Applying the Stacking Ratio to Forest Habitat Mitigation for Lethal Take of Multiple Bat Species under a Habitat Conservation Plan

U.S. Fish and Wildlife Service Region 3

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Summary: Region 3 requests a mitigation stacking ratio when calculating mitigation need for lethal take of multiple species of bats in wind HCPs. This stacking ratio applies to mitigation within documented summer maternity habitat or fall swarming habitat; it does not apply to mitigation at a hibernaculum. Further, this stacking ratio is to be applied when HCP mitigation need is being calculated, not when developing conservation/mitigation banking instruments or similar documents. This white paper describes how to apply the mitigation stacking ratios to calculate total mitigation need.

Background: The biological rationale for the need for mitigation stacking ratios is described in Appendix A: Regional Wind HCP Mitigation Stacking, 1/9/2017 (though note the recommended ratios in that document are not what is addressed herein).

A stacking ratio was determined to be appropriate in a document entitled, "Wind HCP Options" sent by Lori Nordstrom to Region 3 Project Leaders on 4/24/2017. Additional internal discussions about this document occurred through July 2017, but no changes to this component of the document were recommended. The most recent version of the guidance indicated the following: "Stacking – (1.1 if 2 bats, 1.2 if 3 bats, i.e., additional 10% for each bat, or the equivalent in bat conservation as determined by FO)."

While the guidance clearly states what the stacking ratio is, its application has been interpreted differently. Below we describe the methods for applying the stacking ratio and provide an example.

Methods:

When mitigation for lethal take of two or more species of covered bat within an HCP are being performed at a single mitigation location where all species are known to co-occur, the amount of mitigation owed will be calculated by applying the stacking ratio to the number of acres that will serve as mitigation for more than one species, as follows:

Step 1: Use species-specific REA models to calculate how much summer habitat protection or restoration is needed to offset the debit accrued for each species (Table 1, "REA mit ac").

Example: A 20-year project will take 1 female Indiana bat/year, 0.5 female little brown bat/year, and 0.5 northern long-eared bat/year. The Indiana bat REA model indicates that Indiana bat debit can be offset by preserving 130 acres of summer foraging habitat. The little brown bat REA model indicates that little brown bat debit can be offset by preserving 65 acres of summer foraging habitat. The northern long-eared bat REA model indicates that Northern long-eared bat debit can be offset by preserving 56 acres of summer roosting and foraging habitat.

Step 2: For the species with the largest mitigation quantity owed, a portion of that mitigation will not overlap with any other species mitigation and thus no stacking ratio will apply to this portion. To parse out the portion with no stacking ratio applied, start with the largest mitigation quantity owed and subtract the next largest mitigation quantity owed (Table 1 "Parsed ac").

Example: Mitigation owed for Indiana bat is larger than mitigation owed for little brown bat or northern long-eared bat. The portion of Indiana bat mitigation that will not overlap with any other mitigation is=130 acres-65 acres=65 acres. No stacking ratio is applied to this 65 acres.

Step 3: For the species with the smallest mitigation quantity owed, all of this species' mitigation will be stacked with other species mitigation, thus add to this quantity an additional 10% if it is being stacked with one species, or 20% if it is being stacked with two species, etc. (Table 1 "# stacked spp." and "Stacked ratio").

Example: All 56 acres of northern long-eared bat mitigation will be stacked with Indiana bat and little brown bat mitigation. Thus, mitigation owed for northern long-eared bat is=56 acres + (56*20%)=67.2 acres.

Step 4: If there is a third species with a REA mitigation quantity owed in between the largest value and the smallest value, a portion of this species mitigation will only overlap with the species with the largest mitigation quantity owed. To parse out this quantity that overlaps with one species, subtract the smallest REA mitigation quantity owed from the second smallest REA mitigation quantity owed (Table 1 "Parsed ac"). Add to this quantity an additional 10% because it is being stacked with one species (Table 1 "# stacked spp." and "Stacked ratio").

Example: Of the 65 acres of little brown bat mitigation owed, 56 of that will be stacked with Northern long-eared bat mitigation, and that stacking ratio was already applied in Step 3. The remaining mitigation owed for little brown bat is = 65 acres-56 acres= 9 acres. This 9 acres will be stacked only with Indiana bat mitigation, so add 10%= 9 acres + (9 acres *10%)=9.9 acres.

Step 5: Sum all the stacked mitigation acres to yield the total mitigation needed (Table 1 "Stacked mit ac").

Example: Indiana bat only 65 acres + northern long-eared/little brown/Indiana 67.2 acres + little brown/Indiana 9.9 acres= 142.1 acres.

	REA mit ac	Parsed ac	# stacked spp.	Stacked ratio	Stacked mit ac
Indiana	130	65	0	1	65
LBB	65	9	1	1.1	9.9
NLEB	56	56	2	1.2	67.2
Total					**142.1**

Appendix A: REGIONAL WIND HCP MITIGATION STACKING 1/9/2017

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BACKGROUND

The Regional Wind MSHCP mitigation plan includes a provision for stacking, which is defined as mitigating for more than one species using the same acres of habitat. The ecological basis for including this provision is years of mist-net survey and telemetry data that have shown the three Regional HCP bat species to be generally sympatric in suitable summer habitat where their ranges overlap. The three bats are closely related (all in the Genus Myotis) and are all morphologically similar. They are thus assumed to compete for the same food and roosting resources in their summer habitat and to some extent limit the availability of those resources for the others. When this happens, ecological theory predicts one of four outcomes based on how they compete, and described by the Lotka-Volterra equations (Pianka 1988). These outcomes include each species outcompeting the other, unstable equilibrium, and stable equilibrium where both species exist below carrying capacity - Pianka puts the outcome of competition succinctly, "*Interaction between the two organismic units reduces the fitness and/or equilibrium population density of each*." (Pianka 1988). As discussed below, a large body of research has identified the artifacts of interspecific competition among IBAT, northern long-eared bat (NLEB), and little brown bat (LBB).

FOOD RESOURCES

Current research indicates one result of interspecific competition is some level of niche differentiation among bats (see Denzinger et al., 2013, pp. 11 – 13 for a discussion of niche differentiation). The three bat species covered under the Regional HCP forage on essentially the same prey base (Whitaker 2004, see Table 1). This puts them in direct competition, but Lee and McCracken, 2004 found LBB diet to be broader than the other two species. There also appear to be subtle differences in their exploitation of food resources. For example, IBAT predominately feed by hawking insects (USFWS 2007) as do LBB, while NLEB and LBB are also capable of gleaning (USFWS 2014, Feldhamer, et al. 2009). This suggests that NLEB and LBB can to some extent exploit prey (spiders made up around 15% of both species diets in a southern Illinois study) not generally available to the IBAT (Feldhamer, et al. 2009).

In addition, IBAT often forages along edges within forested habitat, LBB are known to forage in much more open areas, and NLEB may preferentially forage in forest interiors (Feldhamer, et al. 2009). The three species may also divide up food resources temporally. Lee and McCracken, 2004 found that IBAT and NLEB peak foraging times were later than that of LBB and that when IBAT and NLEB were captured at the same site, the peak foraging times of those two species also differed. They also found partitioning of the air space between IBAT and LBB (where captured together, LBB foraged lower) but not between IBAT and NLEB or LBB and NLEB. Finally, Bergeson et al., 2013 investigating syntopy between IBAT and LBB looked at selection of habitat at different scales related to home range of the two species. They found that LBB foraging range was significantly larger (7x) than that of IBAT and encompassed multiple habitat types, while IBAT tended to forage only over bottomland forest often where the two species roosted. Interestingly, the LBB foraged in the shared bottomland forest for a short time in the early hours of darkness and then travelled several miles to forage in a different habitat type (Bergeson et al. 2013). A recent study suggests interspecific recognition of echolocation may also help further alleviate the negative effects of competition for the same food resources (Li et al. 2014). Schoeman and Jacobs, 2011 posit that interspecific competition among bats for food remains high despite partitioning as evidenced by the large overlap in prey (see discussion above and Whitaker 2004). Controlled experiments for other small mammals more easily manipulated than bats reveal how competition for food might affect IBAT, NLEB, and LBB (see for example Dickman 1991 and M'Closkey and Fieldwick 1975).

SUMMER ROOSTING RESOURCES

IBATs choose summer roosts preferentially (almost exclusively) under the exfoliating bark of trees (Gardner et al. 1991, USFWS 2007, Bergeson 2012); while NLEB appear more flexible also using crevices and hollows in trees (Lereculeur 2013) and at least in some cases use structures (Henderson and Broders 2008); and LBBs use crevices and cavities in natural roosts (Bergeson 2012), but have adapted to use human structures extensively (Broders et al. 2006). At a study site in Michigan key parameters (in particular use of exfoliating bark, but also type of tree, live or dead tree, height of bat exit) were similar or overlapped for IBAT and NLEB (Foster and Kurta 1999). Lacki et al., 2009 found evidence for competition between IBAT and NLEB for roosts under exfoliating bark. The two species, however, partitioned roosting habitat based not only on structure (bark vs. crevices) but diameter of roost trees, and the height of roosts with NLEB accepting a wider height range than IBAT. In addition, in a southern Illinois study where both IBAT and NLEB were present at two different sites, Carter and Feldhamer, 2005 found that IBAT tended to choose more open areas near the forest edge while NLEB more often roosted in the forest interior. In a study of several bat species including four Myotids in Oregon, the author noted potential interspecific competition for food, but concluded that distribution was most likely attributable to competition for roost sites, which may have been limited by timber harvest at one study site (Perkins 2005).

SUMMARY OF INTERSPECIFIC COMPETITION

In summary, IBAT, NLEB, and LBB compete with each other for food and roost sites. Their similar morphology and life history requirements suggest it. It is also evident that these three species have evolved together to occupy the same places throughout large portions of their ranges – there is no evidence that one species entirely excludes one or more of the others. Numerous studies point to interspecific competition primarily by documenting the strategies (e.g., niche partitioning) that all three species use to circumvent the negative effects of direct competition. In fact, there is strong evidence that they coexist by partitioning available resources. Ricklefs, 2007 states, "*The simplest way to achieve competition coefficients less than 1 [Lotka-Volterra] is for competitors to share resources incompletely by partitioning resources among themselves.*" Partitioning and avoidance behaviors can have their own consequences (e.g., foraging at a time or location more susceptible to predation) and may not be perfect in any case (see Eccard and Ylonen 2002 for a discussion of this in voles). Where avoidance is not perfect, e*xploitive competition* by definition disadvantages one or more species. The less competitive species would be expected to suffer by a variety of mechanisms (e.g., less fecundity or increased predation). It seems likely that both processes are functioning among the three species. The logical conclusion based on ecological theory and available information is that interspecific competition among IBAT, NLEB, and LBB results in a more or less stable equilibrium where they coexist, which by definition reduces the effective carrying capacity of the environment for those species (Ricklefs 2007).

APPROPRIATE LEVEL OF STACKING

Even for less vagile animals that are easier to work with, quantifying the effects of interspecific competition is difficult (Hastings 1987). The Lotka-Volterra equations and work derived from them are by necessity overly simplistic and rely on assumptions that are difficult to measure in the field. Available research tells us unambiguously that complex interactions occur among the three species with respect to food and summer roosting sites. While the effects of competition have been found often to be asymmetrical (i.e., competition affects one species but not the other) (Ricklefs 2007), we have no data to support that conclusion for IBAT, LBB, and NLEB. On the contrary, it appears that all are attempting to avoid competition for either food or summer roosting habitat, or both to some extent. Therefore, we recommend pending additional research findings that we assume an equal effect of each species on the other two. The magnitude of the effect of this interspecific competition on their key life history traits like fecundity and survival, however, are unknown. The available research indicates that it falls between complete exclusion (100%) and no competition (0 %). Because significant partitioning of food and roost sites is apparent, and because we do not perceive large deleterious effects of competition or the avoidance of competition where the three species occur together, we recommend a modest reduction in the value of mitigation of 20% be applied where two species are expected to occupy the habitat and 30% where all three species are expected to occupy the habitat. The interaction effect is assumed to increase as more species are added because habitat itself may be limited and in addition to the increased competition for resources, other effects like predation would be expected to magnify as species interact with more competitors.

SIMPLIFYING ASSUMPTIONS

Calculating mitigation using stacking, while based on the ecology of the bats as described above, is a regulatory tool to ensure consideration of the interactions among covered bat species and sufficient mitigation for those Covered Species under section 10 of the ESA.

• The magnitude of the interaction effects occur uniformly across the landscape.

• Interaction effects among non-covered species are not considered in the stacking calculation until those species become part of the HCP.

• Covered bat species uniformly occupy all mitigation sites where they are determined to be present.

• Covered bat species populations at a mitigation site remain relatively stable.

• The resources available at the mitigation site remain relatively stable.

• Other disruptions affecting the ecology of the bats (e.g., competing invasive species) do not occur at mitigation sites.