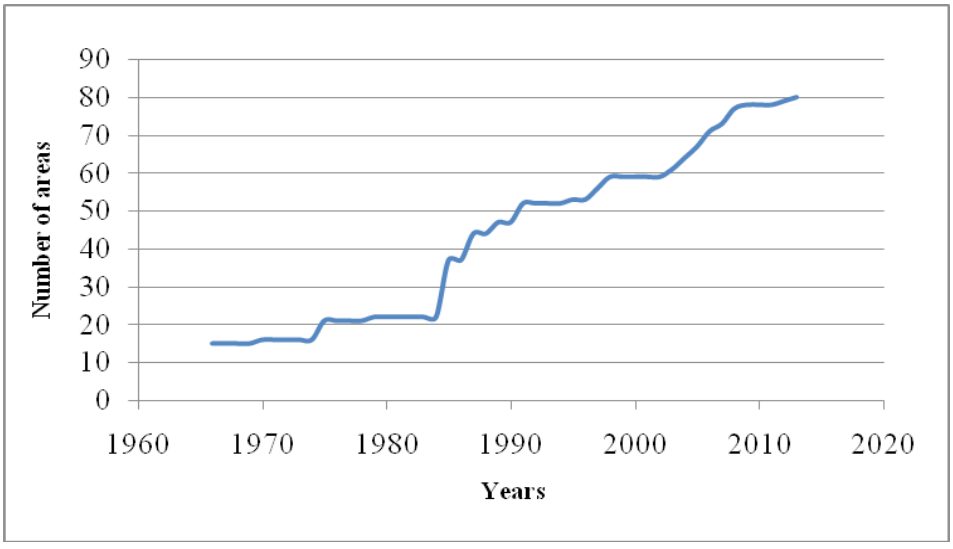

Fig.1. Dynamics of ASPA and ASMA growth in accordance with ATCM decisions (1966-2013).

Prior to 2002 the total area of protected areas amounted to 2765.64 km2, equivalent to 5% of the total number of protected areas as of 2013. Moreover, as shown in Fig. 2, the most significant increase in the area took place in 1991, when there were created two the largest-size protected areas No 152 "Western Bransfield Strait" and No 153 " Eastern Dallmann Bay" (with area of 915,80 km^2 and 609,54 km^2 respectively), which differed by unprecedented marine component in their structure at that time.

In 2002, after the entry into force of Annex V («Protection and Management") of the Madrid Protocol, all existing at the time categories of regions with a special regime were reorganized into Antarctic Specially Protected Areas (ASPA), and at the request of the time there was defined a new category – Antarctic Specially Managed areas (ASMA). The latter are created with the complex object to plan and coordinate the various activities to minimize the cumulative impact on the environment and to improve international cooperation within the framework of territories and adjacent waters having considerable size, but well-defined (Fedchuk, 2009). If the average size of ASPA that is created to protect outstanding environmental, scientific, historical or aesthetic values in a separate local area is only 52.61 km^2, the average size of ASMA is 132 times larger and is 6943.1 km^2. The total area of seven ASMA (48,601.73 km^2) created in the last decade exceeds the total area of all 73 ASPA (3840.48 km^2) more than 12 times or amounts 92.7% of the total area of all protected areas (52442, 21 km^2).

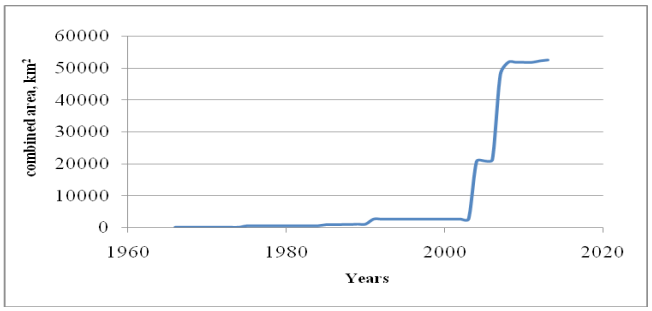

Fig. 2. The dynamics of growth of ASPA and ASMA areas in accordance with ATCM decisions (1966−2013).

Despite the large number of environmental areas and their total area, formation of a spatial network of such areas has not yet acquired a systemic nature and is not representative enough considering the generally accepted eco-geographical zoning of Antarctica (Shaw at al., 2014; Hughes at al., 2013). Moreover, experts note that the rapid growth in the number and area of ASPA and ASMA since 2004 can be explained by political interests of the Antarctic Treaty Parties, which propose the creation of new ASPA and ASMA. It is known that the Antarctic Treaty freezes already existed territorial claims in Antarctica made by some Parties, and does not support new territorial claims. At the same time creation of new ASPA and ASMA and especially the increase of the area of ASPA and ASMA provides some Parties with certain advantages over the other participants in the management and protection of these areas or for claims of exploitation of resources in these areas. Thus, seven countries which have declared their territorial claims in Antarctica designated 68% of all declared ASPAs (Lukin, 2014).

Taking into account, in particular, highly dynamic, almost exponential, growth of ASPA and ASMA areas since 2004, this study is aimed to investigate the quantitative characteristics of the dynamics of ASMA and ASPA growth using Richardson model (Richardson, 1960), the efficiency of which was proved by Thomas Saaty in his work on analysis of the arms race dynamics in the twentieth century (Saaty, 1968).

2. Mathematical modeling

We introduce the following characteristics of the simulated problem:
N – total number of ASPA and ASMA;
Q – total area of ASPA and ASMA.

Based on the analysis of the practice of ASPA and ASMA creating over a period of 1961 – 2013 we can make such statements:

1. Growth in the number of ASPA and ASMA is caused due to the progress of science, which provides grounds for the organization of such areas, as well as due to the national interests of Antarctic Treaty Parties (this mechanism is characterized by the parameter g in equation (1).

2. The achieved quantitative level of ASPA and ASMA requires additional efforts of the States- proponents of the Antarctic Treaty Parties to address the issues of monitoring and controlling the activities in these areas. These extra efforts hold back (reduce) the growth rate of the number of ASPA and ASMA (this mechanism is characterized by the parameter *a* in equation (1).

3. Growth of N – number of ASPA and ASMA is proportional to Q - the area of ASPA and ASMA (this mechanism is characterized by the parameter κ in equation (1).

4. By analogy with the statement 1 growth in areas of ASPA and ASMA due to the progress of science, which provides grounds for the organization of such areas, as well as due to the national interests of Antarctic Treaty Parties (this mechanism is characterized by the parameter *h* in equation (2).

5. By analogy with the statement 2 the achieved level of areas of ASPA and ASMA requires additional efforts of the States- proponents of the Antarctic Treaty Parties to address the issues of monitoring and controlling the activities in these areas. These extra efforts hold back (reduce) the growth rate of the area of ASPA and ASMA (this mechanism is characterized by the parameter *b* in equation (2).

6. Growth of Q – total areas of ASPA and ASMA is proportional to N – the total quantity of ASPA and ASMA (this mechanism is characterized by the parameter *l* in equation (2).

The abovementioned statements can be summarized in the following equations:

$$\begin{cases} \frac{\mathrm{dN}}{\mathrm{dt}} = g - a\mathrm{N} + k\mathrm{Q} & (1) \\ \frac{\mathrm{dQ}}{\mathrm{dt}} = h - b\mathrm{Q} + l\mathrm{N} & (2) \end{cases}$$

where: t – time, and *g*, *a*, *k*, *h*, *b*, *l* (which are > 0) – appropriate parameters of statements 1,2, 3, 4, 5, 6.

To facilitate further analysis we normalize the values of N and Q. For this the current value of N we'll divide by the value N = 64 (value of 2004) and the current value of Q we'll divide by the appropriate value of Q = 20 742, 26 km^2 (value of 2004). That is like it was made above for 2004, the normalized values of N = 1, Q = 1.

Due to continuous growth of N and H observed over the period of 1966-2013, there is a state of unstable equilibrium between the values of N and Q in the proposed model, which indicates presence of a ratio of $ab < kl$ (Saaty, 1968).

To simplify further analysis let us make two assumptions: $k = l$, $a = b$. Then having worked out equations (1) and (2), we will get:

$$\frac{\mathrm{d(N + Q)}}{\mathrm{dt}} = (k - a)(N + Q) + (g + h) \quad (3)$$

Thus, the rate of change in total dimensionless numbers and areas of ASPA and ASMA linearly depends on the reached number and areas of ASPA and ASMA. Under these assumptions, $a < k$, or $(k - a) > 0$, then there is a positive slope of combined characteristics in Fig. 3, and in equation (3) the transition from continuous derivatives to the corresponding discrete values is made.

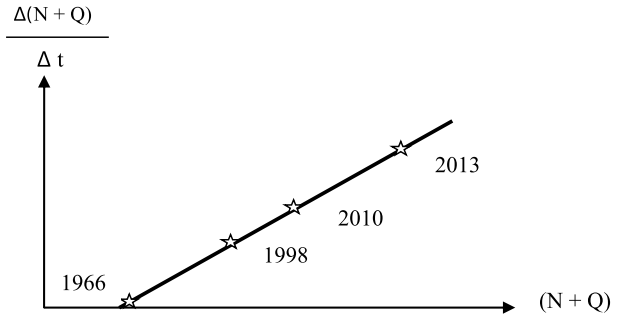

Fig. 3. Qualitative dependence of new combined number and areas of ASPA and ASMA on the reached numbers and areas of ASPA and ASMA.

Let us illustrate the practical use of the proposed model on the example of prediction of ASPA and ASMA Q – areas, for example, in 2020 with the help of the equation (3) and by adjusting the model parameters based on analysis of the growth of number and areas of ASPA and ASMA during the period from 2004 to 2013. In order to determine Δ Q and, accordingly, Q for 2020, it is necessary to compute the value (k − a), (g + h) for the investigated period, and to determine the value of Δ N for 2020. Normalized values of N for 2010 and 2013 are, respectively, 1.218 and 1.25, and normalized values of Q for the 2010 and 2013, are equal to 2.49 and 2.53 respectively. Substituting these data in (3) we obtain the value of ($k - a$) = 0,077, a ($g + h$) = 0,352. Using a linear approximation of the dynamics of N values for the analyzed period, one can take the value Δ N = 95 - 64 = 31 for 2020 and using the determined parameters and Δ N, we will obtain for 2020 value Δ Q = 4,013. Then for 2020 value of Q = 5,013, which is approximately 103,700 km^2 (comparable to the area of Iceland). To improve the accuracy of the proposed mathematical model we can, for example, introduce into the model more complex than in (1) and (2) non-linear functional dependence between the growth rate N and Q and their reached values; enter into the model parameters depending on the time; abandon the assumption on connection of parameters $k = l$, $a = b$.

3. Conclusions

During the action of Antarctic Treaty there is a constant increase in the number and areas of Antarctic Specially Protected Areas and Antarctic Specially Managed Areas reflecting the imperative of environmental sustainability in the spectrum of national interests of Antarctic Treaty Parties. The chosen mathematical method has determined that while maintaining the current trends the total area of protected areas in 2020 may be 103 700 km^2, which is comparable to the area of Iceland.

The obtained quantitative characteristics of dynamics of the number and areas of ASPA and ASMA in accordance with the main tasks of the Scientific Committee on Antarctic Research, will provide policy makers and managers of National Antarctic Programs with additional arguments for decision-making on the further management of human activities and nature conservation in Antarctica as well as the further promotion and protection of national interests in the Antarctic Treaty System. For the general public to obtained quantitative characteristics will contribute to a better understanding of the trends of the international legal regime of Antarctica.

Literature

1. **Fedchuk A**. Structure of broad-scale management in the Vernadsky station area // *Ukrainian Antarctic Journal*. – 2009. – № 8. – p. 307 − 319.

2. **Fedchuk A.** The evolution of the Antarctic Treaty System: a structure and dynamics of the acts adopted for 1961-2011 // *Ukrainian Antarctic Journal*. – 2011 − 2012. – № 10/11. – p. 406−427.

3. **Hughes K. A.,** Pertierra L. R., Walton D. W. H. Area protection in Antarctica: How can conservation and scientific research goals be managed compatibly? // *Environmental Science & Policy*. – Volume 31. – 2013. – P. 120 – 132.

4. **Lukin V. V.** Russia's current Antarctic policy // *The Polar Journal*. – 2014. – Volume 4:1. – P.199 − 222. – DOI: 10.1080/2154896X.2014.913926.

5. **Richardson I. F**. *Arms and Insecurity*. – Pittsburgh, Boxwood, 1960.

6. **Shaw J. D., Terauds A., Riddle M. J., Possingham H. P., Chown S. L.** Antarctica's Protected Areas Are Inadequate, Unrepresentative, and at Risk // *PLoS Biol*. – 2014. – Volume 12 (6). –doi:10.1371/journal.pbio.1001888.

7. **Saaty T. L**. *Mathematical models of arms control and disarmament*. – John Wiley & Sons, Unc. 1968.