Using non-native vegetation to enhance in-stream habitat for native fishes (Year 1 of 2)

FY2022 and FY2023

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Background

Habitat loss and degradation is one of the leading hypothesized mechanisms for declines in native fish occurrence and abundance in the Colorado River basin. Providing adequate habitat for all life stages of imperiled fishes is a primary management action needed in the San Juan River basin (USFWS 2002a,b). In-stream habitat in the San Juan River has been simplified by channel narrowing and reduced channel migration due to an altered flow regime and establishment of non-native vegetation. The latter is primarily Russian olive (*Elaeagnus angustifolia*) that has armored the river banks contributing to habitat simplification to the detriment of native fishes (Stamp et al. 2006; Bassett 2015; Franssen et al. 2015). Low velocity habitats are hypothesized to be important to survival of ESA-listed, young-of-year Colorado Pikeminnow *Ptychocheilus lucius* and other native fishes (Holden 1977; Tyus and Haines 1991; UDWR 2006). Juvenile Colorado Pikeminnow select for low-velocity habitats in the San Juan River (Holden 1999; Trammel and Archer 2000), but these habitats have been reduced due to degradation of in-stream habitat. Given that Colorado Pikeminnow are experiencing continued declines across their range in the Upper Colorado River basin (Osmundson and White 2017; Bestgen et al. 2018), there is a need to assess further management actions to improve survival and retention.

Woody structure provides important complex habitat for fishes (*reviewed by* Crook and Robertson 1999; Roni et al. 2008). Branches of fallen trees provide refuge from predators (Crook and Robertson 1999; Schneider and Winemiller 2008), and woody structure promotes increased food resources by increasing the amount of habitat for colonization of microbes, primary producers, and macroinvertebrates (Angermeier and Karr 1984; Benke et al. 1985; Benke et al. 2001). In-channel woody structure can also create localized scour holes and low-velocity habitats, and accumulation of woody structure can increase habitat complexity at broader scales by promoting bar formation, sediment deposition, and channel avulsion (Stamp et al. 2006). Addition of woody structure to simplified channels leads to increased use by fishes, increased community and functional diversity (e.g., Warren et al. 2009; Sterling and Warren 2018), and increased fish abundance and retention in local habitats (*reviewed by* Roni 2019). To cite just a few examples, Rainbow Trout *Oncorhynchus mykiss* fry biomass was nearly 6x higher at sites with added fine woody debris (0.5 m long x 0.5 m wide x 0.3 m tall) relative to reference sites (Culp et al. 1996), and addition of wood to side channels increased the retention of juvenile Coho Salmon *Oncorhynchus kisutch* during late fall and early winter (Giannico and Hinch 2003).

A previous study adding woody structure to backwater habitats in the San Juan River was conducted in 2003 and 2004 (Golden et al. 2006). No noticeable difference in retention of stocked Colorado Pikeminnow was observed relative to years where woody structure was not added, but unexpected flow changes occurred in both years. These included reduced river discharge immediately following debris pile installation the first year and increased discharge and velocity in backwater habitats following installations the second year; preventing robust comparisons. Still, habitats with woody structure present were identified as preferred habitats for Colorado Pikeminnow (Golden et al. 2006). Thus, it remains unclear whether addition of woody structure would increase in-channel habitat complexity and retention of native fishes, particularly in the main-channel (e.g., Humphries et al. 2020).

Specific objectives and hypotheses

1) Use existing non-native woody structure to increase habitat complexity.
   Hypothesis: Complex habitat is limiting in main channel reaches.
   Prediction: Increasing habitat complexity will lead to locally increased retention and densities of native fishes.
2) Quantify changes in habitat from the addition of woody structure.
   Hypothesis: Simplified reaches of river have limited flow refuges.
   Prediction: Adding woody structure will provide flow refuges by creating low velocity habitat, and increasing local cover and complexity.
3) Quantify differences in macroinvertebrate densities between reaches with addition of woody structure and control reaches.
   Hypothesis: Macroinvertebrates will colonize woody structure providing additional food resources for fishes.

Study area, access, and personnel needs

This proposed work would take place on the San Juan River between Shiprock and Montezuma Creek on the Navajo Nation (Figure 1). Sites will be located entirely on the Navajo Nation, which will ease regulatory permitting by reducing the number of jurisdictions involved (i.e., EPA, Army Corps of Engineers). Still, this project will require Navajo Nation water quality certification pursuant to § 401 of the Clean Water Act, and a Nationwide Permit from the US Army Corps of Engineers. We have already received a waiver from the Navajo Nation EPA for 401 certification. The stretch of river proposed includes portions of geomorphic reaches 3 and 4 where age-0 and age-1 Colorado Pikeminnow are consistently captured during small-bodied monitoring (Zeigler et al. 2018).

Figure 1: Study area map of the San Juan River between Farmington, New Mexico and Mexican Hat, Utah.

Methods

Woody structure experiment-We propose to experimentally test the effects of addition of woody structure (Russian Olive and *Tamarisk*) on juvenile (age-0 and age-1) native fishes, including Colorado Pikeminnow, Razorback Sucker *Xyrauchen texanus*, Flannelmouth Sucker *Catostomus latipinnis*, Bluehead Sucker *Catostomus discobolus*, and Speckled Dace *Rhinichthys osculus*, during baseflow conditions (October-February). Our design will consist of 12 reaches (~300 m) stratified by geomorphic reach (6 in each geomorphic reach) and accessible by raft, road, or a combination of both wherein, each reach will be split evenly into an upstream and downstream sub-reach (~125 m) while maintaining a ~50 m buffer between sub-reaches (Figure 2). At each reach, the upstream sub-reach will serve as a reference and the downstream sub-reach will receive the treatment. Treatments will consist of anchoring woody structure bundles (10, ~4 m^2 bundles) throughout the sub-reach in low-velocity, near-shore habitat on one side of the river channel as to not impede boat traffic. Since we will be placing bundles by hand, they need to be small enough for a crew of 2-3 people to feasibly move around. We will place bundles in the wetted channel (water flowing around all sides) in wadable habitats (<0.5 m deep), and we will space bundles apart to allow sampling to occur between them (i.e., pull a seine or electrofish).We will place bundles at increasing depths from shore which will buffer treatments against fluctuations in flow. Control sub-reaches will remain unaltered. All treatment reaches will receive similar densities of woody structure. We will use existing non-native Russian olive branches at each reach to build woody structures. We will lash branches together using cotton rope and anchor them to the river bottom with wood stakes. This will encourage retention during the evaluation period, but will also allow structures to break down and disperse over longer time periods, similar to woody structure that naturally falls in the river channel. Although monsoonal floods could disperse woody structures, we are limited to what can be done with hand crews, and will anchor structures to promote their retention in place as long as possible for evaluation. We will keep track of changes in position and size of woody structures over time.

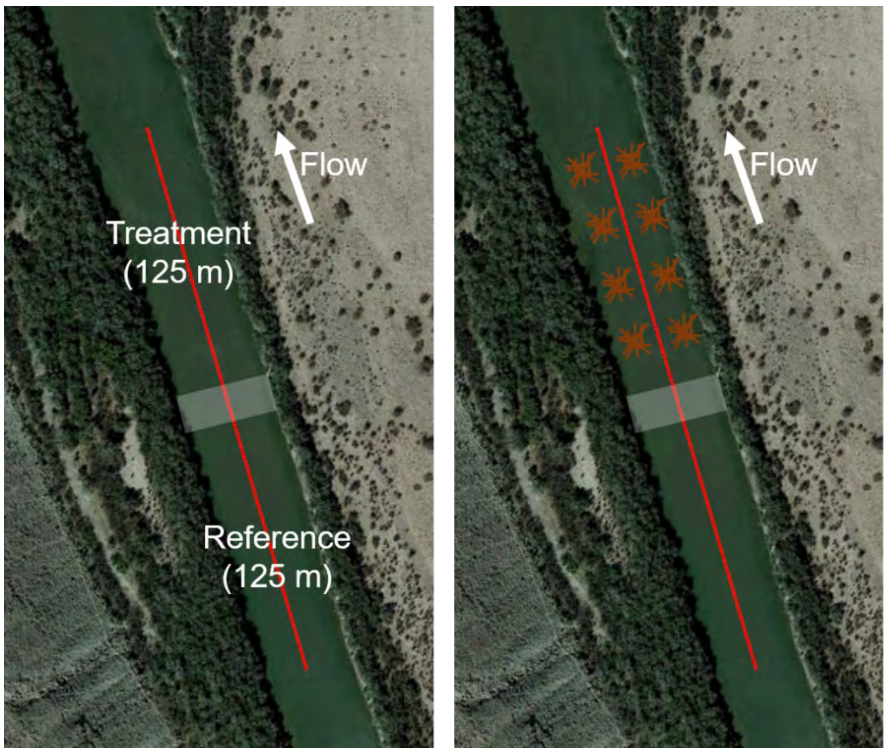

Figure 2: Delineation of a hypothetical 300 m reach on the San Juan River into upstream, reference and downstream, treatment sub-reaches. Note: Woody structures are not to scale and will be placed in low-velocity, near-shore habitat on one side of the river channel.

Fish sampling and detection-We will use a BACI design (Before-After-Control-Intervention) to test for treatment effects and repeat the experiment in two years (2022 and 2023). We will build wood bundles prior to the first sampling event (September) so we can install them immediately following. Prior to installation of woody structures, we will conduct fish sampling at each reach (N = 12). We will sample fishes with a combination of backpack electrofishing and seining all wade-able habitats. We will scan fishes for the presence of a PIT tag, and will tag all fishes > 99 mm TL with a 12 mm PIT tag. We will tag all encountered native species of conservation concern including: Bluehead Sucker, Colorado Pikeminnow, Flannelmouth Sucker, and Razorback Sucker. We will also tag any non-native species of management concern (e.g., Channel Catfish *Ictalurus punctatus*).

Following installation of woody structures, we will resample each sub-reach monthly in October, November, December, and in February the following year. To assess use of woody structures by tagged fish, we will attach two submersible PIT antennas to randomly selected bundles within a treatment sub-reach and also place two antennas in similar habitat in the paired reference sub-reach. This would require a total of 48 submersible antennas. Placing at least two antennas per sub-reach will allow us to estimate detection probabilities. Because the number of antennas available might be a limiting factor, we will install antennas in a subset of reaches within each Geomorphic Reach. We can rotate antennas among experimental reaches within Geomorphic Reaches every three-four weeks to collect detection data at all reaches. For example, if we had 24 antennas, we would be able to place antennas in six reaches, three in each Geomorphic Reach. After those antennas are in place for several weeks (i.e., whenever batteries need charging), we can rotate antennas to the other three reaches within each Geomorphic Reach. This rotation would continue throughout the study period (October-February). We can place antennas in more reaches if more antennas are available, which would eliminate the need to rotate antennas. Since many of the submersible antennas used throughout the Upper Colorado River Basin are deployed seasonally in the spring and summer (e.g., Cathcart et al. 2018), and are not being used during the time of year of our proposed study, we will coordinate borrowing antennas from other researchers in the basin as much as possible.

We will assess reach-scale treatment effects using fish capture data, such as the total number of fishes captured (native and nonnative) in the treatment versus reference reaches. Detection data will provide information on both fine- and broad-scale habitat use and movement and will also provide re-encounters for use in demographic models (e.g., Warren et al. 2009). Of particular interest, we will be able to detect stocked age-1 Colorado Pikeminnow because the San Juan River Basin Recovery Implementation Program (SJRBRIP) is planning on stocking age-1 fish with PIT tags starting in the fall (late October-early November) of 2021. Thus, these data will contribute to re-encounters of stocked fish in addition to the fish we PIT tag during our sampling. We could also coordinate with the SJRBRIP to stock tagged Colorado Pikeminnow in reaches 3 and 4 and in treatment and reference reaches to assess their retention.

Because our ability to capture fishes may vary among sub-reaches, we will perform depletion sampling at a subset of reaches during each sampling trip. Depletion sampling will involve sampling each sub-reach with multiple repeated passes; after each pass all captured fishes will be retained and will not be released until all passes have been completed. We will always sample the treatment sub-reach first. We will block the lower end of the reach with a seine and electrofish downstream into the seine. This design will allow for the calculation of population size ($\hat{N}$), catchability (q; Hayes et al. 2007), and detection probability (p; MacKenzie et al. 2002). If capture efficiency varies among sub-reaches (reference versus treatment), we will use our catchability and detection probabilities to correct fish density estimates. Also, we can estimate sub-reach-scale detection probabilities with the PIT antennas (described above).

Habitat characteristics-We will quantify depth, velocity, and substrate in treatment and reference sub-reaches. Similar to fish sampling, we will measure these variables before woody structures are installed in September 2021, and then immediately following fish sampling events in October, November, December, and in February. We will measure habitat variables along three equally-spaced transects in each sub-reach. Within sub-reaches, transects will be spaced 50 m apart. Along each transect, we will take five measurements of depth (measured with a topset wading rod), velocity (measured with a flow meter), and dominate substrate (e.g., sand). The first measurement will start 0.1 m from the nearest shore, and the other four measurements will be distributed evenly between that point and the edge of the furthest woody structure. To quantify fine-scale habitat conditions around the woody structures we will measure depth and velocity inside or immediately downstream of a random subset of structures at each site each sampling trip. We will also place temperature loggers at a subset of sites in treatment and reference reaches along with PIT antennas.

Macroinvertebrate sampling-Use of treatment reaches by fishes could be due to changes in habitat conditions, but it could also be due to increased food resources from macroinvertebrates colonizing woody structure. Thus, we will sample macroinvertebrates with a combination of kick sampling of a known area (e.g., one square meter) using a D-frame net and scrubbing of woody structure (e.g., Whitney et al. 2014, 2015). We will collect kick samples and woody structure (treatment sub-reach only) along three transects at the bottom, middle, and top of the sub-reach. Along each transect we will collect three replicates each of kick samples (n = 9) and woody structure (n = 9) samples. These two types of samples will be kept separate to allow comparison of kick samples among the reference and treatment sub-reaches. We will collect the same number of kick samples from the reference reach. Macroinvertebrates will be identified to order or family, counted, and measured in the laboratory to estimate biomass.

Data analysis-We will compare fish densities (native and non-native; number of fish per m^2), rarefied species richness (native and non-native), other community metrics (e.g., evenness, dominance), habitat characteristics and macroinvertebrate biomass among reference and treatment reaches. Sampling prior to addition of woody structure will provide us a baseline of natural variability in fish densities among reaches. Comparisons of kick samples will allow a direct comparison of macroinvertebrate biomass between reference and treatment reaches, and we will extrapolate sub-samples from woody structure to assess the amount of biomass added from the woody structure treatment. We will also compare PIT-tag detection data across reaches. We will use a generalized linear modeling framework to test for differences in response variables among treatment and reference reaches. Generalized linear models will allow us to analyze response variables with different structures (e.g., discrete, continuous, but positive-only), and we will include a blocking factor for each reach to account for spatial variation.

Deliverables

An annual report will be provided each year of the study using the same timeline as reports required for the SJRBRIP and Bureau of Reclamation. Likewise, an annual oral report will be given at the SJRBRIP Annual Biology Committee Meeting in February. At the completion of the project a final report will be delivered to both the SJRBRIP and Reclamation, and will include any publications of the work. Scientific publications will be prepared as the work progresses and at the completion of the project. All data collected during this project will be submitted to the Program Office within three months from completion of the project.

Data management

All field notes will be scanned and electronic files will be archived on a server at Kansas State University that has daily backups. All data will be entered in database format in spreadsheets and files stored on the KSU server. Every year we will provide PIT tag and capture data to the SJRBRIP program office to be uploaded into the STReaMS database.

Budget

Period: October 1, 2021 to September 30, 2022

Using non-native vegetation to enhance in-stream habitat for native fishes				
Task Description				
Task	**Item**			
Salaries		**FY22**	**FY23**	**Total**
Project PI: Coordinate project	2 months	$10,833.32	$11,158.32	$21,991.64
Graduate student	12 months	$21,600.00	$22,248.00	$43,848.00
Research Assistant	3 months	$6,240.00	$6,427.20	$12,667.20
Fringe benefits				
Project PI	46.50%	$5,037.49	$5,244.41	$10,281.90
Graduate student	0.80%	$172.80	$177.98	$350.78
Health insurance		$2,017.00	$2,178.36	$4195.36
Research Assistant	8.30%	$517.92	$533.46	$1051.38
Travel				
Field and meeting travel expenses	Per diem	$5,720.00	$5891.60	$11,611.60
	Lodging-Bluff, UT	$2,688.00	$2,768.64	$5,456.64

	Rent a field truck and fuel (1800 miles round trip Stillwater, OK to Bluff, UT and travel to field sites) & from Logan, UT	$10,120.00	$10,423.60	$20,543.60
	Airfare (Stillwater, OK/Salt Lake City, UT to Durango, CO)	$1,000.00	$1,030.00	$2,030.00
Supplies				
Field Sampling Gear	Seines (Memphis Net and Twine)	$600.00	$300.00	$900.00
	Ethanol	$1,400.00	$1,442.00	$2,842.00
	Pine cores	$2,200.00	$2,266.00	$4,466.00
Equipment				
	Chain saws & PPE	$1,700.00	$1,000.00	$2,700
	Temperature loggers	$504.00		$504.00
	Laptop	$1,000.00		$1,000.00
Tuition and Fees (no indirect cost)		$7187.14	$7546.50	$14,733.64
	Total direct costs - Task 1	**$80,537.67**	**$80,636.07**	**$161,173.74**
	Modified Total direct costs (less tuition and fees)	**$73,350.53**	**$73,089.57**	**$146,440.11**
	17.5% MTDC F&A	**$12,836.34**	**$12,790.67**	**$25,627.02**
	Total costs	**$93,374.02**	**$93,426.74**	**$186,800.76**

Budget justification

Personnel: For the first year, funds are requested to support two months of the lead PI's (Pennock) salary. Salary for Co-PI's Budy and Gido are in-kind. For each year, funds are requested to support a graduate student and an experienced technician for 3 months to assist with field work and laboratory and data analysis when not in the field.

Travel: Funds are requested to support travel, lodging, and per diem associated with field work. Airfare is included for travel to one meeting per year.

Supplies: Includes supplies necessary for construction of wood bundles, and supplies necessary for sampling and sample preservation.

Equipment: Includes funds for purchase of chain saws and PPE, 12 temperature loggers, and a field laptop.

Indirect costs: This grant would go through the Cooperative Ecosystems Study Unit (CESU) agreement in place with Utah State University which allows a 17.5% overhead rate.

*We removed the cost for 12 submersible antennas from the revised budget under assurances that we will be able to borrow this equipment from the Program and/or other Upper Basin researchers as necessary.

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Thank you for reviewing our proposal and providing constructive comments. We have responded to BC member comments and questions below in bold.

Response to comments from BC

How can the technical aspects of this SOW be improved?

Crockert (CPW): Since this was tried before (Golden) and flows made the results inconclusive, it would be good to anticipate how a repeat of that situation could be avoided. E.g, how can the analysis account for monsoons & other unexpected events? No other suggestions, this is a well-thought-out project that I would support.

Previous attempts to evaluate addition of woody structure focused on backwater habitats associated with secondary channels. We are focusing our efforts on near-shore main channel habitats which should be less susceptible to extreme changes in flows. Bundles will be placed at increasing depths from shore which will also buffer treatments against fluctuations in flow by ensuring at least some wood bundles maintain connection with the water. We clarified this in the proposal.

Keith (TNC): Consider using branches that have been seasoned (aged) or otherwise treated to minimize risk of unintentional propagation and spread of invasive tamarisk and Russian olive.
Given that Russian olive is ubiquitous in the San Juan River corridor, we do not think the additions of branches will lead to more spread of Russian olive than what is already occurring naturally. Russian olive reproduce mostly through seeds, and it is unverified that vegetative reproduction occurs from cut branches under field conditions (Colorado State Parks, Best Management Practices, 2003; https://www.fs.fed.us/database/feis/plants/tree/elaang/all.html; personal communication, Dr. Mike Kuhns, Extension Forester, Utah State University). Although we appreciate the desire to not spread Russian olive further, using seasoned branches would delay the start of the project. Furthermore, we need to avoid using chemical treatment for personnel safety and issues of impacting water quality per our 401 permitting from Navajo Nation.

Mazzone (Jicarilla Apache Nation): The project could benefit from: Incorporating meso scale temperature monitoring/analysis and comparison between treatment and control reaches. May help guide future structure placement. Noting site aspect/relative position is also a consideration as these could affect meso scale temperatures.
We added that we will deploy temperature loggers at a subset of sites along with the PIT antennas.

Larrick (UMUT): Answer questions: Can native plant material (willow, cottonwood, etc) be used for the bundles? Why or why not. Is there risk of non-native plant material in bundles and used as stakes be transported and sprout/grow downstream?

Native vegetation could be used, but this would make the logistics of the project more difficult since native vegetation is far less common than non-native Russian olive. Russian olive is ubiquitous throughout the San Juan River corridor. Based on our conversations with plant ecologists at Utah State University, there is a very low chance of cut branches sprouting (see above response).

McKinstry (BOR): I think the use of as many PIT antennas as they can get is a good thing.
We agree that the detection data from PIT antennas will provide valuable encounter data.

Miller (Southern Ute Indian Tribe): Page 166, lines 177-120: Block nets should be used during electrofishing sampling. Miller and Lamarra used block nets during population estimate sampling to prevent fish escapement from target areas to get comparable results from specific habitat types. Lack of blocking may allow fish escapement and reduce the accuracy of the density estimates.
Page 167, lines 152-162. Same comments as for Page 166.
Placing block nets across the San Juan River would be logistically very difficult. We propose to use seines to block the bottom of each reach and electrofishing downstream into seines.

Page 167, lines 163-172: The proposed habitat characteristics sampling as stated will not detect differences in channel hydraulics from the woody debris piles. The techniques will only measure open channel hydraulic parameters of unrestricted flow areas. One stated hypothesis is that the woody debris will provide hydraulic conditions that native fish would select over open channel hydraulic conditions. Measurements should be taken within the debris piles as practicable to obtain the depths, velocities, and other parameters that may be important to the habitat selection. This could be accomplished by randomly selecting one or several debris piles for measurement to compare with the open channel characteristics.
Thanks for this suggestion. We've added that we will measure habitat variables within or directly downstream of a subset of debris piles along with the transect measurements.

Page 168, lines 173-181: The purpose of the macroinvertebrate sampling is not stated in the proposal and should be included for full review of the proposal. The transect based sampling approach does not state if these will be placed through the debris piles in the treatment reaches or in open water. The selection of sampling location along the transects is not stated and should be provided for full review of the proposal. There are numerous studies that show that sampling location (near shore, mid-channel, or quartiles) will result in different invertebrate densities. The macroinvertebrate sampling using benthic cores is a non-standard technique for river sampling and could likely be compromised by substrate heterogeneity. No detail is provided for how the benthic cores will be collected such as size of core, coring equipment, or core location selection. Recommended macroinvertebrate sampling techniques as described in Barbour et al. 1999 (EPA Rapid Bioassessment) and Merritt et al. (2008, Introduction to North

American Aquatic Insect) should be considered over benthic cores. Kick sampling in a measured area (e.g. one square meter) using a D Frame net would provide a better data set for riverine habitats with variable substrate sizes. A quantitative method such as a modified Hess sampler would also provide a more robust data set for comparison of benthic prey, if that is the objective of the sampling.
Thank you for these suggestions. We have clarified our purpose for collecting macroinvertebrates and added it to our objectives. We also point out that increased prey resources could be an alternative hypothesis for fish use of wood bundles. We have also replaced benthic core sampling with kick sampling using a D frame net within a measured area.

Page 168, lines 201-206: The deliverables need to include all of the data collected during the project.
We added that all data collected during the project will be submitted to the PO upon completion of the project.

Schleicher (USFWS R6): Line 143: How are you going to determine actual habitat use vs a fish passing by?
The PIT antennas will provide longer-term data on fish use of the wood bundles. Although the sampling will capture snapshots of fish using the treatment reaches, the repeated sampling over time along with comparisons to the reference reaches will help determine the consistency of fish use of these habitats.
Line149: Currently the SJRIP has changed the stocking protocols for Colorado Pikeminnow and will finally be able to implement these new protocols, while it would be nice to test a theory that brush bundles will help retain/used by stocked age-1 CPM I don’t believe it would be appropriate to move stocking locations to do so. If the proposed treatment/reference reaches fall close by then maybe something can be accommodated.
Reaches could be placed in the vicinity of the Montezuma Creek stocking site that the Program already uses. Another option for coordination of reaches and stocking locations could be reaches downstream of river mile 133.5 with the stocking trailer potentially accessing the river via Is Rt 364. We will coordinate with the Program Office before selecting final reach locations.
Line 153: Are you using block nets to account for any emigration due to activity?
See above. We will block the lower end of the reach with seines and shock into them.
Line 155: How are the fish being retained? Additional stress from handling may lead to delayed mortality.
Between depletion passes, fishes will be kept in buckets with aerators and salt and placed in the shade to reduce stress as much as possible.

Warren (Peer Reviewer): It is not clear how you can directly measure variables that will lead you to accept or reject hypothesis 2 (provide flow and predator refugia). The prediction is about retention and survival, which can likely be estimated via sampling (densities and pit tag information). I suggest rewording the hypothesis so it is parallel with the prediction. Perhaps consider replacing buried or missing bundles before or after each sample to set the scene for the next sample. I did some work with similar bundles in a much smaller stream and we had to constantly replace buried or lost bundles. Spates really tended to tear them from the rebar stake or bury them completely. We went out about a month before the next sample and replaced missing bundles as needed (not ideal but a month seemed a reasonable amount of time to attract fishes to the new bundle).

In depletions sampling the upstream and downstream of the sample area are generally blocked. That's probably not possible in the mainstem San Juan. How might that affect the depletion based estimates?
We agree that deploying block nets in the San Juan River is infeasible. However, we will block the lower end of the reach with seines and shock into the seines.
How will you calculate density given you will be using seines and e-fishing? Will you combine them?
We will calculate density as the number fish per area sampled. Reaches will be set up such that the area of each reach will be the same and sampling will be consistent among reaches.
How will you calculate richness given you will likely encounter more individuals in some habitats than others? Maybe consider rarefaction (e.g., Estimate S) or one of the Chao approaches?
Thanks for this suggestion. We added that we will calculate rarefied richness.
I suggest you look at other common structural measures such as dominance (given the native/non-native aspects of the fauna, I like Berger-Parker) and eveness (I like Hurlbert's PIE). It would make the SOW stronger if you give the reader a bit more on the ways you will compare the before communities and the control vs treatment communities?
Thanks for this suggestion. We added that we will calculate other community metrics in addition to densities.

Will you avoid bends in the when you select sample sites? How about secondary channels?
Yes, we plan to place sites in relatively straight, simple reaches in the primary channel.

Ziegler (NMDGF): This project has clear objectives and methods which should address the identified hypotheses. I had just a few comments listed below.
Thank you.
Line 59: Objective 2. It will be very difficult to assess long-term survival of native fish tagged in this study. Some information from Colorado Pikeminnow may be obtained in the future, but the scale of this project will probably not provide meaningful conclusion. I also doubt that any information on survival of other native species will be gained from this study. I suggest removing this statement or clarifying it.
We revised our objectives to focus on what we can feasibly quantify over the course of this study. PIT tag detection data will contribute important information,

but as pointed out, we will not be able to calculate meaningful survival estimates at an annual scale. However, if we obtain enough detections of stocked pikeminnow, we might be able to estimate survival over shorter time scales.
Line 72-74: Being located on Navajo Nation may reduce some permitting issues but I think this work will likely require a 404 permit. I think you should specify which permits are necessary, how those permits will be obtained, and what additional reporting is required. Certain 404 permits require longer-term reporting (up to 5 years) and it would be beneficial to know if the PIs are committed to any long-term reporting that is required.
We have added the specific permits necessary to complete the work to the text. These permits include a Navajo Nation water quality certification under the Clean Water Act and a Nationwide Permit from the US Army Corps of Engineers. The Corps recommended applying for NWP #27: Aquatic Habitat Restoration, Enhancement, and Establishment Activities. This NWP does not require long-term reporting. We have already been granted a waiver from Navajo Nation for water quality certification and have submitted our application for a Nationwide Permit to the Corps.
Line 92: I believe Russian Olive is capable of sprouting and establishing from cut branches. Does this work pose any risk of increasing Russian Olive in the San Juan River corridor? Would you chemically treat Russian Olive prior to planting it in the river?
See response above to Keith (TNC). This should not be an issue and we will not use chemical treatment.
Line 105: As mentioned in the introduction, previous attempts at placing woody debris in the river failed because of changes in flows. Either exposing the debris piles or inundating them so they can not be samples. How are you planning to overcome these issues? Will debris piles also be placed at different depths so at least some of them can be samples when flows change?
See responses above. We clarified that we will place bundles at different depths, and by placing bundles in the primary channel this should reduce the effects of flow fluctuations. Previous work was conducted in backwaters associated with secondary channels.
Line 119: Is > 99 mm the size of all fishes that will be tagged? Current guidance for endangered fishes is to tag fish > 130 mm. It may be beneficial to specify which species will be tagged, I'm not sure of the benefit to the project goals if all species (e.g., Speckled Dace) are going to be tagged.
The PI's have experience and are comfortable tagging fishes down to 45 mm TL with smaller tags (Pennock et al. 2016; Pennock 2017; Pennock et al. 2018; Pennock and Bruckerhoff 2020). However, we'd like to maintain consistent tag sizes as what are currently used throughout the Upper Basin (i.e., 12 mm), and to not influence detection probabilities with use of different sized tags for different sized fish. Although tagging effects can be species dependent, survival of tagged fish is typically high regardless of tag size and species for the size of fish we are proposing to tag (reviewed by Pennock et al. 2016 and Clark 2017). We plan to tag all native species of conservation concern ("three species" and endangered fishes). We will also tag non-native species of management concern, such as

Channel Catfish. We will not tag Speckled Dace. We've added the species to be tagged to the proposal text.

Pennock et al. 2016. Survival of and tag retention in Southern Redbelly Dace injected with two sizes of PIT tags. North American Journal of Fisheries Management 36:1386-1394.

Pennock. 2017. Effects of PIT tags on Red Shiner *Cyprinella lutrensis* and Sand Shiner *Notropis stramineus*. Transactions of the Kansas Academy of Science 120:87-93.

Pennock et al. 2018. Can fishways mitigate fragmentation effects on Great Plains fish communities? Canadian Journal of Fisheries and Aquatic Sciences 75:121-130.

Pennock & Bruckerhoff 2020. Qualitative observations of successful spawning by two species of small-bodied minnows following PIT tagging. Western North American Naturalist 80:253-256.

Line 173-181: Macroinvertebrate sampling. Which objective and hypothesis is this sampling going to address? Is there an identified lack of aquatic macroinvertebrates in the San Juan River? I am familiar with work investigating the relationship between wood in streams and macroinvertebrate density and richness but I am not sure what the purpose of monitoring this would be for this project as it relates to endangered fish recovery.

This was addressed in responses to comments from Miller (see above).

Line 182: A few possible variables to measure are the time in place, the size, and the position of the brush pile over time. Assuming, the brush piles will be displaced and may be reoriented or pulled apart naturally and this may increase or decrease complexity of the habitat and thus the attraction to or away from the structures you may consider measuring these variables.

Thanks for this suggestion. We've added that we will keep track of changes in position and size of woody structures over time.

L182-184: I am curious how Hypothesis 2 (predator refugia) is going to be evaluated. You hypothesize that woody structure would provide refugia from predators, but how are you going to asses this? Does the presence of native fish and potentially predatory fish (e.g., Channel Catfish) indicate that there is no refugia?

We revised our objectives. We might be able to assess this using PIT detection data, but it will be dependent on how many detections of native fishes and predators we obtain since many fish, other than endangered species, in the San Juan River are currently not tagged.

PO: Line 42: Giving a few examples that have shown such microhabitat projects can change fish abundances and retention would provide reassurance that this project has the potential to be effective.

We've provided some examples of increases in abundance and retention. See also Roni 2019 for a comprehensive review.
Lines 55 to 69: All three objectives seem closely related. It would be helpful to 1) articulate specific differences among hypotheses and 2) line up which data sets will be used to answer each hypothesis.
We revised and focused our objectives so it is more clear which datasets will contribute to each objective.
L175 to L179: Please provide the temporal sampling scale for invertebrates and habitat
We clarified that habitat and invertebrates will be sampled when fishes are sampled.
Stocking age-1 Colorado Pikeminnow will be limited to locations accessible by the hatchery truck's gooseneck trailer, so it's unclear how close those stockings could occur to the Treatment and reference reaches. Please consider this and revise the scope as needed.
One of the potential areas for placement of experimental reaches is between Aneth and Montezuma Creek nearby a current stocking location used by the Program. Another could be downstream of river mile 133.5. We will plan on coordinating with the Program Office before selecting final sites and welcome any suggestions.

L193-195: What is the time frame for survival estimates? If it is annual, then how can that be done with only two years of data? If survival will be on a shorter time scale, please describe how sampling would be sufficient to obtain needed data. Overall, the survival analysis section could use clarification.
As pointed out, the duration of the study will not be long enough to obtain annual survival estimates. Survival estimates over shorter temporal scales (e.g., months) might be obtained if enough recapture and/or detection data is obtained; however, we won't know this prior to conducting the experiment. We removed this section from the SOW.

What is this SOW's contribution to recovery?

Crockett (CPW): The contribution to recovery depends on scalability, which I wonder about. If woody debris enhancements prove beneficial, is it feasible to do this on a scale and over a time frame that would have population-level impacts?
Given the amount of Russian olive available and its ubiquitous distribution throughout the San Juan River corridor, we think this project would be easily scaled up. Ongoing restoration efforts in other rivers in Utah (San Rafael, Price, White) use hand crews to remove Russian olive from cottonwood galleries and riparian areas over large reaches of river.

Keith (TNC): Should provide valuable insight into species-habitat response and potential limiting factors for native fishes.

Larrick (UMUT): Addition of woody debris may increase in-channel habitat complexity and retention of native fish.

Mazzone (Jicarilla Apache Nation): This scope proposes to test a simple and inexpensive on ground management action. The SOW targets life stages of extreme importance to the recovery of both endangered fish. The Program is currently lacking regular efficient management actions, if the results of this project are positive the proposed habitat enhancement technique is almost infinitely scalable and relies on simple methods, tools, and an unlimited regenerating supply of materials. “Large Scale” habitat improvements to date have been small in relative nature, limited in spatial extent, time consuming, and expensive. This project seeks to remedy some of the traditional habitat projects aforementioned shortcomings.

Mckinstry (BOR): I like this proposal. I think it is a good test of using complex habitat to improve retention, survival, and eventual recruitment of CPM. We are really limited as to what we can do from the standpoint of “habitat work” and this seems like an easy and CHEAP method to test. It may not work, but what do we have to lose? Let’s try it!!

Miller (Southern Ute Indian Tribe): The contribution to recovery is unknown. The hypothesis of this proposal is that low velocity habitat is limiting native fishes, in particular Colorado Pikeminnow. The data from habitat studies in the San Juan show low velocity habitat steadily increasing since 2003. The low velocity habitat in 2020 was at the highest level since the peak in the 1990s yet there are very few Colorado Pikeminnow collected. The high abundance and low utilization of the current low velocity habitat seems to indicate that something other than low velocity habitat is limiting for younger life stages of Colorado Pikeminnow.
If the addition of woody structure to low velocity habitats leads to benefits to native fishes, we think this could contribute to recovery. Although low velocity habitat has increased in the San Juan River since lows in the early 2000s this could still be a limiting habitat which might be enhanced with cover provided by addition of woody structure.

Schleicher (USFWS R6): It would be nice to know what is happening to stocked CPM after their initial stocking, and find additional ways to retain them in the system. Using non-native vegetation in the river which is readily available would seem to be the most natural way to create more fish habitat. This SOW would be creating a more controlled study on an already present habitat improvement recommendation of creating more debris islands in the river.

Warren (Peer Reviewer): If the bundles do attract young native fishes and hold them, then the Program will have a relatively cheap management option to hold native fishes in the river. It’s almost a certainty the bundles will attract fishes in my opinion, but which ones and how many is the question. The bundles will not be permanent, but if they work at key points in the river for target fishes it would be a huge breakthrough. Fish retention has always been of prime concern in the San Juan river. I support this SOW for the promise of increasing, perhaps greatly, the ability to retain young fishes and increase survival. The Program needs all the habitat management options it can get.

Ziegler (NMDGF): This is an interesting and novel project that should address some of the hypotheses presented in the proposal. However, I am not sure if the project addresses the question the Program currently has about recovery of Colorado Pikeminnow and Razorback Sucker in the San Juan River. The BC has had multiple workshops about addressing perceived bottlenecks to recovery which have centered around recruitment of age-0 fish. This project focuses on age-1 Colorado Pikeminnow and other native fish. While it may increase our knowledge about habitat use of age-1 Colorado Pikeminnow, I am not sure it will address questions we have about the issues with recovery, namely recruitment of age-0 fish. This project will not create the type of habitat the Program has identified as limiting in the San Juan River, zero velocity habitat for rearing of larval and early age-0 juvenile fish. Identifying ways to increase stocked fish survival is likely important, however it is also unlikely that this project may not operate long enough to appropriately track the survival of stocked age-1 Colorado Pikeminnow.
Addition of woody structure can create localized complexity and low velocity areas. Because we will be placing wood bundles in existing low-velocity habitats, this could potentially increase the quality of these habitats by adding cover and potentially increasing food resources in these habitats. This study will not operate long enough to obtain annual survival estimates, but will likely contribute valuable encounter information on PIT tagged fishes and stocked age-1 pikeminnow. Finer temporal scale survival estimates might be obtained if enough detection/recapture data are collected.

I am also cautious about this project since the Program has identified issues with secondary channels becoming blocked with large woody debris causing them to be bermed off and stop flowing. This project could hasten the loss of secondary channels and subsequently large stable backwaters at the terminus of secondary channels. This would be a negative effect overall for recovery, decreasing the types of habitat we've identified as critically important for the recruitment of age-0 Colorado Pikeminnow and Razorback Sucker.
We disagree that addition of wood will cause the loss of secondary channels or associated backwaters. Reductions in flow seems to be a more plausible mechanism for reductions in flowing secondary channels.

PO: Given the identified recruitment bottlenecks for stocked juvenile Colorado pikeminnow, this proposal offers a test to identify whether lack of mesohabitat habitat complexity may be a limiting factor. If the proposal proves effective, scaling it up to a larger scale (even river-wide) seems feasible.