

PARKS AND RECREATION ADVISORY BOARD
AGENDA
September 21, 2016

ADMINISTRATIVE ITEMS

ADMIN-1 Advisory Board Member Introductions
ADMIN-2 Adoption of Minutes – August 21, 2016 Advisory Board Meeting

DISCUSSION ITEMS

D-1 Ragged Mountain Natural Area

CHAIRMAN'S MATTERS

BOARD MATTERS

DIRECTOR'S MATTERS

ADJOURNMENT

ATTACHMENT 1 – Q&A Response from Staff to Advisory Board re: Ragged Mountain

City of Charlottesville
Parks and Recreation Advisory Board – Agenda Item
September 21, 2016

ADMINISTRATIVE – 1

Advisory Board Member Introductions

ADMINISTRATIVE – 2

Adoption of Minutes – August 17, 2016 Parks and Recreation Advisory Board Meeting

ACTION REQUIRED:

Advisory Board adoption of the minutes of the August 21, 2016 meeting.

ENCLOSED DOCUMENTS:

Minutes of August 21, 2016 meeting.

PARKS AND RECREATION ADVISORY BOARD

MINUTES

August 17, 2016

The Parks and Recreation Advisory Board held a regular meeting on Wednesday, August 17, 2016 at 5:30 p.m. held @ Carver Recreation Center. Members present were: Ruth Barnett, Elise Cruz, Llezelle Dugger, Anne Hemenway, Jody Lahendro and Ned Michie. Members absent: David Hirschman and Maurice Walker

Staff: Brian Daly, Vic Garber, Doug Ehman

Adoption of Minutes – May 18, 2016

Motion:

- Elise Cruz made a motion to approve May 18th minutes, Ruth Barnett second, motion was unanimously approved

Adoption of Minutes – June 15, 2016

Motion

- Jody Lahendro made a motion to approve June 15th minutes, Ruth Barnett second, motion was unanimously approved.

Meadowcreek Valley Master Plan Implementation

- Doug Ehman stated that Albemarle County had signed off on the FEMA report earlier this week. Last survey work to be done is in process, should be done this week. Received preliminary design for Brandywine, railroad embankment, high dollars, going to revisit. Need FEMA part of project wrapped up

Tonsler Park Master Plan Implementation Update

- Doug Ehman stated that the final construction documents were pretty much done, restroom building is going in, water issue right now, will dig up circle on the building side, test pits
- Doug Ehman reported that the Field House would start once splash pad is done
- Will rebid concrete steps in September
- Having trouble getting bidders on small projects

Update on Family YMCA/McIntire Park

- Doug Ehman reported that the contractor should be done by Memorial Day, most of the project is on schedule or ahead of schedule
- Botanical Garden – Brian Daly reported that signs went up in spring, will be fall planting, fundraising effort going on, have kept in loop on McIntire Park plans
- Pedestrian bridge – have received permissions

Parks and Recreation Maintenance Project Report

- Doug Ehman stated his Project Manager is no longer with the City, will have updated maintenance report @ next month's meeting
- Ragged Mountain – if board members have any questions, get to David, will help to be prepared for next meeting
- Meeting room for September's meeting – Elise Cruz suggested gym @ Carver

Board Matters

- Anne Hemenway reported that the CHS basketball courts look good
- Ruth Barnett asked if City Market vendors need a permit, Brian Daly replied yes, staff takes applications early in the year for reserved or unreserved spaces. Can make applications during the year for unreserved spaces

Directors Matters

- Vic Garber reported the following on Recreation events:
 - Smith Aquatic Center closed August 17th-31st for maintenance
 - Saturday – Annual Therapeutic Picnic – 10:30-1 pm, music, bingo, food, games
 - Sounds of Summer – Saturday @ Tonsler Park, music by Soul Transit, supported by BAMA Works, family oriented event, center is open, last of the summer series
 - Outdoor pools opened through Monday, will be open weekends after school opens Tuesday through Labor Day
 - Spray parks will remain open until two weeks after Labor Day
- Doug Ehman stated that Clark School will be adding an additional playground – equipment is in, mulch in tomorrow, new style of net climber
 - Pen Park – probably looking @ playground replacement, possibly w/a net climber
 - McIntire Park fields – new led lights in @ McIntire Park, have been in for two weeks, first retro fit system in Virginia, other groups are coming to look @ the lights. Softball players like the lights

Motion – Adjourn Meeting

- Ruth Barnett made a motion to adjourn meeting, Jody Lahendro second, motion was unanimously approved
- Meeting adjourned @ 6:40 pm

Respectfully submitted,

Linda Daly
Secretary to the Advisory Board

City of Charlottesville
Parks and Recreation Advisory Board – Agenda Item
September 21, 2016

DISCUSSION - 1

Ragged Mountain Natural Area

Advisory Board discussion of the outcomes of the planning process for Ragged Mountain Natural Area following the conclusion of the thirty (30) day Public Comment Period.

Ragged Mountain – P&R Advisory Board Questions and Staff Response - September 16, 2016

1 – What did council vote for in October of 2015?

- City Council voted 3-2 to proceed with the planning process and eco study
- City Council then voted 3-2 to proceed with a shared use intent but did not define that intent.
- Council did not pass a resolution nor an ordinance. Rather they advised staff on how to proceed and what to bring back for council to consider following the ‘planning process’

2 – Can we make modifications to existing options (such as Option E without dogs, etc)?

Yes, and the Advisory Board can also choose to vote on each proposed new use independently or create the Board’s own recommendation.

3 – Can we consider shared us in terms of days of the week

That certainly could be a consideration – precedence exists on the Rivanna trail as it relates to dogs being off-leash. However, this would be difficult to enforce and may be confusing to the users. It would have to be self-policing not unlike the dogs off leash on selected days at Riverview Park. There is no practical way it could be patrolled or enforced by Parks and Recreation staff on a daily basis within existing resources.

4 – Option E, bikers are only permitted on one circular trail and not Round Top?

The trails shown in checkerboard in Option E are “shared” – meaning all users can use them, which includes bicyclists. There is more than just one loop and at least one additional trail available to bicyclists in Option E. Bikers have indicated they do not want access to Round Top due to topography and eco-sensitivity.

5 – Is there any actual data on the detrimental impact of dogs and/or bikes on natural resources?

Most data shows that as long as users stay on the trail, and the trail is designed properly, there is little distinguishable difference in impact to natural resources. Dogs must remain on leash and on the trails during their visits as do bicyclists. It is not the staff intent to permit any off trail activity including dogs and bikes.

6 – Will staff be making a recommendation to the Board?

Staff will present the options considered to date and let the board develop and make its own recommendation(s).

7 – How does the DCR/Natural Heritage comment affect planning and how will City respond to DCR?

Staff has discussed the letter with DCR and it was intended to be advisory in nature and not a requirement. DCR indicated that they do not have the staff, nor is it their intent, to get involved in local recreational use planning efforts.

8 – What role will parking capacity play in figuring out an appropriate level of use

We will have to watch the parking capacity no matter what types of uses are allowed to see how volume of use evolves over time and if any parking management needs to be addressed. At the present time staff are not aware of chronic parking related issues except that they have occurred when multiple

trailed boats have been launched. Given that there are several access points to the property staff do not anticipate parking issues unless they are related to water access by boats.

9 – Grand Loop – is the loop circumnavigating the lake a forgone conclusion

Staff understands that as part of the water supply agreement, trails lost to lake flooding were to be restored and that is why the bridge was installed, in order to ensure a full loop trail remains.

10 – How many meetings will it take for the P&R board to come to a vote, and do we need more information about the new county lands (Hedgerow and Arrowhead) and/or a mediation process?

The determination of when to take action on a recommendation to Council is the Board's prerogative. The Master Planning Process does not specifically prescribe when a recommendation is to be made. More about other parklands in question 12.

11 – How should the board or its members respond to request for individual meetings?

That is the Board's prerogative.

12 – Regional planning – how do the other new parks affect our planning for Ragged and do they compare?

The other parks are County park areas and they have a separate and distinct planning process which has yet to begin for either Hedgerow or Arrowhead. County staff has indicated that, at this time, Hedgerow is expected to be a multi-use park, but we do not know at this time what specific activities will take place in which specific locations. The specific mix of activities and locations will be determined during their planning process. Arrowhead, at this time, is scheduled to be a nature preserve and not a recreational park. Each of these areas are also ecologically interesting.

12 – How many miles of trails in the City/County system are designated bike/hike, etc.?

Shenandoah National Park trails are hike only, with dogs allowed on certain trails

All City/County Parks/Trails are shared use with dogs allowed except Ivy Creek (and RMNA)

RTF - ~18 miles

McIntire Park – ~1.5 miles (both sides of park)

O-Hill (this is not technically a park, its UVA property)

Walnut Creek – 15 miles

Preddy Creek – 10 miles

Mint Springs – 2.8 miles

Carter Mountain (Monticello/Saunders) – 2 miles

Lake Anna (is pretty much all private property around the lake)

Beaver Creek – no real trails

Panorama Farms – (private – running clubs only?)

Teventrains – 10 miles (private but open for use)

Sugar Hollow – ~3-4 miles (old roadbeds)

Boars Head/Foxhaven (2.25)/Birdwood

14 – What is the specific reasoning for the areas marked as biological hotspots in the eco-report?

The biological hotspots identify areas of unique or rare plants, micro-habitats or communities.

15 – Can we get a map of areas most affected by invasive plants?

Staff will see if such mappings can be secured.

16 – Can we get a copy of the Smithsonian article noted in the study?

A copy of the full article is attached – staff received it from the author. It was republished in a periodical “The Condor” in 2014, with the study occurring at multiple locations within Virginia in 2001 and 2002. The author has provided his opinion in an email response to staff question:

Q: Thanks for the report copy, I could only find the abstract on line

Do you have any thoughts as to whether allowing

- Jogging
- Bikes
- Dogs on leashes

on natural surfaced trails that are currently restricted to hikers only would have a significant impact on the thrushes?

The trails impact/footprint less than 2% of the total land area, the rest of the land stays trails-free and left entirely for nature.

Thanks
Chris

A: Hi Chris,

My subjective impression is that these activities would likely do little harm to Wood Thrush. Perhaps the greatest concern would be over dogs being released from leashes, as dog walkers are wont to do once they get far enough from the parking lot. I think dogs running through the forest could be fairly disruptive. Joggers and bikers, as long as they stay to the trail, would probably have little impact.

Of course, these are just my subjective impressions based on my time working there and experience with Wood Thrush.

Matt

17 – Can we find out more information about the 6 species birds in the highest categories of concern?

Common	Tier	Information from Audubon website
Bachman's sparrow	1	Typically found in more southern state. Sightings in Virginia probably migratory. Habitat loss is cause of decline (pine forests) Breeding in band from Missouri to NC. Probably more common in Mexico and farther south than the US
Black-throated green warbler	1	Sightings in Virginia mostly migratory other than far western Va. Prefer conifer forest. Breeds in Canada
American black duck	2	Common winter bird in Va. Breeds in Canada. Decline is loss of habitat and competition from other ducks.
Cerulean warbler	2	Ragged is edge of uncommon migration and breeding zone. Primary decline due to cowbird parasitism
Bald eagle	2	More common in winter at Ragged. In recovery since 1970's. {Probably at Ragged due to water for fishing.}
Winter wren	2	Conservation status “Still widespread and common”. Breeds in Canada. Winter migratory in Va.

Tier 1: Critical Conservation Need. Faces an extremely high risk of extinction or extirpation. Populations of these species are at critically low levels, facing immediate threat(s), or occur within an extremely limited range. Intense and immediate management action is needed.

Tier 2: Very High Conservation Need. Has a high risk of extinction or extirpation. Populations of these species are at very low levels, facing real threat(s), or occur within a very limited distribution. Immediate management is needed for stabilization and recovery.

18 – Should the SW corner trail be above or below, outside the 250 meter range, or shoreline?

All the options have various potential impacts. Staff feels it would be best to put the trail near the shore, below the sensitive area, but it is not possible to stay out of the 250 meter buffer (which may be excessive to avoid a plant or group of plants). It is felt that the trail location along/near the shore will have the least amount of impact on the site. The trail location can be scouted with a naturalist to ensure that no rare/unique plants are within the new trail corridor (for any new trails).

19 – What info can staff tell us about complaints about shared us trails already in existence?

We get occasional complaints (~one a year) about people being surprised by a biker approaching from behind. We have not, to our knowledge, had any injuries or crashes between users (that were reported)

20 - What role does the county play at Ragged Mountain?

The County does not have a role in the management of Ragged Mountain. The County is a party to the Rivanna Water and Sewer Authority. The City does not receive staff or monetary assistance from the County to manage RMNA.

21 – What is the expected operational cost under different use choices?

Basically the same for all trail users, costs are trail construction (staff time and volunteers and existing tools) and maintenance (cutting blown over trees, occasional repairs after heavy rains if needed) these costs are included in the annual staff and maintenance budget and will not require any additional funding. If dogs area allowed, and doggy bags are to be provided, that would incur some additional costs. There are no trash cans at Ragged now and this is intended to be a “you take it in you take it out” area. If cans were added and serviced there would be an additional cost. There is a port-o-john that was transferred from Azalea Park when the restroom was built there, and its service contract has a cost associated with it; however all these costs, with the exception of servicing trash cans are in our current base operating budget.

90% of the needed trail is already built. Only the two sections in the west/southwest portion remain to be constructed. 60% of the trails were built by Ivy Creek Foundation 20 years ago and will remain as is, unless they pose sustainability/erosion concerns, and need relocating.



RESEARCH ARTICLE

Landscape and regional context differentially affect nest parasitism and nest predation for Wood Thrush in central Virginia, USA

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ABSTRACT

Many empirical studies have shown that forest-breeding songbirds, and Neotropical migrants in particular, suffer greater rates of nest predation and nest parasitism in smaller forest patches and in fragmented landscapes. To compare the performance of different metrics of spatial habitat configuration resulting from deforestation, we studied nest predation and nest parasitism rates at 200 Wood Thrush (*Hylocichla mustelina*) nests in eight forest fragments ranging from 82 to 9,171 ha in central Virginia, USA. We analyzed nest parasitism rates using logistic regression and we analyzed daily nest predation rates under a multistate competing risks design. For both analyses we compared the performance of 16 covariates, 11 of which related to the spatial configuration of habitat (e.g., patch size, distance to edge, percent core forest in proximity to nest) and 5 of which were unrelated to habitat (e.g., year, serial date, nest height). Distance to agriculture gained the greatest support in analyses of nest predation and suggested that elevated predation rates are manifest primarily within 50 m of edges; at 5, 10, and 20 m, respectively, the estimated predation rates were 87%, 76%, and 68%. In contrast, biogeographic region received the greatest support in analyses of nest parasitism, which also showed increasing rates of Brown-headed Cowbird (*Molothrus ater*) parasitism with percent agricultural land and road density within 500 m of a nest. Among regions, the greatest difference seemed to be a virtual absence of nest parasitism along the Blue Ridge in the absence of disturbance (agriculture or road incursion) whereas the other two biogeographic regions showed 20–50% rates of nest parasitism as background rates. Interactive models between spatial configuration metrics and region gained little support from nest predation analyses, but considerable support from the nest parasitism analyses, suggesting regional context plays a more important role in nest parasitism than in nest predation at these central Virginia sites.

Keywords: MCEstimate, competing risks, edge effects, Wood Thrush, *Hylocichla mustelina*, nest predation, nest parasitism

Le paysage et le contexte régional affectent différemment le parasitisme des nids et la prédation des nids chez *Hylocichla mustelina* dans le centre de la Virginie, aux États-Unis

RÉSUMÉ

Plusieurs études empiriques ont montré que les oiseaux chanteurs forestiers, et les migrants néotropicaux en particulier, subissent des taux de prédation des nids et de parasitisme des nids plus élevés dans des petites parcelles de forêt et des paysages fragmentés. Afin de comparer la performance de divers paramètres de configuration spatiale de l'habitat résultant de la déforestation, nous avons étudié les taux de prédation et le parasitisme de 200 nids de *Hylocichla mustelina* dans 8 forêts fragmentées allant de 82 à 9,171 ha dans le centre de la Virginie, aux États-Unis. Nous avons analysé les taux de parasitisme des nids à l'aide d'une régression logistique et nous avons analysé les taux journaliers de prédation des nids avec une analyse multiple des risques concurrents. Pour chacune des analyses, nous avons comparé la performance de 16 covariables, dont 11 étaient associées à la configuration spatiale de l'habitat (ex.: taille de la parcelle, distance à la bordure, % de forêt à proximité du nid) et 5 n'étaient pas reliées à l'habitat (ex.: année, date séquentielle, hauteur du nid). La distance à une zone agricole obtenait le plus grand support dans les analyses de prédation des nids et suggérait que les taux de prédation élevés se manifestent principalement dans les 50 premiers mètres des bordures; à 5, 10 et 20 m, respectivement, les taux de prédation estimés étaient de 87%, 76%, et 68%. À l'opposé, la région biogéographique recevait le plus de support dans les analyses de parasitisme des nids, qui montraient également des taux croissants de parasitisme par *Molothrus ater* avec le pourcentage de terres agricoles et la densité routière dans les 500 m d'un nid. Entre les régions, la plus grande différence semblait être une absence virtuelle du parasitisme des nids le long de la Blue Ridge en l'absence de dérangement (agriculture ou incursion routière) alors que les deux autres régions biogéographiques ont montré des taux de parasitisme des nids de 20 à 25%

comme taux de base. Les modèles interactifs entre les paramètres de configuration spatiale et la région recevaient peu de support des analyses de prédation des nids, mais un support considérable des analyses de parasitisme des nids, suggérant que le contexte régional joue un rôle plus important dans le parasitisme des nids que dans la prédation des nids à ces sites du centre de la Virginie.

Mots-clés: estimation MC, risques concurrents, effets de bordure, *Hylocichla mustelina*, prédation des nids, parasitisme des nids

INTRODUCTION

Many empirical studies have shown that forest-breeding songbirds, and Neotropical migrants in particular, experience reduced nesting success due to increased frequency of nest predation associated with deforestation (Robbins et al. 1989, Askins et al. 1990). This hypothesis has been tested in studies using both natural (e.g., Donovan et al. 1995, Hoover et al. 1995, Robinson et al. 1995, Fauth 2000) and artificial (Wilcove 1985, Donovan et al. 1997) nests and is well-supported (Batáry and Báldi 2004). Nest parasitism by Brown-headed Cowbirds (*Molothrus ater*) may also be more frequent in deforested landscapes, serving to further reduce nesting success and the number of host young that are produced in nests that escape predation (Donovan et al. 1997, Dowell et al. 2000). With deforestation, remaining forest is often, though not necessarily, more fragmented (Fahrig 2003) and many ornithologists have attributed the observed avian reproductive effects to forest fragmentation (e.g., Robinson et al. 1995). However, in reviewing the evidence for effects of habitat fragmentation on biodiversity, Fahrig (2003) found that the term fragmentation was often used loosely to describe processes that might be better described as habitat loss. She further concluded that there was substantial evidence for negative effects of habitat loss, but relatively weak evidence for fragmentation effects (Fahrig 2003).

Numerous hypotheses have been proposed for how nest predators might be distributed in fragmented landscapes (reviewed by Chalfoun et al. 2002). We adopt the working hypothesis that nest predators exert pressure from matrix habitat into forested habitats. Thus, depending on habitat and landscape configuration, three basic patterns may be observed: (1) our working hypothesis is wrong and there is no effect of habitat and landscape structure on nest predation; (2) nest predators may be more abundant throughout forest patches, especially small patches, in fragmented forests (Chalfoun et al. 2002, Rodewald and Kearns 2011), leading to greater rates of nest predation throughout forest patches; or (3) nest predators may be concentrated along edges, especially of larger patches (Chalfoun et al. 2002, Thompson et al. 2002), leading to increased predation rates along edges. Similar patterns could apply to the distribution of Brown-headed Cowbirds and resultant nest parasitism in deforested habitats.

Initial research into the association between landscape structure and nest predation generally used nest success as the response variable of interest, including the observed fates of nests (Hoover and Brittingham 1998, Driscoll et al. 2005) or the pre-estimated Mayfield (1961) daily survival rates of nests (Robinson et al. 1995, Hoover et al. 1995, Fauth 2000). More recently, researchers have used hierarchical models to estimate daily survival rates as functions of important landscape variables specified as predictor variables (Mattsson and Niemi 2006, Chapa-Vargas and Robinson 2007) together with information-theoretic methods for model selection (Burnham and Anderson 2002). However, nests fail due to causes other than nest predation, such as adverse weather and abandonment (Ricklefs 1969). Thus, methods that fit regression models to nest survival probability alone potentially conflate the hypothesis of interest (that nest predation depends upon patch and landscape structure) with unintended hypotheses (e.g., that adverse weather-related failures and abandonment rates also depend upon landscape structure according to the same functional relationship). Etterson et al. (2007a, 2007b) described a general methodology for competing risks estimation that allows specification of hierarchical models separately by cause of failure that avoids conflation of hypotheses across causes of failure.

In this manuscript, we report analyses of nest predation and other causes of failure for eight sites in central Virginia, USA. The goal of our analyses was to compare the performance of alternative covariates, primarily related to the spatial configuration of habitat in proximity to nests (e.g., patch size, distance to edge, % core forest in proximity to nest), for explaining observed patterns of nest predation and nest parasitism in Wood Thrush (*Hylocichla mustelina*). Our ultimate objective is to provide greater insight about how species respond to specific landscape patterns resulting from deforestation so that land managers might better manage forests to protect the nesting habitat of area-sensitive species.

METHODS

Study Sites

In 2001 we searched for nests and monitored nest predation and nest parasitism rates at four sites in the Shenandoah Valley and one site along the Blue Ridge near

TABLE 1. Sites monitored in central Virginia, USA, 2001 and 2002.

Site	Region ¹	Years	ha	Nests	Parasitized Nests (%)	² m_p	SE
Natural Chimneys Regional Park	Valley	2001, 2002	261	23	8/21 (38)	0.034	0.010
Grand Caverns	Valley	2001, 2002	113	2	1/1 (100)	0.242	0.152
Betsy Bell Wilderness Park	Valley	2001, 2002	93	7	4/7 (57)	0.055	0.024
Paul State Forest	Valley	2001, 2002	82	7	7/7 (100)	0.041	0.021
Blue Ridge Parkway	Ridge	2001, 2002	9,171	86	2/76 (3)	0.043	0.006
Fortune's Cove Preserve	Ridge	2002	9,098	6	2/6 (33)	0.082	0.040
Ragged Mountain Natural Area	Piedmont	2002	1,024	64	23/49 (47)	0.051	0.006
Fernbrook Natural Area	Piedmont	2002	428	5	2/3 (66)	0.049	0.028

¹ Physiographic Region (subregion) as defined by Bailey (1999): Valley = Valley and Ridge (great valley), Ridge = Blue Ridge (northern), Piedmont = Piedmont (foothills).

² m_p = daily predation rate estimated using the 'site' model.

Waynesville, Virginia, USA (Table 1). We chose these five sites to contrast small forest patches surrounded by agricultural land in the Shenandoah Valley with the large, relatively unfragmented forest along the Blue Ridge Parkway. In 2002 we monitored the same five sites and added three sites in the Piedmont area near Charlottesville, Virginia, an urban and suburban landscape (Table 1). The latter sites were added to increase sample sizes and to include sites with intermediate levels of fragmentation relative to the original sites.

Nest Monitoring

Nest-searching was done from April 23 to July 31, 2001, and from May 10 to July 24, 2002, along established forest trails by listening for Wood Thrush vocalizations. After discovery, we monitored nests every 2–4 days until they were no longer active. For failed nests, we scored the cause of failure using all available evidence. We attributed the cause of failure to adverse weather if the nest was found destroyed immediately after severe weather. We deemed nests abandoned if they were found with dead nestlings or unattended eggs. We scored nests as having been depredated if the nest was found empty, but was still in incubation or the nestlings would have been no more than 10 days old on the day the nest was discovered empty.

Spatial Configuration Metrics and Geographic Data

Spatial data used for calculating the metrics described below included land-cover data from the Virginia Department of Forestry (Virginia Forest Cover Map 2005) and road data from ESRI's StreetMap USA (ESRI Data & Maps 2006), which was developed using TIGER 2000 data. Forest classes (Mixed Forest, Pine Forest, and Hardwood Forest) were extracted from the land cover data and re-classed to forest. Core forest was defined as forest greater than 105 m from an edge (corresponding to 7 pixels in the Virginia Forest Cover Map where each pixel was 15 m on a side). Distance from each nest location to the nearest

landscape feature (forest edge, urban or agricultural land class, road) was calculated using the Euclidean Distance tool in ArcGIS. Landscape composition and forest core area metrics were calculated using the ArcGIS Tabulate areas tool.

From the spatial data we developed 22 potential metrics (Table 2, Table 3) to test hypotheses about the effects of the spatial configuration of habitat on nest predation rates. Centered on each nest, we calculated two types of metrics: linear distance measures, which quantified the distance to the nearest edge of a given type (urban, road, agriculture, any non-forest) and areal measures, which quantified the percent of a given landcover class within 500 m of a nest. These two classes of metric correspond to Fahrig's (2003) distinction between metrics that quantify habitat loss (areal metrics of habitat type) and those that quantify fragmentation (distance to edge). Patch size, which we also considered as a predictor variable, has been considered an ambiguous measure of fragmentation due to its likely correlation with forest cover at the landscape scale (Fahrig 2003). Distance metrics were calculated in two ways, first as untransformed linear distance and second as negative exponentially transformed distance (with base 1.2), which creates a function that rapidly diminishes with distance.

Statistical Analyses

Nest predation was modeled as a multistate Markov process using methods described by Etterson et al. (2007a, 2007b). In brief, this requires formulation of one-day transition matrices describing all possible daily outcomes at a nest. In our data there were four possible outcomes: survive, depredated, abandoned, and weather. Because our process of interest was the relationship between nest predation and landscape pattern, the analysis was simplified by combining abandonment and weather into a single category, "other". Thus we modeled three fates: survive, depredated, and other, and covariates were specified only to the fate depredated. Details on the multistate approach

TABLE 2. Explanatory variables considered and effect of spatial configuration variables on nest predation and parasitism rates.

Covariate (Sign) ¹	² Weight, Sig/Models, Sign		Notes
	Predation	Parasitism	
dist.road (–)	0.02, 0/9, –	<0.01, 0/7, +	Minimum distance from nest to any road
dist.agr (–)	0.07, 1/9, –	<0.01, 7/7, –	Min. distance from nest to agric. land class
1.2 [–] dist.road (+)	0.03, 0/9, –	<0.01, 0/7, –	Negative exponential transform. of dist.road
1.2 [–] dist.agr (+)	0.42, 5/9, +	<0.01, 0/7, +	Negative exponential transform. of dist.agr
%dvp (+)	0.12, 3/9, +	<0.01, 2/7, +	% developed area within 500 m of nest
road.dens (+)	0.06, 0/9, +	<0.52, 0/7, –	Total density of roads within 500 m of nest (m/ha)
%agric (+)	0.04, 0/9, +	<0.40, 4/7, +	% agricultural land within 500 m of nest
%core (–)	0.04, 0/9, –	<0.02, 7/7, –	% core forest within 500 m of nest
mesh (–)	0.08, 0/9, –	<0.05, 6/7, –	Expected patch size (Moser et al. 2007)
PAR (+)	0.02, 0/9, –	<0.01, 7/7, +	Perimeter to area ratio of patch
area (–)	0.03, 0/9, +	0.01, 7/7, –	Total area of a forest patch
height (n/a)	0.28, 9/23, +	0.14, 5/23, +	Nest height above ground
year (n/a)	0.05/23	0.26/23	Year in which nest attempt occurred
date (n/a)	0.05/23/+	n/a	Serial date within season
region (n/a)	0.1/56	1.00/45	Physiographic region in which nest occurred
site (n/a)	0/1	n/a	Site at which nest occurred

¹ Sign = Expected sign of main effect of covariate on predation/parasitism rates.

² Weight = summed AIC_c weight of all models in which the variable occurred. Sig = number of models in which the parameter was significantly different from zero. Models = number of models in which the variable occurred. Sign = sign of model-averaged parameter value.

to nest survival modeling are given by Etterson et al. (2007a, 2007b). We implemented this approach using the software MCEstimate (http://www.epa.gov/med/prods_pubs.htm). Nest parasitism was modeled using logistic regression, where the response variable was whether or not a nest was parasitized. Parasitism models were fit using the glmfit command in Matlab's Statistics toolbox (Mathworks 2012).

Model Building Strategy

We originally considered 22 potential variables for spatial habitat configuration as covariates to nest predation and nest parasitism rates (Table 2, Table 3). Using pairwise correlation coefficients, these were narrowed to 11 variables and combined with five additional variables (nest height, year, date, region and site) that we thought might influence nest predation and nest parasitism (Table 2).

With these 16 variables, there were more than 65,000 potential models, considering all subsets of variables, a prohibitive number to consider. Further, many of these models would require estimating too many parameters given the data we have available. Thus we limited the number of models considered as follows. 1) The sixteen univariate models defined by the sixteen variables in Table 2 were all considered (16 models). 2) No model could contain more than one of the eleven spatial configuration variables. 3) The 11 spatial configuration variables were each combined in alternative additive models with one each of the four additional variables (excluding site, which required 7 parameters alone for estimation, 44 models). 4) Each spatial configuration variable was considered to potentially interact with physiographic region, following previous research showing regional and landscape scale differences in response to forest fragmentation (11

TABLE 3. Spatial configuration variables considered, but eliminated from analyses of nest predation and nest parasitism.

Variable	Description	Disposition
dist.urb	Min. distance from nest to urban land class	Eliminated due to correlation with dist.agr ($r = 0.63$)
dist.edg	Min. distance from nest to any forest edge	Eliminated due to correlation with dist.agr ($r = 0.58$)
1.2 [–] dist.urb	Negative exponential transformation of dist.urb	Eliminated due to correlation with 1.2 [–] dist.edg ($r = 0.44$)
1.2 [–] dist.edg	Negative exponential transformation of dist.edg	Eliminated due to correlation with 1.2 [–] dist.agr ($r = 0.81$)
%dvp100	Percent developed land within 100 m of nest	Variables measured at the 100 m scale were eliminated due to their high correlation with the same variable measured at the 500 m scale (r between 0.25 and 0.68, all $P < 0.001$). Suffix '500' subsequently dropped from variable names (e.g., mesh500 = mesh).
road.dens100	Density of roads within 100 m of nest (m/ha)	
%agric100	Percent agricultural lands within 100 m of nest	
%core100	Percent core forest within 100 m of nest	
mcut100	Expected patch size at 100 m scale (Jaeger 2000)	
mesh100	Expected patch size at 100 m scale (Moser et al. 2007)	
mcut500	Expected patch size at 500 m scale (Jaeger 2000)	eliminated due to correlation with mesh ($r = 0.68$)

TABLE 4. Best nest predation models.

Model	AIC _c	ΔAIC _c	Wt
1.2 ^(-dist.agr) + height	778.87	0	0.23
1.2 ^(-dist.agr)	780.61	1.74	0.09
road.dens + height	782.42	3.55	0.04
height	782.45	3.58	0.04
1.2 ^(-dist.agr) + year	782.57	3.71	0.04
1.2 ^(-dist.agr) + date	782.61	3.75	0.03
%dvp + height	782.68	3.81	0.03

models). 5) Each of the eleven interactions between physiographic region and a spatial configuration variable was combined in an additive model with three of the remaining non-spatial variables (nest height, year, and date, 33 models). To these 104 models we added the null model, giving a total of 105 models for nest predation. For analysis of nest parasitism, we could not consider date within season (date), because we didn't know the exact date of nest parasitism. To stabilize model convergence, we also excluded site from consideration. Thus we considered 81 models of nest parasitism.

We used the above model sets to evaluate the importance of our 16 variables in explaining nest predation at our VA sites in several ways. First, of primary interest, for each spatial configuration variable we tallied the weight of all models in which the variable occurred (9 each) as a measure of the relative explanatory value of that variable compared with all other spatial configuration variables. Second, we did the same for the non-spatial variables (nest height, date, and year), which each occurred in 23 models. The remaining two variables, landscape and site, occurred in 56 models and 1 model, respectively, and thus are not directly comparable with other variables. Thus, when considering their influence it is important to keep in mind the number of models in which the variable occurred. A similar procedure was applied to the parasitism analysis, where the numbers of models in which each variable occurred was 7 (spatial configuration variables), 23 (height and year), and 45 (region).

For each spatial configuration variable we also considered the direction and statistical significance of its effect. We did so by tracking the signs of the estimated parameter values corresponding to the effect in each model in which the variable occurred. We examined the statistical significance of each parameter corresponding to a spatial configuration variable by examining whether a 95% confidence interval for the parameter encompassed zero. Finally, we examined the sign of model-averaged parameter values for each of the 11 spatial configuration variables and compared these to expectation under the hypothesis that deforestation and forest fragmentation result in elevated nest predation and nest parasitism rates (Table 2).

Goodness-Of-Fit

Goodness of fit was estimated for all models scoring within 4 AIC_c units of the best model. For the nest predation models two statistics were used, the first based on the model deviance and the second based on a parametric test described by Pigeon and Heyse (1999). For the deviance statistic, *P*-values for lack of fit were generated by characterizing the distribution of the test statistics using parametric bootstrap sampling with 5,000 replicates under the hypothesis that the estimated MLEs were correct. For the Pigeon-Heyse test, nest observations were divided into ten groups and the distribution of the test statistic was assumed to follow a chi-square distribution with appropriate degrees of freedom (Pigeon and Heyse 1999). For the logistic regression models of nest parasitism, goodness-of-fit was assessed using the Hosmer-Lemeshow test (Hosmer and Lemeshow 2000). Values reported in results are MLEs (+/- SE).

RESULTS

We found and monitored 200 Wood Thrush nests among 8 sites over 2 years (Table 1). Of these, 92 nests were in sites on the Blue Ridge, 69 nests were in Piedmont sites, and the remaining 39 nests were at sites in the Shenandoah Valley. Of the 200 nests, 45 were found and monitored in 2001 and 155 were monitored in 2002. Nests were visited on average every 2.3 (± 1.2 SD) days, with 96% of intervals lasting 4 or fewer days.

The most frequent nest outcome was predation (124 nests) followed by fledging (69 nests). The remaining 7 nests failed due to either weather or abandonment. Based on the null model, the average daily nest predation rate was 0.046 (0.004 SE) and the average daily rate of failure due to all other causes combined was 0.003 (0.001). These failure rates resulted in a daily nest survival rate of 0.951 (0.004) and an overall probability of raising young to fledging (assuming a full nest cycle lasts approximately 26 days) of 0.28 (0.03), an overall probability of predation of 0.68 (0.03), and of failure due to other causes of 0.04 (0.01).

Of the 200 nests, parasitism status was observed in 170, with the remaining nests failing before searchers were able to identify the contents. Of these 170 nests, 49 (29%) were parasitized (Table 1). Most parasitized nests had only 1 Brown-headed Cowbird egg (42 nests), but 3 nests had 2 cowbird eggs and 4 nests had 3 cowbird eggs.

Nest Predation

Seven models scored within 4 AIC_c units of the best model (Table 4). Four of these 7 models included a negative exponential transformation of distance to agricultural land and 4 included nest height. These 2 variables also gained the greatest weight among all 105 nest predation models (0.42 and 0.28, respectively, Table 2). The remaining four

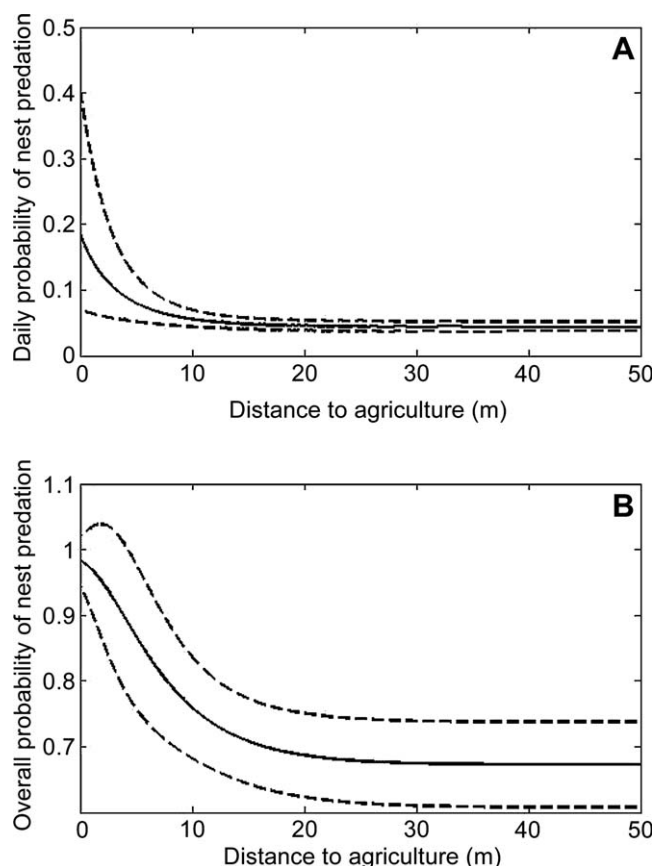


FIGURE 1. Negative exponential increase in predation risk for Wood Thrush nests with proximity to agricultural land for daily probability of predation (**A**) and overall probability of predation (**B**). Figure generated using the best nest predation model ($1.2^{(-\text{dist.edg})} + \text{height}$), at mean observed nest height (3.92m).

variables occurring in the best models gained 12% or less of model weight across the full set (Table 2). Nine models produced significant slope estimates involving three spatial configuration variables, and the sign of these slopes was always in the expected direction under the hypothesis that deforestation and forest fragmentation results in elevated nest predation rates. Model-averaged parameter estimates agreed with expectation for 8 of 11 spatial configuration variables (Table 2). None of the 7 best models exhibited any lack of fit by either the Pigeon-Heyse test or the deviance test.

The relatively large AIC_c weight assigned to models including $1.2^{(-\text{dist.agr})}$ (Table 2) suggests that any negative influence of proximity to agricultural land attenuates rapidly with distance (Figure 1). In the four models in which the transformed distance effect occurred among the best models, the parameter estimate was always significantly different from zero. Models in the best set (Table 4) also suggested that nest predation rates on Wood Thrush nests increase with nest height. All but one model

TABLE 5. Best nest parasitism models.

Model	AIC_c	ΔAIC_c	Wt
region + %agric	143.6	0	0.25
region * road.dens	143.7	0.1	0.25
year + region * road.dens	144.5	0.9	0.16
height + region * road.dens	145.4	1.8	0.10
region * %agric	146.1	2.5	0.07
year + region * %agric	146.8	3.2	0.05

including nest height in the best model set (%dvp + height) resulted in parameter estimates for the height effect that were significantly different from zero.

Nest Parasitism

Six models scored within 4 AIC_c units of the best model (Table 5). All of these included biogeographic region and either road density or percent agriculture within 500 m of the nest. Year occurred in 2 of the 6 best models and nest height occurred once. Biogeographic region garnered 100% of model weight, followed in decreasing order by road density, % agriculture within 500 m of the nest, year, and nest height (Table 2). All other variables received 5% or less of model weight. Fifty-three models produced significant slope estimates involving all of the 11 spatial configuration variables and the sign of these slopes was almost always (46/53) in the expected direction under the hypothesis that deforestation and forest fragmentation results in elevated nest predation rates (Table 2). Model-averaged parameter estimates agreed with expectation for 9 of 11 spatial configuration variables (Table 2). None of the 6 best models exhibited lack of fit using the Hosmer-Lemeshow test.

The best model of nest parasitism included an additive effect of biogeographic region and % agricultural land within 500 m of the nest (Table 5, Figure 2A). The latter variable was significant in all models in which it occurred and its estimated parameter value was always positive, as expected. According to the region + %agric model, the Piedmont sites had the highest predicted rates of nest parasitism, followed by sites in the Shenandoah Valley (Figure 2A). The Blue Ridge sites had the lowest predicted levels of nest parasitism (Figure 2A). The second model, performing as well as the best model, was a model specifying an interaction between physiographic region and road density (Table 5, Figure 2B). Road density was significant in 4 of the 7 models in which it occurred, and in those models its sign was always positive, as expected. According to the region*road.dens model, all regions produced unique relationships between road density and nest parasitism probability, with the Blue Ridge sites showing no parasitism when roads were absent, but a very steep slope of nest parasitism rates as road density increased beyond 15 m ha^{-1} (Figure 2B). Sites in the other

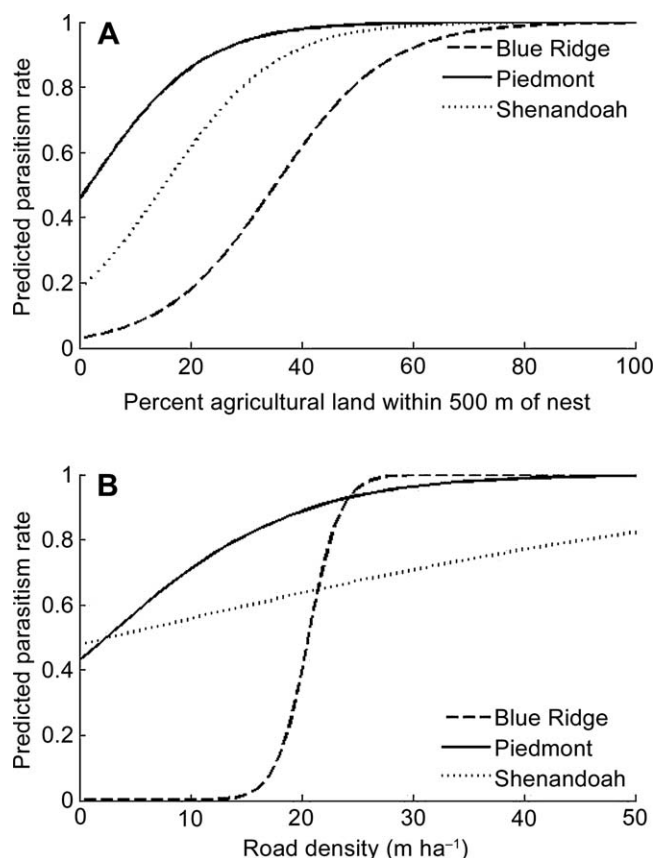


FIGURE 2. Predicted probability of at least one cowbird egg laid in a Wood Thrush nest for the 2 best models of nest parasitism. (A) model = region+%agric, indicating an additive effect of biogeographic region and percent agricultural land within 500 m of nest. (B) model = region*road.dens, indicating an interaction between biogeographic region and the density of roads (m/ha) within 500 m of nest.

2 biogeographic regions had 45–50% background predicted rates of nest parasitism in the absence of roads, but much more gradual increases in parasitism rates as road density increased (Figure 2B).

DISCUSSION

Our results add to the body of evidence that deforestation and forest fragmentation can increase nest predation and nest parasitism rates of forest songbirds in the eastern United States. Across the 11 metrics of habitat pattern, the sign of estimated slopes of univariate regression models overwhelmingly agreed with expectation under the forest fragmentation hypothesis whenever analyses produced slopes significantly different from 0. Further, even among non-significant slopes, the signs generally agreed with expectation. Thus, by many different types of habitat pattern metrics, measured at different scales, we discov-

ered the same basic pattern of increased nest predation rates with increased deforestation and fragmentation.

Our results support the existence of an edge effect on avian nest predation (Batáry and Báldi 2004). At our central Virginia sites, Wood Thrush nest predation rates increase with proximity to edges that adjoin agricultural land. These results show mixed agreement with previous studies of the relationship between Wood Thrush nest success and habitat and landscape pattern metrics. Hoover et al. (1995) and Driscoll et al. (2005) also found support for edge effects on nest success in Wood Thrush, but at least two studies (Friesen et al. 1999, Fauth 2000) did not. Two studies found a relationship between size of the forest fragment in which a nest was located and nesting success (Donovan et al. 1995, Hoover et al. 1995), but again two contrasting studies did not (Friesen et al. 1999, Fauth 2000). We conclude that Wood Thrush response to fragmentation at our central Virginia sites is manifest primarily within 50 m of edges, particularly with agricultural land, and that the value of interior forest quickly saturates with distances greater than 50 m from an edge. This result generally agrees with the conclusions of Paton (1994) that effects should be concentrated near edges. Our results also agree with the review of Marzluff and Restani (1999) who found support for edge effects with both urban and agricultural edges. Finally, our finding of distance to agriculture being the most important explanatory factor for nest predation rates supports the conclusion of Chalfoun et al. (2002) who suggested that responses such as increased predator density at edges were more likely to be observed in agriculture-dominated landscapes.

Several reviews have shown that patterns of avian response to deforestation and fragmentation differ among regions (Lahti 2001, Thompson et al. 2002, Stephens et al. 2003), indicating that the response may also depend upon landscape context within regions. Thompson et al. (2002) and Thompson (2007) suggested that local effects, such as variation in nest success with patch size and the amount of habitat edge, should be most pronounced where levels of fragmentation are moderate (45–55% total forest cover), but reduced or absent in landscapes with low proportions of forest cover (because all forest habitat is close to an edge) and in landscapes with higher proportions of forest cover (because the lack of non-forest habitat will suppress populations of nest predators and Brown-headed Cowbirds). Our regions fit roughly into these groups, with Shenandoah Valley having approximately 28% forest cover, Piedmont sites having approximately 68% forest cover, and Blue Ridge sites having approximately 89% forest cover within 5 km. Nevertheless, we found no evidence for an interaction between regional context and the spatial configuration of habitat in our nest predation analyses,

though our nest parasitism results do support such an interaction.

Fahrig (2003) distinguished the effects of habitat loss on biodiversity from those of forest fragmentation and, in reviewing the literature, found that the former generally has large effects, whereas the latter generally has relatively small effects, which may be difficult to detect. Several of the metrics we have chosen to investigate here (metrics of percent landcover type within 500 m of a nest, such as percent agricultural land) were suggested by Fahrig (2003) to be better indicators of habitat loss than habitat fragmentation. In contrast, Fahrig (2003) held up distance measures as better metrics of fragmentation, and indeed distance to agriculture (negative exponentially transformed) turned out to be the best metric for predicting Wood Thrush nest predation rates in our system. In contrast, a habitat loss metric (% agricultural land within 500 m of a nest) received considerable support in the nest parasitism analysis, but so did road density within 500 m of a nest, which could be argued to measure fragmentation more than habitat loss. In any case, our results highlight the importance of choice of habitat pattern metric in detection and characterization of avian response to deforestation and forest fragmentation.

While we did find evidence for effects of the spatial configuration of habitat on nest predation, the support for such effects was relatively weak. Several studies of Wood Thrush at similar or greater sample sizes (200 nests in our study) have failed to find any effect of spatial configuration on nest success (Friesen et al. 1999: $n = 154$; Fauth 2000: $n = 278$). Similarly, Farnsworth and Simons (1999) calculated nesting success for 416 Wood Thrush nests in the large and relatively unfragmented forest of Great Smoky Mountains National Park and concluded that daily nest survival estimates did not differ much from published estimates for Wood Thrush in fragmented forests of the same region. In contrast, other researchers have found effects of the spatial configuration of habitat on Wood Thrush nesting success with similar or smaller sample sizes than ours (Hoover et al. 1995: $n = 171$; Donovan et al. 1995: $n = 123$; Driscoll et al. 2005: $n = 212$). Thus, our sample size is generally representative of similar studies, some of which found effects, whereas others did not.

Rates of nest parasitism at our central Virginia sites were within the range of those found in other Wood Thrush studies in eastern mid-Atlantic forests (Roth and Johnson 1993, Hoover et al. 1995, Dowell et al. 2000, Petit and Petit 2000) and generally lower than rates reported for midwestern landscapes (Hoover and Brittingham 1993, Trine 1998). Our results strongly support an interaction between regional context and habitat pattern in determining nest parasitism rates, suggesting that the amount of deforested habitat surrounding remaining forest patches helps determine parasitism pressure. In models in which

only additive effects were supported, the three biogeographic regions were not ordered according to the percent of forested land within 5 km of nests (Figure 2A), although the Blue Ridge (the region with greatest forest cover) did have the lowest levels of nest parasitism. Models specifying an interaction between biogeographic region and spatial configuration of habitat generally recovered complex patterns when comparing the Shenandoah and Piedmont sites, but also confirmed the Blue Ridge as having the lowest levels of nest parasitism (Figure 2B).

Our results point directly to potential management actions to protect quality breeding habitat for Wood Thrush and for other species using similar habitats in central Virginia. For Wood Thrush, reduction of the length of forest edges, particularly with agricultural lands, can reduce rates of nest predation. Protection of forest habitat greater than 50 m from an edge should also be a priority. To minimize nest parasitism, road density and intensive agricultural practice could be limited in proximity to forest reserves. Although there were few commonalities between the nest predation results and nest parasitism results, both pointed to proximity to agriculture as being important in determining the predation and parasitism rates, though the functional response was different. Nevertheless, these results suggest that limiting intensive agricultural practice in proximity to forest reserves could help limit both nest predation and nest parasitism rates. Finally, we hope that the competing risks paradigm employed here (specifically modeling predictor variables for nest predation without excluding failures due to other causes) may be useful at other locations and potentially with other management and conservation questions (e.g., Jackson et al. 2011, Johnson et al. 2012, Custer et al. 2014), to help identify and characterize anthropogenic risks to avian breeding success.

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