Ocean and Coastal Management 193 (2020) 105254

Contents lists available at ScienceDirect

Ocean and Coastal Management

journal homepage: http://www.elsevier.com/locate/ocecoaman

Comparing cultural ecosystem service delivery in dykelands and marshes using *Instagram*: A case of the Cornwallis (Jijuktu'kwejk) River, Nova Scotia, Canada

Yan Chen [a,*], Camille Caesemaecker [b], HM Tuihedur Rahman [c,a], Kate Sherren [a]

[a] School for Resource and Environmental Studies, Dalhousie University, Halifax, Canada
[b] Institut Agro, Environment and Landscape Department, Rennes, France
[c] Department of Geography, Saint Mary's University, Halifax, Canada

ARTICLE INFO

Keywords:
Climate change
Coastal wetlands
Cultural ecosystem services
Dikelands
Managed realignment
Salt marshes
Sea level rise
Social media

ABSTRACT

Climate change and sea level rise threaten coastal areas around the world. In the Bay of Fundy area of the Canadian Maritime Provinces, there are 364 km of dykes protecting 32,350 ha of drained agricultural land. The Nova Scotia Department of Agriculture is in charge of dyke maintenance on its coast, and making decisions about which dykes to reinforce for new climate conditions, which to realign (shorten), and which to simply abandon. Decision-makers need to better understand how people value and use dykeland compared with the marsh ecosystems they replaced, and to which areas will return if dykes are abandoned or realigned. Cultural ecosystem services (CESs) refer to nonmaterial contributions from nature to human beings' subjective and psychological aspects that affect their quality of life. We analyzed the CESs delivered by the dykelands and marshes of the Cornwallis (Jijuktu'kwejk) River by using 4 months of *Instagram* data. The results show two different portraits: 1) dykes and dykelands were more associated with aesthetics, recreational use, social relations, and female users; and 2) marshes (particularly a restored freshwater wetland in the study area) were more used by males and locals for artistic and educational value. Foreshore salt marshes were largely unmentioned in the dataset which may indicate that people did not consciously use or benefit from this ecosystem. Social media data are valuable in providing large-scale quantitative understanding of coastal land cover/land use alternatives to supplement other in-depth analysis, while having limitations regarding data noise and user bias, as well as concerns around ethical issues and ongoing data accessibility.

1. Introduction

Climate change and its accompanying hazards have been widely discussed as an impending challenge for human beings. Sea levels have been continuously rising at a speed of around 3 mm/y and the rate has accelerated over the last decades as a result of climate change that threatens the safety of coastal areas around the world (Nerem et al., 2018). The frequency, intensity, timing and distribution of hurricanes, coastal storms and surges are discussed as direct or indirect consequences of sea level rise (Englander, 2015; Michener et al., 1997). The potential flood hazards are often considered as a major risk for coastal human settlements and ecosystems (Garner et al., 2017). With massive shorelines, western and eastern Canada are highly vulnerable to climate change and flood exposures which may greatly damage or destroy ecological, economic, historical, social, and cultural assets (Minano et al., 2018).

In the face of climate change and sea level rise, coastal adaption is required. Dykes and agricultural drainage have been used for centuries and proved to be an effective and efficient approach to secure coastal safety and productive land use against flood hazards, especially in Atlantic Canada (van Proosdij, 2011). A dyke is defined as "consisting of elongate artificially constructed fill or walls, or naturally occurring ridges". Dykes can be built to keep salt water out of coastal marsh, after which the rich marsh soils are desalinated with rain drained each low tide via ditches and one-way gates called aboiteaux, eventually able to be used for farming (Nova Scotia Department of Agriculture Marketing, 1987; van Proosdij, 2011). Outside dykes, foreshore salt marshes can form a buffer zone between the ocean and the land, facilitating sediment

* Corresponding author.
E-mail address: yanchen@dal.ca (Y. Chen).

https://doi.org/10.1016/j.ocecoaman.2020.105254
Received 17 November 2019; Received in revised form 30 January 2020; Accepted 3 May 2020
Available online 22 May 2020

exchange among coastal areas, and maintaining a unique wetland ecosystem. Behind dykes that mitigate direct impacts from ocean storms and surges, dykelands provide fertile farmlands to secure food supplies (van Proosdij and Page, 2012).

Besides these ecological and economic benefits, dykes and the landscapes they shape have come also to encompass recreation, tourism, and non-agricultural infrastructure (Sherren et al., 2016). The use of dykelands has become quite diverse after centuries of development, decreasing in their proportion of farmland and increasing in commercial and residential land uses. Recreational uses, such as hiking, walking, and biking, are often seen on the dyke infrastructures or in the dykelands behind (van Proosdij and Page, 2012). More importantly, the dyked landscapes of Nova Scotia have considerably contributed to the unique identity, lifestyle and history of the region, particularly emblematic of the Acadian culture that first built them in the 1600s (Campbell, 2017).

The dykes in Nova Scotia are now facing overtopping and flood risks due to sea level rise, and maintaining all the dykes is increasingly unaffordable and technically infeasible over the long term. Previous work in the region based on a quantitative survey suggests that local people, particularly females, are likely to reject the removal or realignment of dykes on the basis of flood protection and food security but also cultural issues such as recreation, sense of place and identity (Sherren et al., 2016). Analyzing cultural ecosystem services (CESs) may help decision-makers to understand how people perceive and use dykelands and the salt marshes they replaced, as well as the nonmaterial benefits they can receive from such landscapes (Plieninger et al., 2013). Actual use of landscapes is difficult to monitor in such rural settings, however. Geotagged social media posts have been used in other settings to understand landscape values and uses, but rarely to explore alternatives in the face of proposed changes (Chen et al., 2018). Image-sharing social media platforms such as *Instagram* and *Flickr* have particularly demonstrated their utility as secondary sources to explore such use (Oteros-Rozas et al., 2018; Richards and Friess, 2015; Richards and Tunçer, 2018).

In this paper, we explore three questions about the dykes of a single tidal river, the Cornwallis, called Jijuktu'kwejk by the Mi'kmaw people, which includes the UNESCO-listed dykeland World Heritage Site – the Landscape of Grand Pré: 1) what are the CESs delivered in dykelands and salt marshes according to *Instagram* users; 2) how will different options for the dyke futures likely affect people from the socio-cultural perspective; and 3) what decision might mitigate the most potential negative impacts from landscape and ecosystem changes? The results may help to inform decision-makers in Nova Scotia, but more importantly, also to demonstrate the utility of such social media methods in social impact assessment and to discuss the feasibility of feeding it into decision-making processes.

2. Literature review

2.1. Cultural ecosystem services and their assessment

Cultural ecosystem services have not been consistently defined or integrated within the ecosystem services (ESs) framework, nor have they been sufficiently mainstreamed into policy (Daniel et al., 2012). While ESs arise when the ecosystem's functions meet people's objective or physical needs, CESs refer to nonmaterial contributions from nature to human beings' subjective experiences and psychological well-being that affect their quality of life (Díaz et al., 2018). The Millennium Ecosystem Assessment (2005) defines CESs in a similar way but its list includes some with market values: cultural diversity, spiritual and religious values, knowledge systems, educational values, inspiration, aesthetic values, social relations, sense of place, cultural heritage values, recreation and ecotourism. CESs are important in part because of their recreational benefits for an industrialized society and cultural identity for traditional communities (Milcu et al., 2013). Plieninger, Dijks, Oteros-Rozas, and Bieling (2013) demonstrated the irreplaceability of the cultural values of an ecosystem or a landscape and such values have been increasingly viewed as having the same importance as other ES categories.

CES assessment has been conducted through analyzing photographs or texts but is still underutilized due to the difficulties of assessing nonmaterial and intangible values (Ridding et al., 2018). Some argue that the cultural consequences of ecological restoration and landscape changes are insufficiently captured by the ES framework (Dou et al., 2019). Gould et al. (2014) suggested that maps, situational, or vignette-like questions can help to articulate some of these difficult-to-discuss CESs, and noted that different values are salient for particular populations based on different social backgrounds. Unlike the interview approach applied by Gould et al. (2014), Smith and Ram (2016) integrated disparate elements of CESs from independent disciplines (e.g. landscape and tourism) to create a questionnaire that allows participants to self-complete the questions. Plieninger et al. (2013) developed a GIS-based mapping tool which shows that CESs can spatially distribute according to their intensity, richness and diversity, all of which can also be perceived differently by people from different socio-demographic backgrounds.

Crowdsourced data on social media platforms can provide a promising source to elicit CESs because they can involve a wide population as well as having rich *in situ* information containing messages on landscape values (Ghermandi and Sinclair, 2019). Recently, more and more publications show evidence that photos and texts on social media can provide visual representation of certain CESs associated with the landscape and human activities and their stimuli (Oteros-Rozas et al., 2018; Sherren et al., 2017; van Berkel et al., 2018). Oteros-Rozas et al. (2018) analyzed 1404 *Flickr* and *Panoramio* photos in Europe to understand the attachment between CESs and landscape features. Richards and Tunçer (2018) applied an online machine learning algorithm to analyze over 20,000 photos geo-tagged to Singapore from *Flickr* and mapped CESs based on the results. Another option is assuming a photo posted implies that a service has been delivered, sometimes irrespective of contents; for instance, Figueroa-Alfaro and Tang (2017) leveraged geo-tagged social media data to examine spatial patterns of aesthetic value based on caption keywords not visual contents. Such automation may provide a way to capture and assess CESs over large areas with less manual effort, yet leaves many limitations such as algorithm accuracy and data validation (Richards and Tunçer, 2018).

Although social media data is still underutilized in many research areas, it provides a novel way to assess CESs associated with dykelands and wetlands for our study. The geo-tagged nature of some social media content allows a spatial estimation and understanding of CESs, while the data collection cost is relatively time- and money-saving (Chen et al., 2018). Social media can help provide researchers access to the perspectives and experiences of salient user groups in places of interest who are generating data online. Passive research methods such as collecting secondary social media data may also mitigate the biases introduced by researchers via active survey or interview questions which are pervasive in traditional approaches (Edwards et al., 2013; Shah et al., 2015).

2.2. Nova Scotia dykelands and marshes

In the Bay of Fundy area of the Canadian Maritime Provinces, there are in total 364 km of dykes protecting 32,350 ha of drained agricultural land (van Proosdij and Page, 2012). Agricultural drainage has been practiced since the 1600s, initiated by early French settlers to the area, called Acadians. The dykes have been subsequently extended, sacrificing the coast's former salt marshes to form what remains some of the region's highest quality agricultural land (Campbell, 2017). The dykes are now owned and managed by the provincial government's Department of Agriculture and the dykelands behind have a mix of ownership across public and private sectors, including much non-agricultural land uses such as residential, commercial and transportation (van Proosdij and Page, 2012). There is also significant attachment to the cultural and

historical value of the infrastructure and its resulting landscapes. This attachment is not held only by those who identify as Acadians, but also for locals and other Nova Scotians whose lifestyle and living landscape have been greatly influenced by the dyke features.

The Cornwallis River we focus on here, also named by the Mi'kmaw people of the region as the Jijuktu'kwejk river, runs from its source on the North Mountain to the mouth near Wolfville on the Minas Basin, where Grand Pré is located. In June 2012, UNESCO named the Landscape of Grand Pré a World Heritage Site, where agricultural activities continue today. The discourse on maintaining these and other dykes in the region is thus grounded in a complex consideration of economic, social and cultural factors. Market values such as property prices and agricultural products can be assessed by numbers, however, the social and cultural values provided by the dykelands as well as the tidal marsh ecosystems they largely replaced involve nonmaterial and subjective services such as aesthetics, education, inspiration, recreation, and place attachment.

Due to projected climate change impacts and the lack of money to maintain and reinforce all dykes, potential options must be fully discussed for the dykes' future in the study area, including removal of dykes, breaching them, or realigning them to shorten the infrastructure burden as well as reinforce them for new sea level conditions. Those decisions then call for various amounts of retreat along with creating opportunities for reintroduced tidal flow and salt marsh restoration. Any such options will change the landscape to different degrees and will influence the CESs delivered there.

3. Methods

3.1. Data collection

We selected 44 data collection points around the dykelands of the Nova Scotia side of the Bay of Fundy, which – when each is buffered by a 5 km radius per point – cover around 3,000 square kilometers and all dykelands on that shore. *Netlytic*, an API-based tool providing access to multiple social media sites, was used to extract geotagged *Instagram* posts (including photos and captions) uploaded within those collection areas from April 9th to August 9th, 2018. These cover some of the most popular spring and summer months for outdoor activities in Canada where the winter is usually severe. *Instagram* had more than 1 billion global users in June 2018 and has become one of the most widely and regularly used photo-sharing social media platforms, albeit usually by users under 35 (Pew Research Center, 2019). It allows users to attach comments and hashtags to their photos, which may contain CES indicators (Oteros-Rozas et al., 2018). We chose *Instagram* as the data source because it has been widely used for diverse subject matter including culturally relevant events and documenting people's daily lives (Chen et al., 2019; van Zanten et al., 2016). The collected data included photos, usernames, descriptions, publication dates, and geographic coordinates. The total number of *Instagram* posts collected was 123,749. This raw dataset included indoor photos, selfies, outdoor photos of human infrastructure, landscape, activities, events, celebrities, and so on. It required narrowing to a case study and further screening work to select valid data which contain CES indicators related to our landscapes of interest: dykelands and wetlands/marshes.

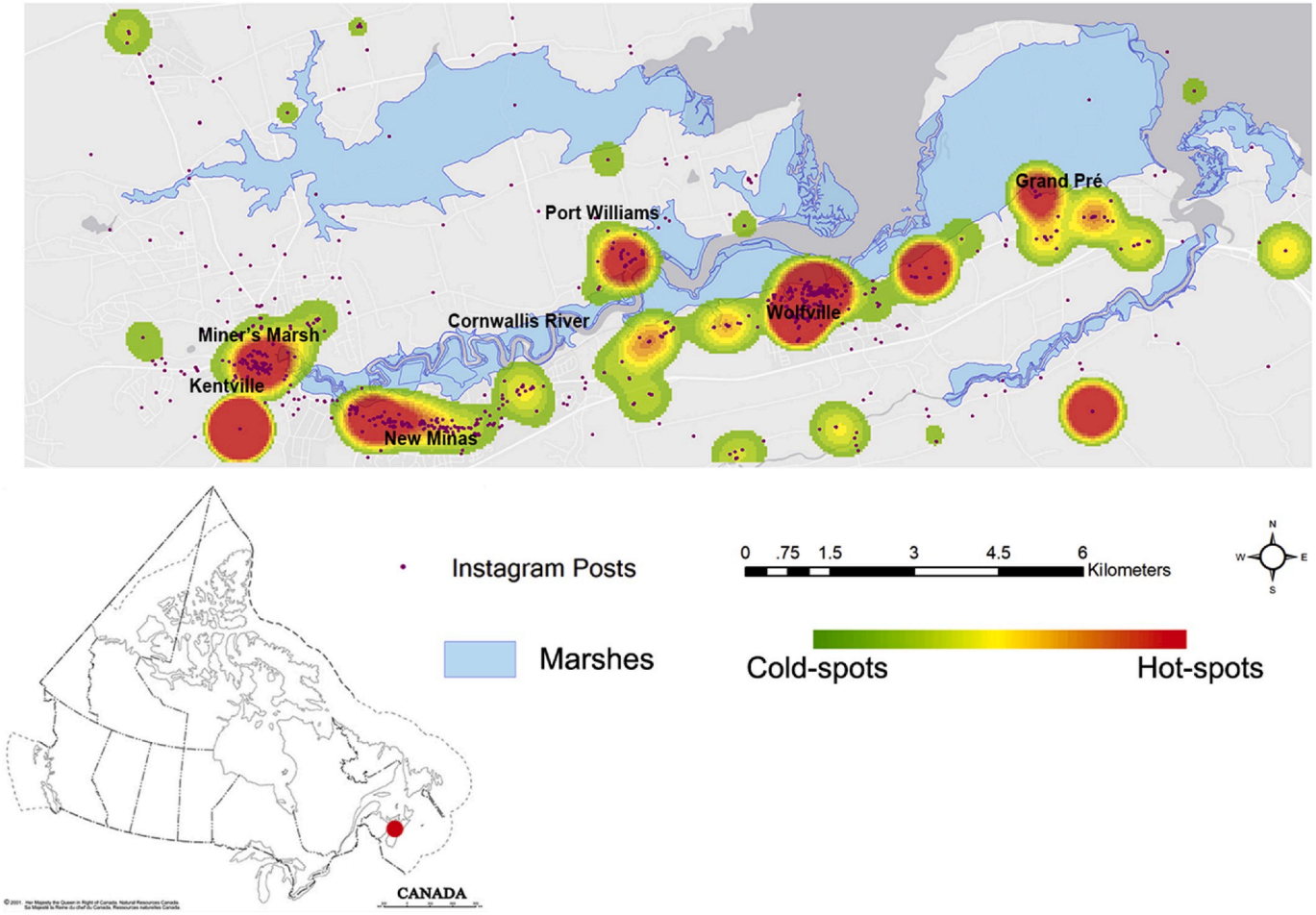

Fig. 1. Map of hotspot analysis of Instagram posts in the Cornwallis River area and Grand Pré (the base map was retrieved from Natural Resources Canada, 2001).

3.2. Case study hotspot analysis

The raw data were imported into *ArcGIS* based on the geographic coordinates and mapped by kernel density analysis. Data tagged along the Cornwallis River from Kentville to Grand Pré were selected as the case study because of data concentration, as well as the importance of the UNESCO-listed World Heritage Site (Fig. 1). This dataset includes the Belcher and Grand Pré dykelands and comprises over 30,000 posts, most of which are concentrated in the towns of Grand Pré, Wolfville, Port Williams, New Minas, Kentville, as well as Miner's Marsh. In fact, unlike the many salt and tidal marshes that sit on the foreshore of many current dykes, protecting them, the restored freshwater marsh at Miner's Marsh was by far the most common use of the term "marsh" in our dataset.

3.3. Filtering and content analysis

The Belcher-Grand Pré dataset contained invalid data such as indoor photos, as well as many photos related to the nearby towns rather than the rural landscapes of interest, so filtering was required before content analysis (Fig. 2 shows the workflow of data analysis). Valid data were determined to be those where any of the keywords dyke/dike, dykeland/dikeland, marsh/marshland, or wetland were identified in the captions. Dike is an alternate spelling of dyke that is considered standard by media outlets in the region. This insured that the accompanying photos are relevant to our research topic. We then manually inspected these valid photos to see if they were landscape-related. Non-landscape photos were excluded (e.g., indoor photos, 'selfies', photos only showing buildings). We decided to keep selfie pictures only if it was taken on the dyke, dykeland or marsh. The final dataset reached a total number of 243 posts (including photos and captions). This is not surprising for such a rural location, and is comparable to that found in other such work on rural landscape change (Chen et al., 2018).

These valid posts were categorized into 2 landscape types—dykeland (74 posts) and marsh (169 posts), none had both—based on keywords and subjected to content analysis. The dataset was contributed by 130 users and 5 of them used both landscape-related keywords in different posts. Only 3 users posted more than 10 posts over the 4 months. The highest number of posts one user posted was 20. Each was assigned to one or more CESs based on the indicators identified during inspection of image and caption contents (see indicators in Table 1). We also identified the users' residential status (i.e., local/non-local) and gender by examination of their *Instagram* account biographical information and geo-tags. The CES categories used in this study were: educational value, aesthetics, sense of place, cultural heritage value, inspiration/artistic, social relation, and recreational activities, adapted from the categories defined in the Millennium Ecosystem Assessment (Millennium Ecosystem Assessment, 2005, Table 1). Textual caption and visual content of each post were examined to code CESs.

3.4. Statistical analysis

Multiple correspondence analysis (MCA) is a multivariate statistical tool mostly used for understanding the underlying associations of a wide range of categorical variables based on relative correlations among the variables. MCA is considered equivalent to Principal Component Analysis (PCA), a widely used statistical technique for analyzing continuous variables, and therefore the key difference between MCA and PCA resides in the scale used for measuring the variables of interest. In MCA, each variable has multiple levels and each level is measured in a binary category (e.g., yes/no) (Abdi and Valentin, 2007). In our study, we used MCA to understand how the *Instagram* users associated different CESs to the two landscapes of interest (i.e., dykelands and wetlands).

While the MCA gives a clear pattern of variable associations, we took the analysis one step further by conducting a Hierarchal Cluster Analysis (HCA) on the MCA results – also known as Hierarchal Clustering on Principal Components (HCPC) (Argüelles et al., 2014). HCA clusters observations based on their Euclidian distances (Husson et al., 2010). We calculated the score of each observation under each dimension (representing each variable association) and conducted the HCA without controlling cluster numbers to understand if there is a pattern among the observations based on each landscape type.

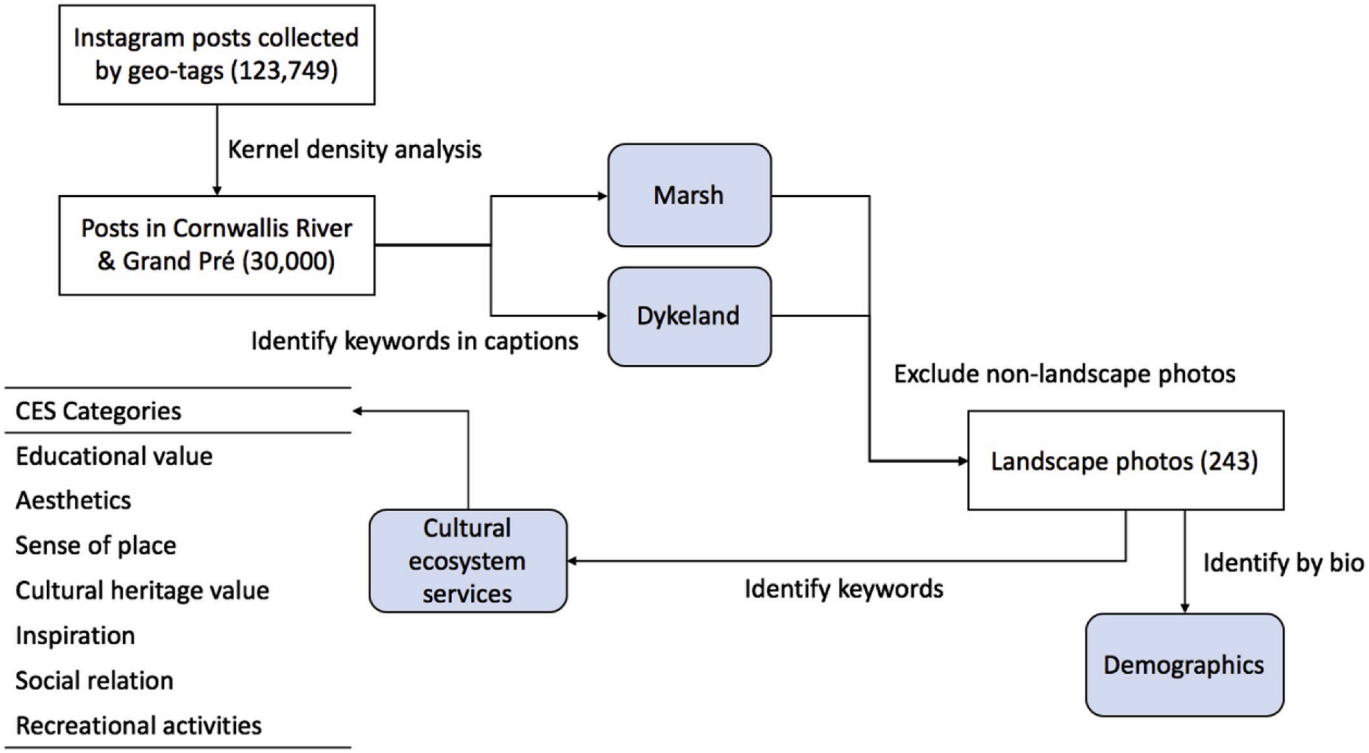

Fig. 2. The flow workflow of data analysis.

Table 1
Coding structure of landscape CES categories.

	Description	Textual and Visual Indicator	Proportion
Educational Values	Ecosystems and their components and processes provide the basis for both formal and informal education in many societies.	student, teacher, historic decision, samples, educational description, name of species	13.6%
Aesthetic	Many people find beauty or aesthetic value in various aspects of ecosystems, as reflected in the support for parks, scenic drives, and the selection of housing locations.	beauty, beautiful, stunning, scenic, nice, view, #nofilter, landscape	26.3%
Sense of place	Many people value the "sense of place" that is associated with recognized features of their environment, including aspects of the ecosystem, those features represent a strong identity for people like their home place or memories attached to a place.	home, my home, missing, my daily view, memories, local	4.1%
Cultural heritage value	Many societies place high value on the maintenance of either historically important landscapes ("cultural landscapes") or culturally significant species.	museum, deportation, acadian, historic site, Grand-Pré museum	3.3%
Inspiration	Ecosystems provide a rich source of inspiration for art, folklore, national symbols, architecture, and advertising.		
Inspiration	Ecosystems provide a rich source of inspiration for people.	inspire, inspiration, creative	2.1%
Artistic	Ecosystems provide a rich source of inspiration for art like photographs, art structures etc.	art, photography, photographer	40.4%
Social relation	Ecosystems influence the types of social relations that are established in particular cultures. Fishing societies, for example, differ in many respects in their social relations from nomadic herding or agricultural societies.	friends, family, children, (more than 2 people on the picture)	13.6%
Activities (Recreation)	People often choose where to spend their leisure time based in part on the characteristics of the natural or cultivated landscapes in a particular area.		
Observing	Ecosystems provide a source of contemplation for people (e.g., a landscape, a sunset)	standing, relax, seat, overlooking	6.6%
Hiking/(dog) walking		hike, path, walk, dog walking, explore	34.6%
Biking		bike, bike ride, biking, cycle	3.3%
Running		run	1.2%
Wildlife watching		bird watching, nature, bird	28%

4. Results

4.1. Data description and CESs

The Cornwallis/Jijuktu'kwejk dataset is 30.4% dykeland (by 59 users) and 69.6% marshland (by 76 users). Marshes were mentioned most in the western part of the study site, around Miner's Marsh, while mentions of dykes were centred around the east, near Grand Pré, the UNESCO World Heritage Site. Most (63.7%) posts were contributed by apparent locals, followed by non-locals (30.1%) and non-identified accounts (6.2%). Females contributed most of the data (61.3%), and the rest were males (34.1%), organization accounts such as schools (2.5%), and accounts for dogs (2.1%).

The most frequently identified CES was artistic value (40.1%) which is related to creative activities such as photography. A further 26.3% of posts demonstrated the aesthetic value of the landscape. The dykelands or marshes also provided venues for maintaining social relations (13.6%) where people could do activities together. Educational value

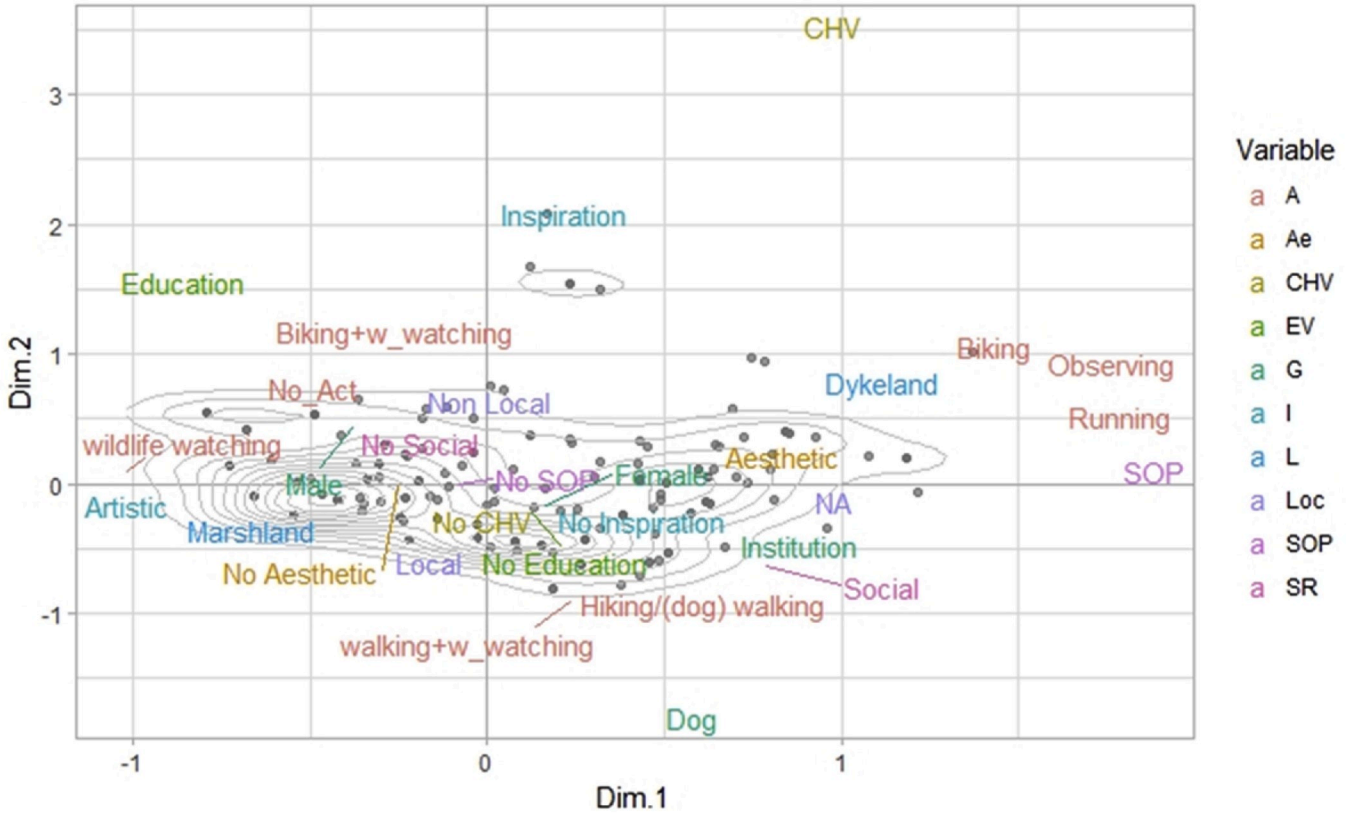

Fig. 3. MCA plot of the pattern of variable associations in dykelands and marshes.

was identified at the same frequency as social relations (13.6%), indicating that dykelands or marshes were suitable for field trips. A sense of place, which refers to people's attachment to the place as a home or memory, was identified in 4.1% of all posts. A further 3.3% revealed the cultural heritage value that is mostly connected with the Acadian history in NS. Dykelands or marshes could also encourage inspiration (e.g., creative thoughts) (2.1%). The recreational use value of these landscapes was widely witnessed, such as hiking/dog walking (34.6%), wildlife watching (28%), observing (6.6%), biking (3.3%), and running (1.2%).

4.2. CES clusters

Fig. 3 displays some prominent patterns in the first two dimensions that place the landscape types far apart and thus distinct in terms of the coding they attracted. First, a gender dichotomy emerges where the dykelands were more likely to be photographed by females for landscape aesthetics, while marshes were more likely to be photographed by males for educational and artistic values. Second, the marshes were slightly more appreciated by locals, but dykelands by females regardless of location. Third, different recreational activities were happening in the two types of landscape: hiking, dog walking, and biking were popular in dykelands, particularly the linear dykes themselves, and wildlife watching in marshes.

The HCA results identified four clusters (Fig. 4). Cluster 1 is associated with the marsh landscape; cluster 2 and 4 are correlated with dykelands; and cluster 3 is not related to any landscape type. The four clusters indicate: 1) Marshes were highly associated with artistic, passive activities (except wildlife watching), and other categories like male, and educational value; 2) dykelands were most prominently associated with cultural heritage value, inspiration, education, aesthetics, and sense of place, as well as activities like observing, biking, running, and wildlife watching; and 3) activities such as hiking, (dog) walking, and wildlife watching were associated with maintaining social relationships. From the cluster dendrogram, locals were not preferentially associated with either landscape type, which was different from the results in the MCA plot – because the MCA method was focusing on variables, and the HCA on categories. Overall, the results show that the two landscape types were used and valued in different ways. Although marshes were more frequently identified from the dataset, dykelands had a more diverse set of CESs and activities.

5. Discussion

This work was initiated to help decision-makers around dykeland futures in the Bay of Fundy region understand the users and values associated with dykes, dykelands and the marshlands they replaced, and to which some areas will return if dykes are removed or realigned. Four months of geotagged *Instagram* images were coded and analyzed for patterns within a case study region including a UNESCO World Heritage Site dedicated to dykeland landscapes and culture.

5.1. Landscape portraits in social media

Dykelands were portrayed as places for aesthetic appreciation and recreational activities with other people (e.g., hiking, dog walking, observing, biking, and running) which helped to maintain social relations. CESs have been critiqued for difficulties in articulation, but elicitation methods and datasets have their own opportunities and biases. Aesthetic value seems the easiest to identify: it is often the most prominent nonmaterial value that has been identified through surveys (Brown and Weber, 2012), and when using social media data, researchers sometimes assume that the act of taking a photo of the landscape implies pleasing aesthetics so that it is possible to map crowdsourced data without careful filtering or coding (Langemeyer et al., 2018). We also detected keywords for different CES categories, such as "beautiful" and "nice" that clearly indicate aesthetic appreciations (Table 1). In addition, however, sense of place and cultural

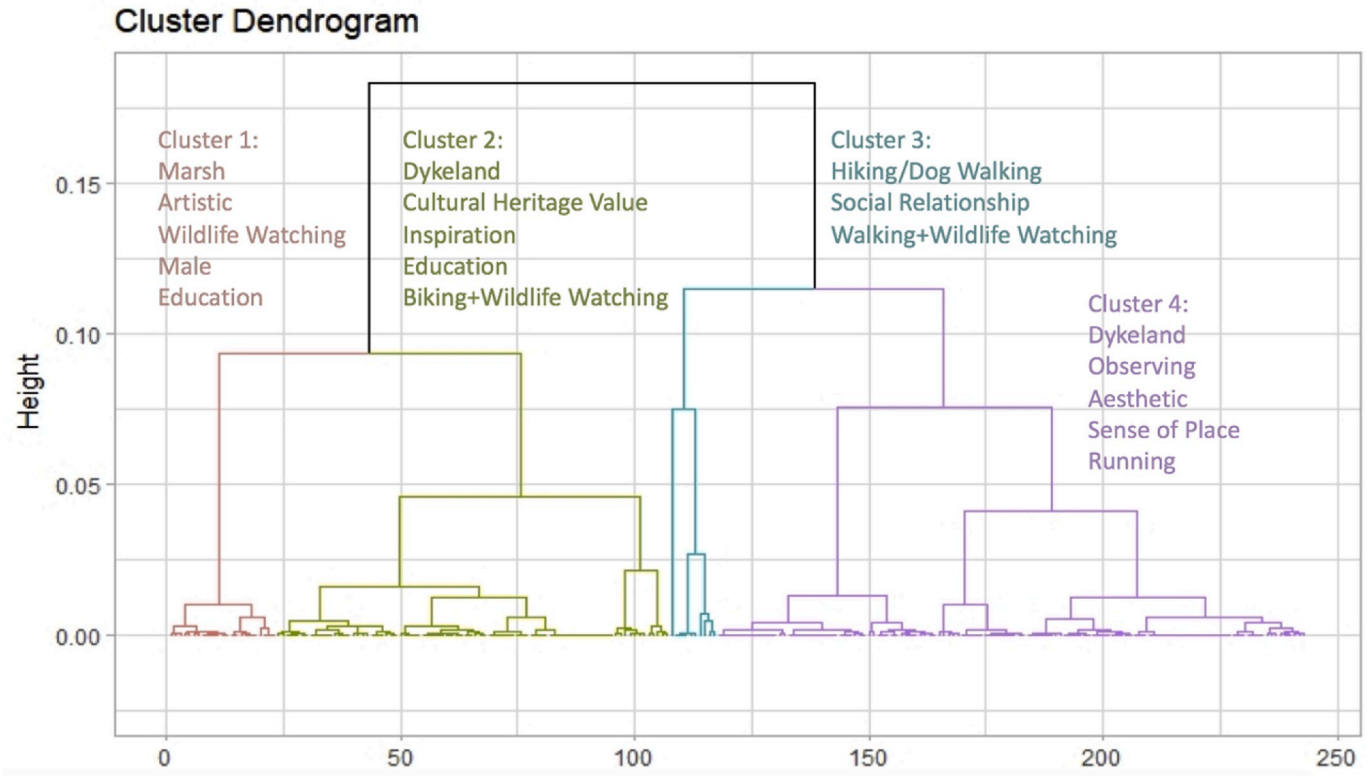

Fig. 4. HCA cluster dendrogram of variable associations in dykelands and marshes.

heritage value were slightly more associated with dykelands than the marshes (Fig. 4). This may be contributed by Grand Pré's status as a UNESCO World Heritage Site and the associated history of Acadians (Campbell, 2017).

The prevalence of images of people conducting recreational activities with friends and families revealed the importance of dykelands in maintaining social relationships. Recreational activities are important ways to leverage nature's positive effects on human wellbeing and quality of life (Díaz et al., 2018), however, recreation has negative impacts on dyke infrastructure for the erosion it can cause (van Proosdij, 2011; van Proosdij and Page, 2012). Here is the potential for conflict between people who benefit from activities like running, biking, and walking on the dykes, and those with responsibility for maintaining and repairing the infrastructure as well as the dykeland landowners who rely on their integrity. Those who oversee the dykes and make decisions for the future have a dilemma: prohibiting these activities to minimize maintenance costs or preserving the recreational and social interaction value to maintain local support.

Marshes (mostly referring to freshwater wetlands in this case study) were portrayed more for artistic inspiration and providing the biodiversity that encouraged wildlife watching and learning about the environment in field trips. Inspiration for art and design is an important CES but is challenging to isolate since it is often linked with cultural and aesthetic values (Fletcher et al., 2014). We distinguished artistic inspiration from pure aesthetics based on whether *Instagram* users clearly defined their photos as photography. Such artistic works can sometimes bring potential economic incomes so, as with recreation/tourism, CESs are not always nonmaterial and nonmarket (Coscieme, 2015).

Marshes also have rich biodiverse ecosystems that allow wildlife watching (e.g., birds) and outdoor classes. Two teachers were identified in our dataset mentioning that marshes were helpful sites for them to visit or collect examples for delivering knowledge to students. However, the term "marsh" was pervasively used to refer to a local freshwater wetland – the Miner's Marsh. The widespread foreshore salt marshes were somehow unmentioned in the dataset, which might indicate that this type of landscape was not widely perceived, valued or utilized by people in the study area. Salt marshes may not be aesthetically valued by many people since they can look barren and muddy, particularly at low tide, and it can also be very dangerous to step into them because of the powerful tides in such areas (van Proosdij and Page, 2012). They are, ironically, typically viewed from dykes, but people may not be aware of what they are looking at; as evident from this work, they do not name the marsh landscapes in their photo captions. This is why linear dykes are such valuable recreational infrastructure, allowing safe coastal access, but the foreshore salt marshes are clearly undervalued, which will limit local enthusiasm for restoring or expanding them (Sherren et al., 2019).

Considering the socio-demographic characteristics, dykelands were connected more closely with females but with no preference between locals and non-locals, while marshes were more associated with males and locals. Interestingly, Campbell (2017) discussed that dykes in Grand Pré were seen as "feminine, emotional, and organic, a picture of annual renewal rather than historic ruin" (p. 62). Over half of the dykeland photos were geo-tagged to the small area of Grand Pré, which might indicate a hidden tie between the place's feminine idiosyncrasy and a more prominent appreciation from females. Sherren et al. (2016) similarly found using a large-scale online Q-method survey that the most dominant discourse was a pro-dykeland one that was largely female and local. Although gender difference in CESs assessment has not been sufficiently studied, understanding it may help policymakers to enhance ecosystem provision (Calvet-Mir et al., 2016). Calvet-Mir et al. (2016) discussed that women are more likely to appreciate nature's inherent or intrinsic value and are more sensitive to the feelings and needs of others. This is consistent with our findings that dykelands were related with females and their appreciation of landscape aesthetics and social relations, while marshes were more men's places for solitary artistic creation and environmental learning, at least in the demographic using *Instagram*.

There was no evidence showing whether the CESs in dykelands were more perceived by locals or non-locals. This may be because, as a World Heritage Site, Grand Pré welcomes thousands of visitors every year, especially during our data collection period from April to August. Thus, Grand Pré and its CESs may benefit an extended population, not only people who live in the dykeland, but also the Acadian descendants and visitors from all over the world, whereas marshes (particularly the Miner's Marsh, walkable from downtown Kentville) were more popular among locals. CESs vary in their constituencies, and this is important for decision-makers to understand.

5.2. Case implications

Decisions are being made about the future of the dykeland system around the Bay of Fundy in the face of climate change. Without reinforcement, many of the current dykes will be overtopped by rising sea levels and storms, which would spontaneously begin to restore dykeland to tidal marsh even if not planned for (Sherren et al., 2019). Many consider the benefits of salt marshes as natural buffers high in coastal areas because of their remarkable capacity to abate wave energy, store flood waters, and provide unique wildlife habitats (Masselink et al., 2017). However, some concerns exist. Masselink et al. (2017) discussed that former agricultural sites are often difficult to restore due to the lasting impacts of livestock and farm machinery. Salt marsh restoration will considerably change the coastal landscape thus it presents the loss of artifacts of Mi'kmaw and settler history as well as human-managed land (Sherren et al., 2016). Although some ESs may be provided by restored salt marshes, this work suggests these will not be the same services; the CESs provisioned by former dykelands may not be replaced locally and there is little evidence from this work of CES deriving from salt marshes. Thus, losing dykelands to salt marshes will greatly reduce socio-cultural values of the landscape, such as aesthetics, recreation, and social relations, as much as it will restore regulating functions and others such as fish nursery habitat. In Grand Pré, the cultural heritage value and the Acadian sense of place and identity will be impossible to compensate, although this would—as a UNESCO site—be the least likely dyke to be changed.

Managed realignment is another option that shortens the dykes so that partial dykelands can be preserved, along with increased foreshore marsh, and this presents a balanced option for preserving essential CESs (Munang et al., 2013). Tengberg et al. (2012) also suggested that landscape and place are the visible linkages between ecosystem functioning outcomes and cultural values, so the most iconic landscape features that contain socio-cultural messages should be preserved. Utility values, such as recreational activities and educational use, may be compensated in the new landscape or other places. However, if the length of realigned dykes is greatly reduced (e.g., changing these recreationally valued dykes to commuting infrastructure), activities such as running, walking, and biking may be considerably limited as well. Although managed realignment is a better opportunity to continue existing CESs delivery, decisions will have to be site-specific, and thus having CES hotspot maps would be helpful.

The last option, repairing the dykes, will largely keep the existing landscape and current CESs provision. Under this scenario, the discussion will turn to the capability of maintaining the dykes in terms of the extremely high cost and overtopping risks in the future. But if expenses are tight, recreational use may be restricted in the existing dykes in the future to avoid damage and erosion.

Given they lack demographic information and are characterized by demographic biases in participation, social media data alone cannot lead to an in-depth or fully inclusive discussion. Thus, having data from more traditional methods may fill the gap. For instance, we compared our results with other research that used Q-method with similar questions (Sherren et al., 2016).

5.3. Using social media to analyze CESs delivery

Social media data and methods have been increasingly leveraged and discussed in recent social science research. Compared to conventional approaches (e.g., interview, survey, etc.), the social media data size is often larger, and the cost is much lower (Chen et al., 2018). It can convey current and place-specific signals because of users' real-time updating behavior (Oteros-Rozas et al., 2018). This also provides insights for decision-makers or researchers to monitor real-time public opinions. Asiedu (2013) admitted in her NS dykeland study that interviews sometimes inevitably cause interviewer influence on the interviewee so that the results can be biased. Passive collection of secondary social media data may be a feasible solution to reduce such bias. Besides, some absent cohorts in conventional research activities may be more easily engaged on social media such as younger generations, people who prefer to express opinions online to hide their real-life identity, and people who are not physically available for face-to-face activities like public consultations.

Social media data also have limitations that researchers must fully realize. First, the large size of data brings a higher proportion of data noise which requires more effort to select valid data. In our case, we filtered the large size of raw data which contained 123,749 posts to 30,000 in the study area to the final valid dataset with 243 posts. The data filtering in this study relied on landscape-related keywords, but not on the visual content, which might exclude valid data. The gaps in our dataset are the same as have been discussed in other research as well, such as lacking voices from people who do not have Internet access, do not use social media or only use particular platforms (Langemeyer et al., 2018). The mismatch of geo-tags and real locations has been identified as a problem in mapping social media data practices (Chen et al., 2018; Oteros-Rozas et al., 2018). We did manual data filtering work to ensure that the landscape showing in the *Instagram* posts was in the study area to avoid such mismatch. In CES studies, the biggest controversy is whether social media data can effectively reveal CESs since they are intangible. Richards and Tunçer (2018) point out the complexity to connect CESs and specific features because the motivations for taking and posting photos online can be various and often opaque. In our case study, we found that *Instagram* posts could reveal some CESs, though likely not all, and that those found triangulate well with previous research in the area (Sherren et al., 2016). Thus, social media are more likely to provide supplementary quantitative data over large spatial scales that can integrate into in-depth qualitative discussions (Richards and Friess, 2015).

Ethical issues and data accessibility have been raised from recent research using social media data (Hesse et al., 2019). Social media data published by public accounts can legally be treated as public data, however, the analysis of such data generated by individuals may lead to the erosion of privacy (Kozinets, 2015; Toivonen et al., 2019). While people can hide their real names or the researchers can anonymize their data samples, if unaggregated data is shown or quoted it can still be possible to identify an individual even with robust data anonymization strategies (Krotoski, 2012; Stephens-Davidowitz, 2017). Fast-changing and fast-updating data and policies, as well as fast-evolving technologies, cannot guarantee future access to social media data (Marres, 2012). For instance, it is no longer possible to acquire *Instagram* data via *Netlytic*, so other approaches would be required for those who seek to do similar work to ours.

6. Conclusion

When facing climate change and sea level rise, coastal safety is of wide concern internationally. In Atlantic Canada, dykes have been used for over 400 years to reclaim salt marsh for rich farmland and protecting the coast from ocean tides and storms. After centuries of development, and significant conversion of salt marshes this way, a high proportion of dykeland has been transferred to commercial and residential land. The CESs delivery in dykelands is now more diverse than ever before. Thus, to analyze CESs provided by dykelands and salt marshes will help decision-makers to understand how anticipated changes to dykes will influence local communities and how to mitigate potential negative impacts. In our study cases, the Belcher and Grand Pré dykelands of the Cornwallis/Jijuktu'kwejk River, posts were identified with aesthetics, recreational use, and social relations, which were more appreciated by females. Marshes (i.e., the freshwater wetland in this study) were more closely associated with artistic creation and educational value for males and locals. The foreshore salt marshes were almost absent from this dataset which might indicate their weak capacity of delivering CESs. The results may recommend a managed realignment option for the dykes which would be more likely to preserve existing CESs while adding some of the regulating and provisioning services associated with foreshore salt marsh. The biggest challenge would be to decide which part of the dyke system to protect and where to replace the CESs, especially since these decisions are pending for the extended Bay of Fundy area. This study also shows that social media data helps to reveal CESs through manual coding and statistical analysis, with a few limitations such as the difficulty of selecting valid data and the gaps among people who do not use social media. Methodological improvements are necessary to increase the validity of using social media data. Meanwhile, these Big Data are still very valuable for quantitative understanding at a large-scale population level to supplement the story. For future research, concerns may also lie in ethical issues and changing policies for the accessibility of social media data.

Acknowledgements and author roles

CC was supported by a Research Star award to Kate Sherren by the Dalhousie Faculty of Management, YC by a SSHRC Insight Grant (KS co-applicant) and NS Research and Innovation Graduate Scholarship, and HMTR by a grant from Natural Resources Canada's Climate Change Adaptation Fund (KS co-applicant). Yan Chen, Camille Caesemaecker and Kate Sherren conceived of the study, Yan Chen collected the data, Camille Caesemaecker conducted the coding, Camille Caesemaecker and HM Tuihedur Rahman carried out the statistical analysis, Yan Chen led the writing of the paper with HM Tuihedur Rahman's help for the method section, and Kate Sherren supervised all aspects.

References

Abdi, H., Valentin, D., 2007. Encyclopedia of measurement and statistics. In: Salkind, N. (Ed.), Multiple Correspondence Analysis. Sage, Thousand Oaks, CA.

Argüelles, M., Benavides, C., Fernández, I., 2014. A new approach to the identification of regional clusters: hierarchical clustering on principal components. Appl. Econ. 46 (21), 2511–2519.

Asiedu, G., 2013. Citizens' Perception of Values Associated with Dykes and Dykelands: the Case of Nova Scotia. Halifax, Nova Scotia, Canada. Retrieved from. https://dalspace.library.dal.ca/xmlui/handle/10222/21745.

Brown, G., Weber, D., 2012. Measuring change in place values using public participation GIS (PPGIS). Appl. Geogr. 34, 316–324.

Calvet-Mir, L., March, H., Corbacho-Monné, D., Gómez-Baggethun, E., Reyes-García, V., 2016. Home garden ecosystem services valuation through a gender lens: a case study in the Catalan Pyrenees. Sustainability 8, 718–731.

Campbell, C.E., 2017. Idyll and industry: Grand Pré. In: Campbell, C.E. (Ed.), Nature, Place, and Story : Rethinking Historic Sites in Canada. MQUP, pp. 54–70. Retrieved from. http://ebookcentral.proquest.com/lib/dal/detail.action?docID=4929855.

Chen, Y., Parkins, J.R., Sherren, K., 2018. Using geo-tagged Instagram posts to reveal landscape values around current and proposed hydroelectric dams and their reservoirs. Landsc. Urban Plann. 170, 283–292.

Chen, Y., Parkins, J.R., Sherren, K., 2019. Leveraging social media to understand younger people's perceptions and use of hydroelectric energy landscapes. Soc. Nat. Resour. 32 (10), 1077–1079.

Coscieme, L., 2015. Cultural ecosystem services: the inspirational value of ecosystems in popular music. Ecosystem Services 16, 121–124.

Daniel, T.C., et al., 2012. Contributions of cultural services to the ecosystem services agenda. Proc. Natl. Acad. Sci. Unit. States Am. 109 (23), 8812–8819.

Díaz, S., et al., 2018. Assessing nature's contributions to people: recognizing culture, and diverse sources of knowledge, can improve assessments. Science 359 (6373), 270–272.

Dou, Y., Zhen, L., Yu, X., Bakker, M., Carsjens, G.-J., Xue, Z., 2019. Assessing the influences of ecological restoration on perceptions of cultural ecosystem services by

residents of agricultural landscapes of western China. Sci. Total Environ. 464, 685–695.
Edwards, A., Housley, W., Williams, M., Sloan, L., Williams, M., 2013. Digital social research, social media and the sociological imagination: surrogacy, augmentation and re-orientation. Int. J. Soc. Res. Methodol. 16 (3), 245–260.
Englander, J., 2015. Climate change and rising sea level: implications for historic preservation. Forum J. 29 (4), 3–8.
Figueroa-Alfaro, R.W., Tang, Z., 2017. Evaluating the aesthetic value of cultural ecosystem services by mapping geo-tagged photographs from social media data on Panoramio and Flickr. J. Environ. Plann. Manag. 60 (2), 266–281.
Fletcher, R., Baulcomb, C., Hall, C., Hussain, S., 2014. Revealing marine cultural ecosystem services in the Black Sea. Mar. Pol. 50, 151–161.
Garner, A.J., et al., 2017. Impact of climate change on New York City's coastal flood hazard: increasing flood heights from the preindustrial to 2300 CE. Proc. Natl. Acad. Sci. Unit. States Am.: Proc. Nat. Acad. Sci. United States Am. 114 (45), 11861–11866.
Ghermandi, A., Sinclair, M., 2019. Passive crowdsourcing of social media in environmental research: a T systematic map. Global Environ. Change 55, 36–47.
Gould, R.K., Klain, S.C., Ardoin, N.M., Satterfield, T., Woodside, U., Hannahs, N., Chan, K.M., 2014. A protocol for eliciting nonmaterial values through a cultural ecosystem services frame. Conserv. Biol. 29 (2), 575–586.
Hesse, A., Glenna, L., Hinrichs, C., Chiles, R., Sachs, C., 2019. Qualitative research ethics in the big data era. Am. Behav. Sci. 63 (5), 560–583.
Husson, F., Josse, J., Pagès, J., 2010. Principal Component Methods - Hierarchical Clustering - Partitional Clustering: Why Would We Need to Choose for Visualizing Data? AGRO-CAMPUS OUEST.
Kozinets, R.V., 2015. In: Netnography: Refefined, second ed. SAGE, London, UK.
Krotoski, A.K., 2012. Data-driven research: open data opportunities for growing knowledge, and ethical issues that arise. Insights 24 (1), 28–32.
Langemeyer, J., Calcagni, F., Baró, F., 2018. Mapping the intangible: using geolocated social media data to examine landscape aesthetics. Land Use Pol. 77, 542–552.
Marres, N., 2012. The redistribution of methods: on intervention in digital social research, broadly conceived. Socio. Rev. 60 (S1), 139–165.
Masselink, G., et al., 2017. Evaluation of salt marsh restoration by means of self-regulating tidal gate - avon estuary, South Devon, UK. Ecol. Eng. 106, 174–190.
Michener, W.K., Blood, E.R., Bildstein, K.L., Brinson, M.M., Gardner, L.R., 1997. Climate change, hurricanes and tropical storms, and rising sea level in coastal wetlands. Ecol. Appl. 7 (3), 770–801.
Milcu, A.I., Hanspach, J., Abson, D., Fischer, J., 2013. Cultural ecosystem services: a literature review and prospects for future research. Ecol. Soc. 18 (3), 44.
Millennium Ecosystem Assessment, 2005. Ecosystems and Human Well-Being: Aframework for Assessment. Island Press, Wahington, DC.
Minano, A., Johnson, P.A., Wandel, J., 2018. Visualizing flood risk, enabling participation and supporting climate change adaptation using the Geoweb: the case of coastal communities in Nova Scotia, Canada. Geojournal 83, 413–425.
Munang, R., Thiaw, I., Alverson, K., Mumba, M., Liu, J., Rivington, M., 2013. Climate change and ecosystem-based adaptation: a new pragmatic approach to buffering climate change impacts. Curr. Opin. Environ. Sustain. 5, 1–5.
Natural Resources Canada, 2001. An outline map without names which shows only Canada's coastline and boundaries. Retrieved Janurary 14, 2020, from. http://www.nrcan.gc.ca/earth-sciences/geography/atlas-canada/reference-maps/16846.
Nerem, R.S., Beckley, B.D., Fasullo, J.T., Hamlington, B.D., Masters, D., Mitchum, G.T., 2018. Climate-change–driven accelerated sea-level rise detected in the altimeter era. Proc. Natl. Acad. Sci. Unit. States Am.: Proc. Nat. Acad. Sci. United States Am. 115 (9), 2022–2025.
Nova Scotia Department of Agriculture Marketing, 1987. Maritime Dykelands: the 350 Year Struggle. Halifax: Marketing. Nova Scotia Department of Agriculture.
Oteros-Rozas, E., Martín-López, B., Fagerholm, N., Bieling, C., Plieninger, T., 2018. Using social media photos to explore the relation between cultural ecosystem services and landscape features across five European sites. Ecol. Indicatiors 94, 74–86.
Pew Research Center, 2019. Social Media Fact Sheet. Retrieved August 1, 2019, from Pew Research Center. https://www.pewinternet.org/fact-sheet/social-media/.
Plieninger, T., Dijks, S., Oteros-Rozas, E., Bieling, C., 2013. Assessing, mapping, and quantifying cultural ecosystem services at community level. Land Use Pol. 33, 118–129.
Richards, D.R., Friess, D.A., 2015. A rapid indicator of cultural ecosystem service usage at a fine spatial scale: content analysis of social media photographs. Ecol. Indicat. 53, 187–195.
Richards, D.R., Tunçer, B., 2018. Using image recognition to automate assessment of cultural ecosystem services from social media photographs. Ecosystem Services 31, 318–325.
Ridding, L.E., et al., 2018. The importance of landscape characteristics for the delivery of cultural ecosystem services. J. Environ. Manag. 206, 1145–1154.
Shah, D.V., Cappella, J.N., Neuman, W.R., 2015. Big data, digital media, and computational social science: possibilities and perils. Ann. Am. Acad. Polit. Soc. Sci. 659, 6–13.
Sherren, K., Bowron, T., Graham, J.M., Rahman, H.M., van Proosdij, D., 2019. Coastal infrastructure realignment and salt marsh restoration in Nova Scotia, Canada. In: Responding to Rising Seas: OECD Country Approaches to Tackling Coastal Risks. OECD Publishing, Paris, France, pp. 111–135. https://doi.org/10.1787/9789264312487-en (Chapter 5), Retrieved from.
Sherren, K., Loik, L., Debner, J.A., 2016. Climate adaptation in 'new world' cultural landscapes: the case of Bay of Fundy agricultural dykelands (Nova Scotia, Canada). Land Use Pol. 51, 267–280.
Sherren, K., Parkins, J.R., Holmlund, M., Chen, Y., 2017. Digital archives, big data and image-based culturomics for social impact assessment: opportunities and challenges. Environ. Impact Assess. Rev. 67, 23–30.
Smith, M., Ram, Y., 2016. Tourism, landscapes and cultural ecosystem services: a new research tool. Tour. Recreat. Res. 42 (1), 113–119.
Stephens-Davidowitz, S., 2017. Everybody Lies: Big Data, New Data, and what the Internet Can Tell Us about Who We Really Are. HarperCollins, New York, NY.
Tengberg, A., Fredholm, S., Eliasson, I., Knez, I., Saltzman, K., Wetterberg, O., 2012. Cultural ecosystem services provided by landscapes: assessment of heritage values and identity. Ecosystem Services 2, 14–26.
Toivonen, T., et al., 2019. Social media data for conservation science: a methodological overview. Biol. Conserv. 233, 298–315.
van Berkel, D.B., Tabrizian, P., Dorning, M.A., Smart, L., Newcomb, D., Mehaffey, M., Meentemeyer, R.K., 2018. Quantifying the visual-sensory landscape qualities that contribute to cultural ecosystem services using social media and LiDAR. Ecosystem Services 31, 326–335.
van Proosdij, D., CBWES Inc., 2011. Dykelands: Climate Change Adaptation. Atlantic Climate Adaptation Solutions Association (ACASA), Halifax, Canada.
van Proosdij, D., Page, S., 2012. Best Management Practices for Climate Change Adaptation in Dykelands: Recommendations for Fundy ACAS Sites. https://doi.org/10.13140/2.1.3113.0405. Retrieved from.
van Zanten, B.T., Van Berkel, D.B., Meentemeyer, R.K., Smith, J.W., Tieskens, K.F., Verburg, P.H., 2016. Continental-scale quantification of landscape values using social media data. Proc. Natl. Acad. Sci. U. S. A. 113 (46), 12974–12979.