A Model to Include Rare and Uncommon Natural Communities as Habitat Blocks for Middlebury, Vermont

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Introduction: Professor Jeff Howarth created a model for forested habitat blocks in Middlebury, Vermont to show potential habitat area for wildlife (Howarth 2023a). The model displays blocks of non-developed and non-agricultural land which have forest cover in a majority of their area. The model also removes qualifying areas which are less than 100 acres in size in order to limit the number of blocks. However, it is possible that this area-based criterion removes some sections of quality habitat within Middlebury that the state government designates as significant natural communities (Przyperhart et al. 2017).

A model which accurately visualizes forested habitat is essential for future conservation planning. If forested blocks represent areas which the Middlebury Planning Commission ought to consider conserving (Przyperhart et al. 2017), it is necessary to construct a base model which does not neglect important areas. Moreover, the current work directly influences models of habitat connectivity, which display the connections between different forested habitat blocks in order to show where wildlife can travel between habitat areas (Prof. Howarth, personal communication, 4/18/2023). This report accordingly addresses the accuracy of the original model. It provides a thorough explanation of changes to the original model which aim to include rare and uncommon natural communities as habitat blocks. The report then critically discusses the resulting changes in how the model visualizes habitat and summarizes next steps.

Background: Sorensen and Osborne (2014) provide that habitat blocks represent natural habitat which is unbounded by human development. Other authors in the scientific literature have used the term when referring to species habitat (Mukherjee et al. 2021; Loucks et al. 2003). Forest blocks, or “contiguous area[s] of forest”, is a legal term (ANR 2018). Forest blocks are approximated by forested habitat blocks, a term used by Middlebury College staff and students which represents habitat areas with majority tree cover (Howarth 2023a).

According to Przyperhart et al. (2017), natural communities (herafter NCs) refer to distinct types of environment which maps, datasets, and scientists can define by their associations of life. The VFWD distinguishes between terrestrial and palustrine NCs, which correspond to upland and wetland areas respectively (VFWD 2013). The VFWD also labels NCs with a designation known as State Rank (Przyperhart et al. 2017); this is a value from 1 to 5 corresponding to rarity, with S1 and S2 as rare, S3 as uncommon, and S4 and S5 as common (VFWD 2013).

The Vermont Agency of Natural Resources (ANR) displays significant NCs on its BioFinder map service (Przyperhart et al. 2017; ANR n.d.). The government determines significance by evaluating the State Rank and future stability of NCs (Austin et al. 2013). The ANR (ANR 2019a) implies, as do Austin et al. (2013) and Sorensen et al. (2015), that planners should conserve significant NCs. Przyperhart et al. (2017) supplies that NCs are vital because they simplify conservation efforts; they allow planners to target groups of flora and fauna for management or protection. The ANR includes that the state NC designations are sufficient to capture all habitat types within Vermont and implies that the Agency believes that the locations of significant NCs will persist (ANR 2019). Przyperhart et al. (2017) also state that NCs can encompass abiotic factors such as the ecosystem service of carbon sequestration. For forests in general, Notman et al. (2006) suggest that such services can additionally include recreation and water provision. Austin et al. (2004), as cited in Sorensen and Osborne (2014), also include that animal and plant populations depend upon habitat block areas for continued survival and reproduction and imply that humans can also find value through forestry and landscape beauty.

State law may relate to forested habitat blocks through both Acts 174 (ANR 2019b) and 171 (ANR 2018). For the former act, an ANR dataset implies that certain forest block areas can preclude managers from establishing renewable energy projects (ANR 2019b). The guidance document for the latter act, which frames how municipalities can understand the local extent of forest blocks, establishes that NCs are an example of a smaller-scale element which planners should consider protecting regardless of area (ANR 2018). Przyperhart et al. (2017) also indicate that planners should protect significant NCs. Austin et al. (2013) include that planners could create an overlay district specifically for NCs, while Przyperhart et al. (2017) imply that town personnel could establish forest blocks as a set of protected areas within zoning documents.

Research Framework: This report seeks to determine the effects of adding rare and uncommon NCs (S2 and S3; Howarth 2023f) into the existing forested habitat block model (Howarth 2023a). Specifically of interest is whether the updated model will visualize habitat in a different manner; perhaps maps will show new blocks in areas which the model did not previously display. It is expected that the model will produce this type of result, for the 100-acre area criterion reduces the potential for smaller areas to be included. This expectation relates to language from Przyperhart et al. (2017), who state that large habitat blocks may not incorporate

all significant NCs in a given area. The original model also does not include the Trombulak Bird Sanctuary, an area which should likely be represented in a complete picture of natural habitat in town (Prof. Howarth, personal communication, 5/2/2023).

Methods: The output of the model will be a map of Middlebury with an updated layout of forested habitat blocks. This output will include any NCs of the S1, S2, and S3 ranks and the forest or grassland which overlaps these areas. The model requires a dataset containing land cover information, where the map of town is broken into 3x3 meter squares (pixels) which are assigned different land cover types such as forest, water, and developed land based on remote observations. The particular dataset which the model uses was included because it contains a buffer around developed land, which more liberally represents human impact (Howarth 2023d). The model also takes the input of a map of the natural communities of the appropriate rank (Howarth 2023f). The language of the data that produced this map matches with the VFWD terminology, and it is thus suitable for use in this project (VFWD 2013).

The model begins with the land cover dataset previously mentioned. It selects only those squares which correspond to forest cover and grass/shrubland; the model considers only these two classes of land cover to represent relevant habitat. It then groups areas where tree or grass/shrubland squares are adjacent to one another (Lindsay 2019). The model subsequently introduces the map of Middlebury NCs and determines which groups of habitat squares overlap with the NC locations. This step identifies habitat blocks which contain the NC areas. As a final step, the model joins this map of blocks together with the map of forested habitat blocks which results from the unaltered model. Habitat blocks which contain NCs are thus included alongside all the original blocks. All blocks from the unchanged model are still greater than 100 acres in size, but the updated model does not constrain any additional blocks in this way. These steps are presented in Figure 1.

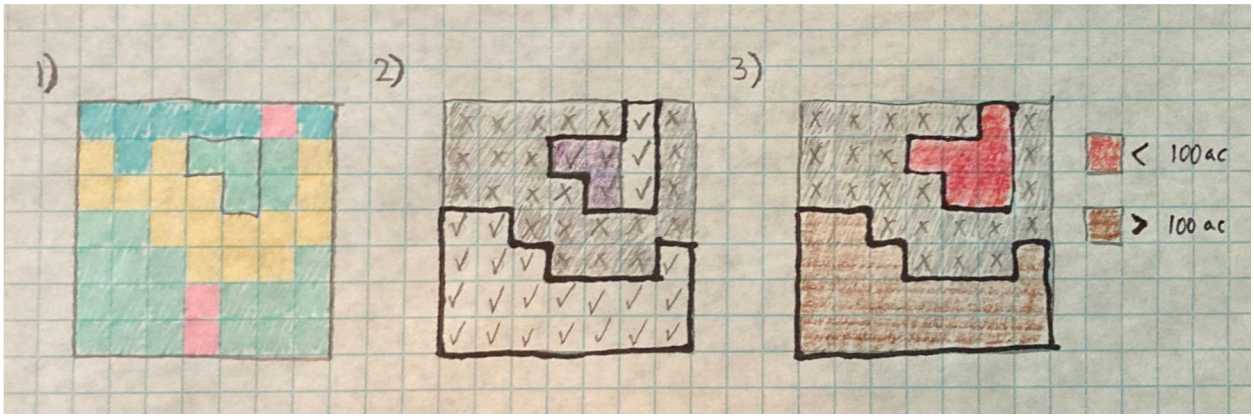

Figure 1. An illustration of the model. *Part 1*: Consider this simplified landscape (not to scale) where each square can represent a different type of land cover. Green represents forest, pink represents grass/shrubland, blue represents water, and orange represents agricultural land. The three squares with an outline are an NC. The forest and grass/shrubland in the top three rows represent a habitat block small enough to be filtered out of the original model, whereas the forest and grass/shrubland on the bottom rows represent a forested habitat block large enough to have been originally included. *Part 2*: The model selects only forest and grass/shrubland squares (check marks) and groups them together according to adjacent squares (Lindsay 2019). Squares shaded in purple represent the NC. *Part 3*: The red and brown areas represent separate habitat blocks in the results of the new model. The model recognizes the red area as a habitat block, even though it does not meet the area criterion, because it contains an NC.

Results: The new model produced three additional habitat blocks (Figure 2a-b). One of these blocks is located close to the town center and contains the Trombulak Bird Sanctuary (Prof. Howarth, personal communication, 5/2/2023) as well as land directly adjacent to Otter Creek (Figure 3a). The other two blocks are located at the confluence of Otter Creek and Middlebury River (Figure 3b). In addition, the model changed the shape of several blocks which were already present in the original map. It would seem that the model added habitat area to these blocks (Figure 4a-b).

a. b.

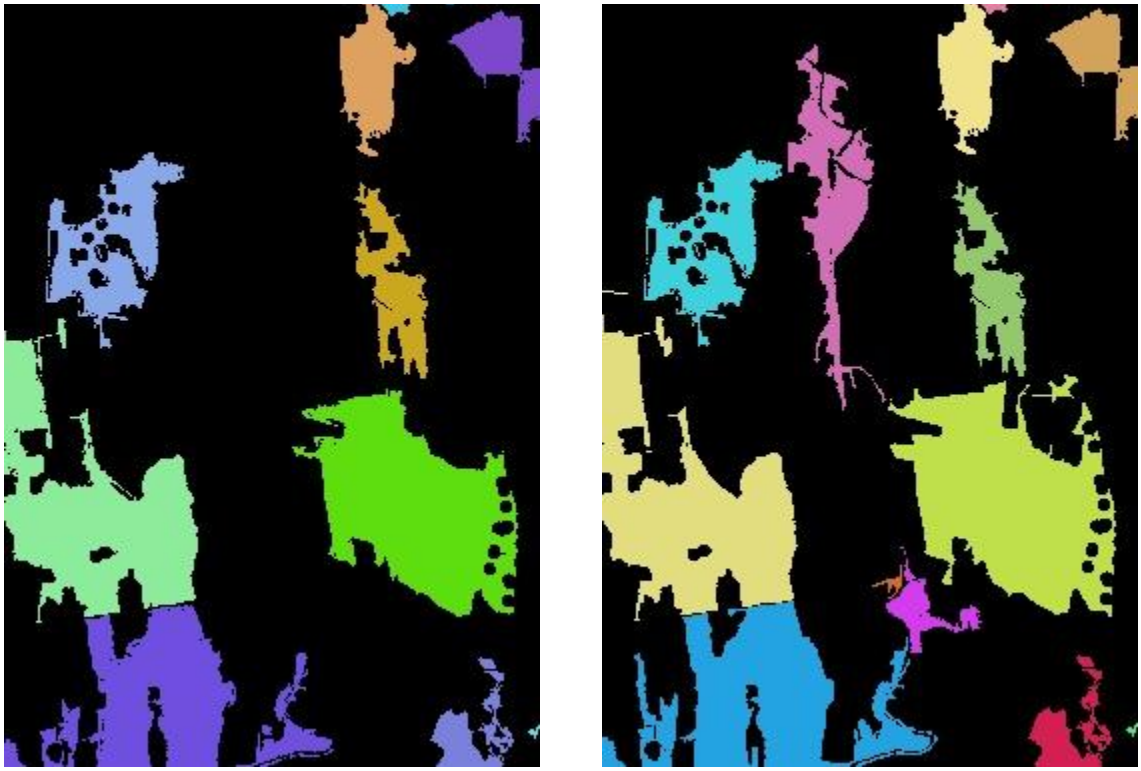

Figure 2a-b. A habitat block comparison across models. (**a**) A location in the original model. (**b**) The same location in the updated model. Though the colors of the blocks are different across models, it is apparent that there are three new blocks in (**b**): one in the top middle of the image (pink) and two in the bottom middle of the image (orange and magenta). Each distinct block is a different color. The black backround represents area which is not part of a habitat block, in order to provide sufficient contrast.

Discussion: The results align with the expectation that the model would produce a map with new habitat blocks not present in the results of the original model (Figure 2a-b). Forested habitat blocks which the previous model identified also contain many NCs, suggesting that their area was large enough to have incorporated these NCs. The model still altered the size of some of these blocks, however (an example is Figure 4a-b), which is likely a result of the model including forest and grass/shrubland which overlapped with the NC area. The three new habitat blocks contain NCs within their area and are located close to Otter Creek or Middlebury River (Figure 3a-c). Their close proximity to rivers compares favorably with Przyperhart et al. (2017), who imply that scientists have observed this as a pattern.

a. b.

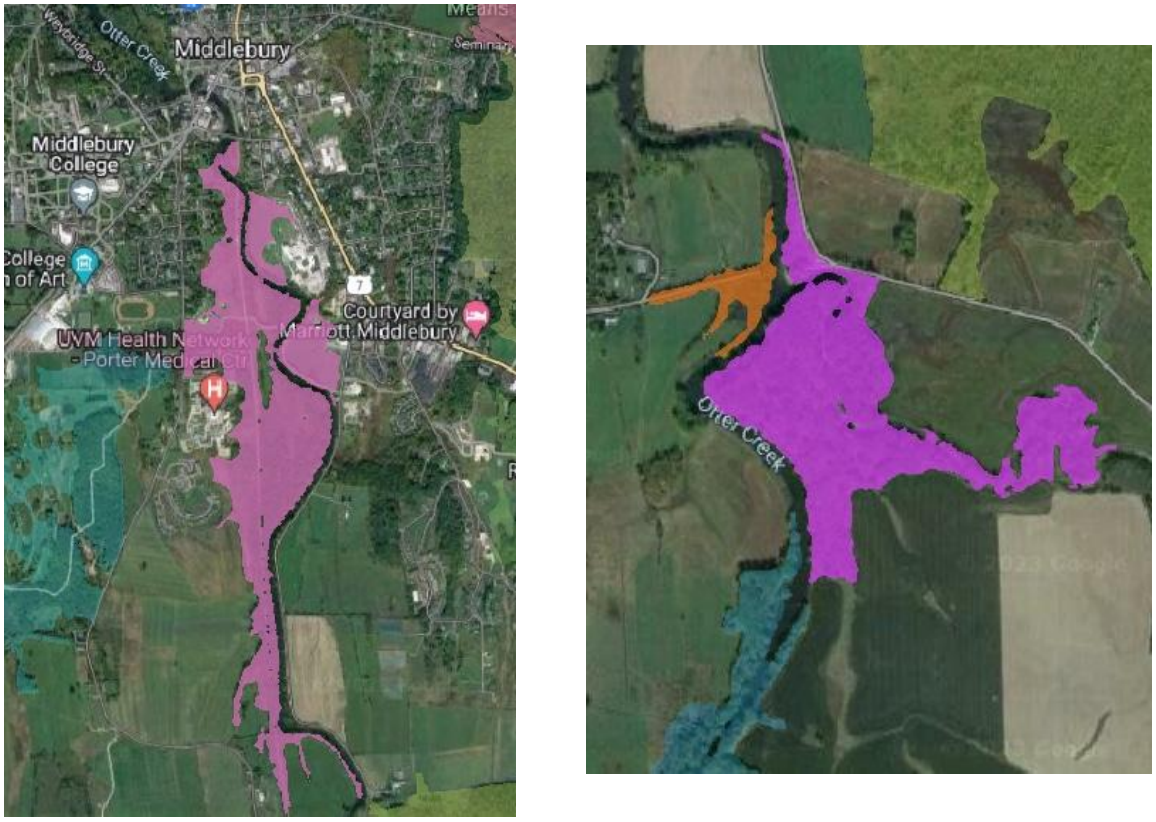

Figure 3a-b. The locations of the new habitat blocks. (**a**) The block (pink) containing Trombulak Bird Sanctuary. (**b**) The blocks (orange and magenta) by the confluence of Otter Creek and Middlebury River. They are located near Farmington Cemetery in the south central portion of town.

The ANR dataset reveals that all three blocks contain palustrine NCs identified as Silver Maple-Ostrich Fern Floodplain Forest. The dataset identifies these floodplain forest communities as having a rank of S3, or uncommon, though S2 NCs exist elsewhere within Middlebury (Howarth 2023f). Przyperhart et al. (2017) include uncommon NCs alongside rare NCs in a recommendation and Gerhardt (2014) also groups these terms in a report for the Town of Newark, Vermont; as such, the lower State Rank of these floodplain forests does not negate their importance for conservation. As ANR produced the dataset which the model used (Prof. Howarth, personal communication, 5/11/2023), the model likely displays significant NCs only

(Przyperhart et al. 2017). This would establish the NCs as quite relevant for conservation planning (ANR 2019; Przyperhart et al. 2017; Austin et al. 2013).

Additionally, the habitat block containing the Trombulak Bird Sanctuary is not under protection, while the other two new blocks appear to have protections on the underlying land (Howarth 2023e). Middlebury College appears to own the sanctuary area but not the entirety of the modeled habitat block, which continues south along Otter Creek (Howarth 2023c; Figure 2b). The College could protect this particular area of the block to align with Przyperhart et al. (2017) and Austin et al. (2013), who recommend that planners work to protect significant NCs.

Recommendations: Future analyses of wildlife habitat and connectivity by Middlebury College and Planning Commission personnel should incorporate natural community areas. In particular, future models should include the areas represented by the three new habitat blocks from the updated model (Figure 3a-b). After Przyperhart et al. (2017), the College should protect the Trombulak Bird Sanctuary area. The Planning Commission should also consider protecting forested habitat blocks present in the original model which remain unprotected (Przyperhart et al. 2017). Austin et al. (2013) also imply that NC maps have the potential to be incomplete and call for planners to evaluate the effectiveness of existing data at representing land cover, so personnel should conduct site visits to existing NCs accordingly.

Conclusion: The model adds three additional habitat blocks which capture uncommon floodplain forest natural communities located close to the Trombulak Bird Sanctuary and the confluence of Otter Creek and Middlebury River. It also adds some additional forest and grass/shrubland to larger forested habitat blocks. This model does not represent other important qualities of the Middlebury landscape, including how specific forest animals such as deer use the land (Przyperhart et al. 2017; Arrowwood Environmental n.d.). As such, this work requires input from other analyses to be complete, including a model which weighs variables such as the shape of the block (Sorensen and Osborne 2014). In the future, personnel from Middlebury College or the Planning Commission should visit the areas affected by the updated model in order to gauge whether it is feasible to include them as wildlife habitat as well as determine whether the ANR NC dataset represents all potential NC areas (Austin et al. 2013; Prof. Howarth, personal communication, 5/11/2023). In addition, a map of historical natural communities according to

soil type, which includes floodplain forest as a type of NC (Howarth 2023b), could aid future studies of whether the modeled habitat blocks sufficiently represent each type of historical natural community or whether the ANR dataset captures all NC areas (Prof. Howarth, personal communication, 5/11/2023).

a. b.

Figure 4a-b. A habitat block comparison across models. (**a**) A location in the original model. (**b**) The same location in the updated model. Though the colors of the blocks are different across models, these images present the same block. It is apparent that the updated model added habitat area to the block which was not present in its original extent.

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I have neither given nor received unauthorized aid on this assignment.

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