Rapid Assessment of Habitat Quality for Nonbreeding Ducks in Northeast Colorado

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Abstract

The ability to assess habitat quality for wildlife is important for evaluating the effectiveness of, or need for, habitat management. Habitat assessment methods generally involve a tradeoff between usability and explanatory power and finding the optimal balance can be challenging. In 2013, Colorado Parks and Wildlife developed a habitat quality rapid assessment method for dabbling ducks (Anatidae) that field personnel used to evaluate wetland management projects. The assessment involves six multiple-choice questions related to vegetation and wetland structure and is designed to be used by people with little wetland ecology training. I tested the ability of the assessment to predict duck density and food availability at 44 sites in northeastern Colorado. I found that the procedure explained 10–22% of the variability in food availability and was not a good predictor of duck density. By altering the grouping of answers as well as the weight of each question, score associated with each answer, and substituting a new question relating to percentage of coverage of duck food–producing plants, the ability of the assessment to explain food availability increased to 30%. Overall, the assessment may be sufficient for relative indication of habitat quality, but if wildlife managers desire precise predictions, further refinement is necessary.

Keywords: Colorado; ducks; habitat assessment; habitat quality; waterfowl; wetlands

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Introduction

The ability to accurately and efficiently assess habitat quality for wildlife is important for assessing the results of, or need for, management activities. Without information on the current state of habitat, managers may be initiate unnecessary activities or overlook necessary management actions. The term "habitat quality" is somewhat vague and Hall et al. (1997:178) defined it as "the ability of the environment to provide conditions appropriate for individual and population persistence." Assessing habitat quality strictly adhering to this definition is challenging, so it is common to use some index of habitat quality (e.g., animal density or abundance, food abundance, survival, etc.; Johnson 2007). For ducks (Anatidae) during the nonbreeding season, the current management paradigm assumes that food, or more specifically, energy availability in the environment, is the main determinant of habitat quality (Central Valley Joint Venture 2006; Soulliere et al. 2007; Playa Lakes Joint Venture 2008). Therefore, habitat management and planning focus on providing abundant, energy-rich food (Central Valley Joint Venture 2006; Soulliere et al. 2007; Playa Lakes Joint Venture 2008). These management and planning strategies assume that migrating and wintering ducks select habitat based on energy availability. This paradigm has resulted in the development of energetic carrying-capacity models (Williams et al. 2014) used for habitat planning and acquisition, and substantial resources spent on managing habitat and hydrology to provide enough energy on the landscape to support population goals.

If habitat management and planning for nonbreeding ducks are focused on energy availability, local estimates of energy availability are necessary (Williams et al. 2014). Most dabbling and many diving ducks primarily consume benthic seeds during winter and migration but transition to diets higher in invertebrates prior to nesting in spring (Hitchcock 2009; Tidwell et al. 2013). Researchers have developed a variety of methods for estimating duck food availability in water features including core sampling (Kross et al. 2008; Stafford et al. 2011; Hagy and Kaminski 2012), visual assessment (Naylor et al. 2005), vacuum sampling (Penny et al. 2006), and clipping vegetation (Haukos and Smith 1993; Gray et al. 2009). Core sampling is one of the most commonly used methods and wildlife managers consider it to provide unbiased and precise estimates if enough samples are taken, although it is very time-intensive (Behney et al. 2014).

Previous researchers have developed rapid visual assessment procedures to quickly and efficiently assess habitat quality for dabbling ducks in terms of food availability (Naylor et al. 2005; Ortega 2013). These procedures generally involve visually estimating characteristics of the wetland including plant taxa composition and some components of wetland structure. In California, Naylor et al. (2005) reported that estimates from their rapid assessment procedure explained up to 88% of the variation in estimates of seed biomass obtained through core sampling. In Illinois, Stafford et al. (2011) reported that the same procedure accounted for 65% of the variation in seed biomass estimated through core sampling. Ortega (2013) developed rapid wetland habitat assessment procedures for a variety of focal species in the lower South Platte River basin in Colorado in 2013, but no research has quantitatively tested these procedures.

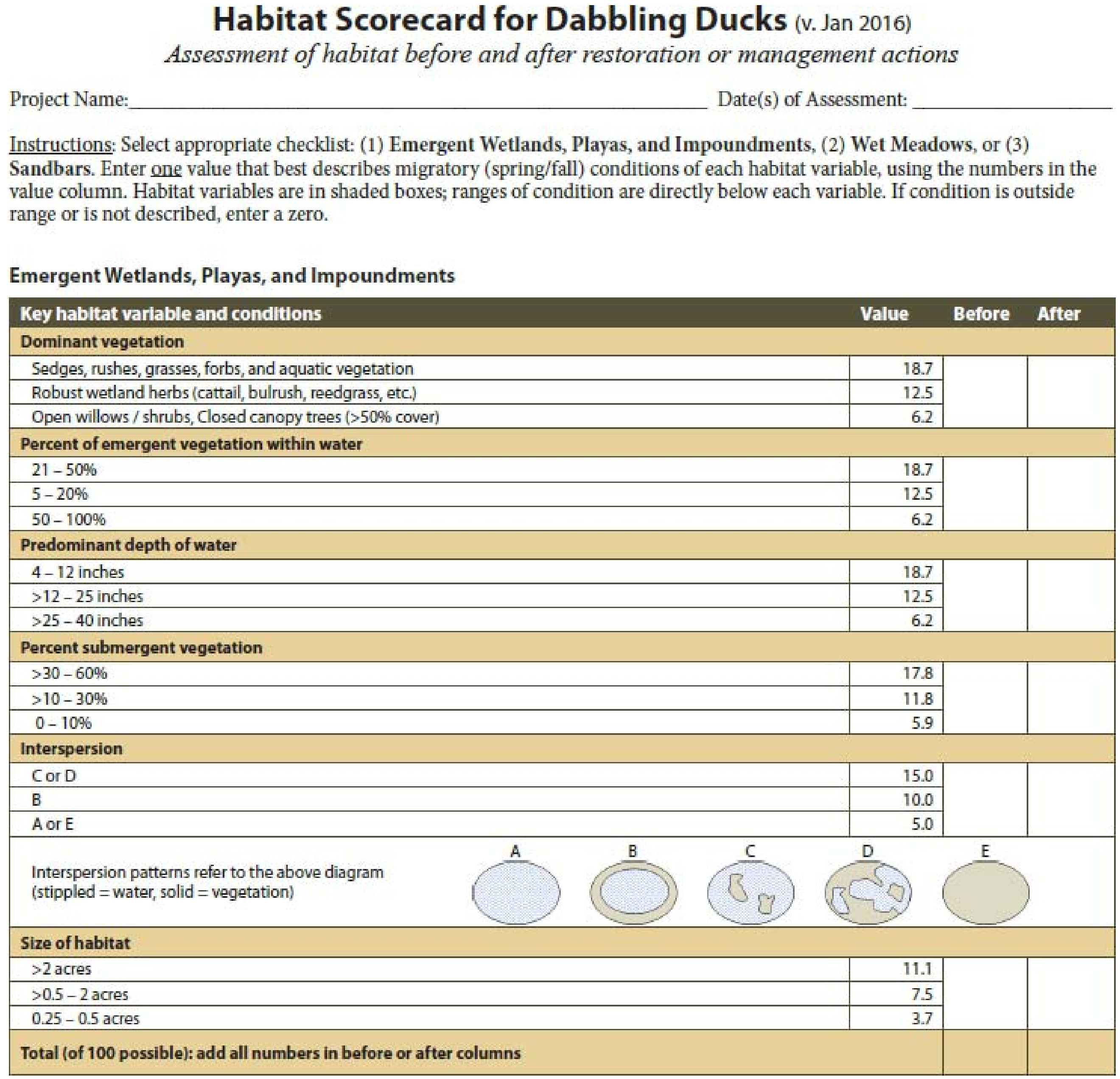
In Colorado, state agency personnel use a simple rapid assessment scorecard to document the need and effectiveness of wetland restoration/enhancement projects on sites where dabbling ducks are the primary management focus (Figure 1). The aim of the rapid assessment is to predict habitat quality for dabbling ducks while maintaining usability for staff with varying expertise in wetland ecology. The scorecard consists of six multiple-choice questions focusing on the dominant type of vegetation, the percentage of the wetland covered with emergent vegetation, predominant water depth, percentage of the wetland containing submergent vegetation, interspersion of open water and vegetation, and overall area. For this scorecard, or any score-based assessment, the maximum score for each question (e.g., question 1: dominant vegetation = 18.7; Figure 1) can be thought of as a weight depicting the importance of that question in predicting habitat quality. For the original scorecard developed in 2013, the agency derived the total weight for each question from a literature review and input from experts as described in Ortega (2013). Each answer was assigned a score either equal to the total weight for that question if it was perceived to be the "best" answer in terms of habitat quality (e.g., question 1: sedges, rushes, etc. = 18.7; Figure 1) or a value less than the total weight depending on how managers perceived it to represent habitat quality (e.g., question 1: robust wetland herbs = 12.5; Figure 1). For example, the first three questions on the scorecard all have a maximum score of 18.7, which is greater than any other questions' maximum score, indicating that when the original scorecard was developed the creators perceived these three questions to be the most (equally) important in predicting dabbling duck habitat quality. For the first question, the first answer (sedges, rushes, etc.) had a score equal to the question's full weight (score = 18.7), indicating that the creators thought it represented the best vegetation type for dabbling ducks. The second (robust wetland herbs) and third answers (open willows, etc.) were thought to represent lower-quality vegetation types and assigned lower scores.

Wildlife managers in Colorado are currently using this scorecard but there have been no objective assessments of its ability to predict habitat quality. Therefore, my objective was to assess how well the scorecard predicted two indices of habitat quality for nonbreeding dabbling ducks in northeastern Colorado: energy availability and duck density. Little information exists on methods for improving rapid visual assessments. In this study, I could alter four components of the scorecard: 1) the questions, 2) the categories making up each answer, 3) the weight assigned to each question, and 4) the score assigned to each answer. I altered each of these components to test if the scorecard's ability to predict habitat quality for dabbling ducks in northeastern Colorado could be improved without a substantial increase in time while maintaining utility for staff with various levels of expertise.

Study Area and Site Selection

I conducted this study in northeastern Colorado in Sedgwick, Phillips, Logan, Morgan, Weld, and Larimer counties. The area is shortgrass prairie with intensive agriculture focusing on cattle production and row-crop farming. I classified water features into six types based on hydrology, morphology, and classification used by previous research and monitoring efforts in the area (Playa Lakes Joint Venture 2008; Lemly et al. 2014): actively managed emergent wetland, passively managed emergent wetlands, sloughs, playas, small reservoirs, and large reservoirs. These water feature types represented a substantial proportion of the overall duck habitat base used in regional habitat planning models (Playa Lakes Joint Venture 2008). I use the term site when referring to a single water feature. Sites were spread out over a 3,331,501-ha area and mean nearest-neighbor distance among sites was 5.1 km.

Most water features in the region (other than playas) are associated with the South Platte River and were within the river basin corridor. Therefore, to ensure a spatially balanced sample, I divided the South Platte River corridor (~10 km from river) into four quadrants (approximately 70 river kilometers per quadrant). Using wetland spatial geographic information systems data gathered from the National Wetlands Inventory (USFWS 2020), Colorado Natural Heritage Program (2020), and Playa Lakes Joint Venture (2019), I compiled a list of all potential sites (both public and private) within each



Habitat Scorecard for Dabbling Ducks (v. Jan 2016)

Assessment of habitat before and after restoration or management actions

Project Name:____________________________________ Date(s) of Assessment: __________________

Instructions: Select appropriate checklist: (1) **Emergent Wetlands, Playas, and Impoundments**, (2) **Wet Meadows**, or (3) **Sandbars**. Enter one value that best describes migratory (spring/fall) conditions of each habitat variable, using the numbers in the value column. Habitat variables are in shaded boxes; ranges of condition are directly below each variable. If condition is outside range or is not described, enter a zero.

Emergent Wetlands, Playas, and Impoundments

Key habitat variable and conditions	Value	Before	After
Dominant vegetation			
Sedges, rushes, grasses, forbs, and aquatic vegetation	18.7		
Robust wetland herbs (cattail, bulrush, reedgrass, etc.)	12.5		
Open willows / shrubs, Closed canopy trees (>50% cover)	6.2		
Percent of emergent vegetation within water			
21 – 50%	18.7		
5 – 20%	12.5		
50 – 100%	6.2		
Predominant depth of water			
4 – 12 inches	18.7		
>12 – 25 inches	12.5		
>25 – 40 inches	6.2		
Percent submergent vegetation			
>30 – 60%	17.8		
>10 – 30%	11.8		
0 – 10%	5.9		
Interspersion			
C or D	15.0		
B	10.0		
A or E	5.0		
Interspersion patterns refer to the above diagram (stippled = water, solid = vegetation)			
Size of habitat			
>2 acres	11.1		
>0.5 – 2 acres	7.5		
0.25 – 0.5 acres	3.7		
Total (of 100 possible): add all numbers in before or after columns			

Figure 1. Rapid assessment scorecard used at all wetland sites to predict wetland habitat quality for dabbling ducks (Anatidae) at sites in northeastern Colorado during fall, winter, and summer, 2015–2016 and 2016–2017.

quadrant for each type of water feature and randomly selected sites within each quadrant.

Playas are farther from the South Platte River than other wetland types. Therefore, I selected study playas by creating a grid (7.5 × 7.5 minute topographic map quadrangles) across northeastern Colorado. I randomly selected two grid cells that contained at least five playas that were greater than 0.25 ha, and then randomly selected playas within each grid cell to sample. Water infrequently inundated playas during this study, which resulted in a lower sample size. Using 0.25 ha as a minimum size cutoff increased my chances of finding inundated playas.

Methods

Field methods

Rapid assessments. Northeastern Colorado is primarily a migration and wintering area for ducks (Colorado Division of Wildlife 1989). Therefore, I conducted the rapid visual assessment procedure at 44 sites (10 actively managed emergent wetland, 8 passively managed emergent wetlands, 10 sloughs, 5 playas, 5 small reservoirs, and 6 large reservoirs) during three sampling occasions throughout two duck nonbreeding seasons 2015–2016 and 2016–2017. The first occasion occurred in late September to represent conditions for fall migrants and the second occurred in February or March once most wetlands thawed to represent conditions at the beginning of spring migration. The third occasion occurred in May to represent conditions after spring migration. Some wetland sites dried periodically, reducing my ability to include them as a sample; however, I sampled most sites during multiple occasions and years (i.e., fall, winter, summer over 2 y) resulting in a total of 182 assessments (Data S1, *Supplemental Material*). I conducted the established rapid assessment procedure (Figure 1) at each site during each sampling occasion and also estimated the percentage of cover of quality duck food–producing plants as a possible improvement to the rapid assessment, similar to Naylor et al. (2005). I defined quality duck food–producing plants as those listed in table 8 in Ortega (2013). These species include grasses, forbs, and aquatic vegetation that produced abundant seeds that ducks consume. In my study area, these generally included barnyardgrass *Echinochloa crus-galli*, smartweed *Polygonum* spp., pigweed *Amaranthus* spp., dock *Rumex* spp., lambsquarters *Chenopodium* spp., bulrush *Schoenoplectus* spp. and *Scirpus* spp., rush *Juncus* spp., sedge *Carex* spp. and *Cyperus* spp., spikerush *Eleocharis* spp., and pondweed *Potamogeton* spp., *Stuckenia* spp., and *Zannichellia* spp. (Behney 2020a).

Food sampling. I used core sampling to estimate food and energy density for all 182 sampling occasions (Data S1, *Supplemental Material*) to compare with rapid assessment scores (Williams et al. 2014). Details of food sampling methods and estimates of food and energy density for these study sites are in Behney (2020a). I randomly distributed seven core samples throughout portions of water features that were shallow enough to facilitate feeding by mallards *Anas platyrhynchos* (< 50 cm, Behney 2014). I processed core samples in the lab where I visually searched through the material and picked out any seed, tuber, or invertebrate and identified items to lowest taxonomic level possible, generally, genus for plant matter and class or order for invertebrates (see supplemental information in Behney 2020a for full list of classifications). I dried all material at 60°C to a constant mass (about 48 h) and weighed to the nearest 0.00001 g to estimate food density and facilitate conversion to energy density based on published true metabolizable energy values (see Behney 2020a). Based on the percentage of the site that was less than 50 cm in depth reported in Behney (2020a) and the total area of the site, I calculated the total energy availability for each site that was accessible to dabbling ducks.

Duck counts. In late winter, after most water bodies thawed and ducks started to arrive (February–March), I conducted weekly duck counts on all sites during mornings (sunrise to 1000 hours). I conducted 498 duck counts (Data S1, *Supplemental Material*). Observers visited each site once per week and noted the number of each duck species present. For most sites, I was able to conduct counts each week and collected 10 or 11 counts throughout each spring (mean counts·site^{-1}·year^{-1} =← 10.4). However, I was not able to visit some sites every week and I excluded sites from analyses with fewer than four samples per year. For water features less than ~ 2 ha, two observers simultaneously walked the perimeter and out into the wetland to flush and count all ducks. Observers made enough passes through the wetland to ensure that they detected any ducks present. Observers conferred with each other throughout the count but I tasked the more experienced observer with counting ducks. For sloughs, two observers walked on either side and into the slough along a 500-m stretch to flush and count all ducks. Sloughs were relatively narrow (generally < 5 m wide) so the possibility of a duck not being detected by observers was low. For reservoirs, I selected a quarter or an eighth of the reservoir and counted all ducks. I used aerial photos in the field to identify the extent of the selected area. Two observers also simultaneously walked the bank or out into any vegetation growing in shallow water to flush any ducks that were not visible. There was no vegetation growing in reservoirs away from the bank in deeper water to prevent detection of ducks using spotting scopes and binoculars. I assumed detection probability was 1 because observers flushed all ducks in smaller water features and those in vegetation in shallow portions of reservoirs. For all sites, the area where observers counted ducks was the same area from which duck food samples were collected.

Statistical analyses

To evaluate the currently used rapid assessment procedure in relation to energy availability for dabbling ducks, I used linear mixed-effects models in package lme4 (Bates et al. 2015) in R (R Core Team 2019) to model energy availability (total kilocalorie found at water depths < 50 cm) for each site-year combination. I log transformed energy availability to increase consistency with assumptions of linear models (Gelman and Hill 2007). I modeled each season separately to determine if one season had more explanatory power than others and included site and year as random effects in all models. For each season, I compared a null model to a model including rapid assessment score (Figure S1, *Supplemental Material*). I calculated the marginal R^2 value (Nakagawa et al. 2017) from the package MuMIn (Barton 2019) in R (R Core Team 2019), which represents the variability explained by the fixed effects only.

To assess the relationship between intensity of dabbling duck use of sites and rapid assessment score, I modeled log(duck density $+ 0.1$) at each site each week over two springs using a linear mixed-effect model in the lme4 package (Bates et al. 2015) in R (R Core Team 2019). I log transformed duck density to increase consistency with assumptions of linear models (Gelman and Hill 2007). I limited analyses to dabbling ducks and did not differentiate among species because the rapid assessment scorecard is meant to apply to all dabbling ducks. I included site and year as random effects in all models to

Table 1. Model selection results for predicting duck (Anatidae) food-energy availability at wetland sites based on rapid assessment score in northeastern Colorado during fall, winter, and summer, 2015–2016 and 2016–2017. Models were linear mixed effects models, K is the number of estimated parameters and *w* is the model weight.

Season	Model	K	ΔAIC_c	*w*	Score coefficient (SE)	R^2 marginal
Fall	Score	4	0.0	0.8	0.04 (0.01)	0.10
	Null	3	3.3	0.2	—	—
Winter	Score	4	0.0	1.0	0.06 (0.01)	0.16
	Null	3	9.9	0.0	—	—
Summer	Score	4	0.0	1.0	0.07 (0.01)	0.22
	Null	3	15.6	0.0	—	—

account for repeated sampling of sites throughout the spring over 2 y. First, I found the best temporal trend of duck density throughout the spring by comparing models including linear, quadratic, and cubic effects of week as well as a null model. I fit these quadratic and cubic effects of week to represent different rates of change in duck numbers throughout migration in the area. To the best temporal trend model, I added the assessment score and compared it to the model without score (Figure S1, *Supplemental Material*). Score and week were not correlated ($r = -0.01$). If the model including score was less parsimonious than the model excluding score, based on second-order bias-corrected Akaike Information Criterion (AIC_c), I concluded it was not a good predictor of duck density. Because I only counted ducks during spring, I used the corresponding winter rapid assessment (February–March) and did not examine seasonal effects in the duck density analysis. For all analyses, I took an information-theoretic approach using change in AIC_c scores (ΔAIC_c) and model weights (*w*) for comparing models (Burnham and Anderson 2002). I assessed consistency of models with assumptions as outlined in Zuur et al. (2009).

Improving the assessment

I tested four ways to improve the rapid assessment procedure using the same sites and data described above: 1) altering groups or ranges of values making up each answer, 2) altering the total weights assigned to each question, 3) altering the scores assigned to each answer within each question, and 4) substituting a new question, percentage of coverage of high-quality duck food–producing plants, similar to Naylor et al. (2005), in place of percentage of emergent and submergent vegetation. Because I used collected data to guide alterations to the rapid assessment procedure, I randomly selected 70% of these data from each season for use in developing an improved assessment procedure (training dataset), while the remaining 30% served as validation data (testing dataset). Both training and testing datasets encompassed data from all three seasons and I did not attempt to analyze seasons separately in this analysis because it would have severely reduced the sample sizes. Assessing the performance of the updated assessment procedure on the testing dataset gives an indication of how well the assessment performs on new data. I only attempted to improve the score with regard to predicting energy availability, not duck density, because I only collected duck density data during the spring, resulting in a lower sample size.

Groupings within each answer. Each question on the rapid assessment is a multiple-choice question, with each choice representing a range of values (e.g., water depth = 4–12 in [10.2–30.5 cm]) or one or more categories (e.g., dominant vegetation = sedges, rushes, grasses, forbs, aquatic vegetation; Figure 1). For the questions with categorical answers (e.g., dominant vegetation), I fit a model in which each individual category received its own estimate of energy availability (Tables 2 and 3). I examined the estimates, grouping them into three or four categories that seemed to best group the data. For questions with answers representing a continuum (e.g., water depth), I examined scatterplots of the actual values versus energy availability and created new breakpoints on the continuum that seemed to best group the data. For categorical and continuum-type questions, I tested models including the new categories or continuum breakpoints predicting energy availability and compared them with the current categories or breakpoints (Figure S2, *Supplemental Material*). If the new categories outperformed the current categories, based on ΔAIC_c and *w*, I used the new categories in subsequent exercises.

Weights assigned to each question. Each question on the rapid assessment scorecard has an associated weight that represents the importance of that question in predicting habitat quality. The score associated with the "best" answer is equal to the weight for that question If every question receives the best possible answer, the total score is 100 (Figure 1). To determine the optimal weight for each question, I treated each question on the rapid assessment as a variable in models predicting energy availability. I calculated relative importance values for each variable (i.e., each question on the scorecard) based on a model set of all possible combinations of the six variables so that each variable occurred in an equal number of models (Anderson 2008; Figure S2, *Supplemental Material*). Relative importance values provide a way to rank each variable's importance in predicting the response variable and are the sum of model probabilities for models in which the variable appears (Anderson 2008). I scaled relative importance values to sum to 100 by dividing the relative importance value for each variable by the sum of all the relative importance values for all variables and then multiplied by 100:

$$RI^*_q = \left(\frac{RI_q}{\sum_{q=1}^{Q} RI_q}\right) \times 100 \qquad (1)$$

Table 2. Current and revised dominant vegetation type groupings for question 1 on the rapid assessment scorecard for ducks (Anatidae) in wetlands of northeastern Colorado. I completed the revised groupings by comparing estimated duck food-energy among the categories. Field technicians sampled duck food-energy during fall, winter, and summer, 2015–2016 and 2016–2017. Letters in the current and revised grouping columns indicate grouping of vegetation types.

Vegetation type	Coefficient (SE)	Current grouping	Revised grouping
Annual forbs	13.4 (0.8)	A	A
Tall sedges, rushes ($>$ 20 cm)	13.4 (0.8)	A	A
Low sedges, rushes ($<$ 20 cm)	12.8 (0.7)	A	B
Robust wetland herbs	12.7 (0.3)	B	B
Mudflat	12.7 (1.3)	D	B
Low grasses ($<$ 20 cm)	12.3 (0.7)	A	C
Aquatic vegetation	12.1 (1.3)	A	C
Dense willows/shrubs	12.1 (0.9)	C	C
Tall grasses ($>$ 20 cm)	11.7 (0.4)	A	C
Open willows/shrubs	11.2 (0.7)	C	C
Open canopy trees	10.1 (0.5)	C	D

where RI^*_q and RI_q are, respectively, the scaled and unscaled relative importance values for question q. I used the scaled relative importance values as the total weight for each question.

Scores assigned to each answer. To determine the score for each answer associated with a question, I treated each question as a variable in single-variable models predicting energy availability, suppressing the intercept so each parameter estimate was associated with an answer to the assessment question (Figure S2, *Supplemental Material*). Because energy availability was log transformed, I back transformed each parameter estimate by calculating e^{estimate}. I assigned the answer with the greatest parameter estimate, indicating it was associated with the greatest energy availability, a score equal to the question's full weight (RI^*_q, see above). I divided the other parameter estimates by the maximum parameter estimate to calculate the percentage of the maximum energy availability each answer represented. I used the resulting percentage of the question's maximum score as the score associated with the lower-quality answers. For example, to assign scores to the answers for the question regarding site size, I modeled energy availability (log transformed) as a function of size (two categories: 0.2 to $\leq$ 0.8 ha and $>$ 0.8 ha; Tables 5 and 6). The coefficient associated with wetlands $>$ 0.8 ha (12.3; Tables 5 and 6) was greater than the coefficient associated with smaller wetlands (11.4 ; Tables 5 and 6) so the answer representing larger wetlands received the questions full weight ($RI^*_{size} = 21$; Table 4). After back transforming both coefficients from the log scale, the coefficient for smaller wetlands was 41% as great as the coefficient for larger wetlands ($e^{11.4}/e^{12.3} = 0.41$) so it was assigned a score 41% of the score assigned to larger wetlands ($21 \times 0.41 = 9$; Tables 5 and 6).

Table 3. Current and revised interspersion groupings for question 5 on the rapid assessment scorecard for ducks (Anatidae) in wetlands of northeastern Colorado. I completed the revised groupings by comparing estimated duck food-energy among the categories. Field technicians sampled duck food-energy during fall, winter, and summer, 2015–2016 and 2016–2017. Letters in the interspersion category column indicate interspersion type from the scorecard (Figure 1). Letters in the current and revised grouping columns indicate grouping of interspersion types.

Interspersion category	Coefficient (SE)	Current grouping	Revised grouping
E	14.2 (1.3)	C	A
D	13.3 (0.3)	A	B
C	12.8 (0.4)	A	B
B	12.0 (0.3)	B	C
A	10.6 (0.4)	C	D

Table 4. Relative importance values scaled to sum to 100 used as total weight for each question on the rapid assessment procedure to predict dabbling duck (Anatidae) habitat quality in wetlands of northeastern Colorado during fall, winter, and summer, 2015–2016 and 2016–2017. The new column substitutes a new question, percentage of quality duck food–producing plants, for percentages of emergent and submergent vegetation.

Question	Relative importance	Relative importance, new question
Area	21	21
Dominant vegetation	21	21
Interspersion	18	20
Predominant depth	19	16
% Submergent vegetation	13	—
% Emergent vegetation	9	—
% Quality food	—	21

New question. I completed this entire process using the questions currently listed on the rapid assessment scorecard. I conducted the same analysis after replacing the questions pertaining to percentages of emergent and submergent vegetation with a new question: percentage of coverage of high-quality duck food–producing plants (Figure S2, *Supplemental Material*). I then compared overall explanatory power of both methods.

Comparing updated and currently used score. I calculated the updated scores incorporating the changes outlined above for the smaller dataset that I withheld for testing. To evaluate the performance of the updated rapid assessment scores, I compared three models with different forms of the score variable. The first model included the currently used score, the second included the updated score derived from the original questions, and the third model included the updated score derived from substituting a new question pertaining to percentage of duck food–producing plants in place of percentages of emergent and submergent vegetation (Figure S2, *Supplemental Material*).

Table 5. Scores assigned to each answer for each question using the same set of questions as in original assessment of habitat quality for dabbling ducks (Anatidae) in wetlands of northeastern Colorado during fall, winter, and summer, 2015–2016 and 2016–2017. Letters displayed for interspersion represent interspersion categories displayed in Figure 1. "Prop. of max" column shows what proportion the back-transformed coefficient (e^{coef}) was in relation to the maximum back-transformed coefficient for each answer. Assigned scores were the proportion of maximum coefficient multiplied by the total weight assigned to that question shown in Table 4.

Question	Answer	Coefficient (SE)	e^{coef}	Prop. of max	Assigned scores
Area (ha)	> 0.8	12.3 (0.2)	219696.0	1.00	21
	0.2 to ≤ 0.8	11.4 (0.4)	89321.7	0.41	9
Dominant vegetation	Tall sedges, rushes, annual forbs	13.4 (0.5)	660003.2	1.00	21
	Low sedges and rushes, robust wetland herbs, mudflat	12.7 (0.2)	327747.9	0.50	11
	Low grasses, tall grasses, willows, shrubs, aquatic vegetation	11.7 (0.3)	120571.7	0.18	4
	Trees	10.1 (0.4)	24343.0	0.04	1
Interspersion	E	13.4 (1.3)	660003.2	1.00	18
	C, D	12.8 (0.2)	362217.4	0.55	10
	B	11.8 (0.3)	133252.4	0.20	4
	A	10.6 (0.4)	40134.8	0.06	1
Depth (cm)	≥ 10.2 and < 30.5	12.9 (0.3)	400312.2	1.00	19
	≥ 30 and < 63.5	12.8 (0.3)	362217.4	0.90	17
	≥ 63.5 and < 101.6	11.9 (0.4)	147266.6	0.37	7
	< 10.2 or ≥ 101.6	10.8 (0.3)	49020.8	0.12	2
% Submergent	> 5 and ≤ 20	13 (0.4)	442413.4	1.00	13
	> 20	12.8 (0.4)	362217.4	0.82	11
	≤ 5	11.5 (0.2)	98715.8	0.22	3
% Emergent	≥ 55	13.6 (0.6)	806129.8	1.00	9
	≥ 10 and < 55	12.6 (0.2)	296558.6	0.37	3
	< 10	11.2 (0.3)	73130.4	0.09	1

Results

Energy

For each season, the model predicting energy availability as a function of rapid assessment score was more parsimonious than the null model (Table 1). Score was positively related to energy availability in all seasons (Figure 2). However, slope coefficients for the score variable and marginal R^2 values were lowest for fall and greatest for summer (Table 1).

Duck density

The most parsimonious temporal model of duck density included a quadratic effect of week. The

Table 6. Weights assigned to each answer for each question and substituting a new question, percentage of quality duck (Anatidae) food–producing plants, for percentages of submergent and emergent vegetation on the rapid assessment of habitat quality for dabbling ducks in wetlands of northeastern Colorado during fall, winter, and summer, 2015–2016 and 2016–2017. Letters displayed for interspersion represent interspersion categories displayed in Figure 1. "Prop. of max" column shows what proportion the back-transformed coefficient (e^{coef}) was in relation to the maximum back-transformed coefficient for each answer. Assigned scores were the proportion of maximum coefficient multiplied by the total weight assigned to that question shown in Table 4.

Question	Answer	Coefficient (SE)	e^{coef}	Prop. of max	Assigned scores
Area (ha)	> 0.8	12.3 (0.2)	219696.0	1.00	21
	0.2 to ≤ 0.8	11.4 (0.4)	89321.7	0.41	9
Dominant vegetation	Tall sedges, rushes, annual forbs	13.4 (0.5)	660003.2	1.00	21
	Low sedges and rushes, robust wetland herbs, mudflat	12.7 (0.2)	327747.9	0.50	11
	Low grasses, tall grasses, willows, shrubs, aquatic vegetation	11.7 (0.3)	120571.7	0.18	4
Trees		10.1 (0.4)	24343.0	0.04	1
Interspersion	E	13.4 (1.3)	660003.2	1.00	20
	C, D	12.8 (0.2)	362217.4	0.55	11
	B	11.8 (0.3)	133252.4	0.20	4
	A	10.6 (0.4)	40134.8	0.06	1
Depth (cm)	≥ 10.2 and < 30.5	12.9 (0.3)	400312.2	1.00	16
	≥ 30 and < 63.5	12.8 (0.3)	362217.4	0.90	14
	≥ 63.5 and < 101.6	11.9 (0.4)	147266.6	0.37	6
	< 10.2 or ≥ 101.6	10.8 (0.3)	49020.8	0.12	2
% Food	≥ 50	13 (0.5)	442413.4	1.00	21
	≥ 15 and < 50	12.9 (0.3)	400312.2	0.90	19
	< 15	11.2 (0.2)	73130.4	0.17	4

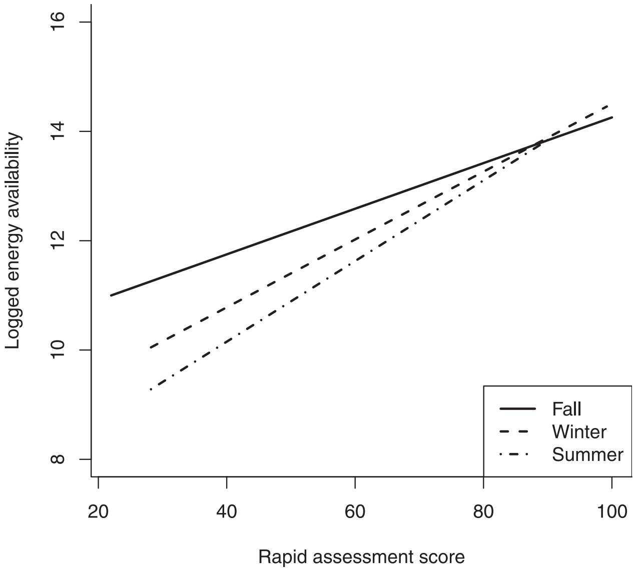


Figure 2. Relationship between duck food-energy availability and rapid assessment score of habitat quality for dabbling ducks (Anatidae). Lines represent model-predicted values. Samples were taken during fall, winter, and summer, 2015–2016 and 2016–2017 in wetlands of northeastern Colorado.

quadratic model was 1.5 AIC_c units better than a model including a cubic effect of week, 20.2 AIC_c units better than a linear effect of week, and 88.5 AIC_c units better than a null model excluding week. When I added the rapid assessment score variable to the best temporal model, the AIC_c score increased by 9.6 units, indicating no support for the score variable in predicting duck density.

Improving the procedure

Groupings within each answer. For dominant vegetation class, my new category groupings ($\Delta AIC_c = 0.0$, $w = \leftarrow 1.0$) outperformed the currently used groupings ($\Delta AIC_c = \leftarrow 9.0$, $w = \leftarrow 0.0$). This resulted from making tall sedges, rushes, and annual forbs their own category (Table 2). For percentage of emergent vegetation, the model incorporating new breakpoints ($\Delta AIC_c = 0.0$, $w = 0.6$) outperformed the model with the currently used breakpoints ($\Delta AIC_c = \leftarrow 0.7$, $w = \leftarrow 0.4$). The new breakpoints resulted in three categories (< 10, 10–55, and $> 55\%$), as opposed to the four that are currently used (Figure 1). For water depth, I could not assign new breakpoints ($\Delta AIC_c = 0.4$, $w = 0.4$) that outperformed the current breakpoints ($\Delta AIC_c = 0.0$, $w = 0.6$). For percentage of submergent vegetation, the model incorporating new breakpoints ($\Delta AIC_c = 0.0$, $w = 0.9$) outperformed a model with the currently used breakpoints ($\Delta AIC_c = 5.1$, $w = \leftarrow 0.1$). The new breakpoints resulted in three categories: < 5, 5–20, and $> 20\%$. For interspersion, the new category groupings ($\Delta AIC_c = \leftarrow 0.0$, $w = \leftarrow 0.7$) outperformed the currently used groupings ($\Delta AIC_c = 2.1$, $w = 0.3$). The new groupings put types E, A, and B, by themselves in their own groups and C and D (Figure 1) together in the same group (Table 3). I did not attempt to alter the groupings for the size question because I could not identify any obvious groupings in the data. For the new variable, percentage of coverage of high-quality duck food–producing plants, I used breakpoints of 15 and 50 resulting in three groups (< 15, 15–50, $> 50\%$).

Weights assigned to each question and answer. Site size and dominant vegetation type had the greatest relative importance scores (Table 4). Percentages of emergent and submergent vegetation had somewhat low values for relative importance and their replacement, percentage of high-quality duck food–producing plants, had a high relative importance (Table 4). Tables 4 and 5 show the new assigned scores for each answer.

Comparing updated and currently used score. To assess the updated procedure on the smaller, testing dataset, I compared three models to predict energy availability. The most parsimonious model included the updated score including the new variable, percentage of high-quality duck food–producing plants ($\Delta AIC_c = 0.0$, $w = 0.7$, $R^2 = 0.30$). The updated score including all the original questions ranked second ($\Delta AIC_c = 2.2$, $w = 0.3$, $R^2 = 0.29$) and the original score performed worst ($\Delta AIC_c = 13.1$, $w = 0.0$, $R^2 = 0.21$).

Discussion

I found that the wetland rapid assessment procedure currently used by Colorado Parks and Wildlife to evaluate dabbling duck habitat quality explained 10–22% of the variability in energy availability among sites and was not a good predictor of duck density. Slight alterations could improve the ability of the rapid assessment procedure to explain energy availability for dabbling ducks to 30%. My alterations included changing the category groupings or breakpoints used in the answers to each question on the assessment, altering the weights associated with each question and score for each answer, and substituting a new variable (percentage of cover of quality duck food–producing plants) in place of percentages of emergent and submergent vegetation. This revised assessment is relatively fast and a diversity of personnel can complete it with minimal training. Depending on the goals of the user, this assessment may be a valuable tool for evaluating the results of, or need for, wetland restoration actions.

The rapid assessment procedure I tested explained less variability in energy availability than other reports. Naylor et al. (2005) reported their procedure explained 54 or 88% of the variability in moist-soil seed density (kg/ha) in California, depending on whether outliers were removed. Stafford et al. (2011) used the same procedure in Illinois and reported that it explained 65% of the variation in moist-soil plant seed density (kg/ha). Both of these assessments focused on predicting moist-soil seed density, whereas I focused on predicting total energy availability. Moist-soil seeds are an important component of duck diet during nonbreeding seasons (Tidwell et al. 2013); however, ducks do consume other plant and animal matter during this time period (Combs and

Fredrickson 1996; Hitchcock 2009; Tidwell et al. 2013). All the rapid assessments procedures focus on plant composition and structure (Naylor et al. 2005; the assessment evaluated here). Because plants are what actually produce the seeds that ducks eat, these rapid assessments likely correlate better with moist-soil seed biomass than overall energy availability. Wildlife managers know less about factors related to animal-based duck food or non–moist-soil plant seed abundance in wetlands, so deriving a procedure that accounts for these food sources may be challenging.

The rapid assessment procedure was a poor predictor of duck density. This may be a result of factors other than energy density influencing how ducks distribute themselves (Brasher 2010; Beatty et al. 2014; O'Shaughnessy 2014; Osborn et al. 2017). The questions on the rapid assessment procedure focused on food availability, but researchers have shown other wetland structure and landscape characteristics to affect duck distribution (Brasher 2010; Beatty et al. 2014; O'Shaughnessy 2014; Osborn et al. 2017) and the current procedure did not account for these. In the same study area, Behney (2020b) reported that energy availability was an important driver of duck distribution during spring but site location along an east–west gradient and size were also important. Incorporating these larger-scale metrics would be possible but would entail a greater time commitment to study how the site relates to other wetlands on the landscape. More generally, animal density may not be a good predictor of habitat quality due to factors such as social dominance (Van Horne 1983).

Altering a rapid assessment procedure involves a tradeoff between usability and accuracy. My recommendations to improve the rapid assessment procedure by altering the grouping/breakpoints of answers, the weights assigned to each question and scores for each answer, and substituting a new question may seem relatively minor. However, it was important in this case to keep the time to complete the procedure brief and efficacious enough that a diversity of staff with varying backgrounds in wetland ecology could use it. The question regarding duck food–producing plants that I added may require some additional training for managers.

In this study, I did not take into account or quantify repeatability of the assessment among observers. As with any assessment involving qualitative measures, observer variation can result in increased variability in data. One goal when designing assessments such as the one evaluated here is to use questions that are as objective as possible to reduce the influence of observer bias. Naylor et al. (2005) reported high repeatability in their wetland assessment procedure among two observers.

Although the rapid assessment procedure was developed and evaluated in Colorado, the procedure may apply to other areas as well. None of the questions on the assessment are specific to Colorado and most of them represent well-documented factors that relate to duck food availability. Plants produce most food for nonbreeding ducks (Hitchcock 2009; Tidwell et al. 2013) so questions regarding the vegetation community (e.g., dominant vegetation type, interspersion, etc.) should be universally important; however, managers may need to alter the specific scores or answer breakpoints for other regions if the ranges of conditions are different from Colorado. For example, if in other regions there are few wetlands less than 0.8 ha, it may make sense to alter the breakpoints to better segregate wetlands based on size. Furthermore, different food sources may result in vegetation types being more or less valued. For example, acorns are an important food source for some ducks in the Mississippi Alluvial Valley (Delnicki and Reinecke 1986) and because trees produce acorns, the dominant vegetation type score associated with trees should be greater than it would in Colorado, where trees do not produce food for ducks.

Conclusion

By altering the answer groupings/breakpoints, weights associated with each question, and scores associated with each answer, users can increase the explanatory power of the rapid assessment procedure from 10–22% to 30%. I recommend substituting a question about the percentage of cover of high-quality duck food for the questions about percentages of cover of emergent and submergent vegetation; however, this comes at the cost of slightly increased plant identification skills necessary to complete the assessment. Overall, I show that this assessment relates to one measure of habitat quality, energy availability, and justify the use of the procedure in cases where great explanatory power is not paramount.

Supplemental Material

Please note: The *Journal of Fish and Wildlife Management* is not responsible for the content or functionality of any supplemental material. Queries should be directed to the corresponding author for the article.

Data S1. Rapid assessment, energy availability, and duck (Anatidae) count data collected in northeastern Colorado during fall, winter, and summer, 2015–2016 and 2016–2017. Separate tabs show each dataset.

Found at DOI: https://doi.org/10.3996/JFWM-20-013.S1 (65 KB XLSX).

Figure S1. Flow diagram of analyses for evaluating currently used wetland rapid assessment in Colorado. Data were collected in in northeastern Colorado during fall, winter, and summer, 2015–2016 and 2016–2017. I performed all model comparisons with an information-theoretic approach using ΔAIC_c and model weights.

Found at DOI: https://doi.org/10.3996/JFWM-20-013.S2 (135 KB PDF).

Figure S2. Flow diagram of analyses for improving the wetland rapid assessment scorecard used in Colorado. Data were collected in in northeastern Colorado during fall, winter, and summer, 2015 –2016 and 2016–2017. I performed all model comparisons with an information-theoretic approach using ΔAIC_c and model weights.

Found at DOI: https://doi.org/10.3996/JFWM-20-013.S3 (135 KB PDF).

Reference S1. Central Valley Joint Venture. 2006. Central Valley Joint Venture Implementation Plan—conserving bird habitat. Sacramento, California: U.S. Fish and Wildlife Service.

Found at DOI: https://doi.org/10.3996/JFWM-20-013.S4 (16.44 MB PDF); also available at https://www.centralvalleyjointventure.org/assets/pdf/CVJV_fnl.pdf

Reference S2. Lemly J, Gilligan L, Smith G. 2014. Lower South Platte River basin wetland profile and condition assessment. Fort Collins: Colorado Natural Heritage Program, Colorado State University.

Found at DOI: https://doi.org/10.3996/JFWM-20-013.S5 (13.31 MB PDF); also available at https://cnhp.colostate.edu/download/documents/2014/Lower_South_Platte_Report_FINAL.pdf

Reference S3. Ortega CP. 2013. Habitat quality for wetland-dependent priority wildlife species in the lower South Platte River basin, Colorado: species assessments and monitoring protocols. Report to Colorado Natural Heritage Program, Colorado Parks and Wildlife, Environmental Protection Agency, Fort Collins.

Found at DOI: https://doi.org/10.3996/JFWM-20-013.S6 (4.07 MB PDF).

Reference S4. Playa Lakes Joint Venture. 2008. Area Implementation Plan for the Shortgrass Prairie Bird Conservation Region (18) of Colorado. Lafayette, Colorado: Playa Lakes Joint Venture.

Found at DOI: https://doi.org/10.3996/JFWM-20-013.S7 (336 KB PDF).

Reference S5. Soulliere GJ, Potter BA, Coluccy JM, Gatti RC, Roy CL, Luukkonen DR, Brown PW, Eichholz MW. 2007. Upper Mississippi River and Great Lakes Region Joint Venture Waterfowl Habitat Conservation Strategy. Fort Snelling, Minnesota: U.S. Fish and Wildlife Service.

Found at DOI: https://doi.org/10.3996/JFWM-20-013.S8 (4.24 MB PDF).

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