Fish, Fishing, and Ecosystem Services and Dysfunctions in the New River

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Abstract

This paper reviews the selected ecosystem services provided by New River to riverside communities. I also highlight threats to sustaining these services and dysfunctions and possibilities for restoration. A framework of ecosystem services is useful for examining threats to future sustainability. These services include four broad categories: provisioning, such as the production of food and water; regulating, such as the control of climate and disease; supporting, such as nutrient cycles and oxygen production; and cultural, such as spiritual and recreational benefits. Present day threats to New River ecosystem services include dams, legacy pollutants, non-native plants and animals, and agricultural runoff. Social justice issues are too often ignored in present management paradigms and we forget to ask, "What do we care about?" If we care about human well-being, it is important that we foster more effective collaborations with the people whose well-being is to be assessed.

Introduction

In this paper I focus on contemporary threats to fish, fishing, and ecosystem services provided by the New River. Rivers differ widely in the mix of ecosystem services that are provided. I highlight the significance of biological resources of the New River and ecosystem functions expected but not provided due to anthropogenic alterations. I focus here on polychlorinated biphenyl (PCB) contamination and the influence on dams that result in ecosystem dysfunctions. I close the paper with a list of suggested restoration actions that should be initiated.

Ecosystem Services

Ecosystem services are benefits people derive from ecosystems; these include **provisioning** of food and water; **regulating** climate and disease; **supporting** nutrient cycles and oxygen production; and **cultural**, spiritual and recreational benefits. In examining the sustainability of the New River, we can examine sustainability through four lenses, which are Environment, Economics, Society, and Technology. In each area, we should articulate our considerations based on two questions: "What do we care about?" and "what needs to change?" Proximity to water

also provides many unexamined cognitive, emotional, psychological, social, physical, and spiritual benefits that unappreciated and beyond the scope of this paper (but see Nichols 2015).

The spring-fed headwaters are the source of our drinking waters, a critical provisioning service. Most community water systems withdraw from groundwater sources (New River Valley Planning District Commission 2011). The Ridge and Valley contains a karst geology where groundwater flows freely through a network of interconnected underground limestone bedrock caves and streams. Water quantity or quality is not a limiting factor for economic growth in the New River basin. But there are many obvious ecosystem services including fish and wildlife, hydropower, water-based recreation, and fishing. Others are more subtle and seldom appreciated.

The New-Kanawha River stretches 446 miles from the headwaters in North Carolina on the western flank of the eastern continental divide to its confluence with the Ohio River. It contains many unique geologic and scenic areas of the eastern US. The high mountains, such as Rich Mountain (4741 ft) and Mt. Rogers, VA (5728 ft), and the lowest valleys were not covered by ice during glaciations, but would have experienced periglacial conditions during glacial maxima. This geologic history results in unique river morphology – New River does not have the text book streambed profile. Rather the river profile is punctuated with distinct segments of high slope. The New River channel morphology is key determinant of habitat and recreational uses.

Many river segments are dominated by resistant bedrock that results in a narrow deeper channel (Spotila et al. 2015). Other segments are dominated by resistant sandstones formations that run perpendicular to water flow, creating a 500 m wide shallow plain that serves as an aquatic playground in summer. Channels are wider where bedrock is highly jointed. Here, the river erodes via plucking and abrasion. Plucking is the wholesale removal of bedrock blocks and abrasion is from bedload carried by the river eroding the channel. These processes transform the channel into an incision plain, which widens via quarrying at the margins. The channel of the New River Gorge in West Virginia was formed by mass wasting influx of large, immobile sandstone blocks from cliffs formed in the cap rock above. The gorge provides some of the best whitewater rafting experiences in the eastern USA.

The unshaded channel morphology of the New River supports distinctive riverine flora. Three common and widespread plants serve as foundational species, which play a strong role in structuring the community. First, the Hornleaf Riverweed *Podostemum ceratophyllum* attaches to bedrock in fast shallow waters. Most of the macrophyte production in New River is riverweed (Hill and Webster 1983, 1984). It is declining across much of its range and stressors include flow alteration, sedimentation, and altered water quality (Wood and Freeman 2017).

Water celery *Vallisneria americana* colonizes slow flowing areas, where it provides oxygen, fish cover, and supports distinct invertebrate communities and waterfowl feeding grounds (Strayer, et al. 2003; Spoonberg et al. 2005). Submerged aquatic vegetation (SAV) serves as feeding grounds by attracting invertebrate prey, influences predator foraging efficiency, and contributes to population recruitment by providing structural complexity that protects fish and their offspring against predators. In addition, SAV often attracts fish, creating refugia that increase capture rates and fosters anglers' satisfaction. Efforts to re-establish water celery have had mixed success (Doyle et al. 1997; Moore et al. 2010; Ross 2016; Copeland et al. 2019).

American Water Willow *Justicia americana* traps and consolidates sediments as it builds limited floodplain habitats and important shallow habitat for many fish and invertebrate species, and reduces erosion of stream banks (Lobb and Orth 1991; Fritz and Feminella 2003). Water willow flowers attract pollinators and the plant is host for caterpillars, such as Hydrangea Sphinx moth *Darapsa versicolor*. Many attempts to establish aquatic vegetation along the edges of littoral zones of lake have planted from stem cuttings or root crowns (Collingsworth et al 2009; Touchette et al. 2011). The American water willow, which quickly spreads along shorelines, often forms highly dense monocultures and tolerates flooding, wave action, and fluctuating water levels (Touchette et al. 2011). Water willow mortality increases during long periods of inundation and may be eliminated with water level fluctuation during the growing season (Strakosh et al 2005).

Dragonflies (Anisoptera) are predators in their aquatic nymph and adult phases. They are also prey for many fishes. Dragonflies are sensitive to sediment, water quality, climatic factors (Bush et al. 2013). Consequently, dragonflies have been referred to as climate canaries for river management. Adults are highly mobile and can relocate to more favorable regions. Four rare dragonflies of the New River are listed in Virginia and/or West Virginia's wildlife action plan (VDGIF 2015; WVDNR 2015). All of these rare dragonflies [Pygmy snaketail *Ophiogomphus howei*, Allegheny river cruiser *Macromia alleghanensis*, spine-crowned clubtail *Gomphus abbreviates*, and green-faced clubtail *Gomphus viridifrons*] were documented in New River near the Fries hydroelectric project (Carey et al. 2018).

The New River supports only 12 species of freshwater mussels (Jones 2015); of these, the Tennessee heelsplitter *Lasmigona hostonia* is state endangered and the Green floater *Lasmigona subviridis* and Pistol-grip *Tritigonia verucossa* are state threatened. A marked loss of mussels was evident in contemporary surveys (Pinder et al. 2002) compared with surveys done by Arnold Ortmann one hundred years ago. Six mussel species have contemporary records in New River above Claytor Lake in Virginia, including the elktoe *Alasmidonta marginata*, green floater (under federal review), pistol-grip, and the more common spike *Eurynia dilatata*, pocketbook *Lampsilis ovata*, and purple wartyback *Cyclonaias tuberculata* (Pinder et al. 2002; Carey et al. 2018). Freshwater mussels depend on a host fish to complete the larval phase of its life history and to permit colonization of mussels after die offs (Jones 2015).

New River was a refugium for flora and fauna during the last glacial period. Glaciers did not reach Virginia and North Carolina but the climatic and barrier effect was a strong influence in the New River fish fauna. During the Pleistocene, the climate cooled and for fish in the New River, it was "no way out and no way in" because of a large ice dam. New River animals had to stay, adapt, or die. The mainstem falls, cascades, rapids prevented upstream dispersal after the Pleistocene glaciation. Therefore, the New River fauna is cool-adapted and many are endemic to the basin.

New River supports a unique fauna of coolwater specialists, including the New River crayfish *Cambarus chasmodactylus* (Russ et al. 2016) and the Greenbriar River crayfish *Cambarus smilax*. In a recent range-wide conservation status assessment of the New River crayfish, Russ et al. (2016) concluded that although the New River crayfish is stable at this time, its geographical

range is restricted—making them more vulnerable to threats. The New River crayfish is currently under federal review for listing under the Endangered Species Act (76 FR 59835). The Greenbriar River crayfish is priority 1 species in West Virginia's Wildlife Action plan (WVDNR 2015). Other crayfish of the New River basin include *Cambarus appalachiensis, Cambarus bartonii, Cambarus sciotensis, Orconectes cristavarius, Orconectes sanbornii,* and *Faxonius virilis* (Roell and Orth 1992; Loughman et al. 2017; Carey et al. 2018). Virile crayfish *Faxonius virilis* were introduced in the New River in Virginia in the late 1990s (Pinder and Garriock 1998) and surveys are needed to document current distributions. Studies of symbiosis with banchiobdellid worms (Thomas et al. 2016; Skelton et al. 2017) makes the New River significant for fundamental research.

And eastern hellbender is a species of special concern in Virginia and under review by the U.S. Fish and Wildlife Service. The hellbender in the New River basin may be of unique lineage. Hellbenders are encountered by locals while fishing, however of the range of water temperatures (25–31°C) recorded in mainstem habitats were well above hellbender's preference for cooler water temperatures (typically 10–23°C), suggesting that these habitats are not optimal for hellbenders (Carey et al. 2018). Juvenile and adult Eastern Hellbenders eat crayfish. Eastern Hellbenders appear to move little throughout the year and remain close to shelter rocks (Burgmeier et al. 2011). In the Blue River of southern Indiana, Burgmeier et al. (2011) found that 79.5% of Eastern Hellbender locations were found on a gravel substrate. Due to multiple dams that limit gene flow in the upper New River, isolated demes of hellbenders may be susceptible to the Allee effect, inbreeding depression, and genetic drift.

There are 8 endemic fishes -- perhaps more (Table 1), which occur nowhere else but in New River and are coolwater specialists preferring temperatures about 19 C or 66 F (Shingleton et al. 1981). The eight endemic fishes include three minnows, two sculpins, and three darters, all groups that typically have little or no long-range migrations.

Table 1. Endemic Fishes of the New River basin and status in Virginia Wildlife Action Plan (VDGIF 2015). SGCN denotes a species of greatest conservation need.

Family	Common Name	Scientific Name	Status
Cyprinidae			
	Bigmouth Chub	*Nocomis platyrhynchus*	
	Kanawha Minnow	*Phenacobius teretulus*	SGCN
	New River Shiner	*Notropis scabriceps*	SGCN
Cottidae			
	Kanawha sculpin	*Cottus kanawhae*	
	Bluestone Sculpin	*Cottus* n. sp.	
Pcrcidae			
	Candy Darter	*Etheostoma osburni*	Endangered
	Kanawha Darter	*Etheostoma kanawhae*	
	Appalachia Darter	*Percina gymnocephala*	SGCN

In addition, the *Notropis rubellus* form is currently considered an undescribed species, *Notropis* sp. cf. *rubellus* Kanawha Rosyface Shiner (Berendzen et al. 2008). The Bigmouth Chub is among the most abundant fishes in shallow waters of the mainstem New River (Lobb and Orth 1991). Here it functions as a foundational species, by constructing gravel mounds during breeding which are also used by many other nest associate fishes (Lobb and Orth 1988)

Candy Darter is an endangered species that inhabits swift, shallow areas with little fine sediment and complex substrate (Dunn and Angermeier 2016). Candy Darter was extirpated from at least seven streams in southern extent of range (Dunn and Angermeier 2018) and is threated with hybridization with the introduced Variegate Darter (Gibson et al. 2018). The Kanawha Darter is a close relative of the Candy Darter and the two distributions do not overlap. Kanawha Darter occurs in fast-flowing riffles in Blue Ridge tributaries of the New River in North Carolina and Virginia.

Appalachia Darters were rarely encountered in samples from the mainstem New River in West Virginia (Easton et al. 1994) but appear to be more associated with stream reaches in the Blue Ridge province (Jenkins and Burkhead 1994). They occur most frequently in the Blue Ridge province and mainstem New River, but five dams block their movements. Bigmouth Chub, Kanawha Minnow, New River Shiner, and Appalachia Darter were the most commonly encountered endemic species in a survey near Fries dam (Carey et al. 2018).

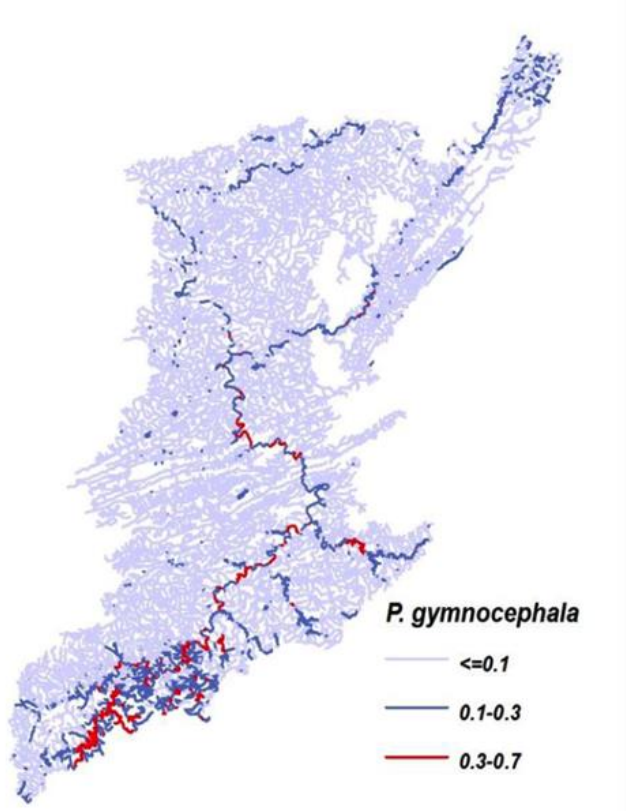

Figure 1. Predicted species occurrence of *Percina gymnocephala* from Frimpong et al. (2014).

New River Walleye persist today despite decades of stocking with Walleye from Lake Erie. Today, efforts to select and stock only New River strain Walleye have restored genetic integrity. The unique genetic strain of Walleye has eggs with 65% larger volume, an adaptive trait for living in less productive waters (Palmer et al. 2007; Hopkins et al. in review). The yolk is the main source of energy and nutrients for the developing embryo and newly hatched larva and larger eggs would be correlated with larger fry (Kamler et al. 2005). This egg size may have little influence on hatchery production; however, it may play a larger role in the reproductive success of the Walleye spawning and rearing in New River. The assumption of the New River Walleye management plan is that the unique Walleye strain is a river-spawning Walleye and may have adaptive traits that permit it to survive better in the New River.

However, annual stocking of Walleye is required to maintain sufficient adults to satisfy Walleye anglers. Fully developing the Walleye fishery in the New River requires addressing the following management questions: In which specific habitats, and under what environmental conditions, should walleye fingerlings be released to maximize first year survival, growth, and numbers recruited to quality creel sizes? What are the optimal stocking rates and schedules to effectively and efficiently achieve management goals? What factors (or life stage-specific bottlenecks) are limiting successful, self-sustaining natural recruitment levels? What sampling design should be used to effectively and efficiently obtain reliable estimates of Walleye recruitment and monitor population trends over time?

Smallmouth Bass is the dominant game fish in the New River; however, we should also appreciate the diversity of other habitats that sustain this valuable fishery. Many other fish and invertebrates utilize a diversity of habitats and are part of the food web (Easton and Orth 1992; Roell and Orth 1992; Roell and Orth 1994; Orth and Newcomb 2002). In at least one study, the biotic integrity of the fish assemblage was correlated with the relative abundance of sport fishes (Dieterman et al. 2019). An abundant and diverse assemblage of fishes also supports populations of piscivorous birds (Green Heron, Great Blue Heron, and Bald Eagle) and mammals (minks and otters) in the New River. New River may provide the best recreational fishing in Virginia and fisheries managers should use available biotic integrity information to inform fishery management plans. The emphasis on trophy fish has diminished the importance of other easier to catch fish such as Rock Bass and Redbreast Sunfish. Trotline fishers who target catfish on the New River, Virginia, are secretive and solitary, and not represented among younger anglers. Anglers targeting Muskellunge are newest arrivals. As Muskellunge grow their diet shifts from minnows, Rock Bass, and sunfish before feeding on suckers (Brenden et al. 2004). With new regulations protecting Muskellunge, consideration should be given to how population changes might alter the interactions that Muskellunge have with other New River fishes (Doss 2017), considering declining trends in in number angler reports of trophy Smallmouth Bass (≥20 in or 5 lbs), declining Smallmouth Bass biomass at the Whitethorne site (Doss 2017, p 45), fourfold increase in density of adult Muskellunge (Doss 2017, p 59), and the observation that Redbreast Sunfish, minnows, Rock Bass, and suckers accounted for about 75% of biomass consumed (Doss 2017, p 64).

Ecosystem Dysfunctions

We need an army of scientists and citizen scientists to keep track of threats to sustainability of ecosystem services provided by the New River. In this section I focus only on climate, invasive species, and hydropower, which are contemporary issues in the New River. Water flows downhill and into groundwater. Tributaries and wetlands are disconnected by dams and human and livestock waste changes New River downstream of impaired tributaries (Leonard and Orth 1985, 1988). Furthermore, with climate change plants and animals have to be able to move and recolonize in order to persist over long time scales and fragmentation influences fish community structure (Fullerton et al. 2010; Perkins and Gido 2012; McManamay et al. 2015; Krosby et al. 2018).

Invasive species of concern in the New River include *Hydrilla verticulata*, Asiatic clams *Corbicula fluminea*, and recent introduction of Quillback *Carpiodes cyprinus* and Notchlip Redhorse *Moxostoma collapsum* (Hilling et al. 2018). Developing plans for invasive species management requires broad impact from stakeholders (Fouts et al. 2017). The rapid and extensive invasion of hydrilla across Claytor Lake—since it was first discovered in 2003—led boaters, homeowners, conservation groups, and state agencies, including the Virginia Department of Game and Inland Fisheries (VDGIF), to begin incremental stockings of sterile (triploid) Grass Carp *Ctenopharyngodon idella* in 2011 as an approach to control hydrilla (CLTAC 2011; Weberg et al. 2015). Although this strategy effectively controlled the invasion of hydrilla, the effects of Grass Carp herbivory on native vegetation inadvertently reduced angler catch rates for bass, leading to several complaints that Grass Carp destroyed the bass fishery in one of the Commonwealth's premier angling reservoirs.

For many of the introduced species in the New River the effects are yet unknown (Hilling et al. 2018; Buckwalter et al. 2018). These unintended introductions have unintended consequences on sustainability of fish and wildlife resources. And we can cannot assess the effects without addition funds. Climate change will alter the pathways by which non-native species enter and affect aquatic systems (Rahel and Olden 2008). Even a single control program, such as the Hydrilla control plan, takes time, money, and human resources away from other tasks.

Construction of dams in the basin changed the ecosystem upstream and downstream. For example, an unanticipated consequence at Bluestone Dame was a productive shallow tailwater downstream that supported abundant larval blackflies *Similium jenningsi*, which filtered on the rich organic matter. The blackfly adults are biting flies, which drift up to the communities near Glade Spring. The state of West Virginia applies a pesticide Bti annually to reduce and remove blackflies from the ecosystem (United States v. Moore 1986). The annual treatment program is an unanticipated cost of dam construction.

The seven mainstem dams have had irreversible effects on biotic and human communities (Table 2). They were built in another era and we should ask "are these dams sustainable in today's economy?" They have diminished the public goods that we derive from the New River. The environmental costs of hydropower are externalities borne by the local communities. The hydropower dams are licensed by the Federal Energy Regulatory Commission. FERC's mandate is to "balance both power interests and environmental considerations." (Kosnik 2010).

Furthermore, at these federally regulated projects "species conservation and ecosystem restoration must be subject to continuing, rigorous assessment using adaptive management…. The central idea is that management decisions must be constantly monitored, evaluated, and modified or reversed when new information so counsels." (Tarlock 2012, p. 1765). With climate change, plants and animals will shift their habitats to track conditions for which they are best adapted. The presence of dams makes this shift much less likely for aquatic plants and animals.

Table 2. Seven mainstem dams on the New River, year of construction, purpose, and production capacity.

	YEAR	PURPOSE	CAPACITY
Fields	1930	Hydro	---
Fries	1903	Hydro	5,213
Byllesby	1912	Hydro	30,100
Buck	1912		
Claytor	1939	Hydro	75,000
Bluestone	1949	Flood control Water quality	---
Hawks Nest	1933	Hydro	108,159

All New River dams were built before we realized the ecosystem services provided by the riverine fauna and flora. Consequently, the current restoration for Walleye in the New River is hampered by dams that both block access to and flood likely spawning and nursery areas. We don't know the effect of altered habitat and warmer temperature conditions in the New River due to operation of Byllesby-Buck hydroelectric plant. Freeman et al. (2001) discovered that summer-spawning fish species numerically dominated the fish assemblage at the flow-regulated site in the Tallapoosa River, Alabama. With warming river temperatures, coupled with the establishment of non-native bass and sunfish, the New River may provide unsuitable habitats for fingerling stages of the Walleye (Bozek et al. 2011). Furthermore, dragonflies, crayfish, mussels, and hellbenders, are influenced by the influence of hydropower on connectivity, gravel substrates. Creation of aquatic habitats were among the successful measures of mitigation that emerged in a review of hydropower projects (Trussart et al. 2002). Monitoring mussel populations and propagation efforts to restore extirpated populations and introduction and monitoring of rare mussels should be discussed as mitigation efforts at hydropower projects (DeRolph et al. 2016).

The Hawks Nest Dam changed large portion of the New River by creating a 250-acre lake and 5.5-mile dewatered reach referred to as the "dries." The latest FERC licensing agreement requires a very small minimum flow in the dries. In addition, the power company will create additional recreational access, a portage trail, and other amenities to accommodate paddlers and

anglers taking advantage of nine new recreational releases from Hawks Nest Dam. Recreational releases should start later this year (Colburn 2018; Steelhammer 2019).

Across the United States, it is estimated that 25% of sediment typically transported in streams is captured in impoundments (Renwick et al. 2005). In New River impoundments, it does not create habitat – rather it smothers habitats. Fish species richness was positively related to fragment length (McManamay et al. 2015; Carey et al. 2018). Much of the fish biomass in the Byllesby and Buck pools was made up of Common Carp (32.4%; Appalachian Power Company 1991, p 14). While dam removals are increasing nationwide, none have not been removed from New River. Yet, these dams and their operations diminish the foundational plant species that would otherwise be common and provide the energy base that drives ecosystem productivity. Water spilled over dams during higher flows is often heavily laden with fine sediments due to the shallow nature of the impoundment and lack of shoreline vegetation and erosion management plans.

In most other reaches of the New River, the American Water Willow traps and consolidates sediments as it builds limited floodplain habitats and reduces erosion of stream banks. These vegetated shoreline zones are important shallow habitats for many fish and invertebrates (Fritz and Feminella 2003; Lobb and Orth 1991). Shorelines with abundant water willow cover had higher abundance of young fishes (Strakosh 2006; Stahr and Shoup 2015; Stahr and Kaemingk 2017). Consequently, water willow re-establishment and a water level fluctuation plan are needed in all of these hydropower impoundments.

Bypassed reaches of the Byllesby-Buck project are sediment-starved and deficient in sand, gravel, and cobble size particles, essential components to support the local flora and fauna. The unshaded bedrock channel morphology of the New River supports distinctive riverine flora, including the Hornleaf Riverweed. However, the species is declining across much of its range and stressors include flow alteration, sedimentation, and altered water quality (Connelly et al. 1999; Wood and Freeman 2017; Davis et al. 2018). Coarse sediment abrades riverweed during storm flows, but the stems and roots may regenerate in four days (Philbrick et al. 2015) and high turbidity limits plant growth. Removal of riverweed reduces macroinvertebrate biomass by over 90% (Hutchens et al. 2004) and reduces benthic fish abundance (Argentina et al 2010). Biomass of riverweed is related to variation in duration of low flow events (Pahl 2009). Thus altered flows diminish riverweed and significant riverine productivity. Energy flows depend on flows from upstream and instream plant dynamics. Dewatering and low velocity permits terrestrial herbivores to remove riverweed from altered tailwaters. The energy pyramid has been disrupted in modified sections of the New River with little compensation or mitigation for impacts.

We should also plan and prioritize for dam removal strategy, which is crucial for climate adaptation. Here we can examine whether the potential exists for consistency in the selection of barriers for removal when conservation objectives targeting species with unique life histories. Migratory sucker occurrence declines in short river fragments (< 20 km, McManamay et al. 2015, 2019). Recent dam removals are opportunistic when liability issues cause abandonment (Bellmore et al. 2016). The recent removal of the Pigg River Dam was completed in Dec 2017 and opened up over 70 miles of river water based recreation as well as habitat for the endangered Roanoke Logperch *Percina rex* (Fabris 2017).

Mitigation or compensation for dam effects is a feasible option, but only comes along when hydropower licenses are ready to expire. Only during the relicensing phase can stakeholders negotiate tradeoffs between mitigation or compensation for project impacts and adaptations to loss of ecosystem services. Claytor dam relicensing included conditions of levelized flow that mimics run of river between mid-April and mid-October. Mitigation and compensation are approaches used by FERC to balance hydropower production with environmental concerns (Trussart et al. 2002).

Sections of the New River are impaired due to polychlorinated biphenyl (PCB) contamination. Although banned since the 1970's they persist in the environment and cause endocrine disruption and are suspected carcinogens. PCBs are hydrophobic and associate with soil and sediments which continue to contribute to PCB resuspension and desorption. The draft TMDL states that "To address contaminated bed sediments where localized hot spots exist (e.g., depositional area behind a dam), mechanical or vacuum dredging could be explored as an option to permanently remove PCBs from the system." (Department of Biological Systems Engineering, Virginia Tech 2018. p. 105). Fields, Fries, Byllesby, and Buck dams have filled with sediments, reducing the volume of impounded water, limiting project life and ecological and recreational values of the impounded sections. There is major concern from the Virginia Department of Environmental Quality about these and other New River impoundments as sources of continued PCB contamination. The Virginia Department of Environmental Quality draft TMDL for PCBs states that "To address contaminated bed sediments where localized hot spots exist (e.g., depositional area behind a dam), mechanical or vacuum dredging could be explored as an option to permanently remove PCBs from the system." (Department of Biological Systems Engineering, Virginia Tech 2018. p. 106). Dredging and flushing sediments were among the effective mitigation measures to prevent reservoir sedimentation in a review of hydropower projects (Trussart et al. 2002).

It is reasonable to question whether hydropower in New River is sustainable. International guidelines call for examination of Technical, Environmental, Social, Economic, and Integrated factors (IHA ND). These guidelines are the culmination of two decades of discussions about what constitutes good practice in hydropower development. Little River dam was built in 1934, as part of the New Deal, yet produced no hydropower for almost 5 years before turbine repairs, which cost $2.7 million (Wall 2019).

Conclusions

An ecosystem framework focuses on services provided to enhance the well-being of people. People are entitled to equal environmental protection regardless of economic class, race, color or national origin. We have the right to live and work and play in a clean environment, but the current situation is not equal; it's never been equal. Some people are more equal than others in the US – if you are poor, working class or a community of color, you get less protection, you get less enforcement of pollution laws. The poorest local anglers have fewer options for fishing for sustenance as the emphasis on enhancing trophy piscivores reduced abundance of sunfish and Rock Bass which are more easily captured via wade fishing. Hydropower directly benefits non-

local corporations and not local communities. Biodiversity losses are due to historical pollution and disconnections that inhibit re-colonization from other river sections or tributaries. Distributive environmental justice looks at who bears risk of energy production and legacy of industrial pollution (Clough 2018). I will conclude my talk with mention of several restoration possibilities before us.

We should have a long-range vision of creating a New–Kanawha River Corridor Water Trail that would stretch 446 miles through many counties that would benefit from infrastructure to attract ecotourism. A sustainable ecotourism enterprise is possible via expansion of existing recreational area and promotion of a water trail extending from Boone, NC to Charleston, WV. Much of the river's course through West Virginia is designated as the New River Gorge National River and the New River is one of the nation's American Heritage Rivers. Palisade Cliffs are a historic landmark, and is the area where Mary Draper Ingles was found at the end of her long struggle back from Ohio after being captured by Indians in the 1700's. Many Class I, II, and III rapids in Giles County make it a destination for the New River Water Trail, which brings in $24 million tourism and supported 220 jobs (Thornton 2016).

This proposed blue / green corridor would provide more effective opportunities for collaborating with many people and communities whose well-being is to be affected by the New River. Installation of a blue/green corridor would benefit everyone in the region. It could act to create jobs, increase property values and economic benefits, improve water quality, biodiversity, and increase tourism and recreational access while decreasing flood damage. Kashian et al. (2018) found that investing in riverfront development as a blue/green corridor would result in $1.77 in additional economic output for every dollar spent

Many people should be consulted on developing and supporting the following restoration possibilities. Their well-being is being affected due to ecosystem dysfunctions. These are some possibilities:

(1) Prioritize dam removals and restore connectivity;
(2) Reduce streambank erosion along tributaries and mainstem;
(3) Expose drowned rapids;
(4) Restore and promote "Safe-to-eat" fish;
(5) Re-establish water celery *Vallisneria* and riverweed *Podostemum* and remove stressors;
(6) Restore mussels;
(7) Restore Walleye;
(8) Restore Musky-free waters;

I began with the question: What do we care about? Before we begin with collaborative efforts toward restoration of lost ecosystem functions we must answer this question.

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