UDC 574:001.895

THE APPLICATION OF NEW TECHNOLOGIES IN ECOLOGY

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Abstract: *In ecology, it is important to know the name of species and where they are found. However, for the conservation purposes, to be able to interpret species distribution, the scientists also need to know about the environmental characteristics of the area such are climate features, soil structure, human population density and many others. Using new technologies such are satellite coverage, molecular techniques, modern computing and modelling, ecologists are obtaining a rich supply of information and gaining the ability to monitor how different regions are changing in terms of biodiversity. Automation of data collection and data analyses are still critical technical challenges that with the development of new-sophisticated technologies will need to be improved during the 21st century. Furthermore, increased use of modern technologies in ecology will help environmental managers in planning strategies and generating governmental policies and procedures critical for saving our environment and preserving biodiversity.*

Keywords: *ecology, technology, innovation, biodiversity*

1. INTRODUCTION

The name of the scientific field of Ecology comes from the Greek word "oikos" *meaning* "home" or "place to live" and -logia meaning "study of". Ecology is a multidisciplinary field that includes the fields of biology, geography and earth science and more specifically includes the biological disciplines of genetics, evolution, physiology and behaviour [1]. In ecology scientists are exploring organisms, their environment, interactions among organisms and interactions of organisms with abiotic components of the environment. Abiotic factors include non-living chemical and physical parts of the environment such are water, light, radiation, temperature and land. In ecology, the characteristics of population are investigated on the levels of distribution, diversity, and distribution. Population is described as a group of organisms from the same species that live on the same geographical region and can reproduce. Ecologist are exploring the characteristics of an ecosystem that

presents a community of living organisms called producers, consumers, and decomposers. For example, in marine environment, coral reef ecosystems are the most diverse marine ecosystems, which provide habitat for approximately 25% of all marine species (**Figure 1**) [2]. Within the foundation of this ecosystem, reef-building corals form mutualistic symbioses with unicellular photosynthetic dinoflagellates of the genus *Symbiodinium*. Break down of symbiosis (*Symbiodinium* algae leave coral host) due to changes in environment such as global warming and ocean acidification leads to coral bleaching. Currently, the worst mass bleaching event (2016) is endangering the wellbeing of one of Australia's most important natural assets, the Great Barrier Reef (GBR) with over 1,000 km of GBR being affected. Monitoring features of the ecosystems and changes happening are greatly improved using modern technologies. A number of new technologies such as molecular biology techniques, satellite remote sensing and modelling, are used to explore the characteristics of ecosystems, population and abiotic components of the environment. In this paper, we will provide an overview of some of the most important technologies currently used by modern ecologists.

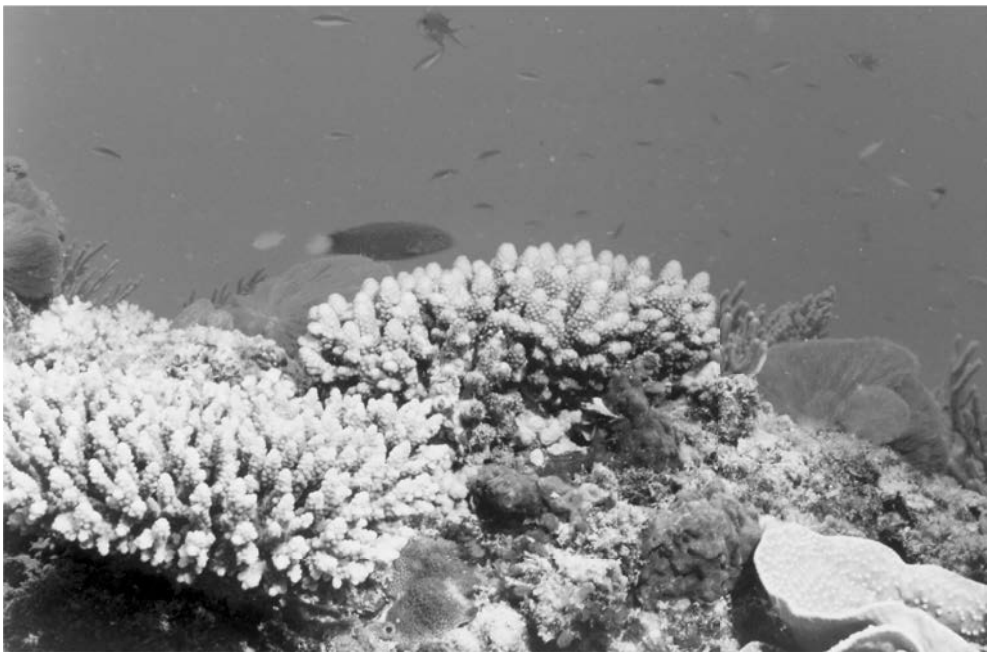

Figure 1. Coral reef ecosystem: the most diverse marine ecosystem providing habitat for hundreds thousands marine species.

2. TECHNOLOGY IN ECOLOGY

Why do ecologists use technology? A principal interest of ecologists is to locate where organisms are found, to report how many occurred at the particular location and to explain why [1]. New technologies are trying to provide more answers to these fundamental ecological

questions and the requirement for improvement in technologies allowing automated data collection and punctual monitoring are constantly rising. A list of major novel technologies used by ecologists and their importance in modern ecology is provided below.

2.1 Molecular techniques in ecology

Numerous molecular techniques have been used by ecologists including DNA fingerprinting, a use of gene markers such as micro-satellites and more recently a use of next-generation sequencing technologies. Using molecular biology techniques allowed the scientific analyses of even ancient DNA, provided new interpretation of the evolutionary events, and at the same time gave new insights into changes happening within populations [3]. Molecular genetic techniques are also providing understandings of population habits, nutrition, and reproduction patterns. Understanding populations and their interactions are allowing us to also better understand current changes in the environment and helping with the development of management strategies critical in saving and managing our natural resources.

Technology	Sequencing method	Major advantages for studies of non-model organisms	Major disadvantages for studies of non-model organisms
Roche 454	Pyrosequencing	Relatively long reads enables assembly of contigs even in the absence of a reference genome	Relatively few reads results in shallower coverage of sequencing; High error rate
Illumina/Solexa	Sequencing by synthesis	Very deep coverage because of large number of reads gives accurate measurements of gene expression levels	Short read length means that a reference genome is desirable for assembly
ABI SOLiD	Sequencing by ligation	Large number of reads and very deep coverage. Low error rate because of duplicate sequencing of each base pair	Short read length means that a reference genome is desirable for assembly. Data in colour space complicates downstream
Helicos tSMS	Single-molecule sequencing	Sequencing of single molecules means that no amplification step is needed, reducing bias in studies of expression levels or allele frequencies	New and still untested in studies of non-model organisms

Abbreviation: NGS, next generation sequencing.

Table 1. Currently available NGS technologies and their characteristics (adapted from [4]).

In the 21st century, advances in next-generation sequencing technologies have transformed biological science (**Table 1**; [4]). In ecological and environmental research, the analysis of environmental DNA with specific gene markers (e.g. species-specific DNA barcodes) has been done via the application of next-generation sequencing technologies (**Figure 2**). Access to massive amounts of sequencing data is leading to a better understanding of population diversity and adaptability to environmental changes.

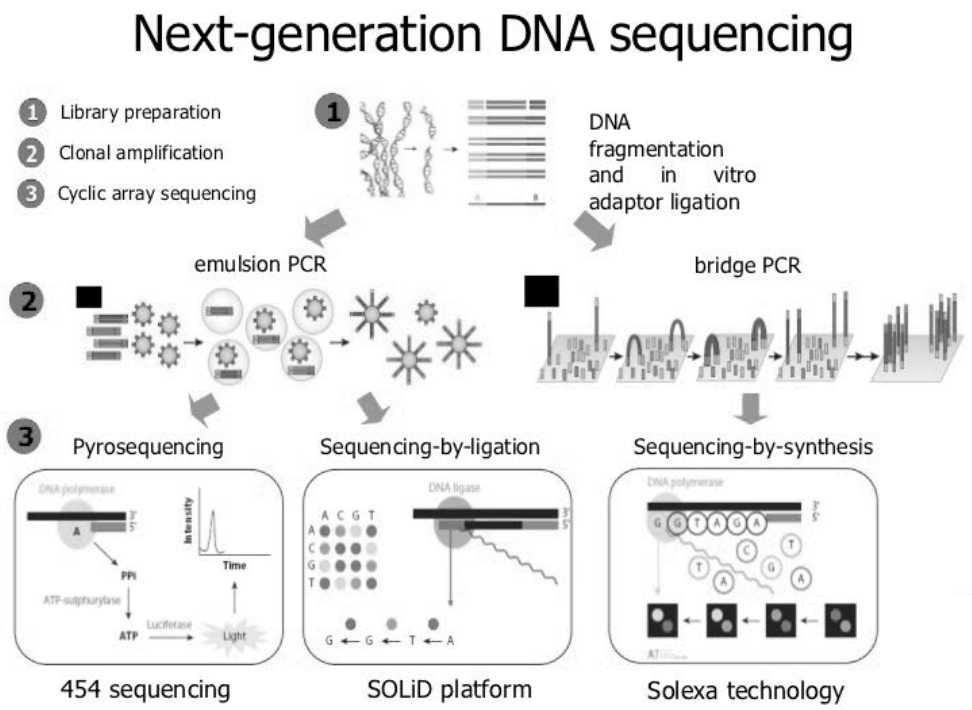

Figure 2. The overview of NGS techniques (adapted from A.S. University of Barcelona).

2.2 Satellite remote sensing

Biological diversity is in decline due to habitat loss, overexploitation of natural recourse and climate change. Monitoring biodiversity and the impacts of changes happening in the environment are important for developing effective mitigation strategies that can be used to prevent potential loss of biological diversity. Satellite remote sensing (SRS) in ecology is used for monitoring abiotic conditions (e.g. temperature, rainfall) offering long-term data important for biodiversity [5] and the distribution, structure, composition of ecosystems (Figure 3; [6]). Information obtained using SRS about trends happening in the environment have significant influence on management plans and also on the development of an integrated management approaches to preserve natural diversity.

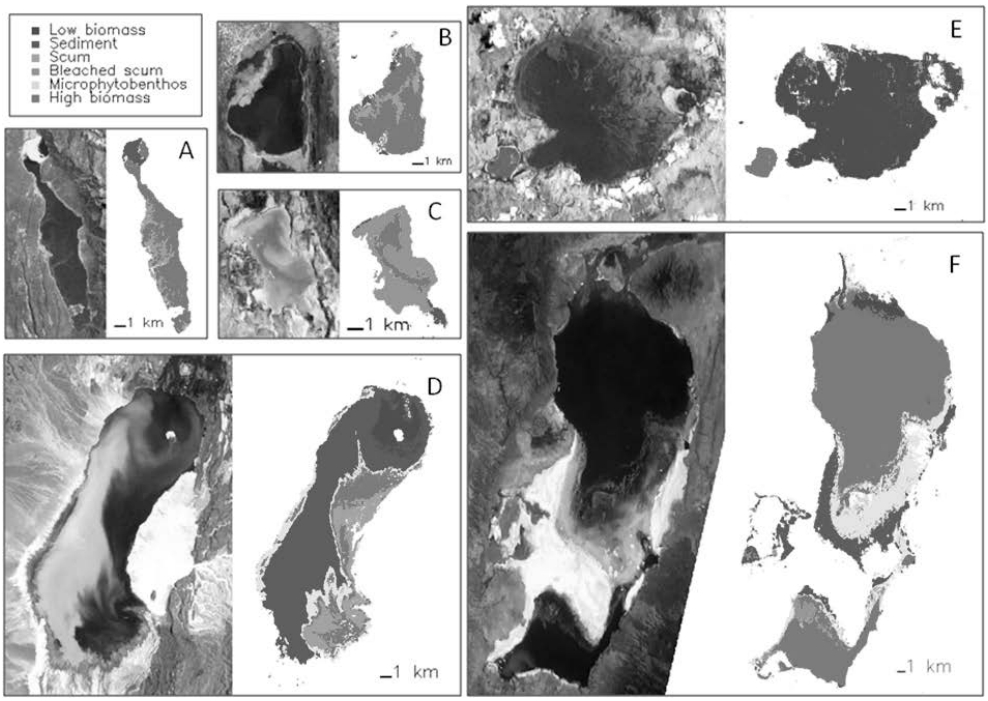

Figure 3. The example of use of SRS in lake ecology [6].

Figure 3 is representing information about the ecological state of alkaline-saline lakes that are extremely remote lakes. The data presented in this study had an accuracy of 77% and consequently demonstrate a huge potential of SRS for application in ecology [6].

2.3 Modelling and simulation

Stimulation of the environmental events using the computer-generated models can allow ecologists to better understand the ecosystems, connectivity and predict changes. These computer models are influencing ecological theory and helping in solving the ecological problems. Computer stimulations have been used for the stimulation of experiments that would never be done in real time and space. Subsequently, this type of experimental stimulation is allowing improved understanding of interactions happening in the environment and their affects on the dynamics in ecosystems [7]. The computer-generated models are so valuable basis of scientifically based predictions that can be used by conservation managers to underpin conservation and management strategies and decisions in the future.

3. CONCLUSION

Ecologists together with environmental managers are facing many challenges due to growing environmental problems and climate change. Using modern technologies such are molecular techniques, SRS, modelling and stimulation are helping in predictions of future ecological events, and better understanding species biodiversity and connectivity. Consequently, new technologies are allowing scientists to meet current challenges by providing enormous amount of data in ecological projects that would otherwise remain too costly and time-consuming. The future of ecology and the future of our environment will be determined by efficient implementation of new technologies in ecological projects and appropriate use of research findings by managers for the development of timely and punctual governmental policies and legislations critical for preserving biodiversity of our planet.

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