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New Haven City Planning Commission
Via email: publictestimony@newhavenct.gov
165 Church Street,
New Haven, CT 06510

RE: ZONING ORDINANCE CITY OF NEW HAVEN, CT § 43.1-13b Proposed Amendment – Scientific Basis for Proposed Ordinance Amendment

Dear New Haven City Planning Commission,

Below, please find a supplemental scientific evaluation of the ways urban development is linked to biodiversity loss and human health, in support of the proposed ordinance amendment. If you have any questions or would like to connect. Please do not hesitate to reach out.

I. Urban Development Directly Reduces Biodiversity and Indirectly Increases Human Health Risks

Urban development has the direct effect of reducing biodiversity and, through biodiversity loss, has the indirect effect of increasing potential pathogen transmission and reducing human physical and mental health. This brief scientific synthesis first describes how urbanization within New Haven may lead to biodiversity loss, then outlines the imminent consequences of such biodiversity loss.

II. Urban Development has the Direct Effect of Reducing Biodiversity.

The most prevalent consequences of urban development include land cover change and spatial constriction within cites. These changes to natural landscapes have the direct result of modifying evolutionary processes within the biotic community. This impacts the evolutionary trajectory of species by strengthening random genetic drift and restricting gene flow within ecologically short time scales, severely impacting entire ecosystems (Johnson & Munshi-South, 2017; Donihue & Lambert, 2014; Diamond & Martin, 2021). The evolutionary modifications consistent with urbanization cause biodiversity loss within urban communities.

Land cover change describes the urbanization process of clearing pre-existing terrain and replacing it with urban construction. As land masses are urbanized, previously natural areas are often replaced with homogeneous non-natives species, typically consisting of turfgrass lawns and tall trees (Ruas, 2022; Lepczyk et al., 2017; Aronson et al., 2017). This has the effect of not only homogenizing the area but also reducing the diversity of any remaining native species (Donihue & Lambert, 2014; Johnson & Munshi-South, 2017). This occurs through the process of strengthening random genetic drift. Genetic drift occurs when the frequency of a gene variant becomes more common throughout a population, meaning gene diversity is reduced (Johnson &

Munshi-South, 2017). When genetic diversity is reduced, species become less adaptable to climate shifts or disease because they lack the genetic diversity necessary to survive environmental changes (ibid.). These effects are already being documented in insect and bird populations within the urban environment (Aronson et al., 2017; Ruas, 2022). Maintaining homogeneous urban land covers involves pruning, removal of leaf litter and 'weeds,' and pesticide use. (Aronson et al., 2017; Ruas, 2022). These processes also impact biotic morphology, physiology, reproductive traits, and behavior as a response to the physical and chemical alteration of species habitats. (Johnson & Munshi-South, 2017).

Second, spatial construction defines the overall layout of an urban area. Any urban expansion reduces biodiversity, but urban areas with a sprawling (i.e., non-compact) spatial construction cause more biodiversity loss than compact urban areas (Sushinsky, 2012). Generally, compact development leaves large green spaces intact with room for corridors between areas, while sprawling development leaves smaller, isolated, and patchy green spaces – as reflected in New Haven's spatial design (ibid.; Beninde, Veith, & Hochkirch, 2015; Ossola & Niemelä, 2018). Patchy small green spaces with few or no corridors are one of the worst triggers of biodiversity loss (Beninde, Veith, & Hochkirch, 2015;Ossola & Niemelä, 2018). Typically, species can roam freely, sharing genetic information between many members of the same species. However, patchy green areas with few corridors cause directed movement of species because they are geographically constrained. This has the effect of spatially partitioning species and restricting gene flow (Armsworth & Roughgarden, 2005; Johnson & Munshi-South, 2017). The reproductive isolation experienced under such restriction limits gene sharing within the affected urban areas and causes artificial speciation (ibid.; Diamond & Martin, 2021). This has already happened in London, England with the speciation between the underground mosquito (Culex molestus) from the surface-dwelling (Culex pipiens) (Byrne & Nichols 1999). The two species were geographically separated because of London's spatial construction, and each diverged. Now, mating between C. molestus and C. pipiens result in infertile offspring (ibid.), meaning the genetic line of the parent mosquitos end with the hybrid offspring. This is just one example of the consequences that can occur from restricted gene flow as a direct effect of spatial construction.

Strengthened genetic drift and restring gene flow are direct effects of urban development. Both phenomena lead to a reduction in gene diversity, causing species to become less resilient and, consequently, more vulnerable to extinction. When this happens on a large scale, biodiversity is reduced. Because biodiversity loss is the immediate impact of urban development, it is a direct effect.

III. Consequences of Biodiversity Loss and Indirect Effects of Urban Development

Through biodiversity loss, urban development will indirectly lead to increased pathogen transmission. Low vertebrate species richness increases the risk of infectious disease outbreak, because pathogens become concentrated among low numbers of species (Aerts et al., 2018). Transmission of these diseases is higher, because the potential prevalence of infected 'vectors' is higher, due to the low level of speciation (ibid.). Additionally, densely populated urban communities undergo increased viral mutation rates, making pathogen transmission from animals to humans a higher risk (ibid.; Schell et al., 2020; Johnson & Munshi-South, 2017). In contrast to biodiversity loss, pathogen transmission is an indirect effect of urban development, because it is one step removed from the changing local environment. Initial biodiversity loss

subsequently alters pathogen transmission rates, making it an indirect impact of urban development.

Biodiversity loss associated with urban development also causes a decrease in human resilience to disease and human mental health. Evolutionary dynamics between humans and their surrounding environment are impacted by biodiversity loss, because ecosystem services (contributions of nature to people) associated with high biodiversity levels become reduced (Des Roches et al., 2020; Aerts et al., 2018). When humans interact with biodiverse natural environments for prolonged periods, the human microbiome becomes enhanced (ibid.; Haahtela, 2019). The human microbiome protects immune balance, making humans more resilient to pathogens and allergens (ibid.; Sun et al., 2023). Consequently, when biodiversity is reduced, the human resilience to pathogens and allergens is also reduced. When humans interact with biodiverse natural environments for short periods, stress levels, depressive symptoms, and attention fatigue are improved (Aerts et al., 2018). Conversely, these findings suggest lower levels of biodiversity can lead to poorer human physical and mental health. Similar to pathogen transmission, the consequences of urban development on human health are indirect because they are one step removed from direct changes to the urbanized environment. The direct effects of biodiversity are a major intermediary factor leading to indirect human health detriments in the urbanized environment.

IV. Conclusion

Overall, urban development reduces biodiversity, increases potential pathogen transmission, and reduces human physical and mental health. But because biodiversity loss is an immediate impact of urban development, it is a direct effect. However, because impacts of pathogen transmission and human health are influenced by the intermediary factor of biodiversity loss, these are indirect effects of urban development.

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