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Restoration of Bull Kelp (*Nereocystis luetkeana*) in the Strait of Georgia

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INTRODUCTION

Kelp forests play an important ecological role in coastal marine ecosystems by providing habitat for several marine species, and by contributing to primary production and carbon storage (Lamb et al., 2011; Pfister et al., 2017; Siddon et al., 2008). *Nereocystis luetkeana*, commonly known as bull kelp, is a species of kelp that grows and forms extensive forests in nearshore subtidal habitats on the Pacific coast (Schoch and Héloíse, 2004). Bull kelp is an annual species that completes its life cycle within a single growing season and reproduces in the same location from year to year (Dobkowski et al., 2019). Unfortunately, bull kelp has declined in the Strait of Georgia over the past several decades and is no longer found in locations where previously abundant (Shaw, Heath, Tomlin, Timmer, and Schellenberg, 2018). Reasons for this decline are unclear because factors influencing bull kelp success, such as light, nutrients, and temperature, may never be entirely independent of each other (Dayton, 1985).

To combat this decline, the Mount Arrowsmith Biosphere Region Research Institute (MABRRI) has aimed to re-establish bull kelp beds within the Strait of Georgia by installing bull kelp enhancement plots; this is conducted using the methods established by Project Watershed for their bull kelp enhancement plots off Hornby Island. The purpose of the enhancement plots is

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to deploy rope that is pre-seeded with bull kelp, allowing bull kelp to grow on the lines, ultimately dropping spores in the surrounding area, and regenerating self-sustaining kelp forests (Heath and Chambers, 2014). In March 2018, MABRRI installed enhancement plots at two sites: the first located within the United Nations Educational, Scientific, and Cultural Organization (UNESCO) designated Mount Arrowsmith Biosphere Region, off the coast of Winchelsea Islands, and the other located northwest of Dodd Narrows in the Northumberland Channel (Shaw et al., 2018). Additionally, in January 2019 MABRRI deployed new pre-seeded bull kelp lines at the same site locations for a second growing season. The work performed by MABRRI, as well as Project Watershed, is an important restoration initiative that aims to contribute to re-establishing bull kelp beds within the Strait of Georgia.

METHODS

One new bull kelp line was deployed at each of the two previously established enhancement plot sites, located off Winchelsea Islands and Dodd Narrows, British Columbia on January 13, 2019. Methods for deployment of new pre-seeded bull kelp lines were the same as the previous year, which closely followed the methods developed by Project Watershed (Heath and Chambers, 2014; Shaw et al., 2018). To deploy a new bull kelp line, spools of thin string that were pre-seeded with *N. luetkeana* were wrapped around a 30-meter long and 19-millimetre diameter polysteel floating rope that was attached to large concrete anchors on either side. The new kelp line for each site was aligned parallel to the old kelp line by deploying the new concrete anchors above the old concrete anchors, which were marked by buoys. Bull kelp lines at both sites were approximately 9 to 10 meters deep.

Following kelp line deployment and over the course of the growing season, May 26th to August 23rd, 2019, SCUBA divers monitored the growth of the bull kelp. Nylon cable ties were attached to each new bull kelp line in intervals of five meters and the individual plants growing at

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each cable tie were measured for stipe length throughout the growing season. In addition, divers video surveyed the kelp by swimming along each kelp line with a GoPro™.

To monitor the potential influence of the enhancement plots on the surrounding biodiversity, fish and invertebrate species seen in the video surveys of the kelp lines were documented. In addition, during each dive, a one-meter squared quadrat was placed in three known semi-permanent locations at each site. Quadrat locations were established by placing bright yellow L-shaped cement blocks on the seafloor in three locations along each new line. The quadrat was placed in the same position at each of the six locations, three at each site, by wedging the bottom left-hand corner of the quadrat in the “L” of the yellow blocks. The quadrats were also video surveyed by GoPro™ and species of fish and invertebrates, as well as other species of kelp, were cataloged from the videos.

Water profiles were collected at each site location using a YSI Pro DSS sonde. A water profile was collected at each site in two locations: an inner site that was approximately 7 metres deep and an outer site that was approximately 16 metres deep. Inner sites were located near the bull kelp lines and outer sites were deeper and further away from the lines. Sonde measurements were taken at intervals of one meter until the seafloor was reached.

RESULTS

Kelp growth

Our visual surveys indicated a general increase in bull kelp biomass over the growing season at both sites. Most of the kelp at both sites were visible at the surface during low tide by the fifth site visit on August 10, 2019 (day 76). However, no kelp was present by the final dive on August 23, 2019 (day 89) at the enhancement plot off Winchelsea Islands while approximately half of the kelp appeared to be present at the surface at the Dodd Narrows site.

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Over the course of the study, four of the six kelp measured at the enhancement plot off of the Winchelsea Islands were present up to day 76 (5th site visit) and grew an average of 0.7 cm/day, reaching a maximum average height of 99.8 cm. The remaining two kelp that were measured were only present up to day 55 (4th site visit) and grew an average of 0.7 cm/day, reaching a maximum average height of 86 cm. By the sixth survey, no kelp were observed on this line at this site.

Figure 1. SCUBA Diver measuring bull kelp at Dodd Narrows site (MABRRI, 2019).

At the Dodd Narrows enhancement plot, only four of the six bull kelp marked with cable ties to be measured were still attached to the line when the initial stipe lengths were measured. Of those four kelp, two of them were still present during our final site visit; they grew an average of 9.8 cm/day and reached an average maximum height of 894.5 cm.

The bull kelp that was transplanted at each site in 2018 did see *sori* (spore) development, however there was greater *sori* development in 2019 at the Dodd Narrow site than in 2018. We are unable to compare for the Winchelsea Islands site due to grazers consuming the bull kelp and not allowing it to fully mature in 2019.

Biodiversity

At the time of deployment when no kelp was present, no species of fish were observed during video and diver surveys of the kelp lines at the Winchelsea Island site. As bull kelp began to appear on the lines, juvenile rockfish (*Sebastes sp.*) were observed swimming around the kelp. Rockfish abundance continued to increase in numbers at this site with an increase in kelp biomass. Similarly, species of perch, pile perch (*Rhacochilus*

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vacca) and shiner perch (*Cymatogaster aggregata*), increased in abundance with an increase in kelp biomass. Once the kelp had reached a mean height of approximately three meters, schools comprised of more than 50 individuals of Pacific herring (*Clupea pallasii*) were observed swimming around the kelp. Schools of herring also appeared more frequently as the kelp continued to grow. Kelp crabs (*Pugettia producta*) were periodically observed at low densities on the kelp at the Winchelsea Islands site throughout the season as well. At the Dodd Narrows site, no fish species were observed during the video and diver surveys at the time of the line deployment and when no kelp was present. However, as the kelp grew, more fish species were observed at the site. Although species of perch and herring were observed during diver and video surveys once kelp appeared. Overall, based on video surveys, fish biomass over time appeared to be less at this site in comparison to the Winchelsea Islands site.

Species observed within the quadrats, appeared to remain consistent throughout the course of this study at both sites. Therefore, no apparent change in biodiversity was observed in the quadrat video surveys before and after kelp growth at either site. Common species of algae that were observed at the Dodd Narrow site were Turkish towel (*Chondracanthus exasperatus*) and sugar kelp (*Laminaria saccharina*). Common species of algae that were observed at the Winchelsea Islands site were rock weed (*Fucus vesiculosus*) and sea lettuce (*Ulva lactuca*). Common species of invertebrates observed at the Dodd Narrows site were Ochre sea stars (*Pisaster ochraceus*), leather sea stars (*Dermasterias imbricata*), and giant California sea cucumbers (*Parastichopus californicus*). Common species of invertebrates observed at the Winchelsea Islands site were purple sea urchin (*Strongylocentrotus purpuratus*), giant California sea cucumber, and frilled dog whelk (*Nucella lamellosa*). Common species of fish that were observed at the Winchelsea Islands site were black eyed goby (*Rhinogobiops nicholsii*). No fish species were observed in Dodd Narrows quadrats during video surveys.

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Temperature

In 2019, the sea surface temperature (SST) reached a maximum of 14.8°C and a minimum of 12.3°C across both the inner and outer sites at Winchelsea Islands throughout the summer months (Figure 1). The maximum difference in SST measurements between the inner and outer sites at Winchelsea on a given day was 0.2°C. The SST reached a maximum of 12.9°C and a minimum of 11.1°C across the inner and outer sites at Dodd Narrows (Figure 1). The maximum difference in SST measurements between the inner and outer sites at Dodd Narrows on a given day was 0.1°C.

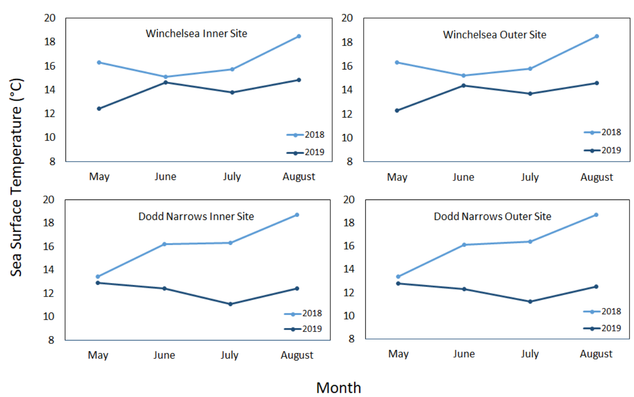

Figure 2. Sea surface temperatures (SST) (°C) of inner and outer sites at MABRRI's bull kelp enhancement plots located near the Winchelsea Islands and Dodd Narrows, British Columbia.

SST measurements were taken at a depth of 1m with a YSI Pro DSS sonde.

SSTs in 2019 were consistently lower every month at the inner and outer sites of both the Winchelsea Islands and Dodd Narrows sites when compared to the 2018 summer months (Figure 1). In 2018, SST had a maximum value of 18.5°C and a minimum of 15.2°C at the Winchelsea Islands site. At both the inner and outer sites at Dodd Narrows, SST reached a maximum of 18.7°C and a minimum of 13.4°C.

Discussion

Overall, the 2019 growing season was successful; an abundance of bull kelp grew at both sites. In 2018, the bull kelp on the lines did not grow from seed, they were established via a transplant (Shaw et al., 2018). It is unclear why the bull kelp seeded lines did not grow in 2018, however it may have been a result of a much later planting than that of 2019 (March versus January), in combination with variations in factors affecting

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bull kelp growth. Some considerations as to why there was greater success in bull kelp growth in 2019 versus 2018 could be the apparent variations in the sea surface temperature between the growing years. Sea surface temperatures in 2019 were consistently lower at both sites, which may have reduced thermal stress on the kelp and supported more successful growth. However, more years of data are required to confirm this hypothesis.

Through the video surveys of the kelp lines at both sites, the surrounding fish biodiversity near the enhancement plots appeared to have increased over time as the bull kelp increased in abundance and length. This suggests that the bull kelp at our sites were successful at providing habitat for organisms in the surrounding area. However, no apparent change in biodiversity was observed in the quadrat video surveys, suggesting that the kelp had no effect on surrounding local benthic invertebrates. Again, more years of data are required to draw more concrete conclusions.

Although during our final dive there were more bull kelp individuals being measured for stipe length at our site near Dodd Narrows, and those individuals had a higher growth rate over time, our video surveys indicated that there were more bull kelp individuals on the line at our site near Winchelsea Islands throughout the majority of the study. We recognize that our sample size of bull kelp individuals measured for stipe length was small and more individuals should be measured during the next growing season to better indicate those differences. This number was chosen due to the uncertainty of the bull kelp success rate using the pre-seeded line method and attaching the nylon cable ties before growth had begun.

The team at MABRRI will be deploying new lines for a third growing season in 2020. We will continue to monitor bull kelp growth over time and aim to quantify its effects on the surrounding areas. In addition, more years of data are needed to observe if the planted bull kelp is able to replenish itself. By collecting more data, this will also help us understand site effects and determine

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the most suitable locations within the Strait of Georgia to implement these techniques and establish a more robust network of bull kelp enhancement plots. Long term efforts to support reestablishing bull kelp through enhancement plots will require further funding and support. Expanding upon our existing network of plots will further increase habitat availability for a variety of organisms, while contributing to a better understanding of the results of this study.

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Baile Átha Cliath
Dublin City

1995-2014

Research at North Bull Island UNESCO Biosphere

An overview of studies completed

Compiled by Dublin City Council

1995-2014

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Research at North Bull Island UNESCO Biosphere

Introduction

North Bull Island, due to its international scientific importance for flora and fauna and also its close proximity to the capital city and many national universities, has long been a resource for education and scientific discovery. Since the establishment of the Biosphere in 1981, there has been a substantial body of work produced by Irish and international researchers. However, this information had not been gathered and collated for the Biosphere and remains housed in university library collections. It is desirable to guide future research by enabling students to see what has already been done and what baseline data has been collected at this important site.

Process

During the periodic review process, Dublin City Council's Biodiversity Manager, Maryann Harris, contacted faculty in the natural sciences in Irish third-level institutions to ascertain the types of unpublished thesis research studies which they have conducted in the past twenty years at North Bull Island UNESCO Biosphere and its surrounding waters. She then conducted a literature review using the library resources of the National University of Ireland - University College Dublin to collate any published research studies that could be found using place-specific keyword searches. She also gathered information on the current degree programmes using the Biosphere, what subjects and levels of students are being taught and the themes of research.

Objectives

While some of the studies are held at the Interpretative Centre at North Bull Island, not all are publicly accessible. Therefore, this document will provide the foundations for a valuable resource for Irish and international researchers. It is planned to extend this study further by engaging a research student to expand the timeframe and keyword searches of the literature review and to compile this into an EndNote bibliography to enable future research. This will then be circulated to national bodies for research and the universities. It may be possible to investigate if any studies have been undertaken in other disciplines. This list will then need to be updated regularly to ensure its value is long-lasting. The results of this study will assist in future planning of research and coordination among educational institutions, the National Parks and Wildlife Service, the Environmental Protection Agency and Dublin City Council.

Acknowledgements

This information could not have been gathered so comprehensively without the assistance of the academic community of Ireland, in particular:

Dr. Marcus Collier, University College Dublin
Dr. Tasman Crowe, University College Dublin
Dr. Robin Edwards, Earth Sciences, Trinity College Dublin
Dr. Stefano Mariani, University of Salford (UK)
Dr. John Parnell, Trinity College Dublin
Dr. Jane Stout, Centre for Biodiversity Research, Trinity College Dublin
Dr. Tamara Hochstrasser, University College Dublin
Dr. Steven Waldren, Trinity College Dublin
Dr. James Wilson, Trinity College Dublin
Dr. Ken Boyle, Dublin Institute of Technology

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Unpublished Research Studies on the UNESCO North Bull Island Biosphere since 1995

Year completed	Title	Author	Institution	Degree
1995	A Study of the Ecology of the Irish mountain hare (*Lepus timidus hibernicus*) with some considerations for its management and that of the rabbit (*Oryctolagus cuniculus*) on North Bull Island, Dublin Bay	Alan Wolfe	UCD	PhD
1995	Phytoplankton in Dublin Bay	Gary Free	TCD	BA (Mod) Thesis
1996	Bull Island: A study of the infauna in relation to the inter-tidal sediments	Derek Mulvany	UCD	MApplSc (Environmental) Thesis
1997	Morphological investigation of *Valerianella* in Ireland	Cliodhna Foley	TCD	BA (Mod) Thesis
1997	Conflations of microphytobenthos with different substrates in North Dublin Bay	Michelle Carolan	TCD	BA (Mod) Thesis
1999	The nitrogen turnover of the saltmarsh of North Bull Island, Dublin Bay	Mary Hayes	TCD	BA (Mod) Thesis
1999	Foraging behaviour of the oystercatcher *Haematopus ostralegus*, in Dublin Bay	Eimear Brennan	TCD	BA (Mod) Thesis
2000	The transport of suspended particulate matter into and out of the South Lagoon - North Bull Island, Dublin Bay	Anne Murray	TCD	BA (Mod) Thesis
2000	A study of the hyperbenthos of Dublin Bay, with reference to the use of dominance curves in the analysis of community structure.	John Brophy	TCD	BA (Mod) Thesis
2000	*Hydrobia ulvae* as a biological indicator of metals in Dublin Bay	Marie O'Malley	TCD	BA (Mod) Thesis
2000	Talitrid Amphipods as a biomonitor of heavy metal pollution in Dublin Bay	S Tinnelly	TCD	BA (Mod) Thesis
2000	An investigation into the emergence patterns	Jennifer Whitmore	TCD	MSc Thesis

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	of the Dublin Bay Prawn, Nephrops norvegicus (L.)			
2001	A Study of the Fungi present on a temperate saltmarsh at North Bull Island, Co. Dublin	Eleanor Landy	UCD	PhD
2002	The ecological effects of *Spartina anglica*, and its management on the mudflats and salt marsh at North Bull Island, Dublin Bay	Mark McCorry	UCD	PhD
2003	Fungal diversity and degradation on a temperate saltmarsh at North Bull Island, Co. Dublin	Niamh Ní Bhroin	UCD	PhD
2004	A study of the feasible and realistic sustainability of North Bull Island, Dublin and its Environment	Enda Flynn	University of Ulster	MSc Thesis
2004	The pollution status of north Dublin Bay	Fionnuala McBreen	TCD	BA (Mod) Thesis
2004	Distribution, relatedness, fitness and behaviour of entomopathogenic nematodes from Bull Island, Dublin	Alec Neil Rolston	NUI Maynooth	PhD
2004	Preliminary investigation of the use of foraminifera as bioindicators of environmental parameters in the Irish coastal environment	Fabrice Richez	TCD	MSc (Env Sci) Thesis
2005	Eutrophication and phytoplankton in the Liffey Estuary and Dublin Bay	Timothy O'Higgins	TCD	PhD
2005	Investigation of the food sources on the cockle (*Cerastoderma edule*) in Dublin bay: multiple stable isotopes approach	Marcin Penk	TCD	MSc (Env Sci) Thesis
2005	A study of a pollution and salinity gradient along north Dublin bay with biodiversity and biomass surveys	Olivia Daly	TCD	BA (Mod) Thesis
2005-2006	Speciation processes and pollinator-mediated selection in nectarless *Dactylorhiza* species	Dr Elisa Vallius	TCD	Post-doc (funded by Academy of Finland post-doc fellowship)

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2006	Evaluating the nitrogen balance in south Bull lagoon using network analysis	John Healy	TCD	MSc (Env Sci) Thesis
2006	Pollution status of the north and south lagoons (the North Bull island) and distribution of *Spartina anglica*	Maria Isabel Valera Martinez	TCD	MSc (Env Sci) Thesis
2007	The alder marsh: ecohydrology and restoration prospects of a desiccating dune slack	Fiona M. Devaney	UCD	PhD
2007	The diets of flatfish in Dublin bay	Christopher Clarke	TCD	BA (Mod) Thesis
2007	A study of meiofauna of Dublin Bay and their use as a biological indicator of pollution	Fiona McIntyre	TCD	BA (Mod) Thesis
2008	The phytosociology and conservation value of Irish sand dunes	Karen Gaynor	UCD	PhD
2008	An Integrated Approach to the Toxicity Evaluation of Irish Marine Sediment	Michelle Giltrap	DIT	PhD
2008	Evaluation of the pollution status of 3 sites in Dublin Bay using a multimarker approach with *Mytilus edulis* as a bioindicator	Linda Daniels	TCD	MSc (Biodiv & Conserv) Thesis
2009	How do social interactions affect territorial behaviour and the formation of such territories? A study of the marine mollusc *Hydrobia ulvae*	Karen Sadleir	TCD	BA (Mod) Thesis
2009	Conservation and monitoring of legally protected and Red Listed bryophyte species in Ireland	Christina Campbell	TCD	PhD Botany
2009	Improving coastal amenity and conservation – North Dublin Bay	Gareth Toolan	UCD	BSc (Landscape Architecture) Thesis
2010	An ecosystem model of the south Lagoon at North Bull Island Dublin Bay	Doireann Nicholls	TCD	MSc (Biodiv & Conserv) Thesis

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2010	Biological Effects of Pollutants in the Irish Marine Environment	Heather Rochford	TCD	MSc Thesis
2010	Effects of maturity status on the measurement of lysosomal membrane stability and condition index in the blue mussel *Mytilus edulis* in Dublin Bay	Ciara Quill	TCD	BA (Mod) Thesis
2010	Endocrine disruption and pollution in Dublin Bay using *Mytilus edulis* as a bioindicator	Andrea Lenderink	TCD	Dipl. Biol. (Bremen)
2010	Imposex biomarkers in *Nucella lapillus* around Dublin Bay	Cathy Maguire	TCD	BA (Mod) Thesis
2010	Trematode parasite prevalence in *Hydrobia ulvae* in relation to host densities and other host-related factors	Laura Williams	TCD	BA (Mod) Thesis
2010	The findings of the project to determine if a strategy for the total eradiation of the invasive species *Hippophae rhamnoides* from North Bull Island is technically feasible and environmentally benign	Desmond Dempsey	National Botanic Gardens	BSc (Hort. Sci.)
2011	The effects of pollution and trematode infection on the health status of *Mytilus edulis*	Sean Kelly	TCD	BA (Mod) Thesis
2011	Contingency valuation of North Bull Island	Richard Deeney	DIT	BSc (Environmental Management)
2012	The current status, distribution and impact of non-native plant species in Irish coastal dunes	Sean Kelly	TCD	MSc (Biodiversity and Conservation)
2012	An integrated assessment of estrogenic endocrine disruption in the Irish marine environment with particular focus on chemical measurements	Jennifer Ronan	TCD	PhD Thesis
2012	Morphological and DNA barcoding-based	Erna King	TCD	PhD Thesis

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	studies of meiofauna community variation along the salinity gradient and response to environmental quality changes within Irish transitional waters			
2012	Stable Isotope analysis and the food web of the Dublin bay ecosystem	Sandrine Laurand	TCD	PhD
2012	Measuring the Impact of Bait digging on the foraging success of migratory waders	Aidan O'Hanlon	UCD	BSc (Zoology)
2013	Pollen limitation in *Oenothera cambrica* Rostanski	Brian Seales	TCD	BA (Mod) Thesis
2013	Taking root in Bull Island	Bróna Waldron	UCD	M. Arch. Thesis
2013	The effects of *Ectocarpus* as a soft engineering technique on North Bull Island	Caroline Sheridan	DIT	BSc (Environmental Management)
2013-2016	Interactions between hydrology and ecology of dune slack ecosystems	Aoife Delaney	TCD	PhD (in progress)
2014	Brent geese social networks	Matthew Silk	U. of Exeter	PhD
2014	Impact of Recreational Activity on the Biodiversity of Bull Island	Aran Keenan	DIT	BSc (Environmental Management)
2014	The distribution and spread of an invasive species, Sea Buckthorn (*Hippophae rhamnoides*) on Bull Island	Aoife Hegarty	DIT	BSc (Environmental Management)
2014	Mapping and Planning Habitats on Open Green Spaces within the Administrative Area of Dublin City Council	Anurag Saha	UCD	MSc (Env Sc)

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Peer-reviewed published research studies of the UNESCO North Bull Island Biosphere

Year	Title	Author(s)	Publication	Vol/Issue	Page Nos.
1997	Organism-induced accumulation of iron, zinc and arsenic in wetland soils	Melanie O. Doyle and Marinus Otte	*Environmental Pollution*	96(1)	1-11
2001	Ecological effects of *Spartina anglica* on the macro-invertebrate infauna of the mud flats at Bull Island, Dublin Bay, Ireland	McCorry, Mark J. and Otte, Marinus L.	*Web Ecology*	2	71-73
2001	What is stress to a wetland plant?	Marinus L. Otte	*Environmental and Experimental Botany*	46(3)	195-202
2001	The diet and landclass affinities of the Irish hare Lepus timidus hibernicus	S. K. Dingerkus, W. I. Montgomery	*Journal of Zoology*	253(2)	233-240
2002	Particulate inputs to Dublin Bay and the South lagoon, Bull Island	James G. Wilson, Mary Brennan and Anne Murray	*Hydrobiologia*	475/476	195-204
2002	Productivity, Fisheries and Aquaculture in Temperate Estuaries	J.G. Wilson	*Estuarine, Coastal and Shelf Science*	55(6)	953-967
2003	Diffuse inputs of nutrients to Dublin Bay	James G. Wilson	*Proc. of the Diffuse Pollution Conference, Dublin, Ireland*	6	105-110
2004	Collembola of North Bull Island – new records for the Irish coast	Maria STERZYŃSKA* and Thomas BOLGER*	*Fragmenta Faunistica*	47 (1):	47–50
2005	The pollution status of North Dublin Bay	Fionnuula McBreen James G. Wilson	*Proceedings of the Conference of the Environmental Sciences Association of Ireland*	15	38-43
2005	Distribution of entomopathogenic nematodes in an Irish sand dune system	Alec N. ROLSTON, Christine T. GRIFFIN and Martin J. DOWNES	*Nematology*	7(2)	259-266
2005	A review of the Irish Anoplura (Insecta: Phthiraptera)	J.P. O'Connor,D.P. Sleeman, F.T. Butler	*Irish Naturalists Journal*	28(2)	62-67
2006	Spatial distribution of nine metals in surface sediment of an urban estuary prior to a large	CJ Buggy, JM Tobin	*Marine Pollution Bulletin*		

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	scale reclamation project				
2006	Records of Irish Agromyzidae (Diptera) including two new species to Ireland	J.P. O'Connor and P.J. Chandler	*Irish Naturalists Journal*	28(7)	280-283
2006	The potential natural vegetation of Ireland	J.R. Cross	*Biology and Environment: Proc. of the Royal Irish Academy*	Vol. 106B, No. 2	65-116
2007	Fish community structure and distribution in a macro-tidal inshore habitat in the Irish Sea	Boris Jovanovic, Craig Longmore, Aine O'Leary, Stefano Mariani	*Estuarine, Coastal and Shelf Science*	75	135-142
2007	Threatened areas of international significance	Alexander Gillespie	*New Zealand Universities Law Review*	22	432-468
2007	The fish assemblage of the intertidal salt marsh creeks in North Bull Island, Dublin Bay: seasonal and tidal changes in composition, distribution and abundance	Violetta Koutsogiannopoulou and James G. Wilson	*Hydrobiologia*	588	213-224
2007	A comparison of energy flow through the Dublin Bay and Baie de Somme intertidal ecosystems and their network analysis	James G. Wilson, Herve Rybarczyck, Bernard Elkaim	*Hydrobiologia*	588	231–243
2007	Benign circulation of rabbit haemorrhagic disease virus on Lambay Island, Eire	N.L. Forester, R.C. Trout, E.A. Gould	*Virology*	358(1)	18-22
2008	Settlement of gilthead sea bream Sparus aurata L. in a southern Irish Sea coastal habitat	G. Craig, D. Paynter, I. Coscia, S. Mariani	*Journal of Fish Biology*	72(1)	287-291
2008	Relationship between body shape and trophic niche segregation in two closely related sympatric fishes	T. Russo, D. Pulcini, A. O' Leary, S. Cataudella and S. Mariani	*Journal of Fish Biology*	73	809-828
2009	Intraspecific variation among isolates of the entomopathogenic nematode *Steinernema feltiae* from Bull Island, Ireland	Alec ROLSTON, Conor MEADE, Stephen BOYLE, Thomas KAKOULI-DUARTE and Martin DOWNES	*Nematology*	11(3)	439-451
2009	An in-situ study using caged *Nucella lapillus* and *Crassostrea gigas*	Giltrap, M., Macken, A., Davoren, M., Foley, B., McGovern, E., Strand,	*Environmental Toxicology and Chemistry*	28	1671-1678

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2010	Current estimates of goose population sizes in western Europe, a gap analysis and an assessment of trends	Anthony Fox et al	*Ornis Svecica - Expanding Goose Populations and their Management Proceedings of the 12th Meeting of the Goose Specialist Group 9–14 October 2009, Höllviken, Sweden*	120(3-4)	115-127
2011	Changes in landscape and vegetation of coastal dunes in Northwest Europe: a review	Sam Provoost, M. Laurence M. Jones, Sally E. Edmondson	*Journal of Coastal Conservation*	15	207-226
2011	Food resource use in sympatric juvenile plaice and flounder in estuarine habitats	Stefano Mariani, Ciara Boggan & David Balata	*Marine Ecology*	32 (suppl. 1)	96-101
2011	A three-dimensional hydro-environmental model of Dublin Bay	Bedri, Zeinab; Bruen, Michael; Dowley, Aodh	*Environmental Modelling and Assessment*	16(4)	369-384
2012	Life at the extreme: lessons from the genome	Dong-Ha Oh, Maheshi Dassanayake, Hans J Bohnert and John M Cheeseman	*Genome Biology*	13	241
2012	"Right" or "Wrong"? Insights into the Ecology of Sidedness in European Flounder, Platichthys flesus	Tommaso Russo,Domitilla Pulcini,Daniele Costantini,Debbi Pedreschi, Elisa Palamara, Clara Boglione, Stefano Cataudella,Michele Scardi,and Stefano Mariani	*Journal of Morphology*	273	33-346
2013	Genetic transformation of western clover (*Trifolium occidentale* D. E. Coombe.) as a model for functional genomics and transgene introgression in clonal pasture legume species	Kim A Richardson, Dorothy A Maher, Chris S Jones and Greg Bryan	*Plant Methods*	9:25	1-11
2013	Pollination activity of Zygaena filipendulae (LINNAEUS, 1758) (Lepidoptera: Zygaenidae) in *Anacamptis pyramidalis* orchid on the North Bull Island (Ireland)	Elisa VALLIUS, Ulf BUCHSBAUM & Vladimir NAZAROV	Entomofauna (Germany)	34(27)	357-368

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2013	Assessment of biomarkers in *Mytilus edulis* to determine Good Environmental Status for implementation of MSFD in Ireland	Giltrap, M., Ronan, J., Hardenberg, S., Parkes, G., McHugh, B., McGovern, E. Wilson, J.G.	Marine Pollution Bulletin	In press	
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Views of researchers using the Biosphere

It's a lovely spot and doing some research there really kick-started my career in Ireland - Dr. Stefano Mariani, University of Salford

I've been using Bull Island for a fair number of years now … since the 1990's…I certainly value having this site close at hand, it provides a very useful site for a variety of teaching and research values. – Dr. Steve Waldren, Trinity College Dublin

I've been using Bull Island as a 'learning laboratory' for several years. In the past, we have taken MSc students into the field to do some sampling and to meet with Pat Corrigan for a talk on management challenges. Each year I take an undergraduate fieldtrip to Bull Island to sample the saltmarshes / intertidal zone as part of a module 'Reconstructing Environmental Change'. - Dr. Robin Edwards, Earth Science Institute

Student groups in years 1, 2, 3 and 4 have met with Pat Corrigan, attending lectures at the Education Centre or talking about aspects of ecology and management relevant to dissertation research. – Dr. Ken Boyle, Dublin Institute of Technology

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Reaching common ground: The potential for interagency collaboration in UNESCO biosphere reserves

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Abstract: In an increasingly urbanized and degraded world, protected areas provide opportunities for people to connect with nature. Biosphere reserves strive for coexistence between the conservation of biodiversity and sustainable development practices through people and agencies living and working in harmony with nature at a regional scale. This article explores the potential for collaboration among stakeholders in biosphere reserves. The diverse range of social actors involved in biosphere reserves provides a good environment for implementing collective impact theory and trust theory. These theoretical frameworks allow for deeper understanding of how stakeholders connect through a more holistic and cohesive decision-making process. Envisioned to facilitate social innovation, these theories have emerged in a variety of settings across the globe to enable collaboration. However, little is known about the implementation and success of these theories in biosphere reserves. This article evaluates the feasibility of the practical implementation of these theories through the lens of environmental education and heritage interpretation in the Beaver Hills Biosphere in central Alberta, Canada.

Keywords: Collaboration, Biosphere Reserve, Collective Impact Theory, Trust Theory, Environmental Education, Interpretation

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INTRODUCTION

The scale and complexity of environmental issues our world faces today is overwhelming, and many agencies are addressing these challenges with comprehensive solutions. The United Nations Educational Scientific and Cultural Organization (UNESCO), formed in 1945, created Biosphere Reserves in the 1970s through the Man and the Biosphere (MAB) Programme. Biosphere reserves are designed to revitalize the dysfunctional relationship between humans and nature. The Programme manifests in the form of a global network of 701 biosphere reserves worldwide as of April 2020. Although established in over 60 percent of the world's countries and accredited with a UNESCO designation, biosphere reserves are a commonly misunderstood concept across the globe (UNESCO, 2017).

Appointed no legal authority, biosphere reserves pragmatize recommendations to achieve UNESCO goals throughout various strategic action plans. Previous to 1995, biosphere reserves were created without a Statutory Framework. These 'first generation' biosphere reserves focused on conservation and scientific research of the natural world, with minimal to no emphasis on cultural, sociological, or economic aspects of such designations (Reed & Price, 2020). More recently, biosphere reserves are gradually shifting this focus towards sustainable community development (Stoll-Kleemann & Welp, 2008). Biosphere reserves explore the potential for local solutions to global challenges to yield a more sustainable future (UNESCO, 2015). With the growing complexity of current environmental crises, strategies from multiple disciplines are called upon to involve the public in finding sustainable solutions (Monroe et al., 2008).

Decision-making processes that incorporate a range of social actors have long been challenging to organizations (Glasbergen, 1998). Biosphere reserves are no exception. Their broad, yet inclusive nature encourages taking a multi-stakeholder approach in problem-solving endeavors. Collaborating on controversial issues can help address stakeholder concerns and

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perspectives from multiple disciplines (deBruin & Morgan, 2019). However, a key question in collaborative processes is why some attempts fail, while others succeed (Saarikoski, 2013). Admittedly, there is no precise answer to this question as many aspects of collaboration are context-specific. However, steps towards achieving successful collaboration can be explored through appropriate theoretical frameworks. Collective Impact Theory (CIT) and Trust Theory actively seek to understand and enhance collaboration through structured approaches. Both theories have their benefits and constraints as they are applied to biosphere reserves; nonetheless, they are useful tools to explore collaborative approaches and instill optimism in stakeholders (Hanleybrown et al., 2012).

This article explores multiple case studies of collaboration in biosphere reserves with a special focus on the Beaver Hills Biosphere (BHB) in Alberta, Canada. The BHB provides a good environment to study collaboration and opportunities for synergies between various stakeholders and their pursuit for sustainable development. In addition, we analyze the opportunities and constraints of collaboration in biosphere reserves through various local and international examples. However, collaboration can be explored amidst any of the various sectors of operations in biosphere reserves. Our focus will be on the potential for collaboration in environmental education and heritage interpretation. Environmental education and heritage interpretation are relevant operations in the BHB (and biosphere reserves throughout the world) as several partnering agencies specialize in this field, providing a variety of unique creation and delivery methods. As an overarching theme, this article investigates the following question: *What is the potential for interagency collaboration in UNESCO biosphere reserves through the lens of environmental education and heritage interpretation?*

THE BEAVER HILLS BIOSPHERE

Decision makers in the Beaver Hills area of central Alberta collaborated in 2002 to create the

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Beaver Hills Initiative (BHI) (BHI, 2016). The BHI attempted to unite the local community, all levels of government, industry, non-government organizations, and academia through the shared goal of a more sustainable future. After over a decade of shared initiatives and coordinated action on sustainable development, the BHB was designated a UNESCO biosphere reserve in 2016. Located just east of Edmonton in central Alberta, the BHB encompasses five rural municipalities (Strathcona, Leduc, Beaver, Lamont and Camrose Counties), along with Elk Island National Park, Miquelon Lake Provincial Park, and several other parks and protected areas (BHI, 2016). Undeterred by the impending threats of urbanization, the BHB provides an ideal setting for coexistence between conservation of biodiversity and sustainable development in Alberta. The BHB is home to unique terrestrial and aquatic ecosystems and hosts a diverse abundance of flora and fauna. Likewise, the BHB hosts over 12,000 permanent inhabitants (Indigenous communities, rural farmers, acreage owners, and village residents) who live, work, and interact with nature on a daily basis (BHI, 2015). As agriculture provides a livelihood to the majority of these inhabitants, the quality of life and economic potential of the BHB is closely tied to nature.

Every day the local communities in the BHB illustrate how to achieve this delicate balance of living and working in nature, while supporting sustainable development. Due to the increasing pressures of urbanization and development, the BHB is compelled to develop partnerships with academic institutions, and to integrate partners at the regional level by working cooperatively with other levels of government agencies, and private individuals (Swinnerton & Otway, 2003). Amidst the inhabitants of the BHB, we can recognize unique partnerships with all orders of government (municipal, provincial, and federal), as well as academic, industrial, and non-government organizations. However, the BHB reaches far beyond established partners and will require inclusivity and collaboration with all members of the local community, Indigenous peoples, and civil society organizations. In order to mitigate conflict, it is essential that these

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diverse perspectives are acknowledged during decision-making processes. This raises the question: ***How can biosphere reserves facilitate interagency collaboration?***

INTERAGENCY COLLABORATION

As collaborative efforts become increasingly valued endeavors in biosphere reserves, the challenges and opportunities that arise can generate valuable lessons. Even though connection is easier than ever before in today's world, meaningful collaboration is anything but widespread. The Oxford dictionary (2020) defines collaboration as "the action of working with someone to produce or create something". This shared goal of "creating something" is of critical importance to successful collaboration. Rather than simply approaching partners asking for cooperation in a preconceived goal by one party, there is increasing benefit in including partners in the goal creation efforts. Admittedly, finding common ground in goal creation can be a long and tiresome process and, like all collaborative efforts, they have their limitations.

BARRIERS TO COLLABORATION

From a broad perspective, there are systematic constraints within the biosphere reserve concept itself. The sheer complexity, frequency, and uncertainty of challenges faced by biosphere reserves present themselves as barriers to collaboration (Walker & Daniels, 2019). Capacity is amongst one of the top constraints for any collaborative effort. Lack of available funding, resources, staff, and time needed to tackle a problem through a collaborative approach has the potential to be a biosphere's greatest downfall (Cuong, 2017). Contingencies to the organizational sustainability of biosphere reserves may also pose barriers through staff turnover, operational changes, and dynamic governments. Additionally, one of the greatest obstacles organizations encounter in the face of collaboration is unrealistic predetermined solutions (Kania & Kramer, 2013). Due to the unpredictable nature of challenges faced by biosphere reserves, going into decision-making processes with an empathetic understanding and

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an open-mind towards a broad range of solutions is far more likely to yield success.

Moreover, one major constraint to collaboration is the adequacy of representation. Inappropriate coordination mechanisms for moderating stakeholder interests can threaten the ability of parties to express their perspective on the topic at hand (Ishwaran et al., 2008). Parties' willingness to compromise goes hand in hand with their ability to empathize with opposing points of view. Stakeholders that feel as if their identities are being threatened by potential decisions are far more likely to react with hostility (Hurst et al., 2019). It is imperative not to devalue the perspective of stakeholders while pursuing any collaborative effort. Doing so can lead to feelings of marginalization which will foster distrust and inhibit conflict resolution (Davenport et al., 2007). Along the same lines, communication challenges persist across disciplines as decision makers struggle to articulate their ideas in layperson's terms for other stakeholders. Duinker et al. (2010) explore the dangers of communicating in a language that is incomprehensible by the various stakeholders. Misinterpretation by parties on the receiving end can lead to defensive responses and unproductive relationships (Hurst et al., 2019). Providing inclusive definitions to facilitate dialogue can be a valuable preventative measure before attempting any collaborative effort (Duinker et al., 2010).

BENEFITS FROM COLLABORATION

Despite the constraints of collaboration, there are numerous benefits. The advantages of integrating multiple perspectives in biosphere reserve decisions stem far beyond merely adhering to UNESCO recommendations. There is value in diversifying knowledge leading to a more cohesive and comprehensive outcome. Within biosphere reserves, tackling complex and controversial issues is unavoidable. An ideal narrative of interagency collaboration diversifies knowledge in decision-making processes to assuage conflict, enhance innovation, distribute power, and build consensus (Hurst et al., 2019). In the context of biosphere reserves, inclusive decision-making is an integral process to produce

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mutually beneficial outcomes. In addition, these efforts at inclusion will catalyze a broader acceptance for management decisions and decrease public push-back (Renn et al., 1995). Engaging a diverse set of stakeholders can lead to increased innovation, as well as reduce duplication of efforts. Collaboration can aid administrators understand the breadth of issues faced by individual stakeholders and address them appropriately. In turn, these collaborative efforts initiated by the biosphere reserve can yield mutual understanding from the public. Biosphere reserves can share their current initiatives with the public and provide tangible ways for local stakeholders to help. As expressed through analyzing collaborative constraints, there is increasing importance in the facilitation mechanism for these efforts. Creating a safe environment, where positive interpersonal connections can be generated, promotes trust and easy sharing of information, ultimately benefiting productivity (de Bruin & Morgan, 2019).

COLLABORATION IN BIOSPHERE RESERVES

At the international level, UNESCO Biosphere Reserves have clearly outlined collaborative efforts as a priority through objectives identified in the *Seville Strategy* (1995) and the *Madrid Action Plan* (2002). *The Madrid Action Plan* promoted collaboration in three objectives and multiple action items (Table No. 1). Most recently, the *Lima Action Plan* (2016) highlights this strategic direction toward collaboration through a variety of outcomes (Table No. 1). Although over a decade has passed between them, both international plans highlight collaboration as an essential outcome for biosphere reserves.

Likewise, on a national level, the Canadian Biosphere Reserves Association encourages collaboration through a document of best practices from Canada's UNESCO biosphere reserves (2019) (Table No 2.).

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Table No. 1. Objectives and action items for collaboration recommended by UNESCO Biosphere Reserves' international strategic action plans: Madrid Action Plan (2002) and Lima Action Plan (2016).

International Strategic Plans	Objectives	Action Items
Madrid Action Plan (2002)	**E.1**-Cooperation, Management and Communication	Increased cooperation and coordination of biosphere reserves with existing international programmes and initiatives
		Integrated information & communication strategy
		Participatory regional networks that are managed in a manner assuring adequate representation of biosphere reserve managers/coordinators
		Enhanced cooperation between experts and practitioners in relevant key issues
		Communication strategies for each biosphere reserve, integrated with national and higher levels
		Functional MAB National Committees in each country managed in a manner assuring adequate representation of biosphere reserve coordinators and other key stakeholders
		Open and participatory procedures and processes in the designation, planning and implementation of biosphere reserves
	E.3-Science and Capacity Enhancement	Biosphere reserves to have research programmes on analyses of ecosystem services and their management through stakeholder participation
		Exchange of educational resources for widespread adaptation and application
	E.4-Partnerships	Improved financial mechanisms for biosphere reserves and regional networks
		Increased involvement, support and buy-in of private sector
		Exchanges between biosphere reserves
		Promote partnerships
		Transboundary biosphere reserves
Lima Action Plan (2016)	**A4**.-Research, practical learning and training opportunities that support the management of biosphere reserves and sustainable development in biosphere reserves	Establish partnerships with universities, research institutions, educational and training institutions, UNESCO Chairs, and encourage managers, local communities and other BR stakeholders to collaborate in designing and implementing projects that inform the management and sustainable development of their BR.
	B1.-Effective BR managers/ coordinators and engaged stakeholders of biosphere reserves	Organize global and regional education, capacity building and training programmes.
	B2.-Inclusive regional and thematic networks	Ensure the participation of all relevant stakeholders in regional and thematic networks.
	B4.-Effective regional and thematic level collaboration	Create opportunities for collaborative research, implementation and monitoring.
	B6.-Transnational and transboundary cooperation between biosphere reserves	Create and implement twinning arrangements between biosphere reserves in different countries.
	C8.-Enhanced synergies between biosphere reserves	Encourage joint promotion and marketing of biosphere reserve products and services among biosphere reserves and beyond.

Table No. 2. Objectives and action items for collaboration recommended by the Canadian Biosphere Reserves Association (2019).

Objectives	Actions
Partnership	Work in partnership with all orders of government, Indigenous peoples, the private sector, civil society organizations, academic institutions, youth, and residents
Communication	Facilitate dialogue, showcase models of co-governance, and coordinate projects that bridge environmental, economic, social, and cultural divides
Reconciliation	Foster reconciliation between Indigenous and non-Indigenous peoples through land-based programs and stewardship

Finally and more specifically, the BHI planted seeds of collaborative outcomes throughout their biosphere reserve nomination document (BHI, 2015). Among their key objectives is to enhance internal partnerships and clearly illustrate the benefits of collaboration. Case studies developed from past BHI surveys give insight into the synergies generated by combining resources of diverse partners (BHI, 2015). The BHB encourages collaboration through their strategic planning documents as well. *The Beaver Hills Heritage Appreciation Development Plan* (Hubsy & Fast, 2004), for example, encourages agencies to collaborate more extensively in order to broaden the audience, widen the scope of services, and reduce duplication. More recently, the BHB's strategic plan (2016-2019) pursues collaborative efforts under two of its main objectives (Table No. 3) (BHI, 2016).

Table No. 3. Objectives and action items for collaboration recommended by the Beaver Hills Biosphere Strategic Plan (2016-2019).

Objectives	Actions
[1E] - Collaboration: Collaboration provides the basis for knowledge and information sharing for conservation and stewardship	Data sharing, develop inventory of land uses, develop matrix of conservation methods, engage municipal and provincial economic development and tourism departments, evaluate and determine BHB members.
[4B] - Partnerships: Partnerships to support understanding of climate change impacts are established.	Identify potential sources of expertise to develop and implement climate change strategy, and support Beaver Hills Tourism partners with tools to adapt to climate change.

Not only do these objectives serve as tangible imperatives to foster collaboration, but they serve as tools to initiate action across biosphere reserves. Complex issues require engagement at a local level to facilitate a reciprocal relationship where the biosphere and the local community are mutually benefiting (Chiara, 2015). Biosphere

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reserves offer a "new paradigm for protected areas" as they commit to meaningful involvement of local people through sustainable development initiatives (Swinnerton & Otway, 2008, p.1). Sustainable development requires an interdisciplinary approach to create broad, long-lasting synergies. As planning and management issues are constantly evolving, stakeholders are inundated with demands from collaborative partners. Biosphere reserves pursue a cooperative environment where stakeholders feel their perspectives are being accurately represented during the decision-making process.

Research has shown that collaboration is critical for effective functioning of biosphere reserves. For example, in examining key factors for the success or failure of biosphere reserves, stakeholder participation and collaboration were regarded as the most important functions (Cuong et al., 2017). Across the globe, the concept of collaboration in biosphere reserves has long been explored. This collaborative potential was first explored locally in 1979, when Alberta designated its first biosphere reserve at Waterton. Since its designation, one of their most successful collaborative efforts has been the "Carnivores and Communities" program (Quinn & Alexander, 2011). Through laborious efforts with the municipality, local ranchers, landowners, and Indigenous communities, biosphere reserve administrators continue to successfully collaborate to minimize human-wildlife conflict. This success is driven through compromise, environmental awareness programming, and a shared goal of coexisting with large carnivores (Quinn & Alexander, 2011). In the same way, a case that earned international recognition in its collaborative efforts was the "War in the Woods" in Clayoquot Sound Biosphere Reserve, British Columbia. The conflict stemmed from controversial natural resource management practices as environmentalists protested logging practices that devastated the integrity of one of the world's last remaining temperate rainforests (Zietsma et al., 2002). Gradually, stakeholders began forming alliances with the notion of endorsing ecosystem-based management and an integrated approach to including local people and First Nations in governance. The fallout of this collaborative effort fostered sustainable resource

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management, as well as increased education and tourism opportunities surrounding the forest (Saarikoski et al., 2012).

Aside from collaborative efforts in Canadian biosphere reserves, we can see successful collaboration across the globe. Allariz Biosphere Reserve in Spain undertook a collaborative effort through their organic waste composting program. The Ministry of Environment introduced this sustainability initiative in response to the public demand to improve urban waste management. Aside from biosphere managers, the collaborative effort included local citizens, food companies, and internal and external experts working together to achieve a common goal (Reed & Price, 2020). Other examples of collaboration at a larger scale are the "UNESCO Ecoparks" of Japan. Following a period of dormancy as Japanese biosphere reserves, five parties (Forestry Agency - national government, Miyazaki Prefecture - provincial government, Aya Town - municipal government, a nation-wide environmental NGO, and a local NGO) undertook a collaborative effort which facilitated a bottom-up approach to enhance conservation and education efforts within the biosphere reserve (Reed & Price, 2020; Tanaka and Wakamatsu, 2018). Still recognized as biosphere reserves through UNESCO, Japan changed their recognizable name to "ecoparks". Japan completely revitalized their biosphere reserve concept through the establishment of a platform that promotes the empowerment of local actors, as well as encourages collaborative efforts, cooperation, and multi stakeholder awareness (Reed & Price, 2020).

THEORETICAL FRAMEWORKS FOR COLLABORATION

The examples of collaborative efforts in biosphere reserves are endless; however, not all of them have been successful. Despite the outcome, the lessons learned from merely trying collaborative efforts are invaluable. Collaboration challenges agencies to think creatively and holistically, likely generating benefits that outweigh the risks. As collaborative efforts become more widespread in biosphere reserves,

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calls for evaluating the success of these initiatives are becoming increasingly common (Conley & Moote, 2003). This interest is fueled by biosphere administrators, public participants, funders, and academics, as they seek to identify potential opportunities and constraints. However, evaluating a concept with intangible measures of success like collaboration can be a daunting task. Biosphere reserves often lack the capacity for such evaluation and become reliant on informally evaluating collaborative efforts. This creates a gap between theory and practice as biosphere reserves expedite collaborative efforts in hopes of achieving their UNESCO-designated goals, while failing to measure their effectiveness (Cuong et al., 2017). Incorporating academic researchers into this process itself can be an example of mutually beneficial collaboration. Researchers can identify the challenges, evaluate the risks, and strengthen the benefits associated with current collaborative efforts by employing appropriate theoretical frameworks. In particular, the Collective Impact Theory (CIT) and Trust Theory provide helpful insights about the inclusion of multiple stakeholders in actively achieving consensus in the decision-making process.

The sheer number of challenges biosphere reserves face can be daunting, and undoubtedly, the solutions lie within a range of expertise from diverse organizations. CIT was first articulated by American social scientists John Kania and Mark Kramer in 2011 with the intent of offering a model for cross-sector collaboration. CIT strives to initiate long-term commitment of important stakeholders to a common agenda for solving a specific problem (Kania & Kramer, 2011a). The versatile approach of CIT tackles prominent issues in the community, encouraging a multi-stakeholder approach (Sagrestano et al., 2018). Through the facilitation of a backbone support organization, CIT is a structured process that facilitates a common agenda, shared measurement, continuous communication, and mutually reinforcing activities among all participants (Kania & Kramer, 2011a). The backbone support organization is arguably the most important condition as it facilitates successful employment of the other conditions

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(Anderson, 2015). The framework also clearly outlines three necessary pre-conditions: adequate financial resources, influential champion(s), and a sense of urgency for change (Hanleybrown et al., 2012). Together, these three pre-conditions and five conditions can facilitate long-lasting, holistic outcomes to any challenge undertaken collaboratively. Employing all five conditions effectively, while simultaneously driving change, is an arduous, yet rewarding, experience (Weaver, 2014).

CIT efforts have gained momentum across the globe, including attempts to reduce childhood obesity through a program called “Shape Up Somerville”, the Global Alliance for Improved Nutrition in Switzerland, and Centers for Disease Control and the Social Innovations Fund initiated by the USA (Kania et al., 2014). A successful collaboration story was the implementation of CIT in the Elizabeth River Project (1993) of southeastern Virginia, USA. After decades of industrial waste disposal into the Elizabeth River, over 100 stakeholders came together with the mission to restore the ecological integrity of the river (Kania & Kramer, 2011b). Dozens of local government authorities, local businesses, schools, community groups, environmental organizations, and universities collaborated to create a structured plan using CIT framework. Each organization played a different role, based on their expertise, to actively facilitate the work of another organization. For instance, one organization coordinated scientific research, another communicated findings to the public, and another created grassroots support and engaged local citizens. Over fifteen years later, the river saw many tangible results including improved water quality, pollution reductions by more than 215 million pounds, a sixfold cut in the concentration of carcinogen levels, as well as the conservation of over 1000 acres of watershed (Kania & Kramer, 2011b).

Certainly, the potential for successful collaboration using CIT is high; however, the potential for its application in biosphere reserves is largely unknown. Biosphere reserves provide a good environment for implementing CIT initiatives as they involve a wealth of

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stakeholders and an opportunity for inclusive and consensus-based decision-making. CIT can facilitate meaningful involvement of actors and can provide a framework to address the complex and contentious challenges faced by biosphere reserves. CIT offers an advanced method of structured collaboration to address the many systemic challenges biosphere reserves face (Anderson, 2015).

However, the supporting theories of CIT are contingent on building on existing collaborative efforts. CIT refers to a supporting dimension: *relationship and trust building among stakeholders.* Hanleybrown et al. (2012) refers to trust as a "softer" dimension, essential to successfully achieving social change through collective impact. The notion of trust pertains to all collaborative efforts as it relates to human psychology and processes that include more than one individual. Trust can be best defined as "a psychological state comprising the intention to accept vulnerability based upon positive expectations of the intentions or behaviors of another" (Rousseau et al., 1998, p. 395). As a concept, trust has been extensively studied and associated with many benefits including facilitating goal attainment and cooperative behaviour (Davenport et al., 2007). In the context of biosphere reserves, trust is a crucial component for virtually every stakeholder involved. Not only is it important to grant trust to partnering agencies, but also sustaining this trust throughout the entirety of the relationship. A lack of trust can have destructive effects that can undermine constructive debates and stakeholder inquiries during decision-making processes (Davenport et al., 2007)

Trust theory embeds itself in four types of trust (Stern & Coleman, 2015). Dispositional trust is a general predisposition to trust based on past experiences of the trustor (Stern, 2018). Rational trust grounds itself in the trustor's evaluation and prediction of the probable outcome of the action. Affinitive trust is based on the relationship of the participating actors. Feelings of social connectedness, shared values, and positive shared experiences can enable affinitive trust. Systems-based trust is the trust in the process and

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procedure, rather than trusting an individual or organization. This leads to the perception of a low risk trust activity (Stern, 2018).

There is a significant body of research pertaining to trust theory and its applications to natural resource management situations. The Midewin National Tallgrass Prairie, in Illinois, USA, explored the perceived role of trust between local communities and USDA Forest Service personnel (Davenport et al., 2007). This study reveals many parallels to the potential of biosphere reserves as agents of trust. Analogous to biosphere reserves, Midewin was established through local efforts and largely relies on the participation of these local actors. Davenport et al. (2007) also explored the importance of the Forest Service being seen as individuals that the community can relate to and interact with rather than a "nameless faceless entity" (p. 365). This process draws on the relevance of affinitive trust in biosphere reserves to create genuine social connections to individual biosphere administrators. Strengthening interpersonal connections has strong potential to positively affect one's willingness to trust, thus facilitating collaboration (Davenport et al., 2007).

Both collective impact theory and trust theory have their advantages and disadvantages, but both can be used as frameworks to evaluate collaborative efforts. Trust theory accounts more directly for interpersonal interactions and focuses on individual attitudes and behaviours (Stern, 2018). As a precursor to CIT, creating relationships with the foundation of trust can help mitigate unnecessary conflict. Due to the complexity and scale of challenges faced by biosphere reserves, CIT appears to be a better suited core model as it oversees collaboration from the agency level. However, trust theory has potential for supporting microscale collaboration at the individual level. Even so, trust theory may be difficult to apply to biosphere reserves for whom individual actors are constantly changing.

Drawing conclusions from past CIT and trust theory applications can help direct future collaborative efforts. These theories can also provide a framework to collaborative

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investigators as they weigh the benefits and costs of collaboration in their sector. Understanding the proposed theories will enable agencies to investigate collaborative potential where they may have previously overlooked such potential. However, it is important to note these theories do not solve the problem at hand, but rather seek to understand and improve the situation. The attempt itself is an important step and offers the intangible benefit of hope that can bring optimism to stakeholders about successfully working together (Hanleybrown et al., 2012).

ENVIRONMENTAL EDUCATION & INTERPRETATION

The framework of collaboration can be applied to any discipline, in any domain. Biosphere reserves are composed of several domains including, but not limited to, land use planning, research, enforcement, and municipal operations. However, this article focuses on interagency collaboration through the lens of environmental education and interpretation. One of the main objectives of biosphere reserves is to foster environmental education for sustainable development (Marks et al., 2017). Through an investigative study conducted in 2015, the potential to examine collaboration through strategic internal partnerships in environmental education was found to be particularly attractive to BHB partners (BHI, 2015). The BHB hosts a considerable variety of agencies engaged in environmental education efforts. Examples of primary interpretive stakeholders in the BHB include, Elk Island National Park, Miquelon Lake Provincial Park, Cooking Lake-Blackfoot Provincial Recreation Area, Ukrainian Cultural Heritage Village, Strathcona Wilderness Centre, Ministik Game Bird Sanctuary, and various representatives from municipal, provincial, and federal agencies (Reinicke, 2016).

Not only is there variation in environmental education stakeholders, but also vast differences in their programs offered and styles of delivery. Environmental education in biosphere reserves comes in many shapes and forms, from community-based environmental monitoring, teaching about local environment through to

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school programming, park interpretive programs, and partnerships in learning and research (Marks et al., 2017). This variation provides an opportunity for extensive knowledge-sharing opportunities, as well as the identification of the most effective and innovative methods of communication. Collaboration between these agencies could manifest itself in joint training and job sharing opportunities, interagency planning meetings, identification of key themes, inventory of existing strategies, and cross-program marketing efforts.

Collaborative initiatives can also benefit these education efforts by reducing duplication and increasing productivity. Due to the variability in audiences and educators, there is no ‘one size fits all’ approach to the creation and delivery of environmental education and interpretation programs. Monroe et al. (2008) highlights four purposes of environmental education: to convey information, build understanding, improve skills, and enable sustainable actions. Collaborative strategies of community education is essential to the success of educators in reaching these goals (Monroe et al., 2008). Generally, biosphere reserves strive to achieve education that meets all four purposes, which is why collaboration is so important.

Not only can collaboration benefit environmental education, but environmental education and interpretation equally hold significant potential as tools to facilitate interagency collaboration. Serving as frontline methods of communication for visitors and the local community, environmental education serves to increase public awareness of the conservation efforts tackled by the biosphere in order to foster stakeholder support and cooperation. Collaboration by the major education agencies within the biosphere can help deliver the message to the greatest amount of individuals. Education has powerful potential in bringing together stakeholders to achieve a common goal. Biosphere reserves provide stakeholders with the opportunity to further this relationship by becoming environmentally literate through environmental education as they pursue a livelihood through nature. Environmental education can help

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minimize the predefined risk of collaborating in a language incomprehensible to the various parties. In this way, environmental education and interagency collaboration can be mutually beneficial.

Another benefit of analyzing collaboration through an educational lens is its applicability to the aforementioned theories. For instance, CIT outlines a clear process to implement collaboration: identify the problem, identify key stakeholders, and create common goals. Drawing from a previous example, Waterton Biosphere Reserve initiated its "Carnivores and Communities" program in 2009. Building on existing community initiatives, Waterton worked with several partners to support community-based and landowner-driven initiatives to reduce human-wildlife conflict (Quinn & Alexander, 2011). Applying the early steps of CIT in regards to this environmental education initiative would materialize as follows:

Identify the problem: conflict between large carnivores and people in southwestern Alberta (special focus on agricultural conflicts: livestock, grain, infrastructure and fencing).

Identify key stakeholders: ranchers, local landowners, farmers, Indigenous communities, parks, biosphere administration, tourists, municipalities, etc.

Create common goals: raise awareness through environmental education (increase public support and understanding of the importance of large carnivores in the area), replace current waste disposal bins with "bear proof bins", host workshops for farmers and ranchers to minimize the risk of wildlife vs livestock conflict, etc.

CIT has the potential to generate more efficient and holistic environmental education in biosphere reserves by bringing individual stakeholders together towards a common goal. Environmental education should encourage the participation of individuals within the biosphere to play their part in "building a better tomorrow" (UNESCO, 1980, p.12).

CONCLUSIONS

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This article sheds light on the applications of collaboration in biosphere reserves. Through an analysis of its promises and perils, potential theoretical frameworks, and scope for environmental education, collaboration remains a constructive endeavor for stakeholders. This research has already begun to foreshadow a sense of the challenges faced by biosphere reserves. Collaborative constraints such as a lack of capacity, identity and trust risks, and skepticism of success, are commonplace among biosphere stakeholders. However, education has the potential to minimize these risks and generate benefits from collaboration. A more thorough investigation will reveal the relevance and frequency of collaborative benefits and challenges within biosphere communities. Investigating and analyzing real collaborative efforts currently practiced in the BHB will highlight the benefits of collaboration summarized in this article.

This research encompasses several limitations. First, with a theory as complex and comprehensive as collaboration, the specificity of the research itself can be a constraint. The limitation of focusing too broadly can overwhelm researchers and restrict their ability of seeing important details. However, narrowing in on collaboration for environmental education may reduce attention to pertinent collaborative challenges faced in other sectors of biosphere reserves. Additionally, this research lacks tangible data to support or oppose the authors' assumptions.

In terms of future research, it is important to further document the benefits, costs, and other dynamics related to collaboration in a variety of biosphere reserves, and the BHB in particular. Researchers could survey stakeholders to better understand the specific barriers and enablers faced by the BHB in light of interagency collaboration. This understanding of the broader issues in achieving successful collaboration could then be applied more specifically to a single operation within the biosphere. With respect to collaborating on environmental education and interpretation efforts, research could be conducted evaluating current communications

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efforts in place, their efficiency, and their potential for improvement.

This research article focuses on the potential for collaboration in environmental education and heritage interpretation of biosphere reserves. However, it would be equally beneficial to investigate the potential for collaboration using collective impact theory and trust theory for any component of biosphere reserve operations (e.g. enforcement, planning). This could generate more holistic partnerships and collaborative efforts that include a true diversity of stakeholders. More broadly, this research could be extended beyond the scope of the BHB. An investigation into collaborative efforts nationally across Canada may also lead to other beneficial findings. For example, are the collaborative barriers faced by this biosphere a result of internal operations, or rather are these challenges entrenched in the structure of Canadian biosphere reserves themselves? Future research could compare collaborative results within many biosphere reserves, and seek out a set of best practices.

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Lessons from the Cascade Head Biosphere Reserve, Oregon, USA

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Abstract

Cascade Head Biosphere Reserve is Oregon's only biosphere reserve. It was one of the first group of U.S. biosphere reserves established in 1976 and is one of only two administered by the U.S. Forest Service among the 28 biosphere reserves that remain in the U.S. MAB network. With its complex social and ecological landscape, Cascade Head is a perfect place to test the biosphere concept. It is a microcosm, and its lessons learned about how to create a resilient relationship between humans and nature apply anywhere. Five themes describe the evolving relationship between people and nature at Cascade Head: resistance, research, restoration, reconciliation, and resilience. Unique aspects of the history of UNESCO biosphere reserves in the United States are not widely recognized in the literature, but can help explain their current relationship to the rest of the world network. Cascade Head provides lessons about the periodic review process required by the UNESCO Man and the Biosphere Program, the problems with rigid models of zonation in biosphere reserves, and the complexity of stakeholders and governance. Three overarching

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lessons from Cascade Head stand out. One is the critical role of individuals and the importance of inspired, value-based, individual action. A second is that despite decades of research, ecological mysteries still abound, and the need for research to underpin decisions will never end. Finally, the Cascade Head story shows the importance of worldviews – how we think about the human-nature relationship – in shaping individual and collective actions.

Keywords: Biosphere reserves, history, U.S. Forest Service

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Introduction

The international network of biosphere reserves coordinated by the United Nations Educational, Scientific, and Cultural Organization (UNESCO) Man and the Biosphere (MAB) Program, and the concept of the "biosphere" from which it arose, are important achievements in the history of ecology, conservation, and sustainable development. Biosphere reserves are supposed to be laboratories for understanding the human-nature relationship and models for other places to learn from as we all struggle toward a resilient relationship between humans and our home planet. Cascade Head Biosphere Reserve is Oregon's only biosphere reserve. It is one of only 28 areas in the United States that remain part of the growing international network of 701 biosphere reserves in 124 countries. It was established in 1976, among the first group of 28 biosphere reserves in the U.S. MAB network, as a place to learn how people could conserve and sustainably use the coastal temperate rainforest ecosystem of the Pacific Northwest.

With its complex social and ecological landscape, Cascade Head is a perfect place to test the biosphere concept, which holds that biodiversity conservation and human development are two sides of the same coin. The mosaic of multiple-use public lands managed by the Siuslaw National Forest and private timberlands in the 75 square mile watershed of the Salmon River demonstrate the linkages between forest management and restoration of wild salmon. Endangered species like spotted owls, marbled murrelets, and the Oregon silverspot butterfly share the landscape with vacationers, hikers, hunters, fishers, and mushroom pickers. One of Oregon's five marine reserves is one of the core areas in the biosphere reserve, conserving the essential links between land and ocean. Lincoln City and Neskowin, hubs

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of a thriving tourist industry, bookend the biosphere reserve geographically on the south and north. Native American tribes are slowly restoring their cultures in the Cascade Head area.

The Cascade Head Biosphere Reserve, like every biosphere reserve, is a microcosm. It is only a tiny part of our planet's thin and fragile living skin, but the efforts of many dedicated people to defend a balance between humans and nature there are illustrative and instructive. The lessons from Cascade Head apply anywhere. The Cascade Head Biosphere Reserve provides a case study that illustrates some important aspects of the unique history of the U.S. MAB program. It is a place where the original concept of biosphere reserves in the United States was implemented, then neglected, but survived and is being restored. It provides an example of how important the U.S. Forest Service (USFS) was in the initial implementation of the concept of biosphere reserves in the United States. The Forest Service is now largely "missing in action" in the US-MAB network, but it still has highly relevant experience and lessons to teach.

The idea behind the development of the UNESCO Man and the Biosphere Program was that we need a network of places dedicated to monitoring and understanding the diverse ecosystems of the Biosphere and developing models and strategies for maintaining or restoring their resilience while still meeting human social, cultural, and economic needs. (I capitalize "Biosphere" here and hereafter when used as a proper noun for the singular and unique living skin of planet Earth.) Although each biosphere reserve is unique, they all face similar challenges and provide lessons for all the others.

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This article grew from research conducted in the Cascade Head Biosphere Reserve from October 2018 to January 2019, while I was the Howard L. McKee Ecology Resident at the Sitka Center for Art and Ecology in Otis, Oregon. As an international ecological consultant, I have worked in 34 biosphere reserves in 17 countries, and I brought a comparative, global perspective to the experience at Cascade Head. Some material presented in this article is adapted from my forthcoming book, *The View from Cascade Head: Lessons for the Biosphere from the Oregon Coast*, which will be published by Oregon State University Press in the fall of 2020.

Historical Context of Cascade Head and the U.S. Biosphere Reserve Network

The relatively sparse scholarly literature on UNESCO biosphere reserves does not adequately recognize or reflect the unique aspects of their history in the United States. This is partly because descriptions of the history of the MAB program often begin in the mid-1970s, when the first biosphere reserves were designated, and earlier foundations of the biosphere concept and its implementation are left out of the story (Ishwaran et al., 2008; Price et al., 2010; Matar and Anthony, 2018). Some scholars have reached somewhat deeper into the history of the concept and its implementation (Reed and Massie 2013, Reed 2016), but not from an explicitly U.S. perspective. Key aspects of the unique history of the U.S. MAB program are illustrated by the experience of Cascade Head, and that history holds important lessons for other UNESCO biosphere reserves.

A brief review of the history of the biosphere ***concept*** will first be useful. The term “biosphere” was first used in something like its modern sense by the

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Austrian geologist Eduard Seuss, in his book *Das Antlitz der Erde*, or *The Face of the Earth*, published in 1885. The term and concept were promoted by a Ukrainian biogeochemist, Vladimir Vernadsky, in a 1926 book, *The Biosphere*, which was translated from Russian to French in 1929, and soon after to English. Frank Golley, an American ecologist and historian of ecology, describes Vernadsky's book as "a scientific expression of a global system of man and nature, which was an antidote to the virulent nationalism that was being expressed at the time, especially in Europe" (Golley, 1993).

Biosphere reserves owe a debt to the work of Vasily V. Dokuchaev (1846-1903), a pioneering Russian geologist and geographer who laid the foundations of soil science. Dokuchaev was instrumental in creating a unique Russian conservation philosophy and model of protected areas, called *zapovedniks*, a word perhaps best translated as "nature preserves." Through the 1890s, Dokuchaev argued that setting aside areas of pristine natural ecosystems that can be compared with managed ecosystems, such as agricultural lands or managed forests, was ultimately important for economic development because they act as scientific controls to study how human actions affect ecological processes. *Zapovedniks* should be closed to all economic activities, he thought, and scientists should study their natural functioning.

In the United States, the *zapovednik*-like model of "nature preserves" exists to a certain extent in U.S. Forest Service Research Natural Areas and in some private nature preserves like those of The Nature Conservancy. But the philosophical foundations of nature conservation in the United States are, in general, based more on scenic, spiritual, and recreational values,

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growing out of the writings and philosophies of people like Henry David Thoreau, John Muir, John Burroughs, and Teddy Roosevelt, in contrast to the utilitarian, scientific foundation of *zapovedniks*.

In the late 1930s, with the Dust Bowl disaster continuing, Aldo Leopold – another founding father of U.S. conservation philosophy – understood the value of *zapovednik*-type nature reserves. In a 1938 essay titled “Engineering and Conservation,” Leopold cited the research of John E. Weaver, a botanist, prairie ecologist, and professor at the University of Nebraska, and wrote that "While even the largest wilderness areas become partially deranged, it required only a few wild acres for J.E. Weaver to discover why the prairie flora is more drought-resistant than the agronomic flora which has supplanted it" (Leopold, 1991). The answer was that wild prairie plants had more complex, and more efficient, root systems, as Weaver discovered by studying the ecological processes in a small patch of undisturbed native prairie. Leopold expanded his vision of the value of preserving, studying, and learning from wild ecosystems in his 1939 essay “A Biotic View of the Land.” He again cites Weaver, saying, “Professor Weaver proposes that we use prairie flowers to reflocculate the wasting soils of the dust bowl; who knows for what purpose cranes and condors, otters and grizzlies may some day be used” (Leopold, 1991).

In 1934, during the same decade as the Dust Bowl and Leopold’s musings, the U.S. Forest Service established the Cascade Head Experimental Forest within Oregon’s Siuslaw National Forest. One purpose was to experiment with silvicultural techniques for the expanding timber industry. Part of the experimental forest was further protected as the Neskowin Crest Research Natural

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Area in 1941 – a "reference" ecosystem for learning how coastal temperate rainforests function. The Neskowin Crest Research Natural Area was, in essence, an American *zapovednik*, perfectly in line with Dokuchaev's concept.

The International Council of Scientific Unions launched a ten-year program of international cooperation to better understand the functioning of ecosystems at large scales in 1964. Called the International Biological Program (IBP), it was modelled on the success of the International Geophysical Year of 1957-58. Science was coming to be seen as a tool for easing the tensions of the Cold War, and chipping away at geopolitical and ideological walls. In 1968, with concern about environmental threats exploding, UNESCO organized a "Biosphere Conference" in Paris, using the word "biosphere" for the first time in international deliberations. A retrospective on the legacy of the conference (UNESCO-MAB, 1993) stated that "The single most original feature of the Biosphere Conference however was to have firmly declared that the utilization and the conservation of our land and water resources should go hand in hand rather than in opposition, and that interdisciplinary approaches should be promoted to achieve this aim." The biosphere concept was used to argue against the idea that biodiversity conservation and human development are incompatible or contradictory.

Following the Biosphere Conference, UNESCO established the Man and the Biosphere Program in 1971. It combined the environment-and-development perspective of the conference and the large-scale, long-term, ecosystem-ecology research of the IBP, and sought to establish a network of places, distributed around the diverse ecosystems of the Biosphere, where we can

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monitor, study, assess, and respond to the changes that humans are causing.

Two events in 1972 significantly affected U.S. participation in the MAB Program. One, the U.N. Conference on the Human Environment, was held in Stockholm, Sweden, where international deliberations about how to save the Biosphere continued. The second, the Moscow Summit between President Richard Nixon and Soviet General Secretary Leonid Brezhnev, was a major step toward Cold War détente. Following the Summit, U.S. and Soviet scientists were tasked with finding ways to work together on issues of mutual interest. The ecosystem research already mounted under the IBP and the proposal for an international network of biosphere reserves seemed to be a place to start.

It just so happened that in 1973, a forest ecologist from Oregon named Jerry Franklin, who had risen through the ranks of the U.S. Forest Service, was posted to Washington, DC, to serve as director of the Ecosystem Studies Program at the National Science Foundation. At NSF, Dr. Franklin was chosen to lead a U.S. delegation to work with the Russians to establish biosphere reserves in the two countries. He and his Soviet counterparts (grounded in the *zapovednik* concept) had a similar conception of what "biosphere reserves" should be about, Franklin told me in an interview. "We didn't want to establish more of the same old 'protected areas,'" but rather places to test models of the biosphere concept. The U.S. Forest Service's network of experimental forests, ranges, and research natural areas, spread across the diverse ecological landscapes of the United States, were logical places to anchor some biosphere reserves, in Franklin's view.

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The Cascade Head Experimental Forest, Research Natural Area, and private lands to the south, including the Salmon River estuary, were designated as the Cascade Head Scenic Research Area (CHSRA) in 1974 – a unique designation within the National Forest System – by the U.S. Congress. The management objective of CHSRA was: "To provide present and future generations with the use and enjoyment of certain ocean headlands, rivers, streams, estuaries, and forested areas, to insure the protection and encourage the study of significant areas for research and scientific purposes, and to promote a more sensitive relationship between man and his adjacent environment." As such, the goals for CHSRA meshed well with the objectives of the UNESCO-MAB Program, just at the time the first US biosphere reserves were being selected.

The first group of 28 biosphere reserves in the United States, including Luquillo in the U.S. territory of Puerto Rico, were designated in 1976. Of those, 12 were on lands managed by the U.S. Forest Service, and three more on experimental ranges, formerly managed by the Forest Service until their management was passed to the U.S. Department of Agriculture's (USDA) Agricultural Research Service. Those 15 biosphere reserves comprised a bit more than half of the original group. The remaining 13 were centered around national parks or wildlife refuges managed by the U.S. Department of Interior. The predominance of Forest Service sites among the first group of 28 U.S. biosphere reserves shows Dr. Jerry Franklin's fingerprints on their selection. Two sites in Oregon, Cascade Head on the coast and the H.J. Andrews Experimental Forest in the Cascades – at both of which Franklin had worked and conducted research since the

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late 1950s – were among the initial group of U.S. biosphere reserves.

In 1995, at its meeting in Seville, Spain, the UNESCO MAB Program adopted the Seville Strategy and Statutory Framework, which formalized the requirements for being considered a biosphere reserve and mandated a periodic review every ten years (Price, et al. 2010; UNESCO-MAB, 1996). This development, standardizing and formalizing the concept, and centralizing and tightening UNESCO oversight, is often described in the literature as a positive inflection point in the history of the international network of biosphere reserves (Price et al., 2010; Reed and Massie, 2013; Reed, 2016). It came, however, at a bad time for U.S. biosphere reserves. As Vernon (Tom) Gilbert, a former National Park Service scientist and proponent of the U.S. MAB Program explained, "In the mid-1990s opponents of the United Nations (UN) and some members of the U.S. Congress alleged that biosphere reserves were part of a conspiracy by the UN and the White House to take control of lands in the U.S." This sensationalized campaign gained support in Congress, which attached amendments to appropriation bills that "prohibited agencies from funding the MAB program, and it was essentially abandoned" (Gilbert, 2016).

At the 4th World Congress of Biosphere Reserves, held in Lima, Peru, in 2016, UNESCO developed an action plan to implement its MAB Strategy 2015-2025, which, among other things, required all biosphere reserves to implement "… an effective periodic review process so that all members of the network adhere to its standards." Only a handful of US biosphere reserves had ever undertaken a periodic review at that point. Eighteen of the 47 then-existing US biosphere reserves chose ***not*** to conduct a periodic review when pressured to

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do so after the Lima meeting, and were withdrawn from the UNESCO-MAB World Network of Biosphere Reserves. Of the 18 that withdrew, a disproportionate share – two-thirds (12/18) – were USFS or Agricultural Research Service-led biosphere reserves.

Among the 28 U.S. biosphere reserves that remain in the program, about two-thirds now are centered on landscapes or seascapes administered by the Department of Interior (mainly the National Park Service). After initially playing a major role in the U.S. MAB program, the U.S. Forest Service can now only count Cascade Head in Oregon and Luquillo in Puerto Rico as its contribution to the network. It can lay a partial claim to two other US biosphere reserves that were originally established on USFS Experimental Ranges, Jornada in New Mexico and San Joaquin in California, now administered by the Agricultural Research Service.

The story of how the U.S. Forest Service came to play such an important role in the early history of the U.S. MAB program raises questions about some of the generalities expressed in the literature about the history of the international MAB network. For the U.S. at least, it is probably not accurate to conclude that biosphere reserves were "…essentially designated through identifying existing sites of high biodiversity value(s)" or that the biosphere reserve concept initially had a "conservation focus" (Matar and Anthony, 2017; Ishwaran et al., 2008). In fact, the first U.S. biosphere reserves were selected to integrate nature conservation, human and economic development, and scientific research – and especially, perhaps, those sites centered on U.S. Forest Service lands.

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The Five “Re”s: Themes from Cascade Head

The important milestones in the evolving relationship between people and nature in the Cascade Head ecosystem can be described by a handful of words with the prefix “re”: resistance, research, restoration, reconciliation, and resilience. These five themes are common elements of efforts to heal the human-nature relationship anywhere. They represent another way of telling the story of biosphere reserves and describing their three intertwined functions: conservation; development; and research, monitoring, and education. (For reasons that are not clear, the MAB Program calls the third of these “the logistic function” or “logistic support.”)

Resistance

Conservation of nature always requires resistance to human actions that destroy or degrade natural habitats, overharvest or overexploit valuable species, and otherwise threaten biodiversity. Resistance to actions that would have damaged or destroyed the natural ecosystems of Cascade Head was an initial, critical element in its story. First came resistance against the greedy, unsustainable logging being promoted by Oregon companies and politicians, which motivated President Theodore Roosevelt and his first Chief of the U.S. Forest Service, Gifford Pinchot, to protect the area as part of a new national forest in 1907. In 1974, resistance to unregulated vacation home and tourism development motivated the creation of the Cascade Head Scenic Research Area. And, in 1976, resistance to the view that human social and economic development and the conservation of nature are opposed and contradictory led to Cascade Head being designated a UNESCO biosphere reserve. Resistance to the decline in populations of gray whales that use the marine environment at Cascade Head led to their protection by

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the United States in 1937. The Oregon silverspot butterfly, which lives in the coastal meadows of Cascade Head, and populations of coho salmon that inhabit the streams and rivers of the area were protected by the U.S. Endangered Species Act.

Research

Research at Cascade Head has led to some important and widely relevant discoveries. That research was only possible because the forces that had damaged ecosystems in many other places had been resisted there. A large part of Cascade Head, already within the Siuslaw National Forest, was designated an experimental forest in 1934, and part of that was further protected as the Neskowin Crest Research Natural Area in 1941 – a "reference" ecosystem for learning how coastal temperate rainforests function. The role of red alder in fixing atmospheric nitrogen and banking it in forest soils is only one of many economically important discoveries made at Cascade Head. Examples of the curiosity of scientists and the serendipity of their research are common, and the long-term ecological monitoring that has occurred provides a valuable baseline for future research, including research to understand the effects of climate change.

Restoration

Restoration of natural ecosystems is another hallmark of the Cascade Head story. The Cascade Head Scenic Research Area Act of 1974 provided a legal framework and some funding for the U.S. Forest Service to begin removing dikes and tide gates and restoring natural tidal flows to areas of the Salmon River estuary that had been converted to dairy pastures starting in the 1930s. This estuarine restoration, carried out in stages beginning in 1978, created a kind of ecological experiment through which, decades later, fish biologists could study the

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use of the restored salt marshes by juvenile coho and Chinook salmon. When the salt marshes were reopened to the tides, juvenile salmon of both species began to feed in them immediately and to an unexpected extent, and those fish made a significant contribution to the numbers of adult salmon returning to spawn years later. The natural life-history diversity in Salmon River salmon began to re-emerge because of the restoration of the estuary. Ecological restoration and research at Cascade Head were linked in a positive feedback loop.

The Cascade Head area is also a case study of cultural restoration among the indigenous peoples of the area. The Confederated Tribes of Siletz Indians and the Confederated Tribes of Grand Ronde both present remarkable stories of determination and persistence in restoring and reviving their cultural practices and indigenous knowledge.

Reconciliation

Reconciliation is a term more commonly associated with social justice – such as in the post-apartheid racial healing process in South Africa – but a lot of healing is needed between humans and the Biosphere too. "Biosphere reserves are about reconciling all people with the lands and waters," Eleanor Haine-Bennett, director of the Canadian National Committee for the UNESCO-MAB Program, told me in an interview. From Cascade Head we can begin to actually see some ecological "restorative justice." For example, beavers have come back to Fraser Creek, now restored to its old channel after it was rerouted around Pixieland, a short-lived amusement park built on filled marshland along the Salmon River in the late 1960s. From Cascade Head, we can envision how restoration of the functioning natural ecosystems of a place can lead

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toward reconciliation of "all people with the lands and waters."

Resilience

Resilience is a final "re" word in the lexicon of Cascade Head. Our home planet is dynamic and changeable, and old ideas of ecological "stability" have given way to a more sophisticated view of the dynamic balance – the resilience – of ecosystems. Think of resilience as the kind of balance it takes to ride a wave on a surfboard, not to stand still on a rock. On a planet prone to chaos, life has so far found adaptive pathways to survival, but humans have caused and accelerated global changes that now stress ecosystems in ways that threaten our own existence. If we are to survive much longer, we must rebuild the resilience of the ecosystems we have degraded. At Cascade Head, as everywhere else in the Biosphere, resistance, research, restoration, and reconciliation can lead us on a path toward a more resilient future.

Periodic Review

The periodic review process, part of the Seville Strategy and Statutory Framework, was introduced two decades after the first U.S. biosphere reserves were designated (UNESCO-MAB, 1996). The current version of the process, dating from 2013, is rigorous and detailed; the current periodic review form runs to 43 pages and more than 100 questions (UNESCO-MAB, 2013). The process can be expensive and also time-consuming, especially if serious stakeholder consultations are conducted. "Determining compliance [with UNESCO-MAB statutory requirements] appears to be the dominant purpose of periodic reviews…" (Reed and Egunyu, 2013) and many biosphere reserves see it as "an imposed procedure to overcome by BR [biosphere reserve] stakeholders" (Matar and Anthony, 2017). Perceptions like

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these, combined with a lack of clear positive incentives for conducting a periodic review and remaining in the MAB network, may partly explain why 18 of 47 U.S. biosphere reserves chose not to conduct periodic reviews and to drop out of the MAB program in 2017.

Why did Cascade Head submit a periodic review and stay in the MAB network, and the H.J. Andrews Experimental Forest, a former biosphere reserve, decline and drop out? I discussed this issue with stakeholders at Cascade Head, and with senior scientists from the USFS Pacific Northwest Research Station and the Andrews Experimental Forest.

At Cascade Head, the letter requesting a periodic review from the U.S. State Department's point-of-contact for the UNESCO-MAB program was sent to the manager of the Cascade Head Experimental Forest. He was overextended with responsibilities and saw no benefits from, or incentives to, conduct a periodic review; but he checked with the District Ranger at the Hebo Ranger District in the Siuslaw National Forest, in whose administrative territory the experimental forest and Cascade Head Biosphere Reserve were located. The District Ranger discussed the issue with her staff, and two hydrologists who had been involved in estuarine restoration in the Salmon River estuary wanted to take on the periodic review task. The local Salmon Drift Creek Watershed Management Council was willing to contribute to the effort. Through a combination of pride and persistence, a small team completed the Periodic Review Report, which was approved by UNESCO-MAB in September, 2016 (Cascade Head Biosphere Reserve, 2016). The team was clearly motivated by their desire to share what they perceived as a wealth of

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knowledge that had been accumulated at Cascade Head over the past 40 years.

At H.J. Andrews Experimental Forest, managers and scientists saw few reasons to conduct a periodic review and remain in the program. The experimental forest was already world-famous for its research on forest hydrology, forest biodiversity, and the relationship of forests and aquatic ecosystems; it had been well-funded for decades by the Long-Term Ecological Research Program of the National Science Foundation. Preparing a periodic review was seen as a burden with little benefit, even though the cutting-edge research being done at the Andrews was squarely at the intersection of biodiversity conservation and sustainable development.

According to Reed and Egunyu (2013) "… the periodic review process can also be considered an opportunity for learning within and beyond the national and international networks." Echoing Bouamrane (2007), Matar and Anthony (2017) suggest that periodic reviews should shift to become "a collective learning process engaging multiple stakeholders and used for adaptive management." A periodic review system that provided incentives for biosphere reserves to share their stories and lessons with other biosphere reserves, rather than to conform to rigid standards, would be welcomed at Cascade Head. The fact that periodic reviews are not treated as public documents and are not widely available publicly – through the UNESCO-MAB website, for example – decreases their value in this regard.

Zonation

Biosphere reserves are supposed to be designed with the three zones, which are supposed to reflect and/or enable their roles in integrating conservation and development

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(UNESCO-MAB, 2020a; Reed, 2016). As listed online on the UNESCO-MAB website (UNESCO-MAB, 2020a):

- "The core area(s) comprises a strictly protected ecosystem that contributes to the conservation of landscapes, ecosystems, species and genetic variation.
- "The buffer zone surrounds or adjoins the core areas, and is used for activities compatible with sound ecological practices that can reinforce scientific research, monitoring, training and education.
- "The transition area is the part of the reserve where the greatest activity is allowed, fostering economic and human development that is socio-culturally and ecologically sustainable."

Idealized diagrams depicting the spatial arrangement of these zones usually show a "bull's-eye" arrangement, with the "core zone" surrounded by the "buffer zone," which is in turn surrounded by the "transition area." The idea underlying this model of zonation within biosphere reserves was to protect examples of undisturbed ecosystems in the midst of a human-modified, and often human-dominated, landscape – a worthy idea, but hard to implement in a simple way almost anywhere in the world.

Several problems arise with this idealized system. One is that definitions can be complicated, confusing, and can vary from country to country and place to place. Although the International Union for the Conservation of Nature (IUCN) has attempted to categorize protected areas, it is still not absolutely clear what is meant by "protected" or "strictly protected," or what categories would manage for "activities compatible with sound ecological practices."

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Ideally, in order to advance the biosphere concept, ***all*** zones in a biosphere reserve – not only the core zone – should contribute "… to the conservation of landscapes, ecosystems, species and genetic variation." For the same reason, ***all*** zones should be "used for activities compatible with sound ecological practices" (not just the buffer zone) and also foster "…economic and human development that is socio-culturally and ecologically sustainable" (not just the transition area). Research Natural Areas within the U.S. National Forest System and *zapovedniks* in the countries of the former Soviet Union would probably be considered "strictly protected" areas – but their objectives are also "scientific research, monitoring, training and education," which is listed as appropriate for the "buffer zone" of a biosphere reserve. Even ecologically sound timber harvest, hunting, or fishing could be "compatible with sound ecological practices," and therefore perhaps appropriate in the "buffer zone," not only the "transition area." Matar and Anthony (2017) are correct in saying that biosphere reserves "cannot fit into only one category [of protected area] since their basic premise is inclusive of multi-management purposes within the functional zonation scheme." They also correctly point out that over the decades since the Seville Strategy in 1996, the MAB Program has supported "a larger integration of the zones' functions… meaning that conservation, sustainable development, and logistic support, can be implemented in all zones but with varying degrees, depending on the functional focus of each zone" (Matar and Anthony, 2017).

Zonation within the Cascade Head Biosphere Reserve provides a case study of the complexity of a real-life, not an idealized, situation. It is, in turn, a lesson about the need for flexibility in delineating and characterizing zones within a biosphere

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reserve. When the Cascade Head Biosphere Reserve was established in 1976, it consisted only of the Cascade Head Experimental Forest and Cascade Head Scenic Research Area, with a total area of about 8,700 hectares. Although a zonation scheme apparently was not a requirement for biosphere reserves at the time, the area nevertheless had a complex, de facto zonation, encompassing a mosaic of multiple-use management objectives implemented by a score of land owners and land managers. The Neskowin Crest Research Natural Area, then 35 years old, was essentially strictly protected for scientific research. It was surrounded by the Cascade Head Experimental Forest, whose management objectives were to understand silvicultural and timber harvesting practices in order to foster both environmental sustainability and economic development. Both of those entities were located in the larger Cascade Head Scenic Research Area, which included lands and waters under a combination of public and private ownership. A preserve managed by The Nature Conservancy was located within CHSRA; its management objectives were also close to strict protection (for biodiversity conservation, research, education and recreation). The other areas within and adjacent to CHSRA presented a complicated map of ownership and management authority.

The periodic review form used for Cascade Head Periodic Review in 2016 (UNESCO-MAB, 2013) required information about zonation, and that it be organized according to the three-zone system. The periodic review team updated and analyzed the land use and land management situation, and redefined the zones of the biosphere reserve. The entire seventy-five-square-mile watershed of the Salmon River was included in the overall boundaries, as were the new

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Cascade Head Marine Reserve and adjacent Marine Protected Areas. In explaining this dramatic expansion of the biosphere reserve, the Periodic Review Report noted that the evolution of watershed-scale conservation efforts and a recognition of the important linkages between ocean and land argued for "a more integrated reserve area that includes a broader array of ecological and economic interests."

In updating the zonation of the Cascade Head Biosphere Reserve, the Neskowin Crest Research Natural Area, the Reference Marsh (a never-drained area of saltmarsh), restored saltmarshes of the Salmon River estuary, and the Cascade Head Marine Reserve became the "core" protected areas. Rather than using UNESCO's term "buffer zone," the Periodic Review adopted the term "Zone of Managed Use," and included CHSRA and the Experimental Forest, TNC's Cascade Head Preserve, Westwind Stewardship Group land that is under a conservation easement, and the Cascade Head Marine Protected Areas, where fishing and other activities are less strictly regulated than in the Marine Reserve itself. The Salmon River watershed, and parts of Lincoln City to the south and Neskowin to the north of Cascade Head, were designated a "Zone of Cooperation and Partnership" – a name chosen as an equivalent of "transition area," and which indicates the aspirations of those who prepared the Periodic Review. In all, the Cascade Head Biosphere Reserve now encompasses about 34,000 hectares, or 130 square miles – relatively small for a biosphere reserve. The spatial arrangement of the zones bears little resemblance to UNESCO-MAB's idealized bull's-eye diagram, with "core" surrounded by "buffer" surrounded by "transition" zones.

Stakeholders and Governance

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The mosaic of land ownership and management authority described above leads to a complicated situation regarding stakeholders and governance; what might be called the "stakeholder landscape" is very complex. One category of stakeholders includes agencies with administrative and legal responsibilities, such as the U.S. Forest Service, the Oregon Department of Fish and Wildlife, Salmon Drift Creek Watershed Council, the City of Lincoln City, Lincoln and Tillamook counties, Oregon State Parks, the U.S. Fish and Wildlife Service, the National Oceanic and Atmospheric Administration (NOAA), the U.S. Environmental Protection Agency, and the Confederated Tribes of Siletz Indians and Confederated Tribes of Grand Ronde. Other landowners and land managers are also important stakeholders: The Nature Conservancy, Cascade Head Ranch, the Westwind Stewardship Group, the Sitka Center for Art and Ecology, and commercial timber companies such as Miami Corporation and Hancock Timber Resource Group. And then there are the nearby academic and research institutions with important roles and interests, including Oregon State University and its Hatfield Marine Science Center. This complexity isn't unusual. Every biosphere reserve I have worked in around the world has a similarly complex ownership and management context.

Although the U.S. Forest Service is the Cascade Head Biosphere Reserve's official administrative point-of-contact with the UNESCO-MAB program, it does not see itself as the "management authority" for the biosphere reserve. In fact, at least in the United States, biosphere reserves are multi-stakeholder, multi-landowner, multi-agency collaborations, and it is questionable whether any of their constituent organizations could be called a

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"management authority." Each administrative or land-owning partner in the biosphere reserve is bound by its own institutional mandates, which are often legal ones, and they do not and cannot operate under a single authority.

Matar and Anthony (2017) concluded that, in general, "… it is unclear whether local BR [biosphere reserve] authorities are using PR [periodic review] reports for any management purposes besides reporting to UNESCO-MAB Secretariat." That is certainly true for Cascade Head; the periodic review was completed mainly to satisfy UNESCO-MAB requirements, and never intended for management purposes. The current periodic review form used to guide the process stipulates that one criterion for qualification as a biosphere reserve is that it should have "a management policy or plan for the area as a biosphere reserve" (UNESCO-MAB, 2013). The periodic review form does ask for a justification of how the biosphere reserve meets this and other criteria, and it explicitly asks about "mechanisms for implementation," including mechanisms to manage human use and activities, a management policy or plan, and the authority or mechanism to implement this policy or plan. The 1976 Cascade Head Periodic Review Report addressed this question by stating that one of the key partners, the Salmon Drift Creek Watershed Council, would "… lead a partnership effort. This effort will result in a Cascade Head Biosphere Reserve working group. This group will generate a management plan for the Biosphere Reserve area" (Cascade Head Biosphere Reserve, 2016). Broad participation by local stakeholders was stated as an aspiration for the process.

Given the reality of multi-stakeholder ownership and management authority,

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creating a management plan for the Cascade Head Biosphere Reserve seems unrealistic. While it may be possible to strengthen communication and coordination among the diverse array of biosphere reserve stakeholders, imposing hard objectives on them would be impossible. A softer goal, such as developing a collaborative, shared "vision" or "mission," seems more suited to reality than a "management plan."

A necessary first step in generating broad stakeholder collaboration in the Cascade Head Biosphere Reserve is simply to raise public awareness of its existence. If you stopped an Oregonian on the street and asked them if they know about the Cascade Head Biosphere Reserve, the probability is high that you would draw a blank look, and a question: "The what?" Most local residents, and even many state and federal agency representatives who manage the fish, forests, and other natural resources in the area, generally don't know much about the Cascade Head Biosphere Reserve, if they are even aware of it. During various presentations I made as the Sitka Center's Ecology Resident in the fall of 2018, including at the University of Oregon and at the Hatfield Marine Science Center, I conducted an informal poll of the knowledge about the biosphere reserve. In a sample of approximately 50 people, half were not aware that Cascade Head was a biosphere reserve. Of the half that were aware of its existence, only ten percent said they knew a lot about it.

The 2007 UNESCO-MAB report *Dialogue in Biosphere Reserves* (Bouamrane, 2007) points out that:

> Many biosphere reserves created before the Seville Strategy (1995) were not rooted in the participation or consultation of local and

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> native communities. … In such cases, initiative for the creation of a biosphere reserve usually comes from a state institution (top-down approach)… In order to initiate the process of sustainable management, the construction of dialogue must be oriented towards the local legitimation of the biosphere reserve.

Cascade Head does not quite fit this description, but does not quite escape it either. At Cascade Head, the designation of the biosphere reserve built on the foundation of a political process that had led to the creation of the Cascade Head Scenic Research Area in 1974. That process was pushed by local stakeholders and led by Oregon politicians in the U.S. Congress, not by the U.S. Forest Service. In naming Cascade Head one of the first U.S. biosphere reserves, the U.S. MAB Program piggybacked on the process among local stakeholders that had already begun. Now, even though Cascade Head Biosphere Reserve is one of the oldest in the U.S. MAB network, a robust stakeholder engagement and collaboration process is just beginning – but that does not negate the value of the experience gained in the 44 years since Cascade Head was designated as a biosphere reserve.

It will take a great deal of work to enable Cascade Head to live up to its potential as a laboratory and model, but there are several hopeful developments that may help. One is that in Oregon, the U.S. Forest Service has become a national leader in experiments in "collaborative management" on its lands (Butler, 2013; McLain et al., 2014; Davis et al., 2015; Davis et al., 2017). Although the U.S. Forest Service does not see itself as the

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management authority for the Cascade Head Biosphere Reserve, it does manage a large proportion of its area, and could bring its experience with collaboration elsewhere in the state to planning and decision-making in the biosphere reserve. In fact, a collaborative process, convened by the USFS Hebo Ranger District, The Nature Conservancy, and the Westwind Stewardship Group, has been underway for the past two years at Cascade Head. It is a forum for a diverse group of relevant government agencies from federal, state, and local levels, along with interested NGO and private stakeholders, to discuss issues concerning public access, trails, camping, parking, and related topics, and to generate management options that would solve concerns about resource protection and growing recreational use. This informal planning process has been facilitated by an outdoor recreation planner, funded through a grant from the National Park Service's Rivers, Trails, and Conservation Assistance Program. This group would be the logical foundation or nucleus for a steering or advisory committee for the biosphere reserve, if and when such a body is developed. Another recent positive development is the formation of a support group for the Cascade Head Biosphere Reserve, whose objectives include raising awareness about it, advocating for actions to strengthen it, and conducting educational activities within it – much-needed tasks given the current low level of awareness of its existence.

Conclusion: Lessons from Cascade Head

Several of the lessons from Cascade Head have been discussed above. One is that understanding the unique aspects of the history of U.S. biosphere reserves can help explain their current relationship to the rest of the World Network of Biosphere Reserves. Another lesson is that the current periodic review process is often seen as

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burdensome and may have deterred some former U.S. biosphere reserves from remaining in the network, and reorienting the process toward shared learning among biosphere reserves would be beneficial. Still another lesson from Cascade Head is that rigid models of zonation do not often fit on-the-ground (or sea) reality, and ideas about zonation should move toward a more sophisticated and integrated view of how to manage landscapes and seascapes for social and ecological resilience. Finally, at Cascade Head there is no single management authority, and never will be. Governance there and in other biosphere reserves requires adaptive flexibility and collaboration among diverse stakeholders. The need is for principles and visions of resilience, not rigid requirements imposed from a "top down" level, whether international or national.

Three additional overarching lessons from Cascade Head stand out. One is the critical role of individuals, whose commitment, hard work, and love of place over many decades have made it such a rich laboratory and model. Their stories are unequivocal in showing the importance of inspired, value-based, individual action. The second lesson is that although ecologists now understand much about how nature works, ecological mysteries still abound. We don't fully understand the migratory traditions of gray whales, the causes of Sea Star Wasting Syndrome, the genetic diversity of the Oregon silverspot butterfly, the life histories of salmon, or the ecohydrology of forests. More research is needed to strengthen the scientific knowledge that underpins decisions about restoring ecosystems and maintaining their resilience in the face of the changes our species is creating in the Biosphere. A third big lesson is the importance of worldviews – how we think

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about the human-nature relationship – in shaping our individual and collective actions. At Cascade Head we can read the history of changing worldviews in the landscape, and begin to imagine how a new, ecocentric worldview could create a resilient relationship between humans and nature here, and everywhere.

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