



Some theoretical considerations: From landscape ecology to waterscape ecology

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ABSTRACT

Being inspired in the process of teaching and studying on tourism geography and heritage landscapes, the author attempts to broaden the scope of traditional studies in landscape ecology. Upon reviewing the progress, limitations and boundaries of landscape ecology, he criticizes the negligence of waterscapes by academics. The author further examines some waterscape conservation policy programs practiced by different nations. These include 10 National Seashores, 4 National Lakeshores, 4 National Rivers, 13 National Marine Sanctuaries and 1 Marine National Monument in USA, 13 Marine National Parks, 11 Marine Sanctuaries and 4 multiple use Marine Reserves in the State of Victoria, Australia, 3 Marine Nature Reserves and 43 Heritage Coasts in UK, and 272 National Water Parks in China. Based on these explorations, the author proposes a few hypotheses on waterscape ecology. Finally, he concludes that as one among many sub-disciplines of applied ecology, waterscape ecology can only achieve its full-fledged growth through concerted efforts among academics, and the supports from both governments and non-government organizations. Meanwhile, the site-specific policy practices with the rapid increasing social needs will likely facilitate the development of this infant school. Hopefully, the birth and development of waterscape ecology will contribute to the prosperity of global academics and the maintenance of earth level environmental health.

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1. Introduction

A scientific discipline can benefit by many researchers or practitioners either conducting daily work or exploring new frontiers. However, if it remains unchanged for a long time, the scientific discipline can become fossilized. Moreover, out-dated ideas and models will not enable the development of excellent students in the university. Taking this into consideration, landscape ecology needs to be reviewed, while some new instruments deserve to be developed for the sake of landscape ecology itself and the overall environmental sustainability at a global level.

2. The development and progress of landscape ecology

2.1. The evolution and popularity of landscape ecology

In the middle of 16th century, Western painters began to have their paintings inspired by nature as a landscape. In 1939, a German Geographer Carl Troll coined the term landscape ecology

[1,2] which later evolved as a prominent study area starting in 1960s, with continued development into the early 1980s. After some introductory publications on landscape ecology appeared in 1980s, China finally saw the rapid development of the concept from 1990s onward. Over the past decade the teaching and researching of landscape ecology has been thriving in universities across all of the country. The speedy evolution of landscape ecology in China and in global community of academics was always encouraged by intellectuals [3,4]. While pioneering researchers regarded landscape ecology as a maturing discipline [5] or at least a maturing sub-discipline, its basic concepts and principles, its relations to the sister disciplines have still been debated furiously [6,7]. Undoubtedly, this kind of discussion and literature summarizing papers did play an active role in pushing landscape ecology into a popular realm of studies.

2.2. The driving force of a vibrant landscape ecology

While exploring into the voluminous literature concerning landscape ecology, we can find that its theories and principles are easily, flexibly and widely applied to many research and practical fields. Hobbs [5] stated that landscape ecology is a typical applied science upon which lies an interface of many (other) disciplines. Although he did not point out the particular domains

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into which landscape ecology could apply, Hobbs presented four highly-related study areas. They are the studies of global change, land use planning, restoration ecology and conservation biology. After Forman wrote about landscape sustainability [8], landscape ecology was repeatedly applied in the studies of land use change and land cover change (LUCC). Because its power for assessing the impacts of LUCC on ecosystem processes, goods and services, and understanding the biophysical and socioeconomic mechanisms of LUCC, landscape ecology demonstrates particular relevance to the sustainability science [9]. Potschin and Roy linked landscape ecology closely with the sustainability science as well [10]. From this point, we are appreciating the potential driving force of landscape ecology which likely helps to promote the environmental sustainability.

2.3. The continuing prosperity of landscape ecology

Regardless of its existing prosperity and vibrancy, landscape ecology seems to continue to grow stronger. As a result, masters and doctoral programs under the name of landscape ecology are mushrooming in China or in other parts of the world. The statistics of publication by the name of landscape ecology has climbed exponentially since 1990s [4]. Ironically, just like the overuse of ecology, eco-tourism, the use of *landscape ecology* greatly outnumbers that of *applied ecology*. In such a situation, can we safely conclude that landscape ecology is an applied ecology? Is it really a popular science, or just a buzzword which is borrowed and used by the public? Is it misused to help destroy the healthy environment just by the name of landscape ecology?

3. The limitations and boundaries of landscape ecology

In order to answer these questions we can discuss on the disciplinary boundaries.

3.1. Intellectual expansion and confusion

The development of science is a process of exploration into new frontiers beyond the unknown world. This is attested by the ever-growing field of landscape ecology which has been expanded by researchers from many academic fields, including ecology, landscape architecture, horticulture, land use, urban/regional planning and design [11], conservation biology [12], recreation and tourism resources, parkland and parkway designs. Unfortunately, the intellectual expansion can hardly solve problems in a specific domain except adopting a holistic approach [13,14]. It leads to a trans-disciplinary or inter-disciplinary methodology [10,15] which compounded the situation of complexity, complicatedness and confusions.

3.2. Academic limitations and boundaries

Seemingly powerful landscape ecology can be used to deal with many issues, but its survival is strongly constrained by many other disciplines and sciences. It is hard to evolve into a new phase because of its lack of independency. This leads to ambiguous disciplinary boundaries with other academic fields. If lots of similar research programs or engineering projects have been launched within a rather short period, equivocal or confused concepts and ideas will unavoidably come into being. If the boundaries are not clearly defined, the troubled situation will not be changed in near future.

3.3. Waterscape: a possibility to widen the academic tradition

Which new window can be hopefully first opened to break the limitations of the existing landscape ecology framework? With retrospections on the studies of landscape ecology over the past decades, we find that landscape ecologists have traditionally focused their attention on terrestrial ecosystems, and water bodies have often been considered either as elements of landscape mosaics or as units that are linked to the terrestrial landscape by flows across boundaries or ecotones [16].

Steele (1989) enthusiastically discussed about the ocean landscape, and insisted on an ecological theory which could cross the land–sea boundary [17,18]. However, water-based scenery has not collectively been researched on a biological foundation until the advent of the 21st century. Fortunately, the Oxford based journal of Freshwater Biology devoted a special issue in 2002 for the publication of riverine landscape studies [19]. In order to facilitate this field of studies, Wiens called for an incorporation of landscape ecology into the domain of waters [16]. Poole attempted to address the uniqueness within the analysis of river discontinuum [20].

Interestingly, five years later, the journal of Landscape Ecology published a featured issue on the studies of waterscape which focused on the marine and coastal systems. All the papers were exclusively contributed by US authors because this supplement issue was edited on a basis of a special session on Marine and Coastal Applications in Landscape Ecology, which was held at the 19th Annual Symposium of the United States Regional Association of the International Association for Landscape Ecology, 2004 in Las Vegas, Nevada [21]. From coastal estuaries to soft-sediment benthoscape, from reef fish assemblages to seagrass landscape, from Mid-Atlantic Coast to Florida Keys to West Coast of the Pacific, a number of different marine habitats were covered within the issue.

The above-mentioned two special collections reflect the major difference of focus on the waterscape studies: continent based fresh water centered European perspective versus ocean based coast and marine oriented North American methodology. This can be continuously interpreted as one heritage passed on from the two arguable major schools of landscape ecology: the European approach that is more humanistic and holistic and the North American approach that is more biophysical and analytical [22]. However, Sullivan et al. surely provided a good exception in USA [23].

It is true that professional waterscape research papers can only be found in these two supplement journal issues plus a number of sporadic publications. Taking the importance of the global waters into account, I recommend a comprehensive water ecology course to be added as an outreach of landscape ecology. If this is done, the combination of riverine or fluvial, estuarine landscapes and the coastal and marine landscapes can be accommodated into unified waterscape ecology. This will definitely widen the academic tradition for landscape ecology while presumably contributing to the maintenance and improvement of a global wide earth health.

4. A global experience based on national practices concerning waterscape

In fact, even before the academics began to systematically research the topics concerning waterscapes, pioneering works had already been done for several decades by a number of governmental sectors around the globe.

4.1. US practices related to waterscapes

United States is recognized as the first country to create a national park in the world. The US National Park Service (USNPS) is widely regarded as having one prominent management model

for protected areas as well. However, the landscape ecologists predominantly care about the terrestrial parks such as Yellowstone or Yosemite. They likely ignored the fact that US National Park system has already accommodated several different waterscape programs for conservation and recreation (Table 1).

Out of the sites, Cape Hatteras was the first National Seashore established in 1953, Pictured Rocks was the first National Lakeshore authorized in 1966, and Buffalo was the first National River designated in 1972. While all these sites are conserved by US NPS, associated recreation and tourism activities are also encouraged in a sustainable manner [24].

Moreover, based on the National Marine Sanctuaries Act (formerly known as the Marine Protection, Research and Sanctuaries Act, 1972), US National Oceanic and Atmospheric Administration (NOAA) was authorized to be responsible for another program specially devoted to the conservation of representative marine environment (Table 2). Presently the National Marine Sanctuary System includes 13 National Marine Sanctuaries and 1 Marine National Monument.

By a broad view, 37 Wetland Management Districts, which is part of National Wildlife Refuge system administered by US Fish and Wildlife Service, can be accepted as kind of waterscape conservation program as well.

4.2. Australian practices on marine parks

Australia's first marine park was established in 1937 at Green Island off the Queensland coast. To date, Australia has built a diverse marine park system. The Marine National Parks are designated to protect the ocean's rich diversity of life. These parks allow fish to spawn and grow, provide un-spoilt natural sites for public visit and offer opportunities for education and research. In order to safeguard healthy and productive oceans, scientists recommend that at least 20–30% of each marine habitat must be fully protected in Marine National Parks [25].

Among all the states, Victoria boasts a world-class system of Marine National Parks. On the 13th June 2002, Victoria's Parliament passed legislation to create a system of Marine National Parks (Table 3). Together, the 13 Marine National Parks and 11 Marine Sanctuaries, encompass 5.2% of Victoria's coastal waters [26].

4.3. UK Heritage Coast and Marine Nature Reserve practices

UK's Marine Nature Reserves (MNRs) are created through the Wildlife and Countryside Act of 1981 to conserve marine flora, fauna and geological or physiographical features of special interest,

Table 1
Waterscape Sites within the US National Park System.

Series name	Site name
National Seashore	(1) Assateague Island; (2) Canaveral; (3) Cape Cod; (4) Cape Hatteras; (5) Cape Lookout; (6) Cumberland Island; (7) Fire Island; (8) Gulf Islands; (9) Padre Island; (10) Point Reyes
National Lakeshore	(1) Apostle Islands; (2) Indiana Dunes; (3) Pictured Rocks; (4) Sleeping Bear Dunes
National River	(1) Big South Fork National River and Recreation Area; (2) Buffalo National River; (3) Mississippi National River and Recreation Area; (4) New River Gorge National River

Table 2
National Marine Sanctuary System administered by the US NOAA.

Region name	Site name (NMS = National Marine Sanctuary)
Northeast	(1) Thunder Bay NMS; (2) Stellwagen Bank NMS; (3) Monitor NMS
Southeast	(1) Gray's Reef NMS; (2) Florida Keys NMS; (3) Flower Garden Banks NMS
West Coast	(1) Olympic Coast NMS; (2) Cordell Bank NMS; (3) Gulf of the Farallones NMS; (4) Monterey Bay NMS; (5) Channel Islands NMS
Pacific Islands	(1) Hawaiian Islands Humpback Whale NMS; (2) Fagatele Bay NMS; (3) Papahānaumokuākea Marine National Monument

Table 3
A marine park system administered by the State of Victoria, Australia.

Series name	Site name
Marine National Parks (fully protected)	(1) Cape Howe; (2) Point Hicks; (3) Ninety-mile; (4) Beach Corner Inlet; (5) Wilsons Promontory; (6) Bunurong; (7) Churchill Island; (8) Yaringa; (9) French Island; (10) Port Phillip Heads; (11) Point Addis; (12) Twelve Apostles; (13) Discovery Bay
Marine Sanctuaries (fully protected)	(1) Barwon Bluff; (2) Beware Reef; (3) Mushroom Reef; (4) Ricketts Point; (5) Jawbone; (6) Point Cook; (7) Point Danger; (8) Eagle Rock; (9) Marengo; (10) The Arches; (11) Merri
Multiple Use Marine Reserves or Parks	(1) Harold Holt Marine Reserves; (2) Point Cook Coastal Park; (3) Nooramunga and Corner Inlet Marine and Coastal Parks; (4) Shallow Inlet Marine and Coastal Park and Wilsons Promontory Marine Park

while providing opportunities for scientific and recreation/tourism activities [27,28]. Only 3 Marine Nature Reserves have been formally designated to date. However, 43 sites were designated as Heritage Coasts which stretches along with the long seashores in England and Wales (Table 4).

4.4. National Water Parks experience in China

Through the Ministry of Water Resources, China initiated a unique waterscape program called National Water Park in 2001. From then, park list was updated once a year. Up to September of 2007, all the seven designations cover a system of 272 park sites (Fig. 1). Interestingly, this program only deals with inland fresh waters. Originally, most of the parks were basically created as dam-locked reservoirs, flooding adjusting projects or irrigational systems for agricultural use. Over 30% of the parks are located in Henan, Shandong, Jiangsu, Jiangxi and Zhejiang Provinces where numerous farmers are densely settling around the sites. Holding a harmonious relationship between flooding prevention, agricultural use and tourism facility development is regarded as a challenging task for the government administration [29].

Table 4

UK's waterscape related conservation sites.

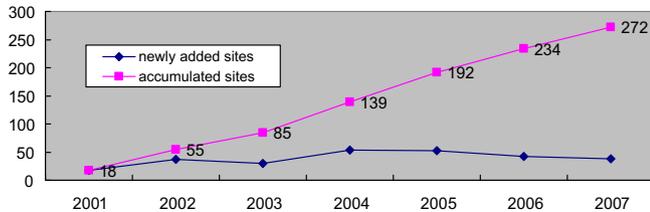
Series name: Marine Nature Reserves (MNR)

(1) Lundy Island; (2) Skomer Island; (3) Strangford Lough

Series name: Heritage Coasts

(1) Aberffraw Bay; (2) Ceredigion; (3) Dinas Head; (4) Dover-Folkestone; (5) East Devon; (6) Exmoor; (7) Flamborough Headland; (8) Glamorgan; (9) Godrevy-Portreath; (10) Gower; (11) Great Orme; (12) Gribbin Head-Polperro; (13) Hamstead; (14) Hartland; (15) Holyhead Mountain; (16) Isles of Scilly; (17) Llyn; (18) Lundy; (19) Morloes and Dale; (20) North Anglesey; (21) North Devon; (22) North Norfolk; (23) North Northumberland; (24) North Yorkshire and Cleveland; (25) Pentire Point-Widemouth; (26) Penwith; (27) Purbeck; (28) Rame Head; (29) St Agnes; (30) St Bees Head; (31) St. Bride's Bay; (32) St. David's Peninsula; (33) South Devon; (34) South Foreland; (35) South Pembrokeshire; (36) Spurn; (37) Suffolk; (38) Sussex Downs; (39) Tennyson; (40) The Lizard; (41) The Roseland; (42) Trevoze Head; (43) West Dorset

Note: Scotland and Northern Ireland have different systems.

**Fig. 1.** The development of National Water Parks in China.

5. Waterscape ecology: a few hypotheses

While putting together the efforts from governments and academics, some interesting questions further deserve to be excavated and explored.

5.1. Who are expected to contribute?

Against such a complicated system of vast global waters, it is important, necessary but tremendously difficult to have a good theory in place for practice. In order to address the dilemma, intellectual, institutional and educational forces are most important in the pioneering stage. Therefore, the central contributors include the following groups:

- (1) Academic leaders: researchers who are studying on hydrology, oceanography, aquatic ecology, landscape ecology, conservation biology...
- (2) Political leaders: politicians or officials working in water resource administration, marine management agency, environment management agency...
- (3) On-site professional managers: managers or rangers working in Water Parks, Marine Parks, Marine Nature Reserves, Heritage Coasts or National Lakeshores...
- (4) Student stewards: university students who are specialized or interested in environmental studies, aquatic environment conservation, or sustainable tourism planning and management...

If the collaboration and co-operation among the above mentioned groups, local residents and all types of NGO stakeholders is present, if the professionals in different continents converge to contribute concerted efforts, waterscape ecology will gradually evolve into a maturing stage.

5.2. What can be borrowed from the maturing landscape ecology

Conveniently, the waterscape ecologists, who mainly research waterscape protected areas with scientific tools of ecology, should and could learn lots from the relatively sophisticated landscape

ecology. By learning the precedent, they can avoid unnecessary frustrations; they can move forward and achieve the planned goals in a proactive stance. Taking the similarities within the same aesthetically oriented ecological restoration or rebuilding framework into consideration, the most useful domains include, but not limited to the following fields from landscape ecology:

- (1) Theories concerning landscape structure: patches, corridors, matrix, hierarchy, configuration, and network...
- (2) Theories concerning landscape dynamics: energy flows, ecological functions, ecological processes, human earth relationships...
- (3) Methodologies concerning landscape management: landscape heterogeneity and biodiversity, landscape maintenance and sustainable use, endangered species based conservation strategies...
- (4) Major events and milestones over the evolution of landscape ecology: this could inspire the burgeoning waterscape ecologists to be grown up...

5.3. Considering the major principles unique for waterscape ecology

In order to be grown up and developed well, the pioneering waterscape ecologists should demonstrate their unique policies. This is because water is basically different from land, and marine environments different from terrestrial features [30]. Either the ordinary laymen or the professional scientists usually know less about the global waters than the land counterparts. Namely, water-based ecosystems are shrouded with mysteries: being quasi-transparent, being quasi-open, being pollution sensible, the mechanism of waterscape evolution and the aesthetic quality maintenance cannot easily be comprehended. From this point, waterscape ecologists can explore their brave new world including but not limited to:

- (1) Static waterscape versus dynamic waterscape: It is a framework of comparative studies within the domain of waterscape ecology. Through this research, different characteristics of landscape processes can be elucidated;
- (2) Freshwater ecology versus marine ecology: This is another important domain of intra-comparative studies. Both freshwater ecology and marine ecology have been popularly studied, their links to aesthetic/recreational values should be enhanced in waterscape ecology;
- (3) Wildlife migration and waterscape change: From small starfish to large mammals such as whales, from zooplanktons to shrimps, from crabs in caves to the seabirds up in the air, the abundant water-dependent wildlife resources provide boundless opportunities for researchers and recreational users alike. The relationship between wildlife movement and waterscape dynamics should be explored in details;

- (4) Ecotoxicology and aquatic pollution studies: In places close to riversides, lakeshores, sea beaches and estuaries, aquatic pollutions should be systematically monitored and studied, either for the purpose of conservation, recreation or sustainable land use. Heavily polluted water bodies cannot form a healthy waterscape;
- (5) Underwater geology, biology and archeology: Intellectual exploration and knowledge expansion concerning underwater worlds will absolutely benefit the on-site professional interpreters. In the end, the public visitors' in-depth understanding on waterscape will drive the conservation on aquatic environment to a new era of success.

6. Conclusion

In the end, several concluding words are summarized as follows.

6.1. From one ecology to many ecologies

Everything changes with time, and the science absolutely evolves into new stages in each coming year. Since the word ecology was coined by Ernst Haeckel in 1866 [31], studies on life sciences have been expanded and revolutionized in a large scale. In fact, disciplines and sub-disciplines merely related to aquatic ecology can be enumerated as many: water ecology (especially freshwater ecology, largely benefits from the development of hydrology), stream ecology (river ecology or riverine ecology, benefits from fluviology or potamology), lake ecology (limnetic ecology, benefits from limnology), estuarine ecology, marine ecology (seashore ecology, shelf sea ecology, deep sea ecology or benthic ecology, benefits from the development of oceanography), coral reef ecology, fish ecology, plankton ecology (phytoplankton ecology and zooplankton ecology), seagrass ecology, and mangrove ecology...

Living in such an eco-boom age, we cannot deny the fact that ecology can powerfully help build new phrases or so-called new academic terms which contribute to the development of life sciences while confusing many novice students. Therefore, it is important to elucidate the complicated situation. If *landscape ecology* needs to be expanded anew, I recommend a cautious welcome to accept the new term *waterscape ecology*.

6.2. Combining the theories with the real world

However, the proposed waterscape ecology presumably will find its way to survive since traditional landscape ecology has its own limitations and boundaries. Considering the increasing public needs for the enjoyment of waterscape, considering the past practices initiated by national governments around the globe, considering the emerging waterscape ecology might open a new perspective, I recommend a bold application of waterscape ecology into the real world to facilitate various Water Park or water related protected area programs.

In order to ensure a success, legislative, administrative and financial supports from governments at local, regional and national levels, and a stronger participation support from the general public are most welcomed. Meanwhile, intellectual exchanges between research institutions, governments across national borders are warmly advocated as well.

6.3. Landscape, waterscape and a good earth

By a national standard, the national territory covers lands and waters. By a global standard, the only one Mother Earth holds continents and oceans. Just like all children wish their mothers stay young and beautiful forever, as wise and responsible global citizens, we all wish the only one Mother Earth maintain healthy and energetic forever. I strongly recommend that a new ecological instrument emerge and be used for a beautiful planet. I wish the combination of traditional landscape ecology and newly born waterscape ecology a success to effectively conserve and gracefully construct a good earth.

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