Upper Rio Grande Report Card Methodology

Methods report on data sources, calculation, and additional discussion

November 2022

Project Team

This project was co-developed and co-produced by the University of Maryland Center for Environmental Science (UMCES) Integration and Application Network (IAN), World Wildlife Fund US (WWF US), University of Massachusetts Amherst (UMASS Amherst), and Audubon Southwest (Audubon SW).

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Goals and objectives

The Upper Rio Grande Report Card was developed to track the condition of water, communities, and nature within the Upper Rio Grande Watershed and to provide recommendations of climate-smart responses to address challenges in the basin. Specifically, the report card and scenario model were designed to leverage broad stakeholder engagement, academic contributions, and communications with the public and decision makers; clearly communicate the current state of a river system and potential future states; and advocate for substantive policy changes or direct interventions to achieve the best future scenario.

The long-term vision for the Rio Grande Basin is to ensure sustainable water resource management that builds basin health and resilience against climate change while promoting livelihood opportunities for local people, economic growth for businesses, and environmental protection for all. Success hinges on collaboration with the people and communities in the basin and providing clear information to enable sustainable decisions about land and water management. This project delivers the benefits of basin report cards while underscoring the imperative of a climate-changed future and providing guidance for the way forward, by combining the report card methodology with Freshwater Resilience by Design, an innovative freshwater scenario analysis approach.

The report card was co-developed with stakeholders from around the Upper Rio Grande Watershed. The selection of indicators reflects the values stakeholders have for the Upper Rio Grande with an emphasis on those values thought to be under threat. To accomplish this, diverse stakeholders were engaged to establish a common understanding and baseline of the current health of the Upper Rio Grande Basin; model possible future scenarios; and create a data-driven, transparent, and replicable report card. The project team held a series of virtual workshops with stakeholders in the basin in October and November 2020. Workshop participants identified values and threats to consider for assessing watershed condition. Specific indicators were subsequently developed within each of four overall categories: Water

Quality and Quantity; Social and Cultural; Management and Governance; and Ecosystems and Landscapes.

The report card provides a picture of the river system's health to inform communities, managers, companies, government officials, and decision makers. Using a Freshwater Resilience by Design approach to model hydro-economic-ecological variables under different scenarios helps assess climate vulnerabilities and tests how different actions could impact the basin. These scenarios provide a series of alternative paths for the future of the basin, and management options to show what can best "raise the grade" and mitigate factors such as climate change and population growth. The Upper Rio Grande Watershed Report Card is an initial assessment of watershed condition. The report card team recognizes that there are many improvements that can be made to the report card indicators, data sources, and methods. Improvements can be made as the process is repeated for future report cards without jeopardizing the ability to track change in watershed condition over time.

Development process

The first stakeholder workshop to develop an eco-health report card and scenario model for the Upper Rio Grande occurred in 2020. The workshop took place virtually over four 90-minute sessions in October and November 2020. More than 50 diverse stakeholders from government, the private sector, academic institutions, irrigation districts, and indigenous communities participated. The goals of the workshop were to 1) identify shared values, threats, and priorities within the basin; 2) propose indicators; 3) identify data sources and expertise; and 4) discuss potential future management options. Indicator categories were conceptualized and smaller working groups for each of these were established. Following the workshop, a series of conference calls were conducted to further define indicators and identify relevant data sources. The UMCES, WWF US, and UMASS Amherst conducted data analysis for each of the indicators once data was identified and obtained from providers.

Figure 1: Four sub-regions of the Upper Rio Grande River Watershed.

With the initial workshops complete, the project team evaluated data availability for each proposed indicator. This included many calls and meetings to work on data issues and establish thresholds and scoring. A webinar was held in November 2021 to present the preliminary scores and further refine indicators and thresholds.

A second webinar was held in April 2022 to complete the scoring and resolve any remaining issues.

Sub-region determination

Watershed sub-regions were determined based on geographic features (such as geology or land use), hydrology (such as drainage basin size, water circulation patterns, water flow), and human geography. All sub-regions should ideally have enough sampling sites for results to be scientifically rigorous and provide consistent analysis.

Based on stakeholder discussions, sub-regions were identified that matched the stakeholder's conceptual model of the watershed.

There are four regions in the report card, from north to south named the Upper Rio Grande-CO, Upper Rio Grande-NM, Middle Rio Grande, and Lower Rio Grande. A set of four polygons were generated for these regions and used throughout the project to select data for grading for each region.

Indicators and thresholds

The indicators in this report card help answer the question "How healthy is the Upper Rio Grande River Watershed?". The indicators that had enough spatial and temporal resolution to use in the report card were Annual low flow, zero flow days, flow alteration, groundwater, agricultural water supply, municipal water supply, water supply for compact, impaired streams, all fish diversity, native fish diversity, silvery minnow, bird diversity, wetland loss, invasive trees and shrubs, riparian areas, affordable housing air quality, social vulnerability index, heat vulnerability index, walkability, cultural and historic places, recreation access, park visitation, fire, protected lands, water resource management, water resource governance, native peoples and acequias representation, and native peoples and acequias support.

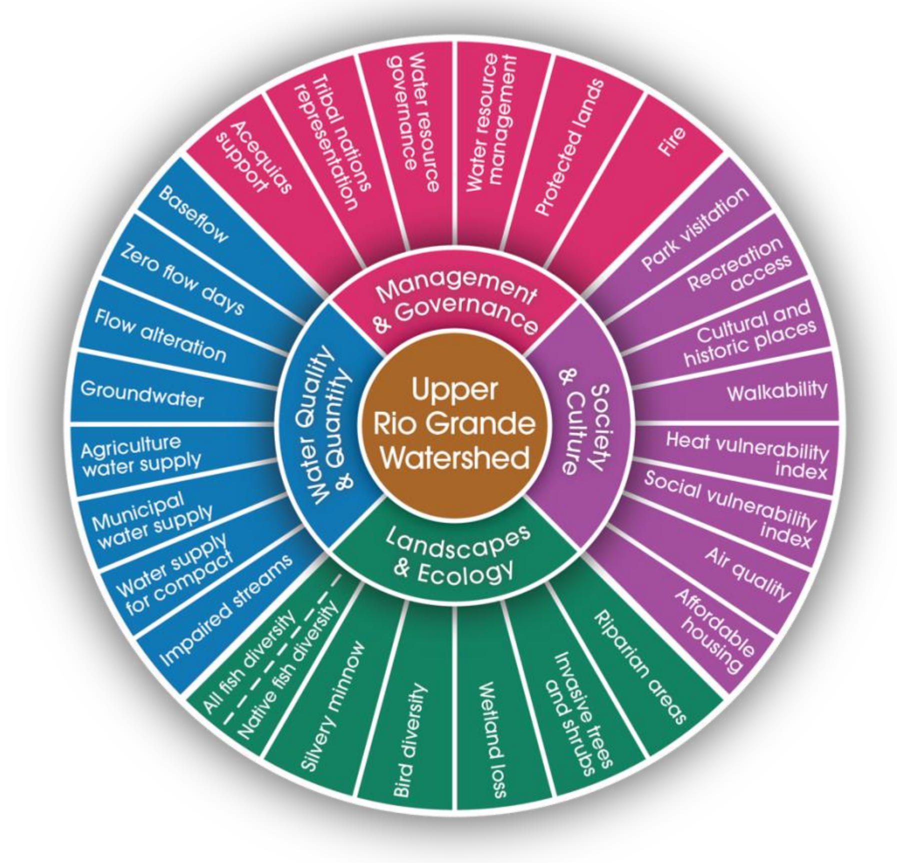

Figure 2: Indicators for the Upper Rio Grande River Watershed. Report Card.

Once these indicators were identified, targets or thresholds for each indicator were developed. Establishing targets for each indicator can be done by using pre-existing standard thresholds from the scientific literature or determining acceptable management goals. A threshold ideally indicates a tipping point where current knowledge predicts an abrupt change in an aspect or some aspects of ecosystem condition. Thus, from the perspective of choosing meaningful, health-related thresholds, this must be the point beyond which prolonged exposure to unhealthful conditions actually elicits a negative response, for the environment or human health. For example, prolonged exposure to dissolved oxygen concentrations below criteria thresholds elicits a negative response in aquatic systems by either compromising the biotic functions of an organism (reduced reproduction) or causing death.

More generally, however, thresholds represent an agreed-upon value or range indicating that an ecosystem is moving away from a desired state and toward an undesirable endpoint. Recognizing that many managed ecosystems have multiple and broad-scale stressors, another perspective is to define a threshold as representing the level of impairment that an environment can sustain before resulting in significant (or perhaps irreversible) damage.

When selecting thresholds, it is important to recognize that there are many already available, and more than likely, there are thresholds available for the indicator that is chosen. A good place to start looking for existing thresholds and goals is in other report card methods or scientific reports and publications. When selecting thresholds, it is important to recognize that there are many already available and there might be preexisting thresholds available to use for the chosen indicators. A good place to start looking for existing thresholds and goals is in other report card methods or scientific reports and publications.

One way to develop threshold values, if none exist, is to relate them to management goals. These goals can then be used to guide the selection of appropriate indicators. Even with the definition of agreed-upon thresholds, there is still the question of how best to use these threshold values in a management and governance context. Recognizing this challenge, thresholds can still be effectively used to track ecosystem change and define achievable management goals for restoration, preservation, and conservation of an ecosystem. As long as threshold values are clearly defined and justified, they can be updated in light of new research or management goals and can provide an important focus for the discussion and implementation of ecosystem management. Alternatively, if stressors are correctly identified and habitats appropriately classified, there should be multiple attributes (indicators) of the biological community that discriminate in predictable and significant ways between the least and most impaired habitat conditions. Reference communities can then be characterized using these data, which in turn can be used to develop threshold values. In order to determine thresholds for the Upper Rio Grande River watershed, working groups of scientific experts were engaged. Data was sourced from many places including, the United States Geological Survey, Middle Rio Grande Endangered Species Program, the National Land Cover Database, and a survey implemented by scientists at the University of Maryland Center for Environmental Science.

Water Quality and Quantity

Annual Low Flow

Data source: United States Geological Survey (USGS), accessed via the web interface at https://waterdata.usgs.gov/nwis

Calculation method:

There were long-term USGS gauge stations in all of the reporting regions; there were 7 sites in the Upper Rio Grande-CO, 18 sites in the Upper Rio Grande-NM, 19 sites in the Middle Rio Grande, and 4 sites in the Lower Rio Grande. The data used were observations from 2020. The *7-day low flow* (minimum flow) was calculated for each 7-day period ending with the focal day in June. The *7-day low flow* was used because it is relatively insensitive to short-term peaks in discharge related to precipitation events that are shorter than a week. The mean *7-day low flow* was calculated for the month of June and was used as the indicator of Annual Low Flow conditions.

Baseline conditions were established for each gauge, against which each measurement of the June mean *7-day low flow* could be compared. The mean and standard deviation of the June mean *7-day low flow* were calculated between 2006 and 2018 and used as the baseline for each gauge (Table 1). We used these statistics to calculate a z-score for every June mean *7-day* *low flow*, and adopted the most recent year (2020) as the grading period. We scaled the z-score between -2.5 and 2.5, corresponding to grades from F to A. Therefore, where the 2020 June mean *7-day low flow* was above the baseline mean, the region received a grade above 50%. Likewise, when the 2020 June mean *7-day low flow* was below the baseline, the region received a grade below 50%.

Table 1: Gauges and Annual Low Flow results.

June low flow (CFS)							
Gauge Name	**RC Region**	**Baseline Mean**	**Baseline StdDev**	**Recent 2 years**	**Grade**	**Trend**	**Trend p-value**
Paulden	2	19.1	1.6	17.7	33.1	-0.29	<0.05
Clarkdale	3	61.9	3.4	58.6	30.4	-0.82	<0.05
Oak Creek Sedona	4	27.3	1.4	27.8	56.8	-0.06	0.29
Camp Verde	5	51.1	13.2	44.9	40.6	-1.31	<0.05
Tangle Creek	6	84.9	18.0	67.8	31.0	-2.18	<0.05

Table 2: Annual Low Flow thresholds.

Thresholds	Score
z-score > 3.5	100
2.5 < z-score < 3.5	80–99
1 < z-score < 2.5	60–79
-1 < z-score < 1	40–59
-2.5 < z-score < -1	20–39
-3.5 < z-score < -2.5	0–19
z-score < -3.5	0

All stations in each region were averaged to the region score. All region scores were area weighted to the overall score.

Zero Flow Days

Data source: United States Geological Survey (USGS), accessed via the web interface at https://waterdata.usgs.gov/nwis

Calculation method:

There were long-term USGS gauge stations in all of the reporting regions: 7 sites in the Upper Rio Grande-CO, 18 sites in the Upper Rio Grande-NM, 19 sites in the Middle Rio Grande, and 4 sites in the Lower Rio Grande. The data used were observations from 2020. The number of days where there was no water flowing through the gauge was calculated. Multiple thresholds with an even interval were used to equate the number of zero flow days to a score (Table 3). Thresholds were determined based on expert opinion.

Table 3: Zero flow days thresholds.

Number zero flow days	Score	Equation
0	100	y=-4x+100
5	80	
10	60	
15	40	
20	20	
25	0	

All stations in each region were averaged to the region score. All region scores were area-weighted to the overall score.

Flow alteration

Data source: United States Geological Survey (USGS), accessed via the web interface at https://waterdata.usgs.gov/nwis

Calculation method:

The Water Management Lab at the University of California Davis completed an Upper Rio Grande Functional Flows Assessment for this indicator. The project determined the hydrologic alteration by characterizing the natural flow regime of the Rio Grande using Functional Flow Metrics and to estimate the degree of alteration when comparing these naturalized flow regime metrics with the current hydrology or that of an alternative water management strategy (scenario). Fifteen USGS gauge stations were used for the analysis. Refer to Patterson & Solis et al. for the complete methods.

Hydrologic alteration was quantified at each site using the differences in naturalized and observed functional flow metrics. For each metric, observed conditions were compared against both the interdecile range (10th to 90th percentiles) and the interquartile range (25th to 75th percentiles) of naturalized conditions. The number of years that observed metrics fell into either the interdecile or interquartile range was tallied out of the 31 years total of observed conditions, and calculated as a percentage. The alteration score for the interdecile range and interquartile range are both considered in the determination of a final alteration status and report card score. The alteration scores at each site were averaged together by functional flow component using an arithmetic mean. These site-specific values were then averaged across each region of the Upper Rio Grande to create region-specific alteration scores representing each functional flow component. Finally, the scores for the regions and functional flow components are averaged together to create one overall flow alteration report card score.

Groundwater

Data source: United States Geological Survey (USGS), accessed via the web interface at https://waterdata.usgs.gov/nwis

Calculation method:

The groundwater indicator is determined as the change in water level for the aquifers in the basin. Thirteen aquifers in the region were examined. The data is from 1980-2015, and data from 2010-2015 is used for the scoring of the indicator. The thresholds came from USGS (Houston et al. 2021). If groundwater level change is >0.1 feet, it's considered a rise; if it's from 0.1 to -0.1 feet it's stable, and if it is <-0.1 feet it's a decline. 0.1ft was set at the 79% score (a high B), and -0.1ft was set at the 60% score (a low B). The scores were scales evenly between these two points using the equation of the line (Table 4).

Table 4: The groundwater thresholds and equation used.

Groundwater Level Change	Score	Equation
0.1	79	y = 95x + 69.5
-0.1	60	

Once the aquifer scores were calculated, they were area-weighted based on the size of the aquifer in each region. This gives the region scores. The regions were area-weighted to reach the overall score.

Agriculture Surface Water Supply

Data source: Data was gathered from the following irrigation districts: San Luis Valley Irrigation Region (SLV), Middle Rio Grande Conservancy District (MRGCD), Elephant Butte Irrigation District (EBID), and El Paso County Water Improvement District #1 (EPCWID). For each district, data included the amount of surface water diverted, the total and adjusted Potential Evapotranspiration (PET) for crops in the irrigated areas, and a range of irrigation efficiency factors, which represent: 1) losses in conveyance of water from rivers to farms; 2) non-productive water losses on farms; 3) unused deliveries (return flows).

Calculation method:

For each region, the Surface Water Fraction was calculated as follows: The Annual Main Surface Water Diversion was divided by the adjusted Potential Evapotranspiration (PET) for crops in the irrigated areas. The resulting value was multiplied by an irrigation efficiency factor of 60%. This efficiency factor was selected because it represents the high side of the range for all districts. For example, for the MRGCD, the reported values range between "as high as 60%" and "30% between 1979-1999". This factor could be changed based on further reviews, considering that lower values will represent a lower surface water fraction and therefore impact the indicator scores negatively.

The Surface Water Fractions resulting from these calculations were scored against district-specific thresholds. Thresholds are based on the assumption that surface water should be enough to satisfy most of the agricultural water demands along with some fraction of other water sources, mainly groundwater, and therefore a surface water fraction between 0.9-0.72 gets the highest score, an “A”. For the SLV, EBID and EPCWID regions, the rest of the surface water fraction thresholds are based on a breakdown of equal intervals. For the MRGCD the thresholds are adjusted to account for the consideration that this region is more reliant on surface water than the other regions. Overall scores were weighted by the average annual irrigated area in each region.

Table 5: Agriculture Surface Water Supply thresholds for SLV, EBID, and EPCWID irrigation regions.

SLV, EBID and EPCWID Irrigation Regions		
Surface water fraction thresholds (%)	Indicator Score	Indicator Grade
90 - 72	100–80	A
71- 54	79–60	B
53 - 36	59–40	C
35 - 18	39–20	D
17 – 0	19–0	F

Table 6: Agriculture Surface Water Supply thresholds for the MRGCD irrigation region.

MRGCD Irrigation Region		
Surface water fraction thresholds (%)	Indicator Score	Indicator Grade
90 - 70	100–80	A
69- 60	79–60	B
59 - 50	59–40	C
49- 40	39–20	D
39 – 0	19–0	F

Municipal Water Supply

Data source: County-level data on average municipal water use across five years, from 1981-1985 and to 1996-2000, were available from the U.S. Census and New Mexico State Engineer's Office. Data for the following counties in each region were available. Upper Colorado: Alamosa, Archuleta, Conejos, Costilla, Hinsdale, Mineral, Rio Grande, and Saguache. Upper New Mexico: Rio Arriba and Taos. Middle: Bernalillo, Catron, Cibola, McKinley, Sandoval, Socorro, Torrance, Valencia, Los Alamos, Santa Fe, and Sierra. Lower: Dona Ana, Sierra, El Paso, and Hudspeth.

Calculation method:

For each county, average water use for every five year period was divided by the corresponding population size. A general linear model, which is a statistical model commonly used to detect trends, was run for each county to determine if per-person water use has increased or decreased (statistically significantly) over time. A score of 100% was assigned to counties where water use has decreased over time. A score of 100% was assigned to counties where water use has stayed the same. A score of 0% was assigned to counties where water use has increased over time. All scoring was based on statistical significance where $p<0.05$ is considered statistically significant. Region scores were the average of county scores within each region. For the overall score, population was used to weight region scores.

Water Supply for Compact

Data source: New Mexico Office of the State Engineer- Interstate Stream Commission (NOSE-ISC) and Colorado Department of Natural Resources- Division of Water Resources (CDNR-DWR): https://www.ose.state.nm.us/Compacts/RioGrande/isc_rio_grande_tech_compact_reports.php

Calculation method:

Water Supply for Rio Grande Compact assesses the amount of water different states deliver under Rio Grande Compact requirements. The Rio Grande Compact is an interstate compact signed in 1938 in the United States between the states of Colorado, New Mexico, and Texas. This indicator only scores the Upper Rio Grande in Colorado and the Middle Rio Grande in New Mexico. This indicator is not applicable for the other two reporting regions.

For each region, the 2020 credit/debit status of water deliveries, in annual cumulative deliveries in acre-feet, was compared to thresholds set by the Rio Grande Compact, New Mexico Office of the State Engineer/Interstate Stream Commission (NMOSE-ISC) and Colorado Department of Natural Division of Water Resources (CDNR-DWR). For New Mexico and Colorado, a value of deliveries >0 indicates a score of A, between 80 and 100%. For New Mexico, deliveries between 0 and -66,500 were scaled to scores between 79 and 60%. Deliveries between -66,500 and -133,000 were scaled to scores between 59 and 40%. Deliveries between -133,000 and -200,000 were scaled to scores between 39 and 20%. Deliveries less than -200,000 received a Failing (F) score.

For Colorado, deliveries between 0 and -33,500 were scaled to scores between 79 and 60%. Deliveries between -33,500 and -67,000 were scaled to scores between 59 and 40%. Deliveries between -67,000 and -100,000 were scaled to scores between 39 and 20%. Deliveries less than -100,000 received a Failing (F) score.

Table 7: Thresholds and status for Rio Grande Compact indicator in New Mexico.

New Mexico Water Supply for Rio Grande Compact		
Indicator Thresholds X= annual cumulative deliveries (acre-feet)	**Article VI Annual Credit/Debit status (Based on Deliveries by New Mexico at Elephant Butte Dam as reported by the Interstate Stream Commission)**	**Indicator Grade**
X >= 0	Credit	A (100–80)- Excellent
0 > **X** >= (-66,500)	Debit	B (79–60)- Good
(-66,500) > **X** >= (-133,000)	Debit	C (59–40)- Moderate
(-133,000) > **X** >= (-200,000)	Debit	D (39–20)- Poor
(-200,000) > **X**	Below 200,000 Debit = New Mexico out of compliance with the Compact	F (19–0)- Failing

Table 8: Thresholds and status for Rio Grande Compact indicator in Colorado.

Colorado Water Supply for Rio Grande Compact		
Indicator Thresholds X= annual cumulative deliveries (acre-feet)	**Article VI Annual Credit/Debit status (Based on Deliveries by Colorado at the State Line as reported by the Interstate Stream Commission)**	**Indicator Grade**
X >= 0	Credit	A (100–80) Excellent
0 > **X** >= (-33,500)	Debit	B (79–60) Good
(-33,500) > **X** >= (-67,000)	Debit	C (59–40) Moderate
(-67,000) > **X** >= (-100,000)	Debit	D (39–20) Poor
(-100,000) > **X**	Below 100,000 Debit = Colorado out of compliance with the Compact	F (19–0) Failing

Impaired Streams

Data source: Data were available from 303d lists of impaired waters for Texas, New Mexico, and Colorado. Stream segments are categorized with designated uses, for example "recreation". Stream segments are then categorized based on whether they meet water quality standards for these uses. Data include the length of stream segments categorized as follows:

- Category 1 – Attaining all designated uses
- Category 2 – Attaining some designated uses, and insufficient or no data information to determine if remaining uses are attained
- Category 3 – Insufficient or no data and information to determine if any use is attained
- Category 4- Impaired or threatened for one or more uses but not needing a TMDL because: TMDL has been completed, or Expected to meet standards, or Not impaired by a pollutant
- Category 5 – Impaired or threatened by pollutant(s) for one or more designated uses and requiring a TMDL. These are the waters entered onto a state's 303(d) list.

Calculation method:

For all regions except Lower Rio Grande, the total length of not-impaired waters in the region (segments in Category 1 and Category 2) was divided by the total length of waters where data allowed for assessment (Category 1+ Category 2+ Category 4 + Category 5), and multiplied by 100. This percent of unimpaired stream length was used as the score for this indicator. For Lower Rio Grande, data were available separately for the New Mexico and Texas portions of the basin. The score was calculated separately for each, and the average of the two scores was used as the score for the Lower Rio Grande.

Landscapes and Ecology

Fish Diversity

Data source: Colorado Park and Wildlife and New Mexico Game and Fish

Calculation method:

Two metrics were calculated for Fish Diversity: 1) Total Fish Diversity and 2) Native Fish Diversity. Each metric was scored for each region by calculating a Simpson's Diversity Index. To calculate the index, first Simpson's Diversity was calculated for each region, using the equation on the next page. Then, the result of that calculation was subtracted from 1 and multiplied by 100, resulting in a score from 0-100%.

Simpson's Diversity (D) Equation:

$$D = \Sigma n_i(n_i-1) \; / \; N(N-1)$$

where:

ni= The number of organisms that belong to species i

N= The total number of organisms

The Simpson's Diversity Index score was calculated for Total Fish Diversity using data for all fishes, including native and non-native species. The data including only native species was used for the Native Fish Diversity score. Both values were calculated because although quantifying native species alone was important in assessing how well the ecosystem functions, some non-native species are important in this environment, particularly to anglers.

Silvery Minnow

Data source: Middle Rio Grande Endangered Species Program, Bureau of Reclamation

Calculation method:

The Silvery Minnow score calculation was based on Catch per Unit Effort (CPUE), and was calculated for three reaches of the Rio Grande: Angostura, Isleta, and San Acacia. CPUE, calculated here as the total number of minnows caught divided by the length of stream sampled multiplied by 100, is a common scientific method of measuring species abundance. The scoring scheme equated a CPUE of 1 or higher to a 40% score, so for each reach the annual score was calculated as 40 x Catch per Unit Effort (CPUE). The final score was the average of annual scores from 2015 to 2019. This score was only calculated for the Middle Rio Grande region.

Bird Diversity

Data source: North American Breeding Bird Survey Dataset

Calculation method:

A Simpson's Diversity Index was calculated for each route along which bird diversity was sampled in each region. This value was multiplied by 100 to achieve a route score. Each region score was calculated as the average of the route scores within the region. Region scores were weighted by the proportion of the area of the basin each region covers in order to calculate the overall Rio Grande score.

Wetland Loss

Data source: National Land Cover Database (USGS); https://www.mrlc.gov/eva/

Calculation method:

The percent difference in wetland area between 2016 to 2019 was calculated. For each region, this difference was compared to the standard deviation using the following equation:

$$y = 20x + 50$$

This equation calculates a score (y) as: the number of standard deviations by which wetland loss (x) differs from zero (no net loss). More simply, the equation sets a -2.5% change in wetland area, or a 2.5% loss, equal to a score of 0%. It sets a 2.5% gain equal to a 100% score. Scores below 0% were reset to 0%, and scores above 100% were reset to 100%.

Table 9: Scoring for Wetland Loss indicator.

Scoring & Equation		
y = 20x + 50		
% wetland change	**Score**	**Letter grade**
-2.5 to -1.5	0–20	F
-1.5 to -0.5	20–40	D
-0.5 to 0.5	40–60	C
0.5 to 1.5	60–80	B
1.5 to 2.5	80–100	A

Invasive trees & shrubs

Data source: The New Mexico Riparian Habitat Map (NMRipMap) (provided by Natural Heritage New Mexico, available at https://nhnm.unm.edu/riparian/nmripmap)

Calculation method:

The percent area covered by invasive trees and shrubs was calculated by region. The area was broken into five bins and rescaled to a 0-100 range to calculate the score for each region, as shown in Table 10. Scores were weighted by area of each region to calculate the overall watershed score. Thresholds (shown in Table 10) were determined through consultation with experts.

Table 10: Scoring for Invasive Trees and Shrubs indicator.

Invasive Trees & Shrubs			
% Invasive Plants	% Non-invasive Plants	Indicator Score	Indicator Grade
0–10	90–100	100–80	A
10–20	80–90	80–70	B+
20–30	70–80	70–60	B
30–50	50–70	60–40	C
50–100	0–50	40–0	D–F

Riparian Areas

Data source: The New Mexico Riparian Habitat Map (NMRipMap) (provided by Natural Heritage New Mexico, available at https://nhnm.unm.edu/riparian/nmripmap)

Calculation method:

The current riparian area was compared to historic riparian area in each region. The percent of historic riparian area remaining today was the score for each region. Region scores were weighted by area to calculate the overall score.

Society and Culture

Affordable Housing

Data source: U.S. Census Bureau; American Community Survey, ACS 2017 (5-Year Estimates), Accessed Online Nov 2019

Calculation method:

The data used to indicate affordable housing was derived from *B25106: Tenure by Housing Costs as a Percentage of Household income in the Past 12 Months*. These data were developed from *Selected Monthly Owner Costs as a Percentage of Household Income* for owner-occupied and *Gross Rent as a Percentage of Household Income* for renter-occupied units. In either case (owner- or renter-occupied), ACS variable B25106 provides the number of households allocating total income to housing at three levels: (1) Less than 20%, (2) 20 to 29%, and (3) 30% or more. For this indicator of affordable housing, we calculated the proportion of households allocating less than 30% to housing.

The "30% of income spent on housing" threshold is a widely recognized indicator of housing costs. For example, the Federal Reserve characterizes a household as "housing cost burdened" if it spends more than 30 percent of its income on housing costs. In 2017, on average, 32% of all households were housing-burdened nationally, meaning 68% spent less than 30% of income on housing.

In recognition of these national statistics, the affordable housing indicator was linearly scaled between 50% and 100%. Regions with less than 50% of households spending less than 30% of income on housing, would receive a score of 0 (F). Conversely, regions with 100% of households spending less than 30% of income on housing received a score of 100 (A). Using this scoring system, a region at the national average of 68% of households spending less than 30% of income on housing would receive a D.

Air Quality

Data source: EPA and New Mexico Department of the Environment

Calculation method:

Scores were calculated individually for three air quality metrics, then averaged for an overall Air Quality Score for each region. The three metrics were Particulate Matter, Ozone (O3), and Nitrogen Dioxide (NO2). Metrics were scored based on Air Quality Index (AQI) values calculated by the EPA. These values were assessed against thresholds set by the EPA (shown in the table below) in order to calculate report card scores on a scale from 0–100%.

Table 11: Air Quality thresholds and scores.

Air Quality Metrics				
Particulate Matter AQI	Ozone AQI	Nitrogen Dioxide AQI	Indicator Score	Indicator Grade
0–50	0–50	0–50	100–60	A–B
50–100	50–100	50–100	60–40	C
100–150	100–150	100–150	40–20	D
150–200	150–200	150–200	20–0	F

Social Vulnerability Index

Data source: Center for Disease Control (CDC) data collected through the American Community Survey

Calculation method:

Social vulnerability is defined by the CDC as the ability of a community to respond and bounce back from hazardous events such as natural disasters, tornados, or disease outbreaks. The Social Index (SVI), calculated by the CDC, measures social vulnerability (by land tract) based on socioeconomic status, household composition, diversity, minority status, language, housing, and transportation accessibility in communities.

SVI was reported by the CDC along a scale from 0 to 1, with 1 indicating the highest level of vulnerability and 0 no vulnerability. Within each region, SVI values for each land tract were rescaled along a scale of 0 to 100 to calculate a score. These values were rescaled so that an SVI of 0 would receive a score of 100% and an SVI of 1 would score 0%. Example calculations of SVI values to report card scores are shown in Table 12.

Table 12: Social Vulnerability Index scoring.

CDC Social Index Values to Report Card Scores		
CDC SVI Value	Indicator Score	Indicator Grade
0	100	A
0.1	95	A
0.3	75	B
0.5	55	C
0.7	35	D
0.9	15	F
1.0	0	F

Heat Vulnerability Index

Data source: NASA and GroundworkRVA Climate Safe Neighborhoods

Calculation method:

This index includes four metrics: tree canopy, impervious surface, land surface temperature (LST), and households in poverty. The index identifies places where there was greater vulnerability of people to heat-related and flooding-related risks, often occurring in neighborhoods afflicted with housing discrimination.

Data were analyzed at the census block level. For all metrics, reported HVI values were converted to a scale from -1 to 1 where 1 was the most vulnerable value and -1 was the least vulnerable value. Equations used to rescale HVI values are on the next page.

HVI conversion equation for tree canopy, impervious surface, land surface temperature:

((x-min)/(max-min))*2 -1

x = the HVI value of a given block group.

min = the minimum value of the range

max = the maximum value of the range

note: the resulting values for tree canopy were multiplied by -1 because lower tree canopy means greater vulnerability to heat.

HVI conversion equation for poverty:

2*x - 1

x = the HVI value of a given block group.

Adjusted HVI index values for each indicator were then added together, creating a final HVI index value, which was on a scale from -4 to 4. A block group with an adjusted HVI index value of 4 would be the most vulnerable, and a block group value of -4 would be the least vulnerable.

HVI index values were converted to scores by rescaling them, in five bins, along a scale from 0% to 100% as shown in the table below.

Table 13: Heat Vulnerability Index scoring.

HVI Index Values to Report Card Scores		
HVI Index Values	**Indicator Score**	**Indicator Grade**
-3 – -4	80-100	A
-2 – -3	60-80	B
-1 – -2	40-60	C
0 – -1	20-40	D
4 – 0	0-20	F

Walkability

Data source: Trust for Public Land (https://www.tpl.org/10minutewalk)

Calculation method:

According to The Trust for Public Land, "walkability" to a park or green spaces is defined as living within a 10 minute walk from a park. Walkability was calculated as follows, for urban areas in the four report card regions.

The total number of people who live within a 10-minute walk of a park was divided by the total population. The percent of the population within a 10-minute walk of a park was the "total population walkability" score.

Next, the percent of individuals in minority groups within a 10-minute walk of a park was calculated as the "diversity walkability" score.

The "total population walkability" and "diversity walkability" scores were averaged for each region to calculate overall walkability scores. Region scores were weighted by population to calculate the report card score for walkability.

Cultural & Historic Places

Data source: UMCES Survey of Rio Grande Basin residents

Calculation method:

The University of Maryland Center for Environmental Science conducted a survey of Rio Grande Basin residents. Four questions from the survey (listed below) were used to score this indicator. Answer options for each question were "Strongly agree", "Agree", "Neutral", "Disagree", "Strongly disagree", "Refuse to answer", and "I don't know". Each response was assigned a score from 0 to 100%, as displayed in the table below, and scores for each question were averaged. Then, the scores across all questions were averaged for an overall indicator score.

Table 14: Survey responses and scores.

UMCES Survey Scoring	
Answer	**Score**
Strongly agree	100
Agree	75

Neutral	50
Disagree	25
Strongly disagree	0
Refuse to answer	Not included in calculations
I don't know	Not included in calculations

Table 15: Survey Statements for Cultural and Historic Places.

Cultural & Historic Places Survey Questions
It is important to me to protect the Rio Grande for cultural use.
Preserving pre-historic and historic sites along the Rio Grande is important.
Pre-historic and historic sites along the Rio Grande are being preserved appropriately.
Cultural sites are respected and maintained in the Rio Grande basin.

Recreation Access

Data source: UMCES Survey of Rio Grande Basin residents

Calculation method:

The University of Maryland Center for Environmental Science conducted a survey of Rio Grande Basin residents.

Four questions from the survey (listed below) were used to score this indicator. Answer options for each question were "Strongly agree", "Agree", "Neutral", "Disagree", "Strongly disagree", "Refuse to answer", and "I don't know". Each response was assigned a score from 0 to 100%, as displayed in the table below, and scores for each question were averaged. Then, the scores across all questions were averaged for an overall indicator score.

Table 16: Survey responses and scores.

UMCES Survey Scoring	
Answer	**Score**
Strongly agree	100
Agree	75

Neutral	50
Disagree	25
Strongly disagree	0
Refuse to answer	Not included in calculations
I don’t know	Not included in calculations

Table 17: Survey statements for recreation.

Recreation Access Survey Questions
Pre-historic and historic sites in the Upper Rio Grande are easily accessible to the public.
People from local community groups and schools are able to enjoy outdoor activities.
Local people and visitors are able to recreate along the Rio Grande.
There is adequate water for recreation uses (e.g. fishing, boating, hiking, hunting)

Park Visitation

Data source: New Mexico Tourism Department and National Park visitation records

Calculation method:

Park visitation scores were calculated by 1) subtracting the lowest number of visitors to parks from 2006 to 2019 from the number of visitors in 2019, then 2) dividing that number by the difference between the highest number of visitors and lowest number of visitors in any year from 2006 to 2019.

Management & Governance

Fire

Data source: LANDFIRE, FACTS (US Forest Service) and National Fire Plan Operations and Reporting System (NFPORS) via the Integrated Interagency Fuels Treatments View portal

Calculation method:

High-risk dry forests that should be treated to prevent wildfires are identified as “targeted treatment areas”. The percent of targeted treatment areas that actually received treatment over a five-year period (2017 to 2021) was calculated. That value was rescaled along a scale from 0 to 100%, so that regions where at least 40% of targeted treatment areas received a score of 100% and regions where none of these areas received treatment scored a 0%.

Protected Lands

Data source: USGS Protected Areas Database of the United States

Calculation method:

USGS classifies lands by "GAP status," which indicates how land is managed in terms of protecting biodiversity. Land that is managed to protect biodiversity is classified as GAP 1 or 2. GAP 3 lands are managed for various uses, including conservation and extraction. There is no biodiversity protection in GAP 4 lands. More details are provided in the table below.

For each region, the percent of land classified as GAP 1 or GAP 2 was calculated. This was divided by 30 to determine how close that region was to achieving the goal of protecting 30% of land by 2030. This calculation determined scores for each region. Region scores were weighted by area to calculate an overall score.

Table 18: USGS GAP status classifications.

Protected Lands GAP Status	
Gap Status	**Description**
1	Areas managed for biodiversity where natural disturbances are allowed to proceed
2	Areas managed for biodiversity where natural disturbance is suppressed
3	Areas protected from land cover conversion but subject to extractive uses such as logging and mining
4	Areas with no known mandate for protection

Water Resource Management

Data source: UMCES Survey of Rio Grande Basin residents

Calculation method:

The University of Maryland Center for Environmental Science conducted a survey of Rio Grande Basin residents. Five questions from the survey (listed below) were used to score this indicator. Answer options for each question were "Strongly agree", "Agree", "Neutral", "Disagree", "Strongly disagree", "Refuse to answer", and "I don't know". Each response was assigned a score from 0 to 100%, as displayed in the table below, and scores for each question were averaged. Then, the scores across all questions were averaged for an overall indicator score.

Table 19: Survey responses and scores.

UMCES Survey Scoring	
Answer	**Score**
Strongly agree	100
Agree	75
Neutral	50
Disagree	25
Strongly disagree	0
Refuse to answer	Not included in calculations
I don't know	Not included in calculations

Table 20: Survey statements for Water Resource Management.

Water Resource Management Survey Questions
I know which organization(s) is/are responsible for managing water resources in the Rio Grande Basin within my community.
I know which organization(s) is/are responsible for managing water resources of the Rio Grande.
There are political efforts/structures participating in water resource management in my region of the Rio Grande Basin.
There are social efforts/structures (e.g. traditional/cultural or informal etc.) participating in water resource management in your region of the Rio Grande Basin.
There are administrative efforts/structures (e.g. tax, permits, policies, by-laws, laws, written rules, written procedures, policies, institutions/organizations) participating in water resource management in your region of the Rio Grande Basin.

Resource Governance

Data source: UMCES Survey of Rio Grande Basin residents

Calculation method:

The University of Maryland Center for Environmental Science conducted a survey of Rio Grande Basin residents. Six questions from the survey (listed below) were used to score this indicator. Answer options for each question were "Strongly agree", "Agree", "Neutral", "Disagree", "Strongly disagree", "Refuse to answer", and "I don't know". Each response was assigned a score from 0 to 100%, as displayed in the table below, and scores for each question were averaged. Then, the scores across all questions were averaged for an overall indicator score.

Table 21: Survey responses and scores.

UMCES Survey Scoring	
Answer	**Score**
Strongly agree	100
Agree	75
Neutral	50
Disagree	25
Strongly disagree	0
Refuse to answer	Not included in calculations
I don't know	Not included in calculations

Table 22: Survey statements for Water Resource Governance.

Water Resource Governance Survey Questions
I have avenues to report water related concerns/problems/issues in my region of the Rio Grande Basin.
I can easily exercise my legal rights regarding water resources in my region of the Rio Grande Basin (e.g. right to clean water, domestic water access).
There are ways for me to participate in managing and/or conserving my region of the Rio Grande Basin.
Local people have capacity to manage and govern the water resources within their region of the Rio Grande Basin.

Water resources are being managed effectively by government bodies in the Rio Grande from its headwaters in Colorado to El Paso that includes coordination between the states.
Water resources are being managed effectively by government bodies in my region of the Rio Grande basin.

Native Peoples and Acequias Representation

Data source: UMCES Survey of Rio Grande Basin residents

Calculation method:

The University of Maryland Center for Environmental Science conducted a survey of Rio Grande Basin residents. Two questions from the survey (listed below) were used to score this indicator. Answer options for each question were "Strongly agree", "Agree", "Neutral", "Disagree", "Strongly disagree", "Refuse to answer", and "I don't know". Each response was assigned a score from 0 to 100%, as displayed in the table below, and scores for each question were averaged. Then, the scores across all questions were averaged for an overall indicator score.

Table 23: Survey responses and scores.

UMCES Survey Scoring	
Answer	**Score**
Strongly agree	100
Agree	75
Neutral	50
Disagree	25
Strongly disagree	0
Refuse to answer	Not included in calculations
I don't know	Not included in calculations

Table 24: Survey statements regarding representation.

Native Peoples and Acequias Representation Survey Questions
There is adequate representation of indigenous communities and tribal nations in water management and planning.

There is adequate participation of indigenous communities and tribal nations in water management and planning.

Native Peoples and Acequias Support

Data source: UMCES Survey of Rio Grande Basin residents

Calculation method:

The University of Maryland Center for Environmental Science conducted a survey of Rio Grande Basin residents. Four questions from the survey (listed below) were used to score this indicator. Answer options for each question were “Strongly agree”, “Agree”, “Neutral”, “Disagree”, “Strongly disagree”, “Refuse to answer”, and “I don’t know”. Each response was assigned a score from 0 to 100%, as displayed in the table below, and scores for each question were averaged. Then, the scores across all questions were averaged for an overall indicator score.

Table 25: Survey responses and scores.

UMCES Survey Scoring	
Answer	**Score**
Strongly agree	100
Agree	75
Neutral	50
Disagree	25
Strongly disagree	0
Refuse to answer	Not included in calculations
I don’t know	Not included in calculations

Table 26: Survey statements regarding Native Peoples and Acequias Support.

Native Peoples and Acequias Support Survey Questions
Tribal nations and pueblos are being supported by federal and state governance.
The funding level for tribal nations and pueblos is adequate.
Acequias are being supported by federal and state governance.

The funding level for acequias is adequate.

Additional Indicators

The following indicators were explored, but ultimately not used in this report card.

Water Quality Index

Data source: United States Geological Survey (USGS)

Calculation method: Scores were calculated for each the following water quality metrics: pH, dissolved oxygen, conductance, and temperature. Current conditions of each metric were compared to water quality standards set by each state. Metric scores for each region were then averaged, yielding region water quality index scores. This indicator was not ultimately used in the report card because it was considered redundant with the impaired streams indicator.

Synthesis

To combine the indicators together, several steps were taken. Indicators were aggregated from the region level to the watershed level through the calculation of a weighted mean. The weights were either the region area or the region population, depending on which was appropriate for the indicator.

Each indicator was averaged to the category level and then each category score was averaged for an overall Upper Rio Grande Watershed Health Score.

Each region score was calculated by following similar steps. The indicator score in a specific region was averaged to the category level and then each category was averaged to the value level. No weighting occurred for the region scores since each region has an individual score. The final overall scores can be seen in Figure 2.

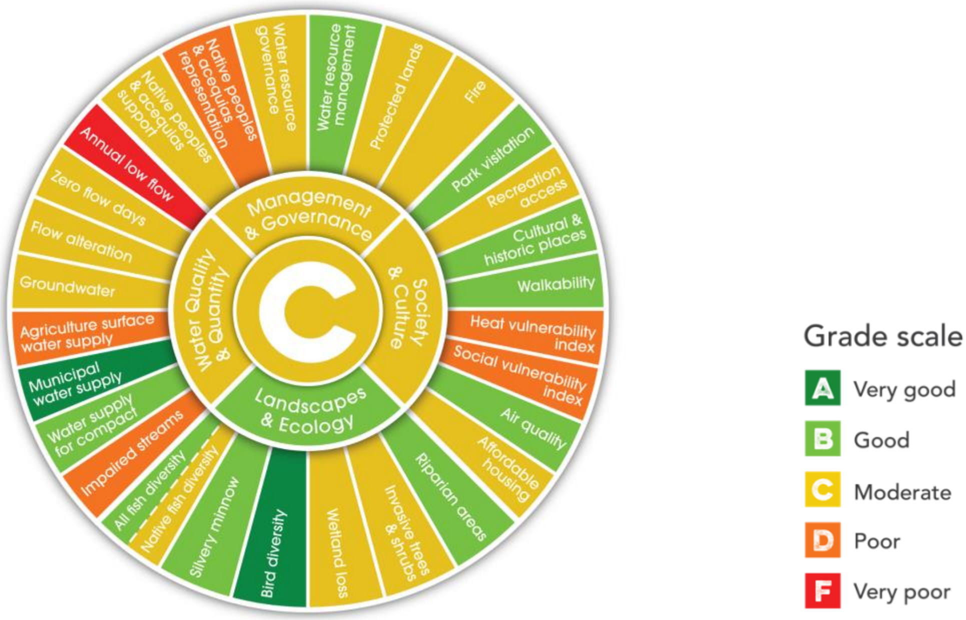

Figure 2: Overall scores for the indicators, categories, and values.

Communication

Watershed report cards, much like school report cards, provide performance–driven numeric grades or letters that represent the relative ecological and social health of a geographic region or component of the ecosystem. They are an important tool for integrating diverse data types into simple scores that can be communicated to decision makers and the general public. In other words, large and often complex amounts of information can be made understandable to a broad audience.

Watershed report cards enhance research, monitoring, and management in several ways. For the research community, they can lead to new insights through integration schemes that reveal patterns not immediately apparent, help to design a conceptual framework to integrate scientific understanding and environmental values, and help to develop scaling approaches that allow for comparison in time. Within monitoring realms, report cards justify continued monitoring by providing timely and relevant feedback to managers and can have the added benefit of accelerating data analyses. For management, they provide accountability by measuring the success of restoration efforts and identifying impaired regions or issues of ecological concern. This catalyzes improvements in ecosystem and social health through the development of peer pressure among local communities. Report cards also can guide restoration efforts by creating a targeting scheme for resource allocation.

Watershed health assessments have become more common in recent years, and report cards are being produced by a variety of groups from small, community–based organizations to large partnerships. Although methods, presentation, and content of report cards vary, the underlying premise is the same: to build community awareness and raise the profile of health impairment issues and restoration efforts.

Some common elements of report cards include:

1. A map of the watershed or region
2. A conceptual diagram

3. Indicator scores
4. A summary of the key features (e.g., ecosystem types, recreation activities)
5. A “What You Can Do” section

For the Upper Rio Grande Basin Report Card numerous meetings were conducted to plan the content, layout, and design of the documents. Many iterations of the report card occurred as the document evolved into its final state. The report card is a 12-page booklet style document. The report card provides background information on the region, the cultural and ecological importance of the river, a hydrologic model, and various management options to consider moving forward. Information about what the public can do to make a difference, in addition to the scores and grades, are also included. This report card provides a synthesis of monitoring data being collected in the Upper Rio Grande Basin in a visually appealing and engaging manner. The report card is supported by a full website which gives additional details of the scores for each region and indicator. View this information at: https://ecoreportcard.org/report-cards/rio-grande/

Appendix

Table A: Bird species included in the Bird Diversity Index indicator.

Common Name
American Coot
American Kestrel
American Robin
Ash-throated Flycatcher
Barn Swallow
Bewick's Wren
Black Phoebe
Black-chinned Hummingbird
Black-crowned Night-Heron
Black-tailed Gnatcatcher
Black-throated Sparrow
Blue Grosbeak
Brown-headed Cowbird
Bullock's Oriole
Burrowing Owl
Cactus Wren
Canyon Towhee
Canyon Wren
Cattle Egret
Cliff Swallow
Common Gallinule
Common Yellowthroat
Crissal Thrasher
Curve-billed Thrasher
Eastern Meadowlark
Eurasian Collared-Dove
European Starling
Gambel's Quail
Golden Eagle
Great Blue Heron
Great Egret

Great-tailed Grackle
Greater Roadrunner
Green Heron
House Finch
House Sparrow
Inca Dove
Killdeer
Ladder-backed Woodpecker
Lesser Goldfinch
Lesser Nighthawk
Loggerhead Shrike
Mallard
Mississippi Kite
Mourning Dove
Northern Mockingbird
Northern Rough-winged Swallow
Phainopepla
Pyrrhuloxia
Red-tailed Hawk
Red-winged Blackbird
Rock Pigeon
Rock Wren
Rufous-crowned Sparrow
Say's Phoebe
Scaled Quail
Scott's Oriole
Snowy Egret
Summer Tanager
Swainson's Hawk
Turkey Vulture
Verdin
Western Kingbird
Western Meadowlark
White-throated Swift
White-winged Dove
Wood Duck
Yellow-crowned Night-Heron

Table B: Fish species included in the All Fish Diversity indicator.

Scientific Name
Ameiurus melas
Ameiurus natalis
Aplodinotus grunniens
Campostoma anomalum
Carpiodes carpio
Catostomus (Pantosteus) plebeius
Catostomus catostomus
Catostomus commersonii
Catostomus plebeius
Ctenopharyngodon idellus
Culaea inconstans
Cyprinella lutrensis
Cyprinus carpio
Dorosoma cepedianum
Dorosoma petenense
Esox lucius
Fundulus sciadicus
Gambusia affinis
Gila elegans
Gila pandora
Hybognathus amarus
Ictalurus furcatus
Ictalurus punctatus
Ictiobus bubalus
Lepomis (Chaenobryttus) cyanellus
Lepomis (Lepomis) macrochirus

Lepomis cyanellus
Lepomis macrochirus
Micropterus dolomieu
Micropterus salmoides
Micropterus salmoides salmoides
Morone chrysops
Oncorhynchus clarki
Oncorhynchus clarki virginalis
Oncorhynchus clarkii × mykiss
Oncorhynchus mykiss
Oncorhynchus nerka
Oncorhynchus ssp. X clarki hybrid
Perca flavescens
Percina macrolepida
Pimephales promelas
Pimephales vigilax
Platygobio gracilis
Pomoxis annularis
Pterygoplichthys disjunctivus
Pylodictis olivaris
Rhinichthys cataractae
Salmo trutta
Salmo trutta × Salvelinus fontinalis
Salvelinus fontinalis
Sander vitreus
Tinca tinca