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WETLANDS CONSERVATION

A Citizen Science State of the World's Wetlands Survey

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Abstract

Citizen science is increasingly recognised as a valuable approach to improve the knowledge and understanding required for robust environmental management. We report on the results of a citizen science survey conducted on the status and trends of over 500 wetlands from across the globe. Whilst many wetlands were reported as being in fair or good ecological character state, many (particularly those already in a poor state) were reported as deteriorating. Although designated Ramsar Sites were reported as currently having a slightly better state than other wetlands, widespread deterioration of Ramsar Sites as well as other wetlands was reported. Significant regional differences were reported on the state of wetlands and their extent of improvement or deterioration. Large wetlands, particularly in Africa but also in Latin America and the Caribbean, were reported to be in a worse, and increasingly deteriorating, state than smaller wetlands in North America, Europe and Oceania. Numerous drivers are contributing to degradation and loss of wetlands. However, our data suggest that positive outcomes can be delivered where local community awareness, implementation of conservation measures, cultural values/traditions, tourism and forestry are proactively integrated in order to achieve the wise use of wetlands.

Keywords Citizen science · Global assessment · Ecological character · Wetland status and trends

Introduction

Despite increasing evidence of the vast value of the benefits that coastal and inland wetlands provide to people (Russi et al. 2013; Costanza et al. 2014; Davidson et al. 2019a), the world's wetlands continue to be converted and destroyed (Davidson 2014; Dixon et al. 2016; Ramsar Convention 2018; Darrah et al. 2019). Understanding the state of wetlands, and their respective geographical distribution, is vital to inform and support policy-makers and decision-takers in acting to better safeguard wetlands so as to deliver on commitments and targets under processes such as the Ramsar Convention on Wetlands, the 2020 "Aichi Targets", the 2030 UN Sustainable Development Goals (SDGs) and the Nationally Determined Contributions (NDCs) under the Paris Agreement. However, there is insufficient information available about the state, and trends in state, of our remaining wetlands.

Although different aspects of wetland ecological character state and trends have been assessed in different parts of the world, and for different purposes, these reports are widely scattered through the literature and their results presented in many different ways. For instance, it has been reported by national governments, in their National Reports to the Ramsar Convention on Wetlands, that there is more widespread deterioration, and that designated Wetlands of International Importance (Ramsar Sites) are reported as deteriorating less than all wetlands (Davidson et al. in press).

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Citizen science has made substantial contributions to many scientific disciplines and has been actively promoted to improve conservation science (McKinley et al. 2017). Citizen science-based survey and monitoring is increasingly recognised and demonstrated as a reliable and valuable complement to standardised ecological monitoring, for example for long-term waterbird population monitoring in the UK (Frost et al. 2017) and globally (International Waterbird Census (IWC), see https://www.wetlands.org/our-approach/healthy-wetland-nature/international-waterbird-census/#read-more) for all bird species in Southern Africa (SABAP, see http://sabap2.adu.org.za), for butterflies (Dennis et al. 2017), for dragonflies (see http://www.cdu.edu.au/enews/stories/citizen-dragonfly), for assessing trends in individual species' abundance (e.g. van Strien et al. 2013; Sparks et al. 2017), for long-term forest monitoring (e.g. Roberts et al. 2015), and for hydrology and water resources monitoring (e.g. Buytaert et al. 2014) including water quality monitoring (Farnham et al. 2017; World Bank 2016; Jollymore et al. 2017). Specific wetland-related initiatives have utilised citizen science for the conservation planning for vernal pools (Oscarson and Calhoun 2007; Jansujwicz et al. 2013), the state of estuarine wetlands (Thelen and Thiet 2008) and long-term impacts of eutrophication on riverine wetlands (Abbott et al. 2018).

Such approaches are increasingly being acknowledged as contributing sound information to inform the achievement of the SDGs (e.g. Baharoon 2015; Lu et al. 2015; Global Partnership for Sustainable Development Data 2016), and can lead to positive conservation-related outcomes (Ballard et al. 2017). Chandler et al. (2017) advocate that governments and non-governmental organisations tap in to all possible data sources, including citizen science initiatives, in order to meet the collective international biodiversity monitoring obligations. The Global Wetland Outlook (Ramsar Convention 2018) echoes this plea, makes the explicit point that not all knowledge needs for wetland monitoring, management and policy making require cost-intensive and sophisticated monitoring, and calls for wetland managers to make the best use of citizen science.

We report on the results of a qualitative citizen science survey of the state of the world's wetlands, designed to contribute to filling the gap in knowledge of the state of the world's remaining wetlands, through inviting anyone who knows a wetland to report on their perceptions of its current state, the recent change in that state, and what drivers they consider are leading to the state and change in state they report. We also briefly address the utility of a citizen science approach to provide insights on the state of the world's remaining wetlands.

Materials and Methods

A questionnaire survey on the state of wetlands was developed jointly by members of the Society of Wetland Scientists' (SWS) Ramsar Section, the World Wetland Network (WWN) and the Wildfowl & Wetlands Trust (WWT). The survey structure was developed from a similar survey for the Mediterranean Basin wetlands earlier conducted by the Ramsar Convention Secretariat (Stark et al. 2004).

Questions in the survey covered inter alia the name, location and area of the wetland; the occupation of the respondent; whether the wetland is wholly, partly or not a Ramsar Site; whether the area of the wetland has recently changed; the current ecological character state of the wetland; the overall trend in the state of the wetland (where trend in state represents a view on the direction of change in state, e.g. improving, not changing, deteriorating over a time period of at least 2 years); the status of 23 potential drivers of wetland state, whether the driver is positive or negative and increasing or decreasing; and, for Ramsar Sites, whether the respondent considered that Ramsar designation has had a positive or negative influence on the state of the wetland. The full questionnaire is provided in the Supplementary materials.

The questionnaire was issued online (using http://www.surveymonkey.co.uk) in six languages (English, French, Spanish, Arabic, Russian and Chinese). To assist respondents without adequate internet access, the survey was also made available in Excel format for offline use in the six languages and also in Japanese. The survey was launched in mid-May 2017 and closed at the end of September 2017. Information about the survey was circulated to a wide range of wetland expert networks, with recipients encouraged to further circulate the survey to their own networks and colleagues.

Survey responses were assessed for their completeness, and only those that provided wetland site information, respondent information, and answers to most or all of the other survey questions were included in the analyses. Since not all these respondents answered all questions, sample sizes of responses varies among the different questions.

We calculated an Ecological Character Status Index (ECSI) to provide a single, comparable metric of ecological character status and trends, applying a method used by Butchart et al. (2010), Wetlands International (2010) and Davidson et al. (in press). Reported state or trend in state is allocated a score of either +1: good/increase/improvement; 0: fair/no change, or − 1: poor/ decrease/deterioration. Where response options included intermediate positive or negative responses these were scored +0.5 or − 0.5. The total number of responses is each scoring category and overall is denoted by n. The ECSI is calculated as:

$$\frac{\sum n_{+1} - \sum n_{-1}}{n_{total}}$$

The index thus factors in the number of reports of "no change". The ECSI range is from +1 to −1. For reports concerning drivers we calculated a Driver State Index as the ratio of positive and negative reports; and a Driver Trend Index as the ratio of reports of drivers increasing and decreasing, both using the same approach as for the ECSI.

Results are presented globally, and regionally for the six Ramsar Regions (see Ramsar Convention (2015)). Sufficient responses to conduct sub-regional analyses were obtained from three Regions, namely Africa (North and Sub-Saharan Africa), Asia (West & Central, South, and East & South-east Asia), and Europe (East & South Europe, and North & West Europe). There were insufficient reports to analyse Caribbean islands separately from Latin America, or Pacific Islands from Australasia. Results are also presented for inland and coastal wetlands; for Ramsar and non-Ramsar Sites; for wetlands of different sizes; and by different categories of respondent.

Statistical analyses were conducted in XLStat and VassarStat (http://vassarstats.net/index.html).

Results

Number of Responses

A total of 600 responses were received. Of these, 59 were either incomplete or were duplicate entries from the same respondent for the same wetland. A total of 541 responses from 92 countries were assessed as being sufficiently complete to include in this analysis. Over 50 responses were received for each of the six Ramsar Regions: Asia 82, Africa 98, Europe 133, Latin America and the Caribbean (LAC) 81, North America 89, and Oceania 58 (Fig. 1).

Ten or more responses were received from 15 countries, the largest number of responses being from the USA (62), Australia (50), UK (31), Spain (25), Colombia (23), Canada (22), Chile (20) and India (20). Responses from these eight countries accounted for 47% of the total of complete responses.

Categories of Respondent

Survey responses were received from a range of types of respondent (Table 1). Most responses came from non-governmental organisations (NGOs) (32.9%) and academia (researchers) (21.4%). Combined, responses from government officials of all types (national and local) accounted for 20.3% of the total responses. Relatively few responses (7.0%) were received from people (landowners, site managers, local residents) 'on the ground' at a wetland, suggesting that the circulation of this survey did not substantially reach such stakeholders or citizens.

The distribution and homogeneity of the type of respondent were evaluated in order to select the appropriate test for assessing statistically significant differences in reporting among different categories of respondent. A Shapiro-Wilk test demonstrated that the data were not normally distributed for the category of respondent and the state of the wetland, the change in state, the region and the length of time the respondent had known the wetland ($p < 0.0001$ for all). A Levene's test was conducted to assess the assumption of homogeneity for the types of respondent and the state of the wetland, the change in state, the region and the length of time the respondent had known the wetland. The Levene's test indicated that the assumption of homogeneity was not met ($F(40,493) = 3.548$, $p < 0.0001$). Therefore, a Kruskal-Wallis test was performed to assess if there was a statistically significant difference among the means for the type of respondent and the reporting on the state of the wetland, the change in state, the region from which they were reporting and the length of time the respondent had known the wetland. The Kruskal-Wallis test indicated that there was a significant difference between the type of respondent and the region from which they were reporting ($K = 45.611$, $\alpha = 0.05$, $p < 0.0001$), the type of respondent and the length of time that they had known the wetland ($K = 41.032$, $\alpha = 0.05$, $p < 0.0001$) and the reporting on the change in state ($K = 27.853$, $\alpha = 0.05$, $p = 0.006$). The test indicted that there was no statistically significant difference between the means for the type of respondent and their reporting on the state of the wetland ($K = 15.312$, $\alpha = 0.05$, $p = 0.225$).

Post hoc tests were conducted to evaluate pairwise comparisons using the Bonferroni correction. This indicated that there were no significant pairwise differences between the type of respondent and the reporting on state or change in state. However, the post hoc test suggested that there were statistically significant differences between the type of respondent and the region from which they were reporting for NGOs and Academics ($\alpha = 0.0006$, $p < 0.0001$), and NGOs and Civil Society Organisations ($\alpha = 0.0006$, $p = 0.001$). Academics primarily responded from Europe (Academics = 32.76%; NGOs = 20.33%) and North America (Academics = 24.14%; NGOs = 9.34%), whereas Civil Society Organisations primarily responded from LAC (Civil Society Organisation = 43.75%; NGOs = 11.54%).

Similarly, the post hoc test indicated that there were statistically significant differences between the type of respondent and the duration over which they had known the wetland, with

Fig. 1 The number of survey responses received from different countries

the duration that students (M = 5.28, SD = 5.56) had known the wetland and NGOs ($\alpha = 0.0006$, $p < 0.0001$; M = 18.58, SD = 14.83), Academics ($\alpha = 0.0006$, $p < 0.0001$; M = 17.52, SD = 12.62), Civil Society Organisations ($\alpha = 0.0006$, $p = 0.0002$; M = 20.53, SD = 14.34) and Landowners ($\alpha = 0.0006$, $p = 0.0002$; M = 19.88, SD = 14.53). This suggests that student respondents have known their wetland for a statistically significant shorter duration than these other categories of respondent, especially NGOs and Academics.

Area and Categories of Wetlands

The sizes of wetlands reported on varied greatly, from 0.001 ha to more than 5 million ha (Fig. 2). Of 507 responses

Table 1 Numbers of survey responses receive from different categories of people

Type of organisation	Number of responses	% of total
NGO	178	32.90
Academic	116	21.44
National/Regional Government (Conservation/Environment) Agency	53	9.80
Consultant	40	7.39
National/ Regional Government Department / Ministry	31	5.73
Local Government Department	26	4.81
Student	16	2.96
Site Manager	16	2.96
Landowner	16	2.96
Citizen/Civil Society Group	16	2.96
Other	11	2.03
Volunteer	7	1.29
Resident	6	1.11
IGO (Inter-governmental Organisation)	4	0.74
Private sector	2	0.37
Unspecified	3	0.55

for which an area was provided, 44.8% (227) were for wetlands of 100 to 10,000 ha, with a further 21.9% (111) of responses for wetlands of between 10,000 and 100,000 ha (Fig. 2). The area values of the wetlands for which responses were received are non-normally distributed with a strong positive skewness (10.25, $SE = 0.108$) and leptokurtic, i.e. there are occasional outliers in the data (116.439, $SE = 0.216$).

More responses were received for inland ($n = 296$, 58.4%) than for coastal wetlands ($n = 144$, 28.4%) or those that included both coastal and inland wetlands ($n = 67$, 13.2%). Inland wetlands showed the greatest diversity of area (from 0.001 to 5,958,785 ha (Fig. 3). However, the interquartile range of inland (Q1 = 73.8, Q3 = 17,000.0 ha) and coastal wetland (Q1 = 185.4, Q3 = 19,125.0 ha) was similar and there was a significant relationship between the wetland type and area ($\chi^2 = 41.932$, $\alpha = 0.05$, $p = 0.0001$).

Inclusion of Ramsar Sites and Other Wetlands in the Survey

Ramsar Sites accounted for 42.5% (230) of responses, with a further 1.7% (9) responses for wetlands that are partly Ramsar Sites. 0.2% (1) of respondents did not know the Ramsar Site status of the wetland. There were multiple reports for 28 (44.2%) of the sites identified as either partly or wholly Ramsar Sites.

Responses from Africa were predominantly for Ramsar Sites (70.4%), whilst the responses from Europe (53.4%) and Oceania (50%) were relatively evenly divided between Ramsar Sites and other wetlands. From Asia, LAC and North America, most wetlands reported on were not Ramsar Sites.

By number of Ramsar Sites, the most comprehensive coverage was for Oceania (36.3% of Ramsar Sites designated within the region) and the least comprehensive was for North America (5.1%) and Europe (6.5%) (Table 2). Of the 2290 global Ramsar Sites (as at 17 December 2017), responses were received for approximately a tenth of all Ramsar Sites, and covered 14.4% of global Ramsar Site area (Table 3).

Recent Changes in Wetland Area

We found that of 465 reports of recent (since 2015) changes in wetland area, most (68.8%) reported no change, with 8.4% of responses reporting an increase and 22.8% a decrease. The frequency of reports of a decrease in area were significantly greater than reports of an increase in wetland area (Kruskal-Wallis two-tailed test: K = 6.204, $\alpha = 0.05$, $p = 0.011$). However, the majority of reports from each region were of no change in wetland area, ranging from 49.2% (LAC) to 82.4% (Oceania). From each region, there were also more reports of area decreases than of increases, the highest percentages being from LAC (41.0% area decreases) and the lowest being from Europe (12.0%). The lowest percentages of area increases were reported from Oceania (3.9%), with the highest percentage increase being from Asia (14.7%).

No change in wetland area dominates (inland wetland 69.8%; coastal wetland 66.9%; both inland and coastal wetland 68.3%). Decreases in wetland area were recorded in greater frequency (between 22.5 and 23.3%) than were increases in wetland area for all three wetland types (between 7.6 and 10.0%). However, the relative change in area is independent of the wetland type (Kruskal-Wallis test: K = 2.333,

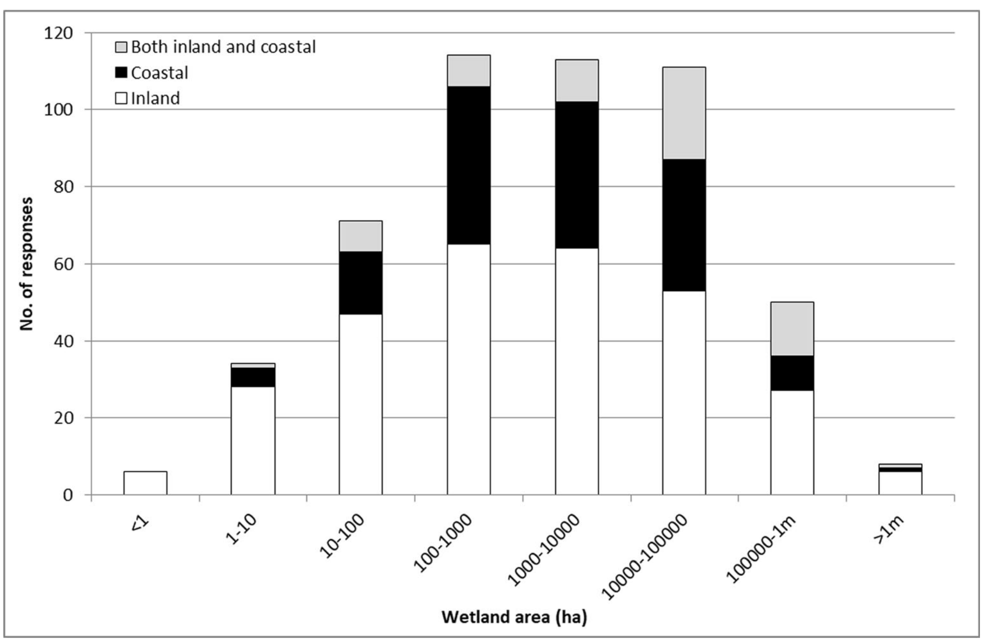

Fig. 2 The frequency of survey responses for wetlands of different areas

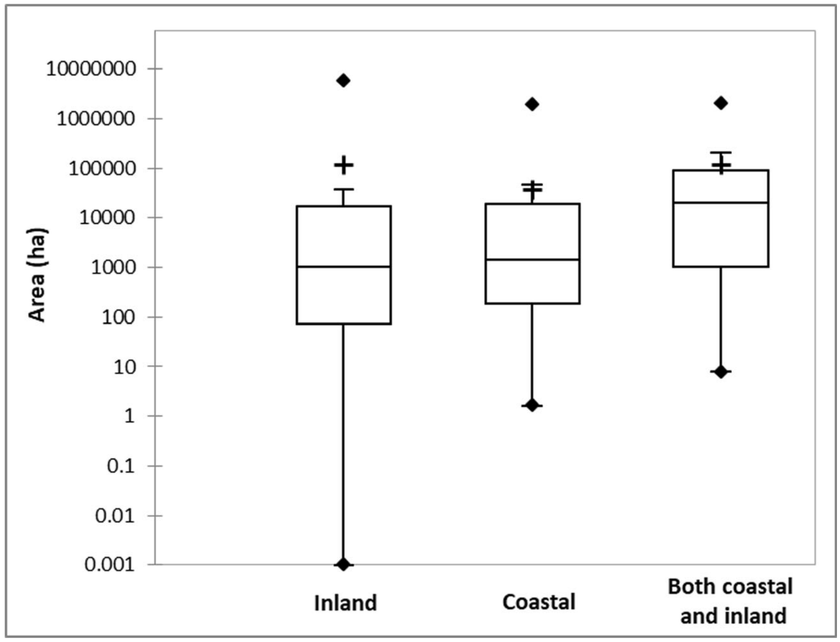

Fig. 3 Distribution of area ranges for the three wetland categories

$\alpha = 0.05$, $p = 0.200$) suggesting that changes in area are occurring across all wetland types.

Reported changes in area of Ramsar Sites reflected a similar picture to that of all wetlands. Approximately 70% of wetlands that were reported to be wholly or partly Ramsar Sites had undergone no change in area. 22.4% of wetlands reported as Ramsar Sites recorded a decrease in area, while 8% reported an increase in the area of the Ramsar Site wetland. However, the relative change in area is independent of whether the wetland is a Ramsar Site or not ($\chi^2 = 0.915$, $\alpha = 0.05$, $p = 0.922$) suggesting that whether the size of a wetland is increasing or decreasing is independent of designation as a Ramsar Site.

Reports of increases and decreases in wetland area came from all sizes of wetlands, with more area decreases (25.5%) than increases (9.5%) reported for all categories of wetland area but with no change in wetland area most frequently recorded (64.0%) across all sizes of wetland. However, the relative change in area is not independent of wetland size ($\chi^2 = 62.907$, $\alpha = 0.05$, $p < 0.0001$) suggesting that there is a relationship between wetland size and whether it is increasing or decreasing in area. A significantly higher number of responses were recorded for decreases in wetlands between 10,000 and 100,000 ha (Adj. Residual = 7.016, $\alpha = 0.05$) and a significantly smaller number of decreases were recorded than expected for wetlands between 100 and 1000 ha (Adj. Residual = −2.715, $\alpha = 0.05$).

Current State of Wetlands

Most wetlands were reported to be in a fair state (45.7%), with a higher percentage in a good state (30.2%) than in a poor state (24.2%). North America had the highest percentage of wetlands reported to be in a good state (47.2%) and Africa the lowest percentage (16.3%) (Table 4). The converse of this was also the same with North America reporting the lowest (10.1%) and Africa reporting the highest (38.8%) of wetlands in a poor state.

There was a significant relationship between wetland state and the region ($\chi^2 = 42.947$, $\alpha = 0.05$, $p < 0.0001$). A

Table 2 Number of Ramsar sites covered by the survey

Region	Total Ramsar sites	Ramsar sites (wholly and partially) with responses	% of Ramsar sites represented in survey
Africa	388	69	17.8
Asia	319	35	11.0
Europe	1092	71	6.5
LAC	194	24	12.4
North America	217	11	5.1
Oceania	80	29	36.3
TOTAL	2290	239	10.4

Table 3 Area of Ramsar sites covered by the survey

Region	Total area (ha) of Ramsar sites	Area (ha) of Ramsar sites (wholly and partially) with responses	% of Ramsar site area represented in survey
Africa	104,257,239	23,774,325	22.8
Asia	18,063,760	891,007.40	4.93
Europe	27,834,335	1,984,671.30	7.13
LAC	42,600,693	3,377,864.80	7.93
North America	23,604,703	158,228.90	0.67
Oceania	9,051,211	2,322,089	25.66
TOTAL	225,411,940	32,508,186.40	14.41

significantly higher number of wetlands are reported to be in a poor state in Africa (Adj. Residual = 3.742, $\alpha = 0.05$) and a significantly higher number of wetlands were in a good state from North America (Adj. Residual = 3.838, $\alpha = 0.05$) and Oceania (Adj. Residual = 2.277, $\alpha = 0.05$). A significantly lower number were reported to be in a good state than expected from Africa (Adj. Residual = −3.300, $\alpha = 0.05$) and LAC (Adj. Residual = −2.477, $\alpha = 0.05$). Sub-regional differences were observed, with significantly more reports of a poor state from Sub-Saharan Africa and significantly more reports of a good state in East and South-east Asia (Adj. Residual = 3.251, $\alpha = 0.05$).

The overall state of wetlands in the regions, and sub-regions, was described by the derived ECSI in Table 4. North America reported the highest ECSI (ECSI = +0.371) while a negative index reported from Africa (ECSI = −0.224) and LAC (ECSI = -0.099) suggesting that the overall state of wetlands reported is close to fair. The lowest ECSI is reported from North Africa (ECSI = −0.357) reflecting a high percentage of wetlands reported as being either poor (42.9%) or fair (50.0%).

No significant difference was observed for the current state of different wetland types ($\chi^2 = 5.160$, $\alpha = 0.05$, $p = 0.271$). Inland wetlands were predominantly reported as being in fair condition (47.9%) and with more in a good state (30.2%) than in a poor state (21.9%). Coastal wetlands were reported to be predominantly in a fair state (46.0%) with the same number being reported as either in a good or poor state (27.0%). More wetlands reported as being both inland and coastal a were in a good state (36.6%) than in a fair (35.2%) or poor (28.3%) state.

There was no significant difference in the state of wetlands that are designated as Ramsar Sites from those that are not Ramsar Sites ($\chi^2 = 4.631$, $\alpha = 0.05$, $p = 0.327$) (Table 5). Wetlands that have been designated as being Ramsar Sites were reported to be in a similar state (ECSI = +0.053) to those that are not Ramsar Sites (ECSI = +0.074). However, a slightly higher percentage of wetlands that are not designated as Ramsar Sites (31.8%) were reported to be in a good state than those that are designated as being internationally important (29.0%). Conversely, a slightly lower percentage of wetlands that are designated as Ramsar Sites (23.7%) were reported to be in a poor state than were those that are not designated as being internationally important (24.3%).

We found that the current state of wetlands varied by size category ($\chi^2 = 27.767$, $\alpha = 0.05$, $p = 0.015$) (see Table 6; Fig. 4), indicating that large wetlands are in a worse state than smaller ones ($r_s = -0.101$, $\alpha = 0.05$, $p = 0.028$). Wetlands between 1 and 10 ha were most frequently reported as being in a good state (46.7%). Wetlands between 1000 and 10,000 ha were most frequently reported as being in a poor state (34.2%) and had the lowest ECSI (−0.126). A significantly higher number of wetlands between 1000 and 10,000 ha were reported to be in a poor state (Adj. Residual = 3.042, $\alpha = 0.05$) than expected and a significantly lower number of wetlands

Table 4 Percentage reports and Ecological Character Status Indices (ECSIs) of the current reported state of wetlands

		% of reports			
Region:	N	Poor	Fair	Good	ECSI
Africa	98	38.78	44.90	16.33	-0.224
North Africa	*14*	42.86	50.00	7.14	-0.357
Sub-Saharan Africa	*84*	38.10	44.05	17.86	−0.202
Asia	81	20.99	43.21	35.80	0.148
West and Central Asia	*7*	14.29	71.43	14.29	0.000
South Asia	*23*	34.78	43.48	21.74	−0.130
East and South East Asia	*51*	15.69	39.22	45.10	0.294
Europe	127	25.20	48.03	26.77	0.016
East and South Europe	*72*	29.17	48.61	22.22	−0.069
North and West Europe	*55*	20.00	47.27	32.73	0.127
LAC	81	28.40	53.09	18.52	−0.099
North America	89	10.11	42.70	47.19	0.371
Oceania	58	17.24	39.66	43.10	0.259
Wetland type:	N	Poor	Fair	Good	ECSI
Inland	315	21.90	47.94	30.16	0.083
Coastal	148	27.03	45.95	27.03	0.000
Both inland and coastal	71	28.17	35.21	36.62	0.085

Table 5 Percentage reports and Ecological Character Status Indices (ECSIs) of the current reported state of wetlands which are Ramsar sites

		% of reports			
Ramsar site	N	Poor	Fair	Good	ECSI
Wholly a Ramsar site	228	23.68	47.37	28.95	0.053
Partly a Ramsar site	9	33.33	66.67	0.00	−0.333
Not a Ramsar site	296	24.32	43.92	31.76	0.074
Don't know	1	0.00	0.00	100.00	1.000

Table 6 Percentage reports and Ecological Character Status Indices (ECSIs) of the current reported state of wetlands by area

Area (ha)	N	% of reports			ECSI
		Poor	Fair	Good	
<1	6	33.33	33.33	33.33	0.000
1–10	30	23.33	30.00	46.67	0.233
10–100	71	23.94	42.25	33.80	0.099
100–1000	113	12.39	46.90	40.71	0.283
1000-10,000	111	34.23	44.14	21.62	−0.126
10,000–100,000	109	22.02	53.21	24.77	0.028
100,000–1 million	51	27.45	39.22	33.33	0.059
>1 million	8	12.50	37.50	50.00	0.375

between 100 and 1000 ha were reported as being in a poor state (Adj. Residual = −3.154, $\alpha = 0.05$).

Change in State of Wetlands

Of 506 reports of the recent (since 2015) trend in the state of wetlands, there were more reports of no change (40.8%) than of improvement or deterioration. However, there was a significant relationship between wetland region and the trend in its state ($\chi^2 = 64.653$, $\alpha = 0.05$, $p < 0.0001$) (Table 7). Significantly more wetlands were reported as showing major deterioration and deterioration in LAC, and significantly fewer wetlands were reported to be undergoing major deterioration in Europe, particularly in North and West Europe (Adj. Residual = −2.007; $\alpha = 0.05$). Significantly more wetlands were reported to be showing an improvement or major improvement in East and South East Asia (Adj. Residual = 3.205, $\alpha = 0.05$ and Adj. Residual = 2.604, $\alpha = 0.0$ respectively). The ECSIs for the trend in state (Table 7) reflected this, with the most widespread deterioration reported from LAC (ECSI = -0.340) and the most widespread improvement reported from wetlands in East and South East Asia (ECSI = + 0.091).

We found a positive correlation between the state of wetlands and the direction of change in condition ($r^2 = 0.479$), suggesting that wetlands with a negative ECSI state also had a negative ECSI for trend in state. Wetlands reported as having a fair to good state (ECSI between 0 and 1) were either demonstrating little change in state or, in the case of those reported from parts of Asia, were reported as improved in state. There appears to be a widening divide between wetlands reported as currently in a good state (over 90% of which are either not changing or improving in state) and those reported as currently in a poor state (over 70% of which were deteriorating in state) (Fig. 5).

There was no significant difference in the trend in the state of different wetland types ($\chi^2 = 7.815$, $\alpha = 0.05$, $p = 0.452$), with all three categories reporting slightly more deterioration than improvement (Table 7). However, when deterioration and major deterioration are combined, wetlands that include

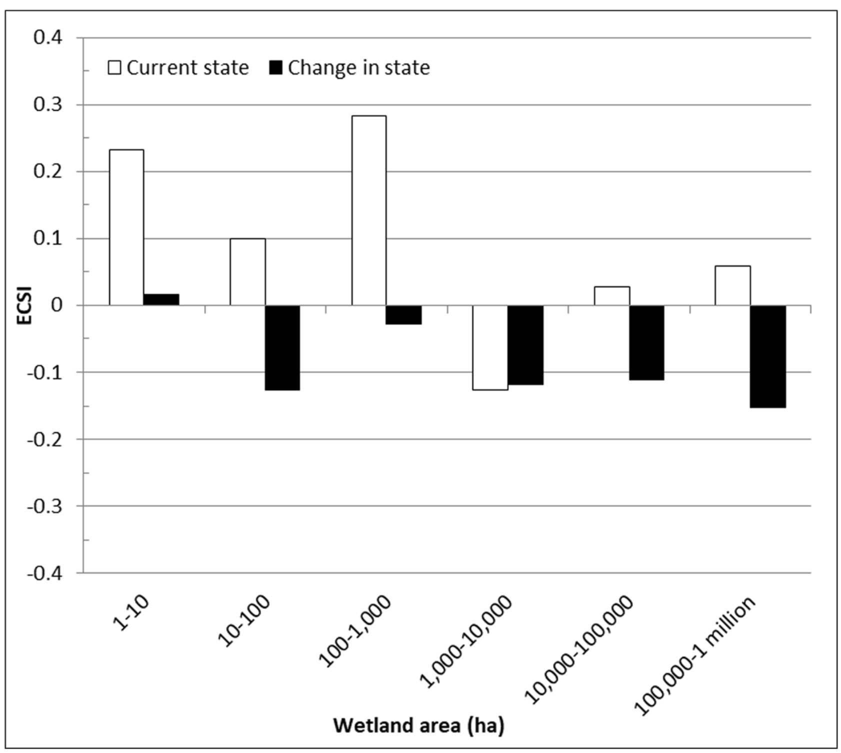

Fig. 4 Ecological Character Status Indices (ECSIs) for current state and change in state of wetlands of different areas (excluding the small number of reports for wetlands <1 ha and > 1 million hectares (see Tables 6 and 9)

Table 7 Percentages and Ecological Character Status Indices (ECSIs) of reports of the recent trend in the state of wetlands

Region:	N	Major Deterioration	% of reports Deterioration	No change	Improvement	Major improvement	ECSI
Africa	98	9.18	31.63	39.80	12.24	2.04	**−0.177**
North Africa	14	14.29	14.29	50.00	14.29	0.00	−0.153
Sub-Saharan Africa	84	8.33	34.52	38.10	11.90	2.38	−0.181
Asia	81	3.70	25.93	35.80	25.93	6.17	**0.025**
West and Central Asia	7	0.00	28.57	57.14	14.29	0.00	−0.071
South Asia	23	0.00	39.13	43.48	13.04	4.35	−0.086
East and South East Asia	51	5.88	19.61	29.41	33.33	7.84	0.091
Europe	127	1.57	26.77	51.18	16.54	1.57	**−0.052**
East and South Europe	72	2.78	26.39	47.22	18.06	1.39	−0.057
North and West Europe	55	0.00	27.27	56.36	14.55	1.82	−0.045
LAC	81	16.05	41.98	17.28	13.58	0.00	**−0.340**
North America	89	3.37	21.35	51.69	14.61	3.37	**−0.035**
Oceania	58	1.72	24.14	43.10	22.41	1.72	**−0.009**
Wetland type:							
Inland	314	5.73	26.43	42.68	18.15	3.18	−0.070
Coastal	149	4.03	32.89	36.91	16.78	1.34	−0.116
Both inland and coastal	71	9.86	29.58	40.85	12.68	1.41	−0.179

both inland and coastal wetlands (39.4%) were undergoing the greatest overall deterioration. In contrast, inland wetlands were reported as having the most widespread improvement (21.3%).

Designation as a Ramsar Site had no significant difference in the changing state of wetlands ($\chi^2 = 5.529$, $\alpha = 0.05$, $p = 0.700$) (Table 8). Of the 216 Ramsar Sites, 37.5% were reported as deteriorating in state, a slightly greater percentage than

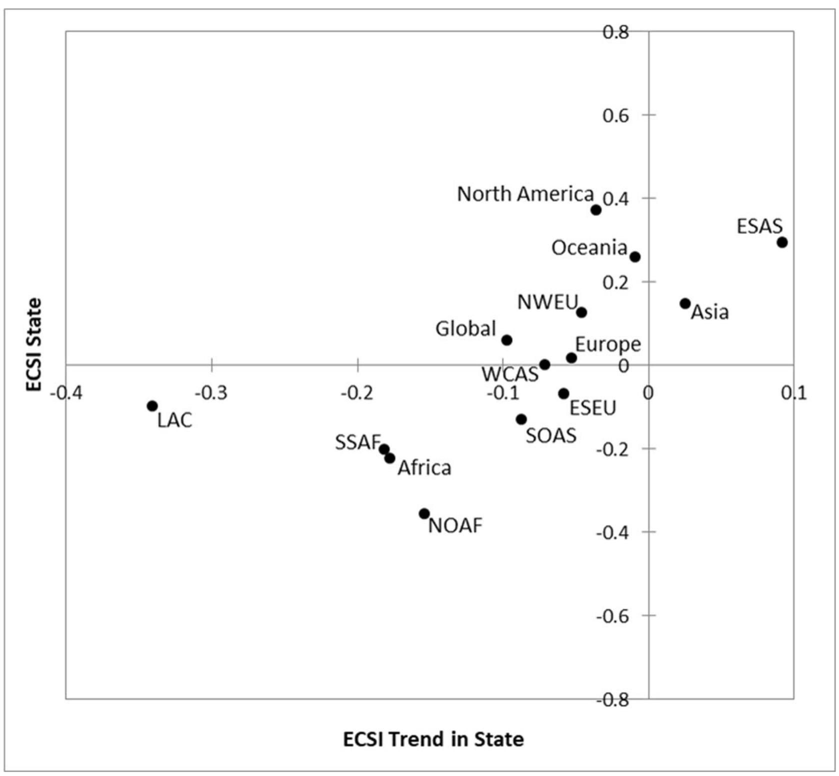

Fig. 5 Regression analysis of Ecological Character Status Indices (ECSIs) of reported state and trend in state of wetlands in different regions and sub-regions ($r^2 = 0.479$). (NOAF North Africa; SSAF Sub-Saharan Africa; WCAS West and Central Asia; SOAS South Asia; ESAS East and South East Asia; ESEU East and South Europe; NWEU North and West Europe; LAC Latin America and Caribbean)

Table 8 Percentages and Ecological Character Status Indices (ECSIs) of reports of the recent trend in the state of wetlands which are wholly, partly or not Ramsar sites

			% of reports				
Ramsar site	N	Major deterioration	Deterioration	No change	Improvement	Major improvement	ECSI
Wholly a Ramsar site	216	5.56	31.94	42.59	18.06	1.85	−0.114
Partly a Ramsar site	9	0.00	55.56	22.22	22.22	0.00	−0.167
Not a Ramsar site	280	6.79	28.21	43.93	17.86	3.21	−0.095
Don't know	1	0.00	0.00	100.00	0.00	0.00	0.000

for non-Ramsar Sites (35.0%). However, the greatest deterioration was reported for wetlands that are partly Ramsar Sites (55.6%, ECSI = -0.167). Only 19.9% of Ramsar Sites and 21.1% of non-Ramsar Sites were reported as improving in state.

Wetland size had no significant difference in the trend in state ($\chi^2 = 23.465$, $\alpha = 0.05$, $p = 0.709$) (Table 9) or their reported trend in state ($r_s = -0.059$, $\alpha = 0.05$, $p = 0.196$). However, there was a general trend of increasing extent of deterioration (or decreasing ECSI score) reported from small wetlands to large wetlands (Fig. 4). The greatest frequency of deterioration was reported for wetlands between 100,000 and 1 million ha (42.9%, ECSI = -0.153). Wetlands of less than 1 ha had the highest frequency of improvement (33.3%, ECSI = 0.083).

Current State and Trend in State of Wetlands Reported by Different Types of Respondent

A Chi-squared test indicated that there were no overall significant differences between the current state of wetlands as reported by different types of respondent ($\chi^2 = 28.500$, $\alpha = 0.05$, $p = 0.240$). However, NGO respondents reported significantly more wetlands in a poor state (Adj. Residual = 2.488; $\alpha = 0.05$) and local government respondents reported significantly more wetlands in a good state than expected (Adj. Residual = 2.356; $\alpha = 0.05$). Students reported significantly more wetlands were in a fair state than expected (Adj. Residual = 1.975; $\alpha = 0.05$).

Similarly, a Chi squared test suggested that there were no significant overall differences among the responses from different types of respondent on the trend of state of wetlands ($\chi^2 = 58.331$, $\alpha = 0.05$, $p = 0.146$), which differed from the Kruskal-Wallis test result reported above. This might have resulted from theoretical values of less than five being present. However, local government respondents reported significantly fewer wetlands as deteriorating than expected (Adj. Residual = −2.497; $\alpha = 0.05$), whereas landowners reported significantly more wetlands deteriorating than expected (Adj. Residual = 2.847; $\alpha = 0.05$) and fewer not undergoing change (Adj. Residual = −1.990; $\alpha = 0.05$). Students reported that significantly more wetlands were undergoing a major deterioration than expected (Adj. Residual = 2.419; $\alpha = 0.05$) whilst academics reported significantly more wetlands were not changing than expected (Adj. Residual = 2.029; $\alpha = 0.05$).

Drivers of the State and Changes in State of Wetlands

The most frequently reported positive drivers of wetland state were: local community awareness ($n = 312$), implementation of conservation measures ($n = 308$), cultural values/traditions ($n = 222$), and tourism ($n = 209$) (Fig. 6). Seventeen of the 23 drivers were reported as negative by >100 respondents, with species introduction ($n = 263$) the most frequently reported.

Table 9 Percentages and Ecological Character Status Indices (ECSIs) of reports of the recent trend in the state of wetlands of different areas

			% of reports				
Area (ha)	N	Major deterioration	Deterioration	No change	Improvement	Major improvement	ECSI
<1	6	0.00	33.33	33.33	16.67	16.67	0.083
1–10	29	6.90	13.79	51.72	24.14	3.45	0.017
10–100	67	10.45	29.85	38.81	16.42	4.48	−0.127
100–1000	106	2.83	29.25	43.40	19.81	4.72	−0.028
1000-10,000	106	6.60	30.19	43.40	19.81	0.00	−0.118
10,000–100,000	103	4.85	32.04	44.66	17.48	0.97	−0.112
100,000–1 million	49	10.20	32.65	38.78	14.29	4.08	−0.153
>1 million	8	0.00	37.50	50.00	12.50	0.00	−0.125

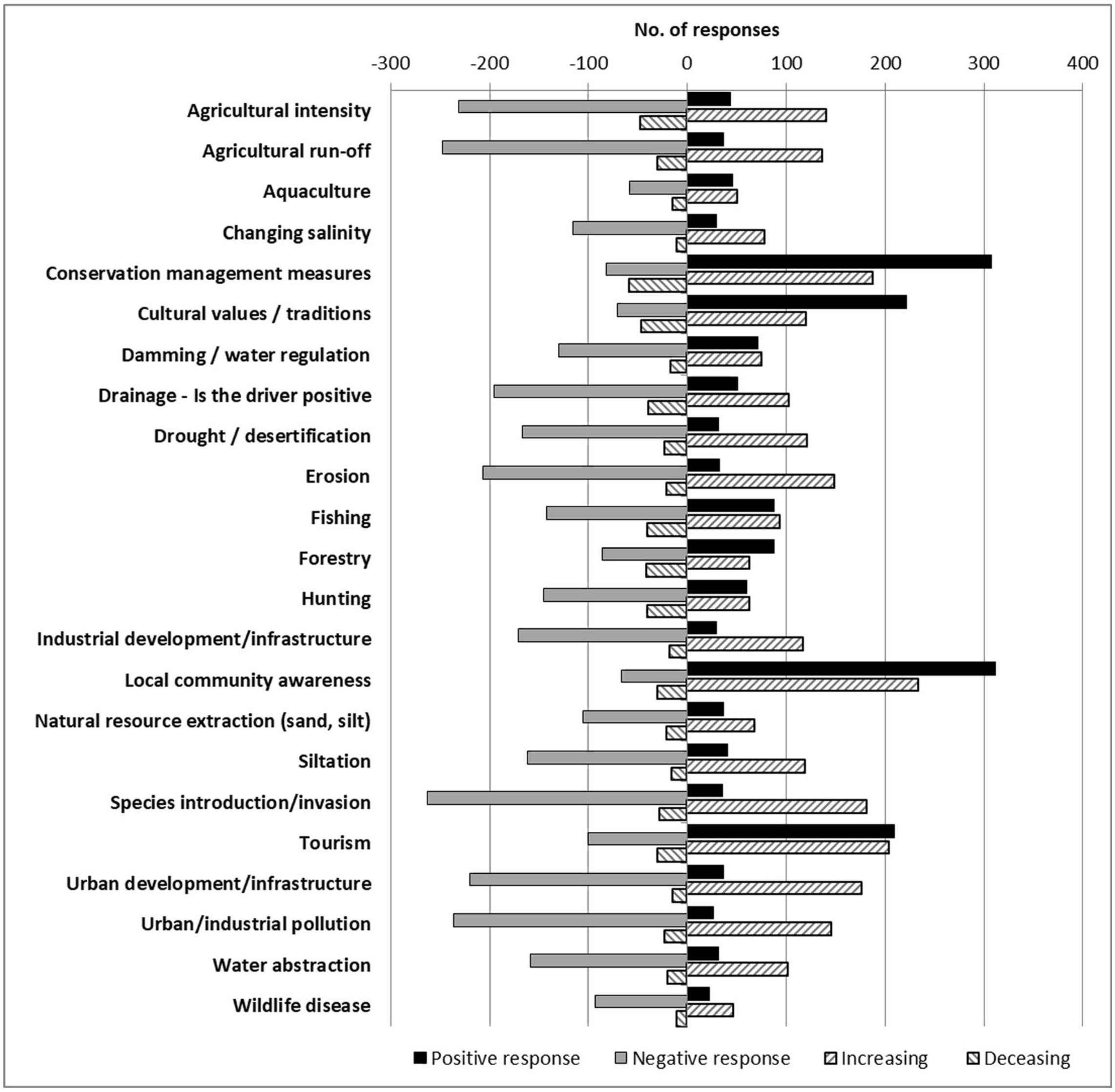

Fig. 6 Responses for drivers of wetland state and rates of change in drivers

There were significant relationships among the state and trend of the drivers ($\chi^2 = 1749.726$, $\alpha = 0.05$, $p < 0.0001$). We found a significant positive correlation among reported positive drivers and a decrease in the positive drivers ($r_s = 0.649$, $\alpha = 0.05$, $p < 0.001$), suggesting that positive drivers are decreasing. There was a significant negative correlation among reported negative and positive drivers ($r_s = -0.524$, $\alpha = 0.05$, $p < 0.011$) suggesting that as positive drivers increase the negative drivers decrease, and vice versa.

Analysis of the Chi-squared adjusted residuals highlights some significant variations from the expected outcomes. Five positive drivers are significantly more positive than would be expected, namely local community awareness (Adj. Residual = 17.270; $\alpha = 0.05$), implementation of conservation measures (Adj. Residual = 17.074; $\alpha = 0.05$), cultural values/traditions (Adj. Residual = 14.345; $\alpha = 0.05$), tourism (Adj. Residual = 9.904; $\alpha = 0.05$) and forestry (Adj. Residual = 4.159; $\alpha = 0.05$). Fourteen negative drivers were reported significantly more frequently than expected, with agricultural run-off (Adj. Residual = 6.899; $\alpha = 0.05$), urban/industrial pollution (Adj. Residual = 6.680; $\alpha = 0.05$) and species introduction/invasion (Adj. Residual = 5.867; $\alpha = 0.05$) being the most significant.

Of the drivers reported to be positive, tourism (Adj. Residual = 3.544; $\alpha = 0.05$) and local community awareness (Adj. Residual = 2.658; $\alpha = 0.05$) were increasing more than expected. Of the drivers reported to be negative, urban development (Adj. Residual = 3.544; $\alpha = 0.05$), erosion (Adj. Residual = 2.070; $\alpha = 0.05$) and species introduction/invasion (Adj. Residual = 1.963; $\alpha = 0.05$) were increasing more than expected. Of the significantly positive drivers, only forestry decreased at a rate faster than expected (Adj. Residual = 4.836; $\alpha = 0.05$).

Figure 7 provides a scatterplot of the current state and direction of change in state of each driver. Drivers in the top right quadrant (local community awareness, tourism, conservation management measures and cultural values/traditions) were both positive and increasing. The many drivers in the top left quadrant are those that were negative and increasing, so likely to be contributing to ongoing wetland degradation.

Discussion and Conclusions

This survey was promulgated in order to inform broad reporting obligations for biodiversity conservation and monitoring, particularly by the Ramsar Convention, and to respond to the Global Wetland Outlook's call to develop citizen science approaches that can contribute to stemming wetland loss and degradation (Chandler et al. 2017; Ramsar Convention 2018). The results, along with other recent assessments (such as Davidson et al. in press), contribute to addressing a knowledge gap for the world's remaining wetlands. The survey reported on approximately 0.48 million km^2 or some 3.6% of the reported total global area of coastal and inland wetlands (Davidson and Finlayson 2018) and received responses that covered more than 10% of the world's Ramsar Sites and over 14% of the global area designated as internationally important wetlands at the time of the survey.

The results reported for Ramsar Sites are of concern. Given that these Sites are a cornerstone of the Ramsar Convention (Gardner and Davidson 2011), coupled with the long-term commitments made by national governments to pay particular attention to maintaining the ecological character of Ramsar Sites (Ramsar Convention 1971), there is an expectation that designation should increase support for protection and management (Ramsar Convention 2018). Consequently, if this commitment is being delivered, Ramsar Sites should be reported as being in a better current state, and with more improvement than deterioration in state, than that of other non-designated wetlands. However, the survey indicates that this is not the case. It is of great concern that recent wetland area losses were reported from over one-fifth (22%) of Ramsar Sites reported in this survey; that one-third of Ramsar Sites were reported as currently being in a poor state; and that the current state of Ramsar Sites was reported as being slightly worse than that of other wetlands. Furthermore, more deterioration than improvement was reported for Ramsar Sites, with deterioration being slightly more widespread than for other wetlands. This is at odds with previous findings that have suggested that Ramsar Sites have a stronger level of legal

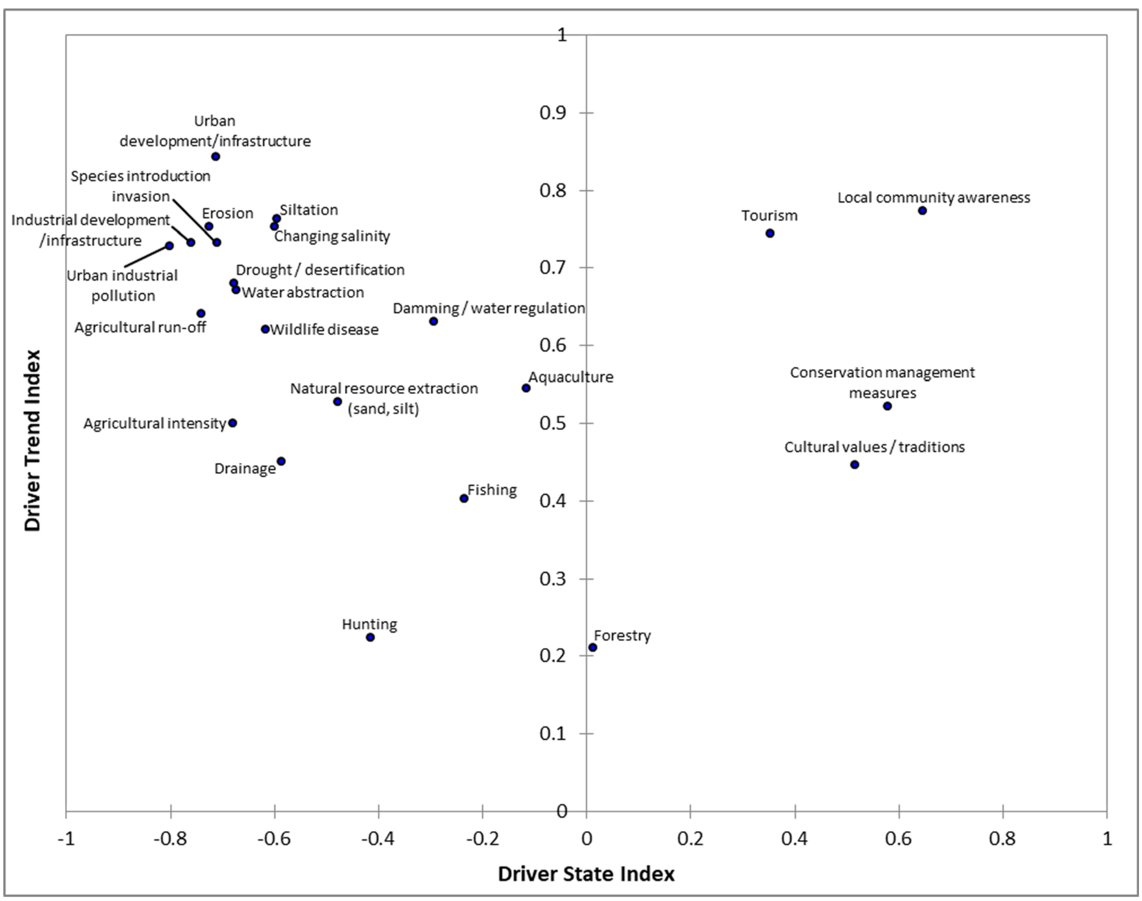

Fig. 7 The relationship between the Driver State Index (ratio positive:negative) and Driver Trend Index (ratio increasing:decreasing) of different drivers

protection and are better conserved than non-Ramsar protected areas (Bowman 2002; Pittock et al. 2015).

The Global Wetland Outlook identified enhancing the network of Ramsar Sites as a strategy to stem wetland degradation (Ramsar Convention 2018). The survey results suggest that without the active engagement of the local community, the implementation of proactive conservation measures and the incorporation of traditional or cultural values then the establishment of a Ramsar Site may not be sufficient, especially in Africa and LAC. Despite the importance of large wetland areas, the survey echoes the views of Keddy et al. (2009) that the designation of large wetlands, in particular, will certainly continue to be a challenge and that the act of designating such areas as Ramsar Sites may not be sufficient to guarantee their long-term protection.

The survey reports that as positive drivers decrease so negative drivers increase. Urban development, erosion and species introduction are increasing most widely. These are not new revelations and have been widely reported previously (see Castillo et al. 2002; Houlahan and Findlay 2004; McInnes 2014). What is not clear from the results of the survey, and beyond the purview of this synthesis, is the extent to which wider ultimate drivers, such as the prevailing socio-economic status, legislative frameworks, governance structures, population changes, broader developmental pressures and climate change, influence the reported state of wetlands and their relationship with current state and drivers of change. Other authors have reported that ultimate, or indirect drivers, such as demographic change (An et al. 2007), poor governance systems (Narayanan and Venot 2009) and climate change (Junk et al. 2013), often manifest themselves as negative direct drivers of wetland degradation and loss. Further analysis of the survey responses in association with other national datasets would be required to elicit any nuancing of the role of drivers on a regional or national scale.

The survey reported that there are five significant positive drivers that are disproportionately improving the state of wetlands: local community awareness, implementation of conservation measures, cultural values/traditions, tourism and forestry. These positive drivers have been recognised in previous studies, for instance through the positive involvement of local communities in wetland management and tourism (Zhang and Lei 2012), the wider importance of integrating local stakeholders within wetland management planning (Herath 2004), working with civil society as a positive change partner (Bennett et al. 2005) and the positive impact that integrating traditional and cultural values can have on wetland management (Papayannis and Pritchard 2011). However, the results of this survey suggest that, to achieve positive management outcomes, local communities and civil society need to be involved in proactive conservation management that recognises and integrates fully the cultural, traditional and tourism values of the site. Additionally the involvement of citizens and civil society groups in citizen science initiatives, such as through this survey, has been demonstrated to be effective in engendering positive conservation outcomes and reinforcing active management activities at a site level (Cooper et al. 2007).

It is beyond the scope of the survey to seek information for each reported site in order to validate individual contributions. However, it is possible to review the overall results with similar assessments in order to make a comparison or to understand novel insights. In a citizen science survey for wetlands in the Mediterranean Basin, Stark et al. (2004) reported similar results: more reports (65%) of wetlands currently being in a good state than in a poor state (35%); more widespread deterioration than improvement in the state of wetlands; and the major positive drivers of change (i.e. those contributing to the maintenance or improvement of the ecological character of wetlands) being conservation measures, local community awareness, cultural values and tourism. Similarly, in an analysis of published smaller-scale ecological character assessments, Davidson et al. (in press) found that more wetlands are in a good than a poor state but deterioration is more widespread than improvement, with the worst state of wetlands being in Africa and the best state in North America and Oceania. An assessment of qualitative reports of trends in the status of all wetlands and Ramsar Sites made by governments through their National Reports to the Ramsar Convention (Davidson et al. 2019b), is also broadly similar, with the deterioration of all wetlands reported as being more widespread than improvement, although for Ramsar Sites national governments reported a more positive trend than has this citizen science survey, and with both surveys reporting worst trends for Africa and LAC and best trends in Oceania.

Citizen science can be considered as public participation in scientific research, especially where members of the public partner with professional scientists to collectively gather large quantities of data (Bonney et al. 2016). However, concerns have been raised over data quality (Crall et al. 2010; Bird et al. 2014) and potential for bias in reporting (Dickinson et al. 2010; Catlin-Groves 2012; Johnston et al. 2018) within citizen science surveys. Incomplete and selective recording by observers (reporting bias) are acknowledged as potential challenges to the accuracy or veracity of citizen science-generated data, but, conversely, the value of non-systematic, opportunistic data collection achieved through citizen science has also been highlighted (van Strien et al. 2013).

Citizen science projects can attract a variety of contributors. The majority of contributors (over 80%) to this survey were drawn from academics, government officials, NGOs and consultants. All of these categories of respondents could be termed 'professional wetland scientists' as well as citizen scientists. Debate remains in the literature as to the definition of a 'citizen scientist' (Haklay 2013; Bonney et al. 2016). Kullenberg and Kasperowski (2016) have argued that citizen science can be defined as a form of science that utilises voluntary contributions that are used by scientists or, alternatively, as a science that assists the needs of concerned citizens and is developed and enacted by citizens themselves. Such definitions do not exclude the involvement of professional wetland scientists, either as contributors or organisers. In fact, Franzoni and Sauermann (2014) have argued that citizen science projects need to find better, non-pecuniary, ways of attracting professional scientists to contribute because of their unique capabilities and knowledge. We promulgate that the involvement of 'professional wetland scientists' within this survey has resulted in a 'win-win' scenario by attracting more scientists into wider engagement work (Poliakoff and Webb 2007; Bauer and Jensen 2011) in tandem with enhancing public participation in the process of data collection thus improving citizens' wider knowledge around the nature of scientific enquiry into the state of the world's wetlands (Riesch and Potter 2014). The survey has also demonstrated that engagement by 'professional wetland scientists' was weaker in LAC, identifying a need to more actively with this sector in any future similar survey work.

The respondents to our survey represented multiple backgrounds and were from different parts of the world with differing socio-economic and legal or regulatory contexts. It is acknowledged that within nature conservation, different scientific disciplines, professions and stakeholders will inevitably support a variety of values, experiences and beliefs (Buijs and Elands 2013; Couix and Hazard 2013). Similarly, some conservation professionals may adapt their views to relay a perspective to, or satisfy, a particular audience (Sandbrook et al. 2011). Such differences can manifest themselves in different evaluations and viewpoints. For instance, it has been argued that national and local governments can be less than transparent in their reporting on biodiversity and natural assets (Siddiqui 2013; Barut et al. 2016). However, whilst the survey reported that there were no overall significant differences between the responses on the current state or trend in state of wetlands across the different groups of respondents, local government respondents were more likely to emphasise positive perspectives. It cannot be ruled out that this group of respondents were possibly employing tactical arguments in order to reflect a preferred position within their reporting (Collar 2003) or framing outcomes in a positive light (Vaganay 2016). Similarly, the analysis cannot reject the suggestion that NGOs were more likely to report negative perceptions of the state of wetlands, possibly to reflect more strategic approaches to 'state shaming' (Murdie and Urpelainen 2015) or as a desire to ensure the 'public's right to know' (Azzone et al. 1997) about their perception of the state of wetlands.

A relatively greater number of academics completed the survey for wetlands in North America and Europe than elsewhere in the world. Karanth et al. (2008) suggest that academics are likely to be less sceptical about the long-term potential of protected areas to deliver conservation goals, and particularly where local people are practicing wise uses, than site staff or local government staff with a more hands-on role. This may go some way in explaining why academics reported significantly more wetlands were demonstrating no change than expected. Alternatively, the relatively high proportion of academic respondents from Europe and North America may reflect a more positive state of wetlands in comparison with reporting from other regions such as LAC where a greater decline in the state of wetlands has been reported (Darrah et al. 2019). It has also been suggested that NGOs may subscribe to the notion of the preeminent authority of science in environmental debates and as such a closer alignment would have been expected between academics and NGO respondents, irrespective of geography (Kinchy and Kleinman 2003). Variance in the views of NGO respondents from those of academics may reflect a desire to sacrifice neutrality for contextual or political purposes (Kinchy and Kleinman 2003); or, alternatively, academics were failing to realise the need for relevance and purifying their own scientific endeavour without passing judgement (Eden et al. 2006) or being overly protective towards the risks to their professional credibility (Horton et al. 2016). Therefore, bias in the data cannot be ruled out, but whilst citizen science data can be perceived as introducing biases into decision-making, this is not unique to citizen science projects with 'professional' scientists needing also to guard against bias in both conducting research and informing decision-makers (Yamamoto 2012; McKinley et al. 2017).

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