

LOUISIANA WATERTHRUSH BREEDING HABITAT ANNOTATED BIBLIOGRAPHY

Lower Mississippi Valley Joint Venture
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Barnes, K. B., N. Ernst, M. Allen, T. Master, and R. Lausch. 2018. LOWA Density and Productivity in Hemlock-dominated Headwater Streams: The Influence of Stream Morphology. *Northeastern Naturalist* 25:587–598.

Background: The Louisiana Waterthrush (LOWA) has been considered an excellent indicator of riparian habitat quality. Density and reproductive success are measurable and may be more useful than LOWA presence/absence in indicating habitat quality. Differences in stream morphologies may drive differences in reproductive success, and certain morphologies may be associated with higher fitness.

Objectives: The goal of this study was to associate LOWA reproductive success with habitat quality in two types of stream morphologies – ravines and benches.

Methods: The researchers captured and banded LOWA along four headwater streams representing both ravine and bench stream morphologies over a four-year period in Eastern Hemlock dominated forests (2010 - 2013). Measured indicators of reproductive success included pairs per kilometer, fledglings per kilometer, nest success, and incidence of double brooding.

Location: Pike County, Pennsylvania

Findings: This study found that LOWA pair densities and fledging densities were significantly higher on streams characterized as benches than those characterized as ravines. Breeding pairs in bench territories also experienced higher nest success and higher incidence of double brooding.

Implications: By associating LOWA reproductive success with stream morphology, this study found that LOWA density and fitness was higher in bench streams than in ravine streams. This information indicated that bench stream morphologies provide highly suitable breeding habitat for the LOWA across the study site.

Topics: stream morphology, LOWA, reproductive fitness, Eastern Hemlock

Bent, A. C. 1963. Life Histories of North American wood warblers, part two. Dover Publishing, Inc., New York, NY.

Background: This work is part of a Bulletin series from the Smithsonian Institute presenting a comprehensive review of North American Avifauna, including natural and life history traits.

Objectives: Focusing on North American Wood Warblers (family Parulidae), the aim of this Bulletin was to synthesize available information regarding natural and life history traits of Wood Warblers in a systematic review.

Methods: The author compiled information obtained from experts for each species and presented a summary of current knowledge pertaining to natural and life history including courtship behavior, nesting behavior, egg characteristics, description of young, plumage characteristics, foraging ecology, general behavior, song, field marks, potential predators/parasites, fall migration, winter distribution and behavior, range and annual distribution.

Location: North America

Findings: This Bulletin presents a comprehensive and fundamental guide to biologically relevant characteristics of North American Wood Warblers.

Implications: Cited by many researchers, this source serves as a fundamental guide to many important natural and life history traits that are useful in informing conservation management and research.

Topics: North America, Wood Warblers, Parulidae, Passeriformes, life history, natural history

Bryant, L. C., T. A. Beachy, and T. J. Boves. 2020. An invasive insect, hemlock woolly adelgid, indirectly impacts LOWA nest site selection and nest survival in the southern Appalachians. Condor 122:1–16.

Background: An invasive insect, the hemlock woolly adelgid (HWA) is causing population declines in the Eastern Hemlock. The direct and indirect impacts of hemlock woolly adelgid invasion on forest birds is largely unknown. Most studies to date focus on avian community diversity, with little research investigating the response of individual species to declining hemlock populations. The LOWA is a riparian obligate songbird breeding in the eastern US. In parts of the LOWA range, Eastern Hemlock may concentrate along streams. The LOWA's preferred food source, aquatic macroinvertebrates from the orders Ephemeroptera, Plecoptera, and Trichoptera (EPT) are associated with these hemlock-filtered streams. LOWA also heavily exploit terrestrial lepidopterans while feeding nestlings, implying some dependence on the streambank and adjacent habitats.

Structurally, hemlocks may provide nesting habitat where roots are exposed along stream banks. The HWA invasion and resulting decline of hemlocks may be detrimental to the LOWA, a species which is known to be sensitive to habitat and ecosystem disturbances including forest fragmentation and stream acidification and pollution associated with shale gas development (hydraulic and other anthropogenic activities). Given these associations of the LOWA habitat characteristics and Eastern Hemlock, this species serves as a good model to study the impacts of the HWA invasion. Ways in which LOWA may be impacted by hemlock mortality include habitat selection behavior and individual fitness.

Objectives: The goal of this study was to investigate the impacts of HWA invasion and hemlock decline on LOWA in the southern Appalachians. Specifically, the authors wanted to better understand how birds were selecting habitats based on habitat features related to hemlock condition as well as evaluate how these habitat characteristics were related to individual fitness.

Methods: This study included areas characterized by varying levels of HWA infestation and hemlock condition. Researchers banded and tracked breeding LOWA males during the 2015 and 2016 breeding seasons. They monitored nests throughout the nesting season to determine daily nest survival rate (DSR) and the number of successful nests (i.e., at least one successfully fledged offspring). Several habitat features were measured at points either associated with both LOWA foraging activity and nesting activity as well as randomly selected points representing available areas. The researchers measured 17 habitat features at each point, including canopy cover at 0-1.5 m, 1.5-5 m, 5-15m, and greater than 15 m. Other features measured included availability of woody debris, in-stream exposed rock, exposed live tree roots, hemlock decline, exposed soil, dominant understory vegetation type, stream width, proportion of hemlock, leaf litter, deciduous ground cover, evergreen ground cover, and water. Generalized linear mixed models were used to assess the relationship between these habitat variables and LOWA foraging and nest site selection.

Location: southeastern Tennessee

Findings: Results suggest that, of the habitat features measured, LOWA foraging site selection was associated with higher proportions of woody debris and exposed in-stream rock. Nest site selection was mostly associated with the interaction of the amount of exposed live roots with hemlock condition. Specifically, LOWA appeared to select nest sites with more exposed live roots only when surrounding hemlock condition was poor. Daily nest survival rate was found to be negatively associated with the proportion of deciduous understory, and DSR was higher in sites where conifers dominated the understory. No association was found between adult survival and any of the measured habitat features.

Implications: Information obtained through this study can be used to inform LOWA conservation management in areas that may be vulnerable to HWA invasion, specifically with regards to nest-site selection and daily nest survival rate. Evidence that DSR is positively correlated with the percent of coniferous vegetation in the understory may allow

managers to prioritize areas for LOWA breeding based off of this fine-scale habitat characteristic. While hemlock condition is thought to influence the abundance of EPT taxa, it did not influence foraging site selection, suggesting that LOWA may not be as reliant on EPT taxa as previously believed. This evidence adds to other studies that have found similar support for more generalist feeding strategies.

Topics: LOWA, Eastern Hemlock, hemlock wooly adelgid, invasive species control, habitat selection.

Chapman, M., J. R. Courter, P. E. Rothrock, and E. Science. 2015. Riparian Width and Neotropical Avian Species Richness in the Agricultural Midwest. Proceedings of the Indiana Academy of Science 124:80–88.

Background: Declining numbers of neotropical migratory birds in the Midwest are partly driven by agricultural land use practices. Riparian buffers are crucial habitat for many of these species, particularly the LOWA, and understanding optimal buffer width to maximize diversity and abundance is key to avian conservation.

Objective: Here, the authors set out to quantify the minimum riparian buffer area required to support optimal avian diversity and abundance.

Methods: The authors surveyed 36 sites with riparian buffers falling into one of three area categories (< 25 m, 25-75 m, and > 75 m) and conducted three sets of point counts throughout the breeding season in 2013.

Location: Mississinewa River, Grant and Delaware Co., Indiana

Findings: The researchers documented 56 species, 25 of which were neotropical migrants (including LOWA). Within the three riparian buffer area categories, LOWA were most frequently associated with the medium width buffer (25 - 75 m). LOWA were detected on 75% of sites within this medium buffer category. Detections of LOWA were lower on sites with large riparian buffers (> 75 m; detected on 33% of sites) and even lower on small buffer sites (< 25 m; detected on 25% of sites). Logistic regression analysis found a significant positive correlation between buffer width and LOWA presence.

Implications: The LOWA was not the focus of this paper, but rather included in a broader focal group. Despite higher LOWA detection rates within medium riparian buffers over large riparian buffers (75% versus 33% of sites) the significant, positive correlation found with LOWA presence and buffer width echo the general consensus in the literature that this species requires wide riparian buffers.

Topics: agriculture, avian conservation, Midwest, Neotropical migrants, riparian width

Conner, Richard N., Via J. W., P. I. D. 1979. Effects of pine-oak clear-cutting on winter and breeding birds in Southwestern Virginia. Wilson Bulletin 91:301–316.

Background: Clear-cutting is a popular approach to timber harvesting given its economic efficiency. This practice results in even-aged, regenerating stands, having implications for the avian community as different species may be associated with different successional stages of forest re-growth. This study was one of the earlier works investigating the response of the avian community to clear-cutting in the pine-oak forests of southern Virginia.

Objectives: The goal of this study was to assess avian response patterns to regenerating clear-cuts in pitch pine-oak forests and determine if these patterns were similar to those detected in other evergreen forests, or if patterns more closely resembled those of deciduous, oak-hickory clear-cuts.

Methods: The researchers conducted surveys along 100 meter transects in four stages of successional regrowth including 3, 10 and 30-year-old clear-cut stands as well as mature stands. Each of 16 transects were surveyed six times per season (breeding and winter, 1976) and researchers used transect results to calculate relative abundance and Shannon's diversity index.

Locations: Jefferson and George Washington National Forests, southwestern Virginia

Findings: In this study, LOWA were only detected in mature stands, with a relative abundance of 0.013. Overall, avian diversity and species richness increased with stand age during breeding season surveys. This pattern differed from those detected in oak-hickory stands, where young stands 3-12 years old supported highest species diversity and richness.

Implications: Results from this study support the association of LOWA with mature forest stands and have important implications for the effects of timber harvesting in pine-oak forests on avian species diversity and richness.

Topics: pine-oak, clear-cut, timber harvesting, breeding birds, avian species diversity, avian species richness

Conner, R. N., and J. G. Dickson. 1997. Relationships between bird communities and forest age, structure, species composition and fragmentation in the West Gulf Coastal Plain. Texas Journal of Science 49:123–138.

Background: Landscape characteristics such as patch size, fragmentation, edge effect, and landscape use patterns influence avian communities, particularly area-sensitive species such as the LOWA. Forest management and other disturbances in the West Gulf

Coastal Plain region (WGCP) result in changes in these characteristics that lead to predictable shifts in the composition of the avian community. Understanding how specific changes to these associated forest characteristics affect the avian community is crucial to informing avian conservation and management.

Objectives: The aim of the paper was to synthesize and present information demonstrating the relationship between forest characteristics, including successional age, forest structure and composition, fragmentation, and avian community composition within the WGCP region.

Methods: The researchers present information organized by landscape / forest characteristics including forest stand age, forest cover type, vegetation structure, fragmentation, and forest area.

Locations: West Gulf Coastal Plain (WGCP) region

Findings: This paper further supports the dependence of LOWA on large patches of contiguous forest and suggests, based on Robbins et al. (1989), that LOWA only become slightly abundant in tracts of contiguous forest larger than 1,000 ha., where probability of occurrence was less than 0.1.

Implications: This demonstration of the relationship between the LOWA and forest patch size adds to an important body of work supporting the importance of forest area for this area-sensitive species. The authors state that large, contiguous tracts of mature forests should be prioritized to implement effective conservation of forest area-sensitive species, such as LOWA.

Topics: avian community, West Gulf Coastal Plain, forest area, forest fragmentation, edge effects, area-sensitive species

**Craig, R. J. 1984. Comparative Foraging Ecology of Louisiana and Northern Waterthrushes. *The Wilson Bulletin* 96:173–183.
<<https://www.jstor.org/stable/4161910>%0AJSTOR>.**

Background: The possibility for sympatric populations of closely related species often requires evolutionary divergence in certain traits and behaviors to reduce interspecific competition. Interspecific differences that may reduce interspecific competition include modifications to foraging behaviors, such as foraging zone, foraging method, and size and type of prey. Previous researchers suggested that these interspecific differences alone may not account for sympatry, and that selection may not be strong enough in variable environments to drive divergence in traits. Others, however, suggest that character divergence in species with high niche overlap that demonstrate low levels of interspecific competition may be driven by periods of low resource availability in a variable environment.

Objective: The goal of this study was to determine the level of inter-specific competition between sympatric populations of the closely related Louisiana and Northern waterthrushes.

Methods: The researcher observed territoriality and foraging behaviors of banded Louisiana and Northern Waterthrushes during the breeding seasons of 1978-1980, recording habitat used (water, ground, foliage, and air), foraging method (picking, leaf-pulling, hawking, and hovering), and foraging frequency. The researcher also sampled aquatic invertebrates to estimate the composition of available prey species within each species' territory.

Location: Ashford Tolland, Connecticut

Findings: This study suggested high overlap in foraging behaviors of the Louisiana and Northern Waterthrushes. Territory size differences between the Louisiana and Northern Waterthrushes were not significant. Observed individuals exhibited little interspecific territoriality, although territories frequently overlapped. Prey searching behavior was similar between the two species. Picking and leaf-pulling were the most employed foraging methods in both water and ground foraging. Foraging behavior did not differ between species prior to leaf emergence. After leaf emergence, Northern Waterthrush spent more time foraging in foliage, whereas the LOWA remained closely tied to ground and water foraging. Prey taken by the LOWA mostly consisted of isopods, gastropods, Ephemeroptera nymphs, and larvae of Trichoptera, Culicidae, and Dysticidae. LOWA's preferred territories with a higher abundance of Trichopterans than Northern Waterthrushes. Territories of LOWA's also had a higher biomass of invertebrates greater than 13 millimeters in length, although no statistical difference was found in the overall invertebrate biomass between territories of the two species. Results suggested that both species require invertebrates of various sizes.

Implications: The lack of territoriality, along with the similarity in foraging behaviors (site and method) suggest that interspecific competition is weak, and therefore unlikely to be responsible for the evolutionary divergence of these two closely related species.

Topics: interspecific competition, avian foraging behavior, LOWA, Northern Waterthrush

Dickson, J. G., F. R. Thompson, R. N. Conner, and K. E. Franzreb. 1999. Effects of silviculture on neotropical migratory birds in central and southeastern oak-pine forests. NCASI Technical Bulletin 134–135.

Background: Silviculture practices can have profound impacts on species with specific habitat requirements, like the LOWA, while other species may benefit from such land use patterns.

Objectives: The aim of this paper was to synthesize and present information on the relationship between avian community patterns and silviculture practices in different forest types, including central hardwood, loblolly-shortleaf, longleaf-slash pine, and bottomland hardwood forests.

Methods: This paper presents landscape level impacts of forest stage and management in loblolly shortleaf pine, longleaf-slash pine, and bottomland hardwood (oak-gum-cypress) forests on the neotropical migratory bird community. Stand ages included first year regeneration stands, sapling stands (10 - 20 years), pole timber stands (20 - 60 years), and mature stands. Management strategies including group selection and single tree selection were also considered.

Locations: southeastern United States

Findings: While this work included many focal species, with regards to the LOWA, this work demonstrated that, in central hardwood forests, LOWA are only present in pole timber and mature stands, or mature stands undergoing group and single-tree selection silviculture. In even-aged loblolly-shortleaf pine stands, LOWA are only present in mature (35 - 50 years) and old growth (> 50 years) stands. Referencing Hamel et al. (1982), this paper shows that LOWA are regular inhabitants of oak-gum-cypress forests in the southeast.

Implications: This paper presents further support that habitat requirements for the LOWA include mature forest stands in the southeast, particularly in central hardwood or loblolly-shortleaf pine stands, while also reinforcing the association of the LOWA with bottomland hardwood forests in the southeastern United States.

Topics: silviculture, central hardwood forest, loblolly-shortleaf pine forest, longleaf-slash pine forest, bottomland hardwood forest, oak-gum-cypress, breeding birds, timber management

Eaton, S. W. 1958. A life history study of the LOWA. Wilson Bulletin 70:210–235.

Background: This descriptive study is an important early work highlighting various components to LOWA natural and life histories.

Objectives: The goal of this study was to observe LOWA over both breeding and wintering seasons and document biologically meaningful behaviors and characteristics.

Methods: The researcher observed a total of 16 nests during the breeding seasons of 1947, 1948, and 1949, and 7 non-breeding individuals during winters of 1948 and 1949. Among the characteristics documented were variation in plumage (seasonal and age),

breeding ground arrival times (males and females), territory size and territoriality, song features, habitat features, nest features, incubation, nestling features, fledgling features, food (breeding and winter), parasitism, fat deposition, weight, molt, and exoparasites.

Location: Ithaca, New York and Cienfuegos, Cuba

Findings: This work highlights key characteristics that have been repeatedly associated with LOWA breeding habitat. LOWA were determined to occupy roughly 400 meters of stream. During the early breeding season, foraging occurred entirely in the stream, where LOWA flip leaves and other debris searching for aquatic macroinvertebrates. As the season progressed, LOWA utilized the terrestrial areas of their territory for foraging as well. LOWA were observed to appear most comfortable on bare, flat rocks of the stream and glen floors. Nests were constructed from material generally within 30 meters of the nest. Most nests were positioned on the south side of the ravine, between 0.5 and 4.0 meters above the ground. Nest construction observed during this study typically consisted of individuals digging cups in the exposed dirt of streambank and filling this with leaves from adjacent areas within the stream and on land. Nests included leaves from oak, elm, and maple trees species. Fledglings were observed dispersing up 4.8 kilometers one-month post-fledging. Within the study area, small streams dried up towards mid-July and birds were found foraging on land along the stream or shore. Nestling diet from samples included gastropods, coleoptera (adults), and other unidentified fragments. Adult diets included chironomid (e.g., midges) larvae, dipterid (flies) larvae, and coleopterid (beetles) adults. While Plecoptera (stoneflies) and Ephemeroptera (mayflies) were only identified in the stomach contents of one individual, LOWA were observed to favor these insects (nymphs just before hatching and slow flying adults after hatching). Brown-headed cowbirds parasitized 56% of the 16 nests observed. During this study, 70% of 60 LOWA eggs successfully fledged.

Implications: This study represents one of the first to thoroughly document these natural and life history traits for the LOWA, informing many future studies and guiding conservation management for this species.

Topics: LOWA, life history, natural history, Ithaca, Cayuga Lake

Farwell, L. S., P. B. Wood, D. J. Brown, and J. Sheehan. 2019. Proximity to unconventional shale gas infrastructure alters breeding bird abundance and distribution. *Gerontologist* 59:1–20.

Background: In the central Appalachian region, shale gas development is rapidly driving forest disturbance and fragmentation, having potential impacts on populations of breeding birds.

Objectives: The aim of this study was to determine the relationship between the abundance of songbirds and proximity to shale gas development and infrastructure.

Methods: The researchers assessed the response of 27 species representing forest interior, early successional, and synanthropic species, to shale gas development. To quantify proximity to shale gas development and infrastructure, the researchers generated and used a land classification map including forest, timber harvest, shale gas development and associated infrastructure. Point count surveys were conducted at 142 survey stations separated by ≥ 250 meters during the breeding seasons of 2008-2017. Generalized linear mixed models were used to relate species abundances with distance to shale gas development.

Locations: Lewis Wetzel Wildlife Management Area, West Virginia

Findings: Over 50% of the species assessed in this study responded negatively to proximity to shale gas development or infrastructure (e.g., roads, well pads). While not significant, LOWA abundance was negatively associated with shale gas well pads and linear gas infrastructure (e.g., roads).

Implications: The negative association with LOWA abundance and proximity to shale gas development is crucial given that fracking has been increasing in many parts of the LOWAs range. This study is a step towards better understanding how shale gas development impacts the LOWA.

Topics: Appalachians, avian guilds, energy development, forest songbirds, hydraulic fracturing, land-use change, Marcellus-Utica, unconventional shale gas

Frantz, M. W., P. B. Wood, S. C. Latta, and A. B. Welsh. 2020. Epigenetic response of LOWA Parkesia motacilla to shale gas development. Ibis 162:1211–1224.

Background: Shale gas development imposes environment stressors throughout riparian

ecosystems, such as the accumulation of heavy metals such as barium (Ba) and strontium (Sr) within the food chain. An obligate riparian songbird, the LOWA is vulnerable to shale gas development and resultant environmental stressors. DNA methylation is an epigenetic mechanism that could potentially result from environmental signals (such as the presence of heavy metals such as Ba and Sr) that can modify gene expression in wild bird populations. Given that the LOWA is a top predator, bioaccumulation of heavy metals such as Ba and Sr may occur where streams are within close proximity to shale gas development.

Objectives: The goal of this study was to analyze patterns of DNA methylation across sex and age, as well as correlate DNA methylated sites in LOWA with concentrations of Ba and Sr in feathers and assess the influence of shale gas development on DNA methylation.

Methods: The researchers captured, banded and monitored 146 individuals and 159 nestlings during 2013-2015, collecting blood samples via brachial venipuncture for epigenetic analysis. Annual shale gas disturbance was digitized for the study area so that each LOWA territory could be classified as disturbed or undisturbed. Two derived variables included “TerrGas” (shale gas disturbance within 60 m of stream centerline) and “TerrRunoff” (presence or absence of potentially contaminated shale gas runoff from upstream sources). Analysis of molecular variance (AMOVA) was used to describe overall methylation variation by sex, age, and shale gas disturbance.

Locations: Lewis Wetzel Wildlife Management Area, West Virginia

Findings: Results from this study suggested variation in methylation patterns between males and females (fewer methylated sites in males). The researchers also observed an overall decrease in methylated sites with age. Males in territories classified as disturbed had fewer methylated sites than those in undisturbed sites. Furthermore, feather analysis of Ba and Sr concentrations showed that adult males experienced a negative correlation with methylated sites and concentrations of these heavy metals. Adult females, however, showed a positive correlation between Sr concentrations and methylation. No correlation was detected in nestling feathers.

Implications: The results of this study link shale gas disturbance with sex and age specific patterns in DNA methylation and gene expression in the LOWA. Such modifications to gene expression could potentially have harmful impacts on reproductive fitness and, as a result, long-term population trends.

Topics: bioindicator, contaminants, DNA methylation, Marcellus-Utica, shale gas

Frantz, M. W., P. B. Wood, and G. T. Merovich. 2018a. Demographic characteristics of an avian predator, LOWA (*Parkesia motacilla*), in response to its aquatic prey in a Central Appalachian USA watershed impacted by shale gas development. PLoS ONE 13:1–19.

Background: Shale gas development, or fracking, in the central Appalachians has increased over recent years, having disproportionate impacts on forested habitats and often occurring within close proximity to streams. Aside from forest loss and fragmentation, impacts from shale gas activity include increased concentrations of sediments and contaminants. The LOWA is a riparian obligate songbird with a foraging behavior that depends largely on pollutant-intolerant benthic macroinvertebrates, such as taxa from the orders Ephemeroptera, Plecoptera, and Trichoptera (EPT taxa) and, as such, is particularly vulnerable to shale gas related disturbance. Previous studies have identified a positive relationship between LOWA reproductive success and habitat quality as it relates to shale gas development.

Objectives: As a follow up to previous studies, the researchers aimed to assess the usefulness of assessing the aquatic prey community along with riparian habitat quality indices in predicting LOWA habitat quality. This study also sought to determine the potential for shale gas associated runoff to influence changes in aquatic prey communities within LOWA territories, as well as quantify the demographic response of LOWA to these changes.

Methods: The researchers used aerial photography to map shale gas related disturbance within the study area and assessed riparian habitat quality using the Prosser and Brooks LOWA HSI along with the U.S. EPA Rapid Bioassessment Protocol for high gradient streams. LOWA were monitored and territory length, density, and nest survival (including daily nest survival rate or DSR) were quantified for 14 stream reaches in 2011, 2013, and 2014. Benthic macroinvertebrates were sampled from in-stream riffle habitats at 178 nests sites shortly after either the nestlings fledged, the nest was abandoned, or the nest failed. Two metrics were used to quantify aquatic prey composition including the West Virginia Stream Condition Index (WVSCI) and the Genus Level Index of Most Probable Stream Status (GLIMPSS). The researchers used spatial generalized linear mixed models (SGLMMs) to determine relationships between LOWA demographic characteristics, benthic macroinvertebrate community, and riparian habitat quality.

Locations: Lewis Wetzel Wildlife Management Area, West Virginia

Findings: The results of this study varied over years, but collectively suggest a threshold of shale gas activity at which LOWA respond negatively to changes in prey communities. Shale gas disturbance decreased from 2011 to 2013 and then increased from 2013 to 2014. In 2011, researchers found a significant negative correlation between GLIMPSS, EPT richness and abundance of pollutant-intolerant genera with LOWA territory length, where territory length increased with lower prey availability. Macroinvertebrate community biomass and density showed a positive response to increasing EPA habitat assessment score in 2013. In 2014, researchers observed a higher proportion of pollutant intolerant taxa with increasing EPA and HSI scores. Researchers also observed smaller LOWA territories with increasing density of aquatic prey in 2013. In 2014, however LOWA territory size increased despite increased EPT richness. No significant relationship was found between clutch size, number of fledglings, and territory density with prey metrics. The best supported model suggested that rain positively influenced DSR in both 2013 and 2014. Shale gas runoff was shown to negatively influence DSR in 2014.

Implications: The variable results presented in this study suggest that there is likely a threshold of shale gas activity to which the aquatic prey community, and subsequently LOWA, respond negatively. This paper suggests that the disassociation between territory length and aquatic prey density in 2014 may have resulted from the LOWAs ability to expand their foraging niche to include parts of the territory undisturbed by shale gas activity and runoff. Collectively, this work presents important evidence highlighting the potential impacts of shale gas development on LOWA reproductive success (e.g., shale gas runoff negatively impacted DSR) having important implications for the conservation of this species.

Topics: shale gas developments, LOWA, habitat suitability, EPT, demography,

Frantz, M. W., P. B. Wood, J. Sheehan, and G. George. 2018b. Demographic response of LOWA, a stream obligate songbird of conservation concern, to shale gas development. Condor 120:265–282.

Background: Rates of shale gas development have been increasing in the eastern United States having potentially detrimental effects on breeding populations of the stream obligate songbird, the LOWA. Regions of highest LOWA abundance co-occur with the Marcellus shale region which is undergoing rapid shale gas development. Disturbances associated with shale gas include core forest disturbance and contamination of stream water.

Objectives: The goal of this study was to assess the influence of shale gas development on the LOWA breeding population.

Methods: The researchers assessed LOWA demographic response to shale gas development during the breeding seasons of 2009-2011 and 2013-2015 by monitoring 58.1 km of first and second order forested streams. Over the study period they monitored 400 LOWA territories. Riparian habitat quality was assessed with a previously established LOWA Habitat Suitability Index (HSI) and the United States Environmental Protection Agency (EPA) rapid bioassessment for high gradient streams. Images from the National Agriculture Imagery Program (NAIP) were used to detect and classify shale gas related forest disturbance. Other variables included streamside gas disturbance, run-off potential, proportion of LOWA territories disturbed by gas, and run-off potential in each territory. To quantify nest survival and productivity the researchers estimated LOWA nest daily survival rate (DSR). Nests that fledged at least one offspring were considered successful. This study also compared nest success with adult mortality rate to characterize habitats as sink or source.

Location: Lewis-Wetzel Wildlife Management Area, West Virginia

Findings: This study found overall declines in LOWA territory density, nest survival, productivity, and habitat quality that correlated with increased shale gas related disturbances. The source-sink threshold suggested that areas disturbed by shale gas development are habitat sinks, and populations breeding in these areas may be vulnerable.

Implications: This study highlights the threat that shale gas development poses to breeding populations of LOWA. Significant relationships between LOWA demographic variables and gas disturbance related variables may enable future research to incorporate these variables into models predicting LOWA habitat suitability and riparian ecosystem health.

Topics: LOWA, shale gas development, demographic response, bioindicator species, riparian ecosystem health

Frantz, M. W., P. B. Wood, J. Sheehan, and G. George. 2019. LOWA (*Parkesia motacilla*) survival and site fidelity in an area undergoing shale gas development. *Wilson Journal of Ornithology* 131:84–95.

Background: Shale gas development (hydraulic fracturing, or "fracking") impacts many of the riparian habitats that species, such as the stream-obligate LOWA, depend on. Much of the LOWAs breeding range overlaps with one of the largest shale gas beds in the country - the Marcellus-Utica shale region. Fracking and the resultant acidification is known to negatively affect the stream benthic macroinvertebrate communities, which provide a critical food source for breeding LOWA. This decrease in habitat quality associated with fracking may result in a decrease in site fidelity, which is typically high in LOWA, as birds search for more optimal breeding habitat.

Objectives: The goal of this study was to quantify rates of breeding site fidelity, assess habitat features that might influence annual return rates, and estimate annual survival across streams associated with various degrees of shale gas activity.

Methods: The researchers monitored LOWA on 14 first and second order streams. Aerial photography was used to map shale gas disturbances throughout the study area. A stream was classified as disturbed if any fracking infrastructure was within 60 meters of the stream. LOWA territories were mapped each year along stream reaches. For each stream and territory, they calculated proportion disturbed by shale gas and the potential for runoff. LOWA were banded during 2009-2011, and 2013-2015. Territories and nests were monitored for return rates, daily nest survival, adult survival, and breeding success. The Prosser and Brooks 1998 HSI was used to quantify riparian habitat at each LOWA nest.

Locations: Lewis Wetzel Wildlife Management Area, West Virginia

Findings: Site fidelity declined in both males and females from an initial rate of 63% in 2009-2010, to 32% in 2015. Three factors that were associated with site fidelity in males included an increased proportion of shale gas disturbance, lower EPA rapid bioassessment for high gradient streams scores, and lower HSI scores. Among females, this study showed that site fidelity decreased with the number of previous breeding attempts. Given the overall decline in site fidelity, the increase in shale gas activity, and positive relationship found between male site fidelity and proportion of territory disturbed by shale gas activity, it is unclear if the increased rates of fidelity among males was due to fracking.

Implications: While this study demonstrated that LOWA return rates were relatively high on shale gas disturbed territories with lower habitat suitability, collective research suggests that these impacted territories may serve as population sinks. Previous research conducted by the author and colleagues linked lower breeding productivity with shale gas disturbance meaning continued site fidelity in these impacted habitats could have negative impacts on the LOWA population long-term. As such these habitats could represent ecological traps.

Topics: bioindicator, source-sink, headwater stream, Marcellus-Utica, site fidelity

Hamel, P. B. 1992. The land managers guide to the birds of the south. The Nature Conservancy, Chapel Hill, NC.

Background: This guide serves as a reference for how birds in the Southeastern U.S. use available forested habitats, providing a synthesis of the status, distribution, and habitat requirements for each species, including the LOWA.

Objectives: The purpose of this book is to assist land managers in implementing sound and effective management practices.

Methods: This body of work was developed from unpublished reports prepared for the Southeastern region by the United States Forest Service.

Locations: southeastern United States

Findings: In this guide, Hamel describes key habitat requirements for the LOWA to generally include forested, rocky streams. Estimates of breeding densities are provided for four different habitat categories with the highest densities in the southeast region predicted for saw timber oak-gum-cypress, followed by saw timber mixed pine-hardwood, saw timber oak-hickory, and pole timber elm-ash-cottonwood.

Implications: This guide has been cited by many publications describing LOWA breeding habitat and highlights the association of LOWA with mature forests, particularly oak-gum-cypress within the southeast region while also suggesting that 100% deciduous forest provides sub-optimal habitat relative to mixed deciduous / coniferous forest composition.

Topics: LOWA, habitat relationships, forest management

Hayden, T. J., J. Faaborg, and R. L. Clawson. 1985. Estimates of minimum area requirements for Missouri forest birds. Transactions of the Missouri Academy of Science 19:11–22.

Background: Two important concepts for conservation of birds include the relationship between community composition and diversity with habitat area, and the dependence many species have, such as the LOWA, on habitat area. Understanding which species are limited by habitat area and their area requirements is crucial for effective conservation of long-term, sustainable populations.

Objectives: The purpose of this study was to identify birds with habitat area requirements within the study area and estimate the minimum areas required to sustain long-term, viable populations.

Methods: The researchers identified breeding birds within 15 upland oak-hickory dominated forest sites in 1983 and 1984. Forest patch sizes ranged from 1.2 ha to over 1000 ha, broken up into four classes (1.2-2.2, 4.6-14.9, 42.2-53.6, and >340 ha). Statistical analysis was used to determine if species occurrence was independent of forest area class.

Locations: Boone, Callaway, Audrain Co. Missouri

Findings: This study confirmed that LOWA occupancy is dependent on forest area. LOWA did not occur in any forest patch smaller than 42.2 ha. Most were only found in tracts larger than 341 ha. Percent of occurrence for LOWA was low in this study (15%) which is to be expected given this study focused on upland hardwood while the LOWA is typically associated with bottomland forest.

Implications: This study presents a potential minimum forest area requirement for the LOWA, at least for those breeding in the upland forests of Missouri. This minimum value is referenced in the 2009 HSI developed for LOWA by Tirpak et al. as unsuitable habitat. That LOWA were typically only found on forest patches greater than 341 ha supports other previous work suggesting that at least 350 ha of forest will provide suboptimal LOWA habitat.

Topics: birds, habitat requirements, island biogeography, nongame management

Hyder, S.N. 2002. Investigation of the relationship between floodplain geomorphology and riparian songbird communities. University of Georgia.

Background: Riparian habitats support a diverse community of songbirds. Different geomorphological features associated with riparian ecosystems may influence the surrounding riparian community. Understanding how these habitat features might impact avian communities is crucial given high rates of anthropogenic induced change.

Objectives: The goal of this thesis was to assess relationships between geomorphological characteristics of streams and valleys with riparian songbird communities.

Methods: The researchers surveyed 40 sites including naturally forested riparian habitats, buffered riparian habitats (adjacent timber harvesting) and beaver swamps during spring of 2000 and 2001. Quantified geomorphological variables included in-stream habitat type (pool, riffle, and run), length, width, and depth of each habitat unit, width to depth ratio of the channel, substrate composition (sand, silt, or clay), woody debris, bank slope, median particle size, and percent canopy cover. Floodplain width was estimated, and total buffer width measured on sites where timber harvesting occurred. The researchers also conducted vegetation surveys including percent ground cover. Mean abundance and species richness were calculated from songbird surveys conducted along streams. Species richness and abundance were compared across forested sites (no timber harvesting), buffered sites, and beaver swamps.

Locations: Piedmont region, Georgia

Findings: Positive correlations were detected between LOWA presence and increased channel slope, low canopy cover, and higher percent riffle, although these relationships were not statistically significant. Significant differences in LOWA abundance were found between forested vs. buffered, forested vs. beaver, and buffered vs. beaver habitats. LOWA abundance was highest in undisturbed forested riparian habitats, followed by buffered riparian habitats. LOWA were absent from beaver swamp habitats.

Implications: The association of LOWA abundance with low canopy cover was insignificant and inconsistent with the larger body of literature highlighting LOWA habitat requirements. As such, this relationship should be considered with caution. Other correlations, although not significant, were consistent with known LOWA habitat requirements, such as high proportion of riffles and a preference for high to moderate gradient streams.

Topics: LOWA, riparian habitats, geomorphology, breeding habitat, bottomland hardwood forest

Jorgensen, J.G., Dinan, L.R., Brogie, M.A., Silcock, J.R., Klaphake, C., and Steinauer, G. 2014. Breeding bird diversity, abundance, and density at Indian Cave and Ponca State parks, Nebraska, 2012-2014. University of Nebraska, Nebraska Game and Parks Commission.

Background: In the Midwest, changes in fire regimes are affecting deciduous oak forests and woodlands and species within. Fire may impact many understory and ground nesting bird species. While the impacts are negative for some species, fire may benefit others.

Objectives: The aim of the study was to initiate a long-term avian species monitoring program and compare diversity and community composition between burned and unburned management units in two sites within the study area.

Methods: The researchers conducted surveys during late Spring of 2012, 2013, and 2014.

Results of transect surveys were used to calculate avian diversity, community similarity, and relative abundance across sites. The Shannon-Weiner Diversity index was used to calculate avian diversity across study sites and Jaccard's index was used to measure community similarity across sites.

Locations: northeastern Nebraska

Findings: In this study, LOWA were only found in burned sites. LOWA were absent from unburned study plots.

Implications: This results from this study provide important insight on the response of LOWA to burn practices. The absence of LOWA from unburned plots suggests that this particular fire regime, and an open understory with a diverse ground cover plant community, may provide better habitat than plots experiencing no fire. This study provides baseline data to continue monitoring species within the study site and document long-term response of the avian community to burn practices.

Topics: Fire management, avian diversity, breeding birds, Nebraska

Kilgo, J. 2018. Effect of Stand Width and Adjacent Habitat on Breeding Bird Communities in Bottomland Hardwoods. Wiley on behalf of the Wildlife Society Stable URL : h. 62:72–83.

Background: Bottomland hardwood forests have been subject to disturbance and are declining in area, largely due to timber demands. The loss of available bottomland hardwood habitat may have negative impacts on avian communities, particularly area-sensitive species such as the LOWA. In addition to forest area, however, riparian buffer width is suggested to be influential for the avian community. Understanding how species respond to differences in riparian buffer width is an important element to forest management.

Objective: This study sought to assess avian abundance and richness across riparian buffers ranging from less than 50 to over 100 meters in width.

Methods: Surveys were conducted during the breeding seasons of 1993-1995 in stands classified as < 50m, 50 - 150 m, 150 - 300 m, 300 - 1,000 m, and > 1,000 m. Habitat characteristics measured included canopy cover, vegetation profile, tree species and

size, and basal area of hardwood pole and saw timber. Bird populations in each stand were sampled using point counts. The effect of stand width and habitat variables on species richness was assessed using a generalized linear model (GLM).

Locations: western and central South Carolina

Findings: In this study, probability of detecting LOWA was highest in narrow riparian buffers 25 meters wide (probability of detection = 0.44). Probability of LOWA detection decreased as riparian buffer width increased.

Implications: This study demonstrates that even small riparian buffers up 25 meters wide may be important to LOWA conservation, despite the area-sensitivity of this species.

Topics: bottomland hardwoods, breeding birds, landscape management, minimum area requirement, South Carolina, species richness

Knutson, M.G., Hoover, J.P., and Klaas, E.E.1995. The importance of floodplain forests in the conservation and management of neotropical migratory birds in the Midwest. In Management of midwestern landscapes for the conservation of neotropical migratory birds.U.S. Department of Agriculture, U.S. Forest Service, North Central Forest Experimental Station. 198.

Background: Avian communities differ between floodplain forests and upland forests of the central Midwest. Threats facing both floodplain forests and upland forests include, most prominently, forest loss. Given the high abundance of some species within floodplains, as well as documented increased nesting success, conservation efforts should focus on maintaining large, contiguous tracts of both floodplain and associated upland forests along with the restoration of previously degraded habitats.

Objectives: The goal of this paper was to present information on the dynamics and structure of floodplain forests in the Midwest, the floodplain forest bird community, potential threats to floodplain-nesting birds, as well as floodplain management and conservation.

Methods: The author organized this work via an extensive literature review, describing each component, including the dynamics and structure of floodplains in the Midwest, the avian community (migration, dispersal and breeding), threats and management concerns. A case study is presented to describe differences in the floodplain vs. upland forest bird communities. Researchers used point counts to establish presence of avian species and calculate relative abundance for each species. Researchers also located and monitored nests to determine nesting success.

Locations: southern Illinois

Findings: Information provided in this work regarding the LOWA highlight an affiliation of this species with upland and floodplain forests within the Midwest. Findings from the comprehensive review suggest that LOWA were more abundant in upland forests than in floodplain forests (relative abundance = 0.56 and 0.38, respectively). Results from the case study also supported a preference of the LOWA for upland forest over floodplains in the Midwest when researchers failed to detect LOWA in floodplain forests.

Implications: This review and case study suggests that forest type preferences for the LOWA varies, and may include both upland and floodplain forests, with a tendency towards upland forests within the Midwest region.

Topics: floodplain forest, upland forest, avian community, forest loss

Latta, K. 2009. What determines success? Breeding habitat characteristics of the LOWA (*Seirus motacilla*). 1–15.

Background: The LOWA, the only stream-obligate songbird bird in the Eastern United States, is considered an important bioindicator species given its dependence on healthy stream quality and the presence of macroinvertebrates, specifically, species of the orders Ephemeroptera, Plecoptera, and Trichoptera (EPT) – which are particularly sensitive to environmental changes in stream chemistry. LOWA occurrence in a riparian habitat is positively correlated with the abundance of EPT taxa and, therefore, suggests high stream quality. Understanding the factors contributing to LOWA breeding success in riparian habitats will allow researchers to better predict LOWA occurrence, and, therefore, stream-quality.

Objectives: The goal of this study was to assess the relationship between several ecological variables in LOWA breeding territories with reproductive success.

Methods: Researchers located LOWA nests during the 2007 breeding season and collected the following data: bank type, bank height, bank orientation, nest cup visibility, distance of nest to the stream, and dominant vegetation type. Individual LOWA were banded, and nesting success monitored throughout the breeding season to determine nest success.

Location: Pittsburgh, Pennsylvania

Findings: LOWA territories assessed in this study were, on average, roughly 50,000 m², along an average stream length of roughly 7,000 m. Streams in LOWA territories were characterized by riffles, runs, and pools. Territories with fledgling success had a higher proportion of canopy cover and oak trees than territories where fledging was unsuccessful, which had a higher proportion of poplar trees. This study also showed that territories where fledging was unsuccessful consisted of a higher percentage of

intermittent streams than territories where fledging was successful. Canopy cover and poplar tree density were statistically significant in their ability to predict fledging success.

Implications: This study showed that, within the study area, LOWA has higher reproductive success in riparian habitats with greater canopy cover and perennial streams, highlighting two potentially valuable predictor variables to assess habitat suitability for the LOWA.

Topics: bioindicator, nesting success, LOWA, habitat quality,

Latta, S. C., L. C. Marshall, M. W. Frantz, and J. D. Toms. 2015. Evidence from two shale regions that a riparian songbird accumulates metals associated with hydraulic fracturing. *Ecosphere* 6.

Background: Hydraulic fracturing, or fracking, poses environmental risks associated with forest disturbance and the erosion and sedimentation of waterways. Contamination of surface waters and streams occurs throughout parts of the fracking process, and it's unknown to what degree these contaminants are infiltrating the riparian food chain. The LOWA is a top predator of aquatic prey in first and second order streams and are subject to bioaccumulation of chemical contaminants. This status as a top predator, along with its association with high quality streams, makes the LOWA a good bioindicator with which researchers can investigate the impacts of shale gas fracking on riparian and terrestrial systems.

Objectives: The goal of this study was to investigate the accumulation of two chemical contaminants associated with shale gas development: barium (Ba) and strontium (Sr) in riparian systems using the LOWA as a bioindicator species.

Methods: The study took place from 2010 to 2013, during which researchers sampled 285 LOWA feather samples for presence of Ba or Sr. Evidence of bioaccumulation was compared between study sites associated with fracking and sites where no fracking had occurred.

Location: Lewes Wetzel Wildlife Management Area, northwestern West Virginia, Westmoreland Co. Pennsylvania, Van Buren, Conway, and Faulkner counties, Arkansas

Findings: The results from this study revealed significantly higher concentrations of both Ba and Sr in LOWA feathers collected on fracked sites that those collected on non-fracked sites.

Implications: This study helps to highlight the potential impact of shale gas development on riparian habitats by revealing that the LOWA is bioaccumulating associated chemicals in affected regions.

Topics: bioindicator, contamination, LOWA

Loman, Z. G., W. V. Deluca, D. J. Harrison, C. S. Loftin, B. W. Rolek, and P. B. Wood. 2018. Landscape capability models as a tool to predict fine-scale forest bird occupancy and abundance. Landscape Ecology 33:77–91. Springer Netherlands.

Background: Landscape Capability models are an important tool for predicting current and future habitat distributions that can be implemented in conservation planning.

Objectives: The goal of this study was to evaluate a set of Landscape Capability (LC) models and test their ability to predict occupancy and abundance for seven bird species associated with spruce-fir, mixed conifer-hardwood, riparian, and wooded wetland habitats, including the LOWA, which was included to represent hardwood or mixed-hardwood forest types.

Methods: A validation set was generated using point count data from previous monitoring efforts and used to test the accuracy of the models.

Location: northeastern U.S.

Findings: LOWA detection points were primarily in the Appalachian Landscape Conservation Cooperative (LCC) region. The model performed well at explaining variation in LOWA occupancy. LOWA occupancy was better predicted by smaller buffer width (100 m), as opposed to large buffers ranging from 1 - 500 km. Most LOWA detections occurred in northern hardwood conifer and central oak-pine forests.

Implications: Results from this suggest that the LC performed best at explaining LOWA occupancy at a small scale of 100 m buffer width. The accuracy of the LC demonstrated here imply that this model may be a useful tool for LOWA conservation in the northeastern U.S.

Topics: Appalachians, Breeding Bird Survey, distance sampling, Landscape Conservation Cooperatives, North Atlantic, Point Counts, Removal sampling, validation, verification

Marshall, L. C. 2012. Territories, territoriality, and conservation of the LOWA and its habitat, the watershed of the upper Buffalo National River. University of Arkansas: 1–223.

Background: The presence or absence of the LOWA has long been considered an indicator of stream water quality due to their dependence on pollutant-sensitive aquatic macroinvertebrates, particular from the order Ephemeroptera, Plecoptera, and Trichoptera (EPT taxa). These aquatic organisms are vulnerable to changes in land-use and the resultant impact on stream water quality through increased run-off pollution and sedimentation. There are various studies at the local scale that provide evidence to support this relationship between LOWA, EPT availability and abundance, and stream water quality, suggesting that LOWA breeding density and success is positively influenced by an abundance of EPT prey sources and circumneutral stream quality. The Buffalo National River watershed is experiencing extensive conversion of forest to agriculture. Given that only a small percentage of the riparian habitats associated with this watershed fall under federal protection, it is likely that anthropogenic activity is impacting the water quality and possibly the ability of the landscape to support LOWA breeding populations.

Objectives: In this study, the researcher set out to map and monitor LOWA territories on both federally protected and unprotected reaches of stream adjacent to anthropogenic activity and define a functional relationship between LOWA territory length and riparian habitat quality.

Methods: The researchers located 219 LOWAs on 23 territories from 2005-2008, monitoring nests every three days. For each territory they measured percent canopy cover and several variables associated with macroinvertebrate community composition including family biotic index (FBI), EPT richness, percent dominant taxa of EPT, gastropoda, and Chironomidae. Macroinvertebrates were sampled to mimic leaf-pulling foraging maneuvers both prior to and following several flooding events so that the researchers could assess any potential changes to the invertebrate community that may result from high water events. Tests for significance included two-factorial ANOVA and multiple regression techniques.

Locations: Buffalo National River watershed, northern Arkansas

Findings: Protected and unprotected stream reaches differed significantly in several bioassessment metrics, including a higher percent of pollutant tolerant taxa (including Chironomidae larvae) and a lower percent of pollutant intolerant taxa (Plecoptera and Trichoptera) in unprotected stream segments. FBI values also indicate higher levels of organic pollutants in unprotected versus protected stream reaches. Territories on unprotected stream reaches were significantly longer than those on protected reaches. While there was no significant difference in canopy cover between territories based on legal protection status, results do suggest that percent canopy cover is more variable on unprotected territories than protected territories. Percent canopy cover was significant in predicting an increase in territory size with decreasing canopy cover. No significant

difference was found in nest success and site fidelity across protected and unprotected streams.

Implications: The findings reported in this study echo previous work highlighting the association of LOWA with high-quality riparian habitats, in particular the percent of Plecoptera and Trichoptera taxa, further supporting the use of LOWA as a biological indicator of stream quality. The association between percent canopy cover and territory length can be used to assess habitat suitability for the LOWA across a gradient of canopy cover.

Topics: LOWA, stream ecological assessment, riparian songbird, aquatic invertebrate prey, bioassessment

Mason, J., C. Moorman, G. Hess, and K. Sinclair. 2007. Designing suburban greenways to provide habitat for forest-breeding birds. *Landscape and Urban Planning* 80:153–164.

Background: Avian diversity has been shown to decrease in response to human development. In a suburban landscape, forest corridors and greenways can help mitigate the negative effects of development and suburbanization, providing important habitat for birds, particularly forest-interior species that are sensitive to anthropogenic disturbance. Greenway effectiveness is influenced by several factors including within-greenway habitat quality, greenway width, and adjacent land use cover.

Objectives: The goal of this study was to estimate how within-greenway forest corridor width, vegetation structure, and adjacent land use and cover impact the avian community and ultimately provide guidance on the design and management of effective urban greenways for avian species sensitive development.

Methods: Using a point-count sampling technique, the researchers conducted surveys during spring of 2002 and 2003 on 34 forested segments of greenway. Forested corridor widths ranged from 32.5 meters to 1300 meters (mean - 207.57 meters). Land cover was determined with aerial imagery. Greenway vegetation composition and structure was measured as percentage of mature forest, young forest, managed area, and stream within a 50 m radius. The researchers also measured percent canopy cover, canopy height, percent pine and hardwood, percent vine cover, percent shrub cover, and percent ground cover. Total avian species richness and abundance was calculated for each greenway segment as well as within-guild species richness and abundance.

Locations: Raleigh and Cary, North Carolina

Findings: One of 53 species detected in this study, LOWA were only recorded in greenways wider than 300 meters.

Implications: These findings are consistent with LOWA being a forest area-sensitive species.

Topics: breeding birds, corridor width, forested greenways, urban planning

Mattsson, B. J., and R. J. Cooper. 2006. Louisiana Watherthrush (*Seiurus motacilla*) and habitat assessments as cost-effective indicators of instream biotic integrity. *Freshwater Biology* 51:1941–1958.

Background: Human modifications to the landscape may result in the degradation of aquatic ecosystems as erosion and run-off increase. Reliable indicators of stream water quality historically include the presence and abundance of stream macroinvertebrates representing the orders Ephemeroptera, Plecoptera, and Trichoptera (EPT). Challenges in measuring the presence and abundance of EPT taxa include the technical knowledge of insect identification and substantial time investments. The LOWA is a stream-obligate songbird with a diet consisting largely of EPT taxa. Given the strong association with LOWA, EPT taxa, and stream water quality, LOWA presence, more easily observed than EPT, may serve as a reliable indicator of aquatic ecosystem health.

Objectives: The objectives of this study were to assess the utility of LOWA as bioindicators of aquatic ecosystem health along with the U.S. Environmental Protection Agency (EPA) rapid visual habitat assessment protocol (VHA), which are known to be good indicators of stream integrity.

Methods: The researchers selected study sites with varying degrees of stream integrity. Study sites were surveyed during the breeding seasons of 2002-2004 and LOWA presence was identified as either absent, single male, or breeding pair. EPT taxa were sampled, and metrics calculated included EPT richness, ratio of EPT to macroinvertebrate abundance, the Family Biotic Index (FBI) and macroinvertebrate biomass. The researchers performed EPA VHA to score study sites. Habitat characteristics assessed included epifaunal substrate, embeddedness, velocity/depth regime, sediment deposition, channel flow status, channel alteration, frequency of riffles, bank stability, vegetative protection, and riparian buffer width. The authors constructed linear regression models using the previously measured variables relating to LOWA presence and EPA VHAs and tested model ability to predict abundance and richness of EPT taxa and aquatic ecosystem health.

Location: Athens-Clarke and Macon Counties, Georgia

Findings: The model performed best at predicting variability in stream health when LOWA occupancy was combined with EPA VHAs. LOWA occupancy was a useful indicator of % EPT, FBI, and EPT biomass, but not EPT richness.

Implications: Findings from this study suggested that LOWA is a useful indicator of the health of stream ecosystems. The study highlighted the association of LOWA occupancy with streams characterized by high biotic integrity and factors associated with a healthy stream ecosystem can be useful in predicting LOWA breeding habitat suitability.

Topics: bioindicator, aquatic ecosystem health, LOWA breeding habitat, benthic macroinvertebrates

Mattsson, B. J., and R. J. Cooper. 2009. Multiscale analysis of the effects of rainfall extremes on reproduction by an obligate riparian bird in urban and rural landscapes. *Auk* 126:64–76.

Background: Headwater riparian ecosystems provide crucial ecological services which may be impacted by climate fluctuations and human disturbance. Precipitation extremes can alter the hydrology of a stream and have serious consequences for the biological community within that ecosystem. The LOWA has been considered a good indicator to overall stream health given its dependence on healthy riparian ecosystems. LOWA breeding success may be affected by climate and anthropogenic factors at multiple spatial and temporal scales.

Objectives: The objective of this work was to determine the relationship between LOWA reproductive success and factors relating to anthropogenic land use, territory quality, and precipitation, at multiple spatial and temporal scales.

Methods: The authors mapped 139 LOWA territories in 13 forested headwater drainages during the Springs of 2002-2005. They recorded habitat quality characteristics such as percent riffles per territory, percent understory cover, percent forest cover, territory area, distance to urban edge, distance to rural edge, percent urban, percent field, and mean daily rainfall. LOWA reproductive success was estimated by quantifying nestling survival rate across territories. The researchers modeled reproduction for 190 nests with a set of 13 potential models using parameters associated with habitat quality and precipitation to determine the most parsimonious model.

Location: north-central Georgia

Findings: Results of this study indicated that intermediate levels of precipitation (3-10 mm day⁻¹) during the nesting period were associated with maximum daily nest survival rates. High levels of precipitation, however, were associated with maximum nestling survival (> 14 mm day⁻¹). Territory size was inversely related with nestling survival. At the larger landscape scale, LOWA nestling survival was lowest when distance to rural was over 160 m but within 1.75 km. Weak associations were found between urban land use factors, distance to urban edge, percent riffles per territory, and year and timing of nesting.

Implications: This research provides important insight into the effects of precipitation on LOWA reproductive success at multiple nesting stages as well as the proximity to rural land use and territory size. Given the significant relationships found among these factors and LOWA reproductive success researcher may better predict how this species will respond to climatic fluctuations and land use changes over time.

Topics: LOWA, climatic fluctuations, land use, reproductive success, riparian ecosystem

Mattsson, B. J., S. C. Latta, R. J. Cooper, and R. S. Mulvihill. 2011. Latitudinal variation in reproductive strategies by the migratory LOWA. Condor 113:412–418.

Background: Long distance migrant birds breeding across a large latitudinal gradient may evolve localized reproductive strategies under different environmental conditions throughout the breeding range. Two hypotheses to explain patterns of variation in reproductive strategies across latitudinal gradients include the season-length hypothesis and the food-limitation hypothesis, the former of which predicts birds breeding towards the southern extent of the range are more productive due to a longer growing season while the latter predicts birds breeding towards the northern extent of the range are more productive due to higher food availability. The LOWA has an extensive breeding range in the eastern United States and serves as a model species for testing the season-length and food-limitation hypotheses.

Objectives: The goal of this study was to observe and quantify differences in LOWA reproductive strategy and output across a wide latitudinal gradient to support or refute either the season-length hypothesis or food-limitation hypothesis.

Methods: The researchers located LOWA nests and documented the number of eggs, nestlings, and fledging's during the breeding seasons of 2003-2005. A statistical model used to compare reproductive success between two localities included number of eggs laid, number of young fledged, nest-survival rate, length of time between nesting attempts, and probabilities of renesting and double brooding.

Findings: Three factors were significantly different between the northern and southern breeding localities including replacement nest egg-laying rate, replacement nest clutch size, and probability of renesting. Overall fecundity was similar across breeding sites.

Location: central Georgia, southwestern Pennsylvania

Implications: The authors showed that average territory size was larger towards the southern extent of LOWA range, and attribute this to comparatively low food-availability in these habitats. This study found that LOWA fecundity did not vary significantly across breeding study sites, although factors associated with replacement nests were significantly different. The authors suggest that this difference may be due to variations

in the phenology of insect abundance across the two study sites. Across Georgia and Pennsylvania, insect abundance is similar earlier in the season when first nesting attempt takes place. While insect abundance remains high towards the northern extent of the range, towards the south, insect abundance drops in the latter half of the season when replacement nesting is typically taking place, potentially explaining the comparatively low productivity of replacement nests.

Topics: LOWA, geographic variation, reproductive strategies, fecundity

McClure, C. J. W., and G. E. Hill. 2012. Dynamic versus static occupancy: How stable are habitat associations through a breeding season? *Ecosphere* 3:art60.

Background: Most studies of breeding habitat use in migratory bird species assume that habitat use does not change throughout the breeding season. With most studies focusing on the early stages of the breeding season, this assumption of static habitat use throughout the season may result in a bias understanding of habitat use. There are several known examples where habitat use has been known to shift across breeding season in birds, highlighting the need expand our understanding of habitat use during the entire breeding season.

Objectives: This study aimed to determine whether habitat use by breeding birds is static across the breeding season.

Methods: The researchers conducted point count surveys throughout the breeding season of 2005, splitting the season into an early round (May 15 – June 15) and later round (June 15 – July 15), with 24 days separating surveys at each site. Percent land cover (classes from Alabama GAP landcover data) and percent canopy cover were calculated within a 100 m buffers surrounding each point location. The researchers used occupancy modeling for each survey periods and tested the hypothesis that birds moved among habitats throughout the breeding season. The LOWA (LOWA) was one 15 species of conservation concern analyzed in this study.

Location: Tuskegee, Alabama

Findings: Factors influencing the detection of LOWA during this study included percent canopy cover and presence of water. LOWA tended to shift towards sites more closely associated with water as the breeding season progressed.

Implications: This study further enforces our understanding of the LOWA's preference for riparian habitats. Since water levels tend to be lower later in the breeding season within the study site, the researchers suggest that LOWA may be selecting sites near perennial streams and water sources.

Topics: LOWA, breeding season, habitat selection, occupancy modeling, Gulf Coastal Plain, Alabama

Means, J. L., and K. E. Medley. 2010. Old Regrowth forest patches as habitat for the conservation of avian diversity in a southwest Ohio landscape. Ohio Journal of Science 110:86–93.

Background: Large patches of mature deciduous forest are declining due to conversion to agriculture and other land use practices. Contiguous tracts of old growth forest provide crucial habitat for forest-dependent bird species such as the LOWA. Given the continued conversion of forest for anthropogenic land use, it is important to understand the contribution of remaining old-growth forest stands to bird diversity to effectively manage the landscape for avian conservation.

Objectives: The aim of this study was to quantify avian diversity in small patches of old-growth forest, focusing on mature forest-associated species. The authors also investigated how avian diversity differs among remnant forest stands in relation to physical, ecological, and landscape characteristics.

Methods: The researchers used aerial photography to map old regrowth forests and selected nine patches ranging in size from 0.9 to 11.2 ha. Point count surveys were conducted during May and June 2009 to quantify avian diversity. Habitat characteristics measured and compared included topography, tree species, diameters at breast height (dbh), percent canopy cover, percent woody ground debris, tree height for all canopy and subcanopy trees greater than 10 cm (dbh), and density of snags. The researchers compared species presence (or absence), species richness, and relative percent of species identified with regional bird data.

Locations: south-western Ohio

Findings: The nine study patches were all characterized as closed canopy, deciduous forests with well-developed understories. During this study LOWA were detected within study patches, including a patch as small as 4.2 ha that was characterized as partial floodplain.

Implications: The results of this study support the association of LOWA with mature, old growth forests and water. This study also provides evidence of LOWA presence in patches much smaller than those typically occupied by LOWA.

Topics: eastern deciduous forest, forest-dependent birds, avian diversity, old growth forests

Mueller, A., D. Twedt, and C. Loesch. 1999. Development of management objectives for breeding birds in the Mississippi Alluvial Valley. Proc. of the 1995 Partners in Flight ... 1–15. <http://www.lmvjv.org/library/research_docs/2000_RMRS-P-16_12-17_Mueller_Twedt_Loesch.PDF>.

Background: Bird Conservation Plans (BCPs) specific to individual physiographic regions (e.g., the Mississippi Alluvial Valley or MAV) are important for effective conservation. Given the limitations to obtaining complete and accurate ecological information, the best conservation approach may require action based off of limited information. With an adaptive management approach, however, as more relevant information becomes available to the scientific community, conservation plans and recommendations can be modified to ensure a more informed approach.

Objectives: The goal of this paper was to provide a model for establishing regional avian conservation plans based off of the best available information.

Methods: The authors present a six-step approach for establishing conservation goals for avian species and demonstrate the use of this approach for the MAV. They first established priority species for the region followed by habitat priorities. Next, they identified habitat requirements to support populations of identified priority species within these habitats, such as forest area. The distribution of suitable habitat needed to meet individual species' population requirements is then determined using GIS analyses. Next, researchers set site-specific objectives and goals for the entire population for each species.

Locations: Mississippi Alluvial Valley

Findings: Using the process outlined in this paper, the researchers estimate that minimum forest patch size to support 500 breeding LOWA is 7,200 acres.

Implications: This study provides a useful tool for land managers that can help prioritize areas within the region based on that habitats ability to support avian priority species such as LOWA. The information provided here further supports the association of LOWA with large forest patches. With optimal area quantified, researchers and managers are better able to implement effective conservation.

Topics: Mississippi Alluvial Valley, Bird Conservation Plan, Partners in Flight, forest area requirements, priority habitats, priority species

Mulvihill, R. S., F. L. Newell, and S. C. Latta. 2008. Effects of acidification on the breeding ecology of a stream-dependent songbird, the LOWA (*Seiurus motacilla*). *Freshwater Biology* 53:2158–2169.

Background: Riparian ecosystems are vulnerable to acidification resulting from both mining and acid rain. Benthic macroinvertebrates from the orders Ephemeroptera, Plecoptera, and Trichoptera (EPT taxa) are an important food source for the stream obligate songbird, the LOWA. EPT are acid-intolerant and can't persist in acidified streams. Given that LOWA are often associated with territories consisting of high proportions of EPT taxa, stream acidification may have serious implications for LOWA presence and reproductive success.

Objectives: The objective of this study was to investigate the relationship between stream acidification and LOWA abundance and breeding success.

Methods: The researchers surveyed reaches roughly 2-3 km in length along 8 first and second order streams from 1996-2005 (n=2) and 1998-2000 (n=6). Data recorded along each stream included % EPT and stream chemistry. The researchers banded and observed LOWA on each stream. All nesting attempts were documented, and nests were monitored for nesting success, which was defined as at least one fledged individual.

Locations: Laurel Highlands, southwestern Pennsylvania

Findings: The researchers monitored a total of 207 LOWA territories on acidic and circumneutral streams. Acidic streams were characterized by lower breeding density, larger territories, and lower macroinvertebrate biomass. Overall %EPT was similar, but there was a significantly lower proportion of Ephemeroptera taxa in acidic streams versus circumneutral streams. The number of successfully fledged young was significantly lower on acidified stream. Site fidelity was highest in circumneutral streams

Implications: This study showed that acidification of streams likely has detrimental effects on the LOWA breeding population.

Topics: LOWA, acidification, riparian ecosystem health, mining, benthic macroinvertebrates

Murray, N.L., and F. Stauffer. 1995. Nongame Bird Use of Habitat in Central Appalachian Riparian Forests. *The Wildlife Society Stable* URL:<http://www.jstor.com/stable/3809118>. 59:78–88.

Background: Riparian habitats generally support high avian diversity, as they represent an ecotone with unique characteristics between aquatic and upland habitats. In the central Appalachians, however, the gradient between riparian zones and upland habitats

is somewhat uniform, and it's unclear how these habitats impact the composition of the avian community.

Objectives: The aim of this study was to investigate the influence of riparian habitats in hardwood and hemlock forests in the central Appalachians on avian species richness and abundance.

Methods: The researchers conducted point counts during the breeding seasons of 1990 and 1991 on 16 sites along second order streams with riparian buffers at least 60 meters wide, characterized as mature, second growth forest. Habitat characteristics were measured for each site, including snag abundance, canopy and understory tree species composition and height, ground cover, and distance to stream.

Locations: Jefferson National Forest, southwestern Virginia

Findings: Unsurprisingly, this study found that LOWA were most often detected within four meters of a stream. LOWA were absent from sites farther than 154 meters from a stream, demonstrating a statistically significant response to distance to stream. This study also showed that LOWA were statistically more likely to occupy riparian areas dominated by deciduous hardwoods rather than hemlock.

Implications: This study supports a stronger association with deciduous riparian habitats than with hemlock-dominated riparian habitats. This information is important as it provides more evidence to increase confidence in the ability to predict habitat suitability for the LOWA in southwestern Virginia.

Topics: forest habitat, neotropical migrants, nongame birds, riparian, Virginia

Nott, M. P., D. F. DeSante, and N. Michel. 2003. Management strategies for reversing declines in landbirds of conservation concern on military installations: A landscape-scale analysis of maps data. A report to the U.S. Department of Defense Legacy Resources Management Program. 123.

Background: The United States Department of Defense (DoD) provides substantial breeding and stopover habitat for bird species in North America. One challenge natural resource managers face on these military installations involves the juxtaposition of necessary military activity, disturbance and avian conservation. Ecological models can help land managers understand how landscape patterns can impact the avian community, enabling them to better balance conservation and military operations.

Objectives: The goal of this study was to develop landscape-scale models to guide management practices intended to reverse declining population trends in neotropical migratory birds.

Methods: The researchers used banding data from 1994-2001 for 13 DoD installations for 31 landbird species, in conjunction with land cover data to construct demographic-landscape models and explain the relationship of landscape patterns with reproductive success, number of adults and young, and populations trends.

Locations: eastern and central United States

Findings: LOWA experienced increasing population trends on four of the seven installments where they were present, while a negative trend was found on three installments. The model generated showed that LOWA were associated with large tracts of landscape characterized with 50-90% forest cover (600-1100 ha of forest in a 2-km radius area) that contain 50-100ha of water. Positive relationships were found between the number of young and adults, along with reproductive success, and the total amount of water and forest edge. The authors also found a negative association with amount of shrubland cover and water edge, but the ecological significance of these findings is not clear.

Implications: While the findings support that LOWA are associated with stream and heavily forested habitats, the authors suggest that the positive association with LOWA abundance and reproductive success and forest edge indicates that some fragmentation may be beneficial, mainly with regards to juvenile dispersal. The authors suggest that LOWA management include the maintenance of upland forested riparian habitats with dense, shrubby forest edge habitat. In addition to this recommendation based on their model, the authors also site previously established guidelines for LOWA management that included upland streams buffered by at least 50 meters of forest on each side, with forest area totaling over 100ha. No reference is provided for these guidelines, however.

Topics: avian conservation, land management, demographic-landscape models, Birds of Conservation Concern

Parnell, J.F. 1969. Habitat Relations of the Parulidae during Spring Migration. University of California Press on behalf of the American Ornithologists' Union Stable URL: <http://www.jstor.org/stable/4083411>. Spring 86:505–521.

Background: Many wood warblers, including the LOWA, are uniquely adapted to different habitat niches. Given these adaptations, it is likely that birds exhibit habitat selection and preferences during migration as well as the breeding and wintering seasons. Little work, however, has focused on habitat use by warblers during migration.

Objectives: The goal of this study was to determine the relationships between habitat characteristics and habitat use among warblers during Spring migration.

Methods: The researcher sampled birds along 19 transects over the course of two consecutive spring migration and nesting seasons (1962 and 1963). Transects included

seven forest types including floodplain forest, pine forest, oak-hickory forest, pine-hardwood forest, dry thicket, wet thicket, and beech forest. Analysis of Variance (ANOVA) was used to determine difference in habitat selection across warbler species.

Locations: Raleigh, North Carolina

Findings: This study showed that LOWA selected floodplain forest and beech forest habitats and were absent from all other forest types in this study.

Implications: This study presents information that can be used to predict LOWA habitat suitability within the study region, showing that LOWA prefer floodplain and beech forest habitats over the other forest types.

Topics: Warblers, migration, habitat use, forest type

Peak, R. G., and F. R. Thompson. 2006. Factors Affecting Avian Species Richness and Density in Riparian Areas. *Journal of Wildlife Management* 70:173–179.

Background: Riparian ecosystems support a high degree of avian biodiversity, and are conservation targets to help mitigate the impacts of habitat loss on birds. Many studies have focused on the influence of riparian width on avian richness and abundance, but few have looked at other characteristics such as vegetation composition and structure. The influence of grassland-shrub buffers adjacent to forested riparian areas on avian abundance and diversity is largely unknown.

Objectives: The aim of this study was to assess how grassland-shrub buffer strips (presence and width) influence avian species richness.

Methods: The researchers surveyed bird communities during the 2000 and 2001 breeding seasons along three narrow (55-95 m) and three wide (400-530 m) forested riparian areas with an adjacent grassland-shrub buffer as well as three narrow and three wide riparian areas with no grassland-shrub cover. Habitat features measured included dbh (greater than 1.3 meters high and over 0.5 cm), woody stems taller than 50 cm (species and dbh), ground cover, and percent canopy cover. Proportion of bottomland to upland forest at each study was also calculated, along with avian species richness and mean density for forest area-sensitive and grassland-shrub-nesting birds.

Locations: northeastern Missouri

Findings: This study showed that riparian buffer width best predicted LOWA density. LOWA were found at higher densities in wide riparian zones, and highest in those with no grassland-shrub buffer.

Implications: The results of this study further support the association of LOWA with wide forested riparian buffers, (400-530 m).

Topics: avian species richness, breeding bird density, buffer strip, forest area-sensitive species, grassland-shrub-nesting species, information theoretic approach, Missouri, riparian area, songbird

Pennington, D. N., and R. B. Blair. 2011. Habitat selection of breeding riparian birds in an urban environment: Untangling the relative importance of biophysical elements and spatial scale. Diversity and Distributions 17:506–518.

Background: Urbanization presents a substantial challenge to efforts to conserve biodiversity. Despite this threat, many native bird species continue to inhabit urban areas. The spatial arrangement of urban and natural habitat features may influence avian habitat selection across multiple spatial scales within an urban environment.

Objectives: The objectives of this study were to investigate the influence of habitat characteristics at both small and large scales and compare the relative importance of habitat characteristics at these different scales to avian density. In addition, the authors sought to identify the spatial scale to which different bird species show the strongest response to habitat characteristics.

Methods: The researchers conducted avian surveys at 71 plots arranged along an urban gradient during the breeding seasons of 2002, 2004, 2005, and 2006. Relative density for 48 bird species was modeled to assess the relationship between density and small-scale woody vegetation composition and landscape level features including tree cover, grass cover, and building density.

Locations: Cincinnati, Ohio

Findings: The model suggested a positive response of LOWA to canopy height, which was an important variable for predicting LOWA density.

Implications: These findings support the association of LOWA with mature forest.

Topics: Birds, conservation, biogeography, habitat selection, heterogeneity, landscape spatial scale, urban

Prosser, D. J., and R. P. Brooks. 2011. A Verified Habitat Suitability Index for the Louisiana Waterthrush (Un Índice Verificable de Adecuación de Habitat Para *Seiurus motacilla*) Published by: Blackwell Publishing on behalf of Association of Field Ornithologists Stable URL: <http://www.jstor>. Habitat 69:288–298.

Background: Habitat Suitability Index (HSI) models are valuable tools used to guide wildlife management decisions. Testing the accuracy of HSIs is critical if these models are to be used in decision making. Methods for testing the accuracy of a HSI include calibration with qualitative data, verification with quantitative presence data, or validation through quantification of some population measure.

Objectives: The goal of this study was to generate and verify a HSI for the LOWA.

Methods: Surveys for LOWA presence were conducted during Spring of 1994 and 1995. Variable selection for model development was guided by a thorough literature review. Previous research showed that during the breeding season LOWA are riparian obligates occupying first through second order streams with microtopography consisting of riffles and pools. Preferred land cover included interior forest consisting of a mix of deciduous and coniferous canopy cover with an understory composed of herbaceous vegetation, moss, and ferns. Secondary habitat included slow streams and river swamps. The LOWA was found to build nests in stream banks and the roots of upturned trees. Variables selected included cover (forest cover, percent shrub cover, ratio of deciduous to coniferous canopy cover, herbaceous cover density and height), food (stream order and microtopography, stream clarity and substrate), nesting (presence of fallen trees, stream bank slope and herbaceous cover type), and landcover.

Findings: The authors successfully developed a HSI for LOWA, specific to the Mid-Atlantic region, using eight predictor variables relating to cover, food, and nesting. Verification showed that areas where LOWA is present have higher HSI than areas where LOWA is absent.

Location: Blair, Centre, Huntingdon, and Union counties, Pennsylvania

Implications: The HSI developed here solidifies our understanding of optimal LOWA breeding habitat. The use of the variables relating to cover, food, and nesting, highlights the importance of these habitat features in estimating habitat suitability for this riparian specialist and can be used to support future HSIs developed for LOWA.

Topics: breeding habitat, habitat suitability index modeling, riparian habitat, LOWA

Robbins, S. C., D. K. Dawson, and B. A. Dowell. 1989. Habitat Area Requirements of Breeding Forest Birds of the Middle Atlantic States. Wildlife Monographs 103:1–34.

Background: It is well documented in the literature that large tracks of contiguous forest area are key to the conservation of many bird species. Different species, however, have different area requirements. Understanding the area requirements for species of conservation concern can help managers prioritize areas for conservation.

Objectives: This study aimed to determine minimum area requirements and identify habitat characteristics associated with relative abundance for 75 species of forest birds, including the LOWA.

Methods: The authors sampled forests across four geographic regions throughout the Mid-Atlantic region from 1979-1983. Study sites contained forests falling into one of eight area classes (< 2 ha, 2-6 ha, 6-20 ha, 20-50 ha, 50-150 ha, 150-500 ha, 500-1,500 ha, and >1,500 ha). Vegetation and habitat characteristics were measured at 469 point count locations and stepwise multiple regression analysis was used to determine which variables influenced relative abundance for 75 species of forest birds. The authors used logistic regression to assess the association between species probability of occurrence and forest area whenever forest area was identified as an important variable.

Locations: Maryland

Findings: This study found that, of 15 variables, increased LOWA relative abundance was associated with higher tree basal area, larger forest area, increased moisture gradient, a lower percentage of coniferous forest cover, and increased foliage density at 0.3-1 meters. Logistic regression showed that optimal forest area for LOWA was at least 3,000 ha, while the suggested minimum area for breeding was 350 ha. LOWA were detected in patch sizes as small as 24.7 ha.

Implications: The findings of this study highlight several habitat characteristics that influence LOWA relative abundance, including tree basal area, forest patch size, moisture gradient, proportion of coniferous forest cover, and understory foliage density. Optimal patch size for maximum LOWA abundance was >3,000 hectares, providing further evidence that LOWA rely on large areas of contiguous and mature forest. This number, along with the minimum area suggested for breeding is useful in establishing a gradient in habitat suitability based on forest patch area.

Topics: Forest birds, habitat structure and composition, LOWA, forest management

Robinson, S.K. and Wilcove, D.S.1999. Forest fragmentation in the temperate zone and its effects on migratory songbirds. Bird Conservation International 4:233-249.

Background: Neotropical migrant populations are on the decline and forest fragmentation and forest loss is largely to blame. Among other negative consequences, such as lower dispersal and colonization rates, forest fragmentation may lead to increased nest predation and cowbird parasitism, as cowbirds are generally found along the forest edge rather than the interior.

Objectives: The goal of this study was to present evidence of the declining neotropical migrant songbird populations and discuss the association of this trend with forest fragmentation in breeding habitats while providing recommendations for forest management practices to minimize fragmentation.

Methods: Evidence for declining migratory songbird populations was compiled from the literature, along with the factors that facilitate increased extinction rates in response to fragmentation. These factors include dispersal and colonization, changes in forest successional stage, food resources, microhabitats, nest predation, and brood-parasitism.

Locations: Midwest, North America

Findings: The information compiled in this study suggest higher rates of brood parasitism in LOWA populations breeding in a fragmented landscape (50% parasitized) than in a moderately fragmented, forested landscape (25% parasitized). Brood parasitism reduced reproductive success (number of successfully fledged offspring) in LOWA by 73%. Despite these rates of parasitism in fragmented habitats along with reduced productivity, this paper suggests that LOWA typically avoid brood parasitism by selecting interior forest habitats.

Implications: The information presented here suggests that, while brood parasitism may be relatively lower in LOWA than in other species, this species is still vulnerable, particularly in a fragmented landscape.

Topics: Forest fragmentation, neotropical migratory songbird, brood parasitism, cowbird, reproductive success

Sauer, J. R. E., J. E. Hines, K. L. Fallon, J. Pardieck, D.J., Ziolkowski, and W. A. Link. 2014. The North American Breeding Bird Survey, Results and Analysis 1966-2012. Version 02.19.2014. Laurel, MD. <<http://www.mbr-pwrc.usgs.gov/bbs/bbs.html>>.

Background: The Breeding Bird Survey (BBS) was established during the 1960s as a continental-wide monitoring programs for breeding birds in North America.

Objectives: The objective of the Breeding Bird Survey (BBS) is to systematically assess the status and trends of North American bird populations at both continental and regional scales with the aim to guide effective conservation and management strategies.

Methods: The BBS consists of 3,700 routes along roads, each 24.5 miles long with 50 stops at 0.5-mile intervals, where researchers conduct three-minute point counts.

Locations: North America

Findings: Results from years of BBS data suggest that LOWA have been declining in the WGCPO since 1966.

Implications: The population decline detected by the BBS suggests that LOWA is a species of conservation concern within the WGCPO region.

Topics: North America, breeding birds, United States Geological Survey, population trends

Schulz, C. A., D. M. Leslie, R. L. Lochmiller, and D. M. Engle. 1992. Herbicide effects on cross timbers breeding birds. *Journal of Range Management* 45: 407-411.

Background: Herbicides used in range management throughout the Cross Timbers region of central Oklahoma may have effects on breeding forest birds.

Objectives: The goal of this study was to assess the impacts of tebuthiuron and triclopyr herbicide use on non-game forest breeding birds, including the LOWA.

Methods: This study included nine pastures representing three replicates of three experimental treatments as well as a control site with no herbicide application. In 1988 and 1989, habitat measurements were taken at a series of 10.8-hectare grids throughout the study site and included foliage height and diversity, density of snags and slash (downed debris), snag basal area, slash volume, percent herbaceous ground and shrub cover, and percent canopy cover. Bird surveys were conducted on all grids to identify species and estimate densities for each species at each grid.

Location: central Oklahoma

Findings: Control sites had greater canopy cover, lower snag density, lower slash volume, and lower herbaceous cover. This study found that the LOWA was statistically more likely to be found on control plots. LOWA were absent from all nine treatment plots in this study. Density of LOWA territorial males was roughly six per 10.8-hectare plot.

Implications: The results of this study provide further evidence to support the association of LOWA with closed canopy forests. This study also highlighted a potential relationship between LOWA presence and percent herbaceous ground cover, as well as snag and slash densities, although these associations are not prominently supported in the literature.

Topics: Breeding non-game birds, herbicide, habitat-alteration, Oklahoma, tebuthiuron, triclopyr

Skinner, C. 2003. A breeding bird survey of the natural areas at Holden Arboretum. Ohio Journal of Science 103:98–110.

Background: Avian community diversity and composition can be important proxies for overall ecosystem health. Bird surveys are an efficient way to monitor avian communities and ecosystem health.

Objectives: The goal of this study was to estimate species richness and abundance of breeding birds in various habitats.

Methods: The researchers conducted avian surveys during Spring, 2001, recording observations of individuals for each species.

Locations: Cleveland, Ohio

Findings: Results from this study indicate that LOWA preferred both mature upland and bottomland forest.

Implications: This study adds to the breadth of information supporting an association of the LOWA with both mature upland and bottomland forest.

Topics: Breeding birds, ecosystem health, bioindicator, Ohio

Stucker, J. H., and F. J. Cuthbert. 2000. Biodiversity of southeastern Minnesota forested streams: relationships between trout habitat improvement practices, riparian communities and the LOWA. Natural Heritage and Nongame Wildlife Program 1–146.

Background: The LOWA is a species of conservation concern in Minnesota due to a restricted range and an observed decrease in the population over time. Conservation of habitat is critical for this riparian specialist. To prioritize areas for protection in Minnesota, towards the northern extent of its range, it is crucial to understand what habitat characteristics are associated with LOWA reproductive success.

Objectives: The goal of this study was to better understand LOWA reproduction and nest site characteristics as well as assess habitat differences between areas where LOWA were found breeding and where LOWA were absent.

Methods: The researchers included 22 segments of first through third order streams with roughly 90% canopy cover. Point counts were conducted during spring of 1995 and 1996 to assess avian communities and playbacks were used to detect LOWA. LOWA nests were identified and tracked to determine nesting success. Measured nest-site characteristics included height above water, distance to stream, and composition of nest material. To assess the composition of the aquatic community the researchers sampled benthic macroinvertebrates from riffles and identified to species or the finest taxonomic level possible. The researchers measured Simpson and Brillouin diversity indices, species richness, proportion of representatives from the orders Ephemeroptera, Plecoptera, Trichoptera (EPT taxa) and Chironomid dominance, and three LOWA specific indices of food intake. Measures of water quality included two indices: The Hilsenhoff Biotic (HBI) and Family Biotic (FBI) Indices. Stream and streambank measurements included length of riffles, runs, and pools within each stream segment as well as percentage of exposed rock. Streambank slope, percent of exposed bank, and vegetative community were also recorded.

Locations: southeastern Minnesota

Findings: The researchers observed 24 nests from 22 stream segments. Average territory length was 460 meters. Average nest height was 1.3 meters above the waterline and average distance to stream was 1.4 meters. Nests occurring along the streambank were generally associated with a slope of 69°. Maple leaves were most abundant among nesting material and nests, on averaged, faced 94°. Of the 24 nests observed, 23 fledged at least one fledgling. Cowbirds parasitized at a minimum of 15 nests, which resulted in a decline of fledgling success from 2.3 per nest to 0.8 per nest. In general, the avian community in areas where LOWA were found nesting included significantly more forest interior species and fewer species adapted to disturbed habitats. Streams where LOWA were found nesting had significantly more riffles, fewer runs, higher percentage of exposed rock, more bare soil on the streambank, and a small bank slope, than those where LOWA were absent. Proportion of EPT taxa were higher in streams segments where LOWA were present, although there was no significant difference in water quality.

Implications: This study increases our understanding of LOWA breeding habitat towards the northern extent of its breeding range, highlighting critical habitat features such as nest site characteristics, food availability, and stream morphology. This information can be used to help prioritize areas for LOWA conservation based on these habitat characteristics.

Topics: LOWA, nest site characteristics, riparian ecosystem, reproductive success, conservation

Thompson, B. n.d. Process for establishing priority refuge resources of concern.

Background: Priority refuge resources of concern are useful in guiding ecological goals and objectives for the refuge. Most priority resources on refuges are plants or animals of conservation concern.

Objectives: The goal of this Appendix was to describe the procedures followed to establish priority resources of concern for Silvio O. Conte National Fish and Wildlife Refuge.

Methods: The process for establishing priority resources of concern included collecting information and data from experts to create a list of potential species and habitats of conservation concern within the watershed.

Locations: Connecticut, Massachusetts, New Hampshire, and Vermont

Findings: The collective, expert-derived information regarding LOWA presented in this Appendix suggest that breeding habitat for this species includes large tracts of mature, contiguous hardwood forest (250 acres or more). Forest types important for LOWA breeding include deciduous or mixed forests along medium to high-gradient first to third order, perennial streams.

Implications: The information here provides evidence that can guide conservation planning and inform models predicting habitat suitability in this species. This work reinforces the LOWAs association with mature, contiguous hardwood forests along first and second order perennial streams.

Topics: priority refuge resources of concern, Silvio O. Conte National Fish and Wildlife Refuge,

Tirpak, J M, D. T. Jones-Farrand, F. R. Thompson, D. J. T., W. B. Uihlein. 2009. Multiscale habitat suitability index models for priority landbirds in the Central Hardwoods and West Gulf Coastal Plain/Ouchitas Bird Conservation Regions. U.S. Department of Agriculture, Forest Service General Technical Report NRS-49, Northern Research Station, Newtown Square, Pennsylvania, USA.

Background: The North American Landbird Conservation Plan was established with several goals, one of which was to translate population targets for species of concern to habitat goals in the Central Hardwoods and West Gulf Coastal Plain/Ouchitas regions. The LOWA is a species of concern in both regions.

Objectives: This goal of this study was to determine the landscapes' ability to sustain specified populations of priority species, such as LOWA, based on the extent of available habitat using a Habitat Suitability Index (HSI) modeling approach.

Methods: The HSI developed for LOWA in this study was informed by the following variables: landform (floodplain-valley, terrace-mesic, and xeric ridge), landcover (low-density residential, transitional-shrubland, deciduous, evergreen, mixed, orchard-vineyard, woody wetlands), successional age class (grass-forb, shrub-seedling, sapling, pole, and saw), distance to stream, percent canopy cover, density of small stem vegetation, forest patch size, and percent forest loss in a 1 km radius.

Findings: HSI model verification and validation showed a positive association between LOWA presence and average HSI score, suggesting that the model developed in this study is appropriate in predicting the landscapes' ability to sustain LOWA populations. Across all landform types, LOWA habitat suitability score was highest in deciduous forest and woody wetlands with mature stands. Optimal distance to stream was less than 30 meters while optimal canopy cover was >90%. LOWA habitat suitability decreased with increasing small stem density. Optimal patch size was greater than 3,200 hectares and optimal landscape composition consisted of > 90% forest within a 1 km radius.

Location: West Gulf Coastal Plain/Ouchitas and Central Hardwood regions, eastern United States

Implications: This study showed that the variables used in this HSI are valuable indicators of LOWA habitat suitability, demonstrating that these factors are crucial indicators of LOWA breeding habitat quality.

Topics: LOWA, Habitat Suitability Index, landbird conservation, West Gulf Coastal Plains/Ouchitas, Central Hardwood,

Trevelline, B. K., S. C. Latta, L. C. Marshall, T. Nuttle, and B. A. Porter. 2016. Molecular analysis of nestling diet in a long-distance Neotropical migrant, the LOWA (*Parkesia motacilla*). *Auk* 133:415–428.

Background: Composition and availability of food resources are crucial factors for the success of populations of long-distance neotropical migrants. Next-generation and DNA barcoding techniques allow for non-invasive methods to determine the dietary composition of birds and other taxa from fecal matter. The LOWA is a species of concern given it is a useful bioindicator for stream and riparian ecosystem quality. LOWA reproductive success is lower for breeding pairs with territories along streams characterized by poor water quality. This negative association of LOWA breeding success is largely attributed to the availability of benthic macroinvertebrates from the orders Ephemeroptera, Plecoptera, and Trichoptera (EPT taxa), which are extremely sensitive to changes in water chemistry that result from stream degradation.

Objectives: The purpose of this study was to use molecular techniques to determine the dietary composition of LOWA nestlings and assess how this change throughout the nesting season.

Methods: Fecal samples were collected from 130 LOWA nestlings throughout the 2013 nesting season. The researchers collected benthic macroinvertebrates along the streams where nestlings were sampled several times throughout the season. DNA was extracted from collected fecal samples and a region of mitochondrial DNA was amplified and sequenced using general arthropod DNA barcode primers in order to detect the composition of arthropods in nestling diet throughout the nesting season.

Location: Van Buren Co. and Conway Co., Arkansas and Westmoreland Co., Pennsylvania

Findings: Benthic macroinvertebrate sampling showed mean relative abundance of EPT taxa was moderately high and similar across study sites. DNA analysis revealed that taxonomic richness of LOWA nestling diet was similar in both study sites at the order level. At a finer taxonomic resolution, richness was higher in Pennsylvania than in Arkansas. The most common order found in nestling fecal samples in the Arkansas study site was Diptera, followed by Lepidoptera. In Pennsylvania, the most common order was Lepidoptera. When considering only EPT taxa, Ephemeroptera were the most common across both study sites. Ephemeroptera richness was higher in Pennsylvania. Orders Plecoptera and Trichoptera were absent from nestling fecal samples in Arkansas and only present in a few samples from Pennsylvania. The analysis of nestling diet over time in Arkansas suggests the three most common orders detected in fecal samples (Lepidoptera, Diptera, and Ephemeroptera) were found at similar rates throughout the nesting period. In Pennsylvania, the detection of Lepidoptera increased throughout the nesting season while Ephemeroptera decreased.

Implications: This study showed that LOWA may be more reliant on terrestrial taxa, specifically Lepidoptera and Diptera, than previously believed. Of the EPT taxa, Plecoptera and Trichoptera were underrepresented, despite the availability of these food sources. This new understanding suggests that, while the EPT taxa may be important food sources in the early breeding season, LOWA nestling diet does not appear to be largely dependent on this group during the post-incubation period. Therefore, the quality and composition of terrestrial habitats in LOWA territories may be very important for nestling survival and should be considered when assessing the overall quality of LOWA habitat.

Topics: Louisiana Waterthrush, DNA barcoding, next-generation sequencing, nestling diet, Lepidoptera, Ephemeroptera, Diptera

Trevelline, B. K., T. Nuttle, B. D. Hoenig, N. L. Brouwer, B. A. Porter, and S. C. Latta. 2018. DNA metabarcoding of nestling feces reveals provisioning of aquatic prey and resource partitioning among Neotropical migratory songbirds in a riparian habitat. *Oecologia* 187:85–98. Springer Berlin Heidelberg. <<https://doi.org/10.1007/s00442-018-4136-0>>.

Background: Emergent aquatic insects are an important food source for many neotropical migratory songbirds, in particular, the LOWA, which breed only in riparian habitats. Although it is well understood that LOWA rely heavily on these emergent aquatic insect taxa in riparian habitats, this understanding exists at a coarse taxonomic level. Previous studies may have missed meaningful information that could be obtained by identifying prey to the genus or species level, such as preferences for specific taxa and taxa that vary in their tolerance to stream pollution. Understanding, at a finer taxonomic scale, a preference for prey sensitive to pollution could be useful in identifying suitable LOWA habitat based on the proximity of possible sources of pollution related to human activity.

Objectives: The goal of this study was to determine nestling diet using DNA metabarcoding of three breeding neotropical songbirds, including the LOWA.

Methods: Focusing on LOWA, as well as the Acadian Flycatcher and Wood Thrush, the researchers systematically located and monitored a total of 43 nests (9 LOWA nests), obtaining 137 nestling fecal samples during spring of 2015. DNA was extracted and sequenced from fecal samples using universal arthropod COI “mini-barcode” primers. An index of dietary niche breadth was calculated, and an analysis of variance (ANOVA) was used to determine differences in aquatic-prey preferences across the three focal species. Other factors measured included interspecific dietary niche overlap and interspecific differences in diet variability.

Location: southwestern Pennsylvania

Findings: LOWA nestling diets were characterized by lower dietary richness and a narrower dietary niche compared to the Acadian Flycatcher and the Wood Thrush. The most frequently detected order of arthropod across all nestlings was Lepidoptera (99% of all nestling diets). Terrestrial Lepidopterans that were most common included Terebidae, Geometridae, and Noctuidae. Dipterans were also common among nestling diets with the exception of LOWA nestlings where most Dipterans consumed were aquatic. This study found several orders were largely unique to LOWA nestlings, including Decapoda, Ephemeroptera, Megaloptera, Plecoptera, and Trichoptera. LOWA nestlings also consumed a significantly larger proportion of aquatic prey taxa than the other two species.

Implications: The results from this study provide further evidence that LOWA primarily forage on benthic and emergent aquatic insect taxa. The significant differences found in the preference of LOWA for aquatic taxa suggest resource partitioning among the three focal species. This study also supports previous work suggesting that LOWA will opportunistically consume terrestrial Lepidoptera, deviating from their typical aquatic

invertebrate prey. The high taxonomic resolution of this study provides a better understanding of LOWA nestling diet, suggesting, down to the genera level, that LOWA frequently consume prey that are sensitive to changes in water-quality associated with human activity.

Topics: nestling diet, Louisiana Waterthrush, riparian habitat, emergent aquatic insects.

Twedt, D. J., J. M. Tirpak, D. T. Jones-Farrand, F. R. Thompson, W. B. Uihlein, and J. A. Fitzgerald. 2010. Change in avian abundance predicted from regional forest inventory data. *Forest Ecology and Management* 260:1241–1250. Elsevier B.V. <<http://dx.doi.org/10.1016/j.foreco.2010.07.027>>.

Background: As climate conditions continue to change, the distributions of avian habitats are expected to respond to new ecological conditions. Understanding avian response to future habitat projections is crucial for effective conservation planning. The Forest Inventory and Analysis (FIA) is useful in assessing trends in forest area, while the Breeding Bird Survey (BBS) is used to track trends in avian populations. Historical relationships between these two data sources can guide predictions for avian response to future changes in forest type and distribution.

Objectives: The aim of this study was to investigate the historical relationship between forest-dependent bird species with forest area, forest composition, forest age, and land ownership in the southeastern United States.

Methods: The researchers used BBS data in conjunction with FIA data to model the relationship between avian abundance and forest characteristics.

Locations: southeastern United States

Findings: The model generated in this study suggested that LOWA abundance is negatively associated with the proportion of hardwood forest with bottomland species.

Implications: The negative relationship detected between LOWA abundance and the proportion of hardwood forest with bottomland species suggests a preference for upland, hardwood forested habitats over bottomland hardwood habitats.

Topics: Abundance, birds, Breeding Bird Survey, Forest Inventory Analysis, habitat, prediction, Southeastern United States, temporal change

Vance, M. D., L. Fahrig, and C. H. Flather. 2003. Effect of reproductive rate on minimum habitat requirements of forest-breeding birds. *Ecology* 84:2643–2653.

Background: Understanding how species will respond to habitat loss is crucial to implement effective avian conservation. Forest area requirements vary greatly across forest-breeding birds, and changes to forest area may impact reproductive rates and success and ultimately population persistence within an area. One theory relating reproductive rate with forest area suggests that birds with higher reproductive rates require less habitat to ensure population persistence than birds with lower reproductive rates.

Objectives: The goal of this study was to test the theory that birds with higher reproductive rates require less habitat for long-term population persistence than birds with low reproductive rates.

Methods: BBS data was used to determine "proportion presence" for 41 forest-breeding bird species over a 10-year study period. The researchers used the U.S. Geological Survey (USGS) Land Use and Land Cover (LULC) data set to estimate percent forest cover at each of 779 focal landscapes.

Locations: central and eastern United States

Findings: This study suggested that LOWA probability of presence is highest in areas with 99% forest cover.

Implications: This study provides further empirical evidence supporting the LOWAs dependence on large patches of forest.

Topics: Breeding Bird Survey, deforestation, extinction threshold, forest-breeding birds, habitat amount, habitat loss, minimum area requirements, minimum habitat requirements, population persistence, reproductive rate

Wood, P. B., M. W. Frantz, and D. A. Becker. 2016. LOWA and benthic macroinvertebrate response to shale gas development. *Journal of Fish and Wildlife Management* 7:423–433.

Background: The detrimental effects of shale gas development on natural ecosystems and biodiversity include deforestation and fragmentation, changes in runoff and hydrology, increased erosion and water contamination, and stream sedimentation. The LOWA is a stream-obligate bird and LOWA density is associated stream pH and the relative abundance of insects representing the orders Ephemeroptera, Plecoptera, and Trichoptera (EPT taxa). Given this dependence, LOWA are vulnerable to environmental

changes associated with shale gas development and considered to be good indicators of riparian ecosystem health.

Objectives: The goal of this study was to assess the impacts of shale gas development on benthic macroinvertebrate communities and LOWA density, nesting success and habitat quality.

Methods: The researchers sampled benthic macroinvertebrates, mapped LOWA territories, observed nesting success and assessed riparian habitat quality using a previously generated habitat suitability index model and the Environmental Protection Agency Rapid Bioassessment Protocol in streams both impacted and unimpacted by shale gas development. The relationship between LOWA metrics including territory density, clutch size, and number of fledglings, and benthic macroinvertebrate metrics was assessed using a Pearson correlation matrix. Three models included 1) a set of temporal and rainfall covariates, 2) covariates relating to habitat quality, and 3) covariates associated with the macroinvertebrate community.

Location: Lewis Wetzel Wildlife Management Area, West Virginia

Findings: This study showed that benthic macroinvertebrate metrics that differed between shale gas development impacted streams and unimpacted streams included overall EPT richness, genus-level index of most probable stream status (GLIMPSS), density of small (0-3 millimeters in length) macroinvertebrates, and the number of intolerant taxa – all of which were higher in unimpacted streams, indicating higher aquatic ecosystem quality. A strong and significant positive correlation was found between LOWA density and benthic macroinvertebrate metrics including GLIMPSS, biomass, and density, with the strongest correlation being with EPT density.

Implications: This study provided further evidence of the negative impacts of shale gas development on benthic macroinvertebrate communities in streams. The information reinforced here suggests that the distribution of shale gas development areas and activities may be useful in predicting the quality of LOWA habitat, given the strong negative influence of these activities on the benthic macroinvertebrate community.

Topics: shale gas, LOWA, benthic macroinvertebrates, nesting success, aquatic ecosystem health