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To: Humboldt County Planning and Building Department

From: H.T. Harvey & Associates and Stantec Consulting, Inc.

RE: Supplement to Compensatory Mitigation Strategy for Marbled Murrelets Impacted by Operation of the Humboldt Wind Project

This memo is a supplement to the Mitigation Strategy Report that describes actions to compensate for take of marbled murrelets by the Humboldt Wind Energy Project. Here, we provide additional details to the strategy that support the logic and efficacy of this proposed mitigation. First, we present a "minimum benefit" calculation based on a worst-case production of new adult murrelets estimated to result from the proposed corvid management actions. Second, we provide a more extensive explanation of why direct observation of murrelet behavior, activity, and reproduction is not possible for this or any other potential mitigation strategy that could be proposed for murrelets. The efficacy of the proposed mitigation necessarily relies on monitoring changes in corvid abundance and activity as a proxy for the changes in murrelet nest depredation and resulting increased production of chicks.

Estimation of Minimum Benefit from Proposed Mitigation for Marbled Murrelets

The mitigation strategy proposed for marbled murrelets encompasses four groves of old-growth forest within Van Duzen County Park (VDCP) and an additional grove that is contiguous with VDCP and owned by California State Parks called Cheatham Grove. For Steller's jays and other corvids, Cheatham Grove is within traveling distance from the human recreational sites within VDCP, based on observations of jay movement from campgrounds to surrounding forests in both central and northern California (Goldenberg et al. 2016, West et al. 2016). As such, murrelets nesting in Cheatham Grove will benefit from the proposed corvid management actions.

While Cheatham Grove does have some of the infrastructure needed to minimize anthropogenic food availability to various wildlife species, including murrelet nest predators, it lacks the interpretive outreach and visitor education needed to ensure that visitors are motivated to avoid intentional feeding of jays or to understand the importance of keeping recreational areas in old-growth forest "crumb clean" and ensure corvid access to food rewards is minimal. As described in the original report, the Humboldt Wind Energy Project designed its mitigation strategy to include outreach and monitoring at Cheatham Grove which would make corvid management in this grove comprehensive and ensure that corvid management infrastructure can achieve its intended benefit.

In addition to active visitor outreach and education proposed within Cheatham Grove, comprehensive corvid management actions proposed for the neighboring VDCP will also benefit Cheatham Grove. This is because jays roosting in Cheatham or the directly adjacent Humboldt Grove (one of the four groves in VDCP) can presently obtain supplemental foods from the campgrounds and other recreational sites in VDCP, and this alone can increase the number of jays within Cheatham Grove. Additionally, the influx of human foods into VDCP during times when jays are nesting and provisioning young allows individuals to produce a greater number of higher quality (i.e., well fed) young. This increase in the number and quality of young serves as a source of new jays that mature and disperse from these campground areas and eventually resettle near the stands where they hatched (see West et al. 2019) which includes Cheatham Grove. Additional jays settling in these stands will further elevate the abundance of jays within or using Cheatham Grove. This interaction of jays with both Cheatham Grove and VDCP is why the calculated benefit of the proposed mitigation actions reported in the Mitigation Strategy Report included Cheatham Grove in all scenarios.

However, to make a full appraisal of the range of potential benefit of the mitigation strategy, we present a calculation of minimum benefit as an extreme "worst-case" scenario. The calculations used for this purpose are the same as those presented in the Mitigation Strategy Report except that they ignore any potential benefits of predator reductions to murrelets nesting in Cheatham Grove despite its proximity to VDCP. The assumptions used for this minimum benefit calculation were the same as those used in the report for other scenarios, except for the base number of nests at the start of mitigation; for these calculations, we assumed a very low density of 1 murrelet nest per 67.4 acres, or 2 nests, are initiated each year in the entire extent of old-growth forest of VDCP. Just as in the Mitigation Strategy Report, we then estimated the production of new murrelets resulting from a range of corvid reduction scenarios, starting with a 32% reduction (the level of reduction achieved in the first year following implementation of the crumb clean campaign elsewhere in California; Suddjian et al. 2009), as well as a 40% reduction (identified as needed to maintain viable murrelet populations in central California; Peery and Henry 2010), the most-likely evidence-based reduction 50% (the level of reduction ultimately achieved following implementation of the crumb clean campaign; Suddjian et al. 2009), and the maximum evidence-based reduction 80% (achieved in high-use areas following implementation of the crumb clean campaign; Bensen 2008).

Under the worst-case scenario murrelets nesting in Cheatham Grove would not benefit from a reduction in predator attraction and abundance at the adjacent VDCP. Using only VDCP, the proposed mitigation actions were estimated to produce new adult murrelets in excess of the maximum estimate of take of 7.77 murrelets over the 30-year life of the Project for all of the worst-case predator reduction scenarios (Table 1). Thus, the replacement ratio (the number of new breeding adults produced compared to the maximum take estimated by the probabilistic collision risk model) calculated for the most extreme worst-case scenario (minimum spatial benefit and minimum expected predator reduction) was 1.5:1. When this replacement ratio for the extreme worst-case scenario is calculated using the average take estimated by the deterministic collision risk model (6.1 birds lost in 30 years) rather than the maximum estimate of take, two new murrelets would be produced for every one estimated as lost due to collisions. Instead of the minimum expected predator reduction, when we assume that predator reductions will be similar to what has been achieved elsewhere (50%), the proposed mitigation is estimated to produce 3.5 murrelets for every murrelet potentially lost from turbine collisions under this scenario.

The number of nests currently initiated by murrelets in VDCP are unknown. Currently, there are not any viable non-invasive methods to determine the number of murrelet nests in an area (see next section below). Furthermore, in areas where predator abundance is elevated due to anthropogenic food subsidies such as VDCP, up to 71.4 -90% of nests may be depredated and failure can occur shortly after initiation (see Golightly and Schneider 2011, Hebert and Golightly 2006, and others). Because nests may be present for a very limited duration, any surveys to enumerate nests initiated in an area saturated by predators would have to be comprehensive and occur shortly following each initiation to avoid underestimation of the nest density; one of the most obvious signs of a nest, the fecal ring made by a chick (see section below), would not be produced despite initiation of a nest if nest predation occurred in the egg stage or even early chick rearing. Calculations of benefit assumed that murrelets currently initiate a single nest every ~67 acres in VDCP (or approximately 2 nests per year) and do not assume the two nests reach advanced stages of development. Given the current abundance of corvids in VDCP, these two assumed nests may only survive just a few days out of the entire season (making them impossible to detect by any present method except perhaps radio telemetry, which requires that they survive a minimum of 3-4 days to detect the on-off-on incubation pattern). Thus, 1 nest per 67 acres represents a minimum guess of the true number of nests currently initiated in VDCP. Importantly, the calculated benefit of mitigation only requires that nests be initiated in the affected area and not that the nests used to establish the baseline density for calculations actually survive to fledge chicks. Thus the mitigation is effective even if there are no successful nests presently in VDCP. Nests in this situation are precisely the target of the Corvid Management Strategy proposed for VDCP and the Crumb Clean Campaign.

Table 1. Cumulative gain of adult murrelets estimated to result from a worst-case scenario that assumed the proposed corvid management strategy will only benefit murrelets nesting within VDCP and not the adjacent Cheatham Grove. Additional assumptions were an initial starting point of 2 nests initiated in the entirety of VDCP per year (equivalent to 1 nest initiated per 67.4 acres) for a range of anticipated corvid reduction scenarios that ranged from worst to best (32 to 80%). Resulting replacement ratios were calculated by comparing the cumulative addition of new breeding adults to the loss of 7.77 adult murrelets over 30 years as estimated by the probabilistic collision risk assessment.

% Corvid reduction	Gain in breeding murrelets in 30 years	Mitigation replacement ratio (new : lost)
32	11.99	1.5 : 1
40	17.68	2.3 : 1
50	27.15	3.5 : 1
80	66.84	8.6 : 1

Monitoring Murrelet Activity and Behavior at Terrestrial Sites

Monitoring of threatened or endangered wildlife is generally difficult because, by definition, they are rare and typically have low abundance. Also exacerbating the difficulty of finding and observing threatened species is the requirement that the techniques used to do so does not impact an individuals' health or safety and that their reproduction is not compromised or diminished. These problems are even more extreme for marbled murrelets because of where they nest, where they forage, and their cryptic behaviors. Although murrelets were first described in 1789, it was not until 1974 that the first nest was found (Binford 1975); by the time murrelets were listed as threatened in 1992, only 23 nests had been found though out the murrelet range. In California, murrelets generally nest high in the canopies of old-growth trees (averaging 48 or 41 m above ground; Golightly et al. 2009, Baker et al. 2006, respectively). Murrelets are susceptible to predation on their daily trips between foraging sites on the ocean and their nests located in remaining patches of old-growth forest that are many miles inland. Murrelet eggs (they only lay one) and chicks also are vulnerable to predation and nest failure can be remarkably frequent in areas where nest predators (specifically corvids) are abundant. Behaviorally, murrelets minimize these risks by flying in low-light conditions (i.e., very early morning and, when feeding chicks, just before dusk) so that they can avoid falcons and hawks as they transit inland to nests and can enter the nest tree undetected. While minimizing predation of themselves and their nest, this behavior contributes to the difficulty of finding nests. Notably, murrelets also have a cryptic coloration and feather pattern when nesting and when at the nest they remain motionless to avoid detection by predators such as hawks, jays, and ravens (Golightly and Schneider 2010).

Thus, an attempt by biologists to locate a nest requires an extreme amount of effort and, even then, only a small fraction of nests are precisely located. One technique that has been used requires climbing trees (many over 300 feet tall) and searching limb by limb. If climbing occurs during the nesting season, there is risk of flushing the nesting adult or chick, or leading nest predators such as jays or ravens to the nest site. If climbing occurs after the nesting season, often the only evidence of nesting is the presence of a fecal ring which requires that a chick survives for many days to produce the ring and, as such, nests that fail early often leave few to no remains and go undetected. A second technique used to find nests is catching birds at sea and following them back to their nest using radio telemetry. This technique only finds the nests of radioed birds and cannot target murrelets nesting in a specific parcel of forest. Even if a nesting attempt is detected using this method, precisely locating the nest is challenging and has a low success rate. Importantly, the added weight of the radios can potentially compromise the survival of the adult carrying the transmitter. Radar, a technique used to monitor flights by murrelets, can illuminate flight paths and passage rates through a particular open air space, but cannot locate nests, determine the number of nests, or even identify stands used for nesting by individual birds. The Pacific Seabird Group (PSG) has developed an audio-visual (AV) protocol (Evans Mack et al. 2003) that can identify stands that support nesting or behaviors essential to reproduction (courtship, socialization), but these AV techniques cannot determine how many nests occur in a stand, where nests are located in the stand, or if nests are successful. Further, because of the rapid failure of nests, interannual variability in the initiation of nesting, and the relatively long duration between subsequent surveys, these AV surveys can entirely miss nesting activity by murrelets in a stand that they do in fact use for nesting. It is recognized that this technique regularly fails to detect occupied behaviors when in fact birds have nested in a stand. The PSG is working on an improved technique and protocol, but they are not yet in use or tested, and will still not provide insights into reproductive success. Techniques to count murrelets at sea are discussed in the Strategy Report and Collision Risk Report; at sea surveys cannot be used to monitor the impact of specific projects at this scale.

Because of these problems for monitoring murrelets at nests, systematic attempts to quantify changes (plus or minus) in population size or individual reproductive effort are not possible. Consequently, other metrics must be used to infer changes. In the case of the mitigation effort at VDCP, the change in abundance or activity of corvids will be monitored as the most proximal outcome of the proposed corvid management actions. Increased survival of murrelet nests by reducing the abundance of their nest predators is the intended goal of proposed mitigation actions and, as such, effectiveness will be assessed by monitoring changes in predator abundance in the stands targeted by corvid management. Because corvids are not rare and are readily detected both visually and by their calls, they can be measured with some precision and there has been power to detect changes in abundance in the time frame needed to evaluate effectiveness of the strategy once implemented.

It is important to recognize that monitoring of murrelets will be problematic for virtually all types of mitigation in the terrestrial landscape. For example, mitigation of projects that use habitat enhancement through vegetation management or by habitat acquisition cannot quantitatively detect changes in reproduction or populations (except at a very large scale such as an entire region; see Falxa et al. 2016 for large scale habitat analyses). Consequently, these kinds of mitigation use proxies such as the amount of acreage altered or acres of old-growth forest acquired to infer protections and enhanced survival and production of murrelets. In these cases and for the mitigation at VDCP, the intent is to ultimately add to recovery of murrelets, but the ability to detect the effectiveness of recovery efforts directly is not possible at small scales given the challenges of locating and observing murrelet nests; for monitoring each project must rely on the metric most proximally associated with action taken.