TEXAS ACADEMY OF SCIENCE - POSITION PAPER ON U.S.-MEXICAN BORDER BARRIER: THE WRITING IS ON THE WALL

All living things, including humans, exist in complex interdependent relationships known as ecosystems. Destruction and degradation of natural ecosystems are the primary causes of declines in biodiversity, the key indicator of ecosystem health (Haddad et al. 2015). Healthy ecosystems provide many services: they clean the water, purify the air, regulate the climate, maintain soils, recycle nutrients, and provide us with raw materials and resources for medicines, fuel, fiber, and food. The controversy over whether or not to build a physical barrier along the U.S.-Mexico border has highlighted important scientific factors related to biodiversity that should be considered in order to inform and affect the construction — or abstention from construction — of a barrier along the U.S.-Mexico border intended to deter human immigration. Texas has more at stake in this debate than any other state in the U.S. due, in part, to the physical-geographic fact that Texas comprises over two thirds (2018 km/1254 mi) of the total U.S.-Mexico border length (3145 km/1954 mi) and encompasses the largest remaining unspoiled area of the borderlands, the Trans-Pecos portion of the Chihuahuan Desert.

Scientific concern over territorial boundary management effects upon U.S.-Mexico borderland ecology is increasing. Prior to 2007 concern over border security focused on illegal immigration and drug smuggling with little attention given to conservation and wildlife (Cohn 2007). Over the past decade, scientists have called for more research and consideration regarding environmental effects upon borderland biodiversity (e. g., Liu et al. 2019). Three ways in which border infrastructure and security operations threaten biodiversity include 1) construction activity bypassing environmental laws, 2) degradation, fragmentation, and elimination of habitat, and 3)

devaluation of bi-governmental conservation investments and scientific research (Peters et al. 2018). Two of the six ecoregions bisected by the U.S -Mexico border are in Texas, the Trans-Pecos and the Tamaulipan thornscrub. Fowler et al. (2018) recently expressed environmental concern over threats to Texas biodiversity through a scientific literature review of 14 publications focusing on examples of habitat fragmentation and ecosystem damage in the Tamaulipan thornscrub. The Trans-Pecos represents some of the last remaining unspoiled ecosystems in the U.S -Mexico borderlands. From a scientific point of view, key environmental issues associated with the construction of a U.S -Mexico border barrier that should be considered include: physical area requirements, land use change effects on hydrology and habitat fragmentation, and altered ecology of soils, vegetation, and wildlife. Additionally, all of these environmental issues will influence future generations of people inhabiting the area.

The land area required to construct a U.S.-Mexico border barrier is significant. A cleared swath roughly 12–20 m (39–66 ft) wide, equivalent to four or five highway lanes, would be physically occupied and irreversibly altered. However, in addition to land clearing for the physical barrier itself, an estimated additional 12–20 Ha, per km of barrier, will be required for construction staging and access roads (USDHS et al. 2008). Considering that the Texas-Mexico border stretches 2018 km (1254 mi), the potential landuse requirement for barrier infrastructure amounts to 443 km^2 (171 mi^2). Ecological edge effects further magnify the total amount of natural habitat that could ultimately be affected. The clearing of linear tracts (i.e., road corridors) penetrating into previously undisturbed areas decreases the interior habitat size and renders local plants and animals more exposed and vulnerable. This latter phenomenon gives rise to habitat fragmentation, complete separation of formerly connected areas, which in turn leaves isolated populations susceptible to

inbreeding. Eventually species extirpation (i.e., removal, destruction, extermination) may result, and in worst case scenarios, species extinction may occur (Haddad et al. 2015).

Land use change, caused by physical barriers (i.e., fences) and supporting road networks, presents a significant concern as they negatively affect habitat and associated regional ecology through reduced biodiversity (Forman & Alexander 1998; Trombulak & Frissell 2000). Roads bisect the landscape, fragmenting habitat, and degrading ecosystems. Seven general effects of roads were identified by Trombulak & Frissell (2000): mortalities caused by both road construction and collisions with vehicles, alterations of both the physical and chemical environments, changes in animal behavior, increased spread of exotic species, and increased human land use. Epps et al. (2005) demonstrated reduced connectivity and genetic diversity in desert bighorn sheep populations due to roads and fences in the Mojave and Sonoran Desert regions of California. Roads and barriers reroute natural drainage patterns that further alters the landscape through sediment erosion, entrainment, and deposition processes (Montgomery 1994). Land use changes driven by human activities have been shown reduce microbial and faunal abundance and the overall diversity of soil organisms (Rocca et al. 2019). Reduced biodiversity in soils may impair numerous ecosystem functions, such as nutrient acquisition by plants and the cycling of resources between above- and below-ground communities (Wagg et al. 2014). High levels of suspended sediment in streams and springs resulting from expanded roadways and illegal traffic in borderland areas have been shown to negatively affect fish populations in southern Arizona (Clark Barkalow & Bonar 2015). Limiting and strategically locating road expansion may be the most cost-effective and straightforward way to achieve biodiversity and sustainability goals (Laurance et al. 2014; Ibisch et al. 2016).

Fences are used to protect and manage resources, delineate land ownership, and define political boundaries but at the cost of accelerated ecosystem fragmentation. Even fences designed for positive benefits (i.e., conservation fencing) may have negative consequences for others (i.e., limit movement) (Jakes et al. 2018). For example, along the U.S.-Mexico border human migration and drug smuggling causes habitat degradation and pollution as people traveling through remote areas create trails, produce human waste, and discard used supplies (e.g., USGAO 2004, ADEQ 2019). Fences may reduce human traffic and their associated impacts on the environment (Schieffelin 2012). However, the wall may worsen rather than improve vehicular traffic, even after its initial construction. Government vehicles travel over roads and trails in these areas, both for patrolling and to install and maintain fences, walls, and surveillance equipment. Smugglers may be displaced into more remote and relatively pristine areas. Whether a fence is a useful management tool or a problem for ecosystem conservation depends upon the point of view. Solutions based on ecological concepts and empirical data must find balance between social needs and natural ecosystem conservation (Jakes et al. 2018).

Since accelerated construction began in the 1990's, border fence infrastructure has been shown to amplify runoff and exasperate flooding (Norman et al. 2010; Sorrensen 2012). Fences and grated channels, when clogged with runoff debris, act as temporary dams which back up and channelize flood waters. At least half a dozen incidents have occurred at fenced portions of the US-Mexico border since 2006 causing millions in damage and loss of human life (Sadasivam 2018). Additional infrastructure is likely to have similar outcomes through hydrological and hydraulic changes unless environmentally conscious strategies are applied (Granados-Olivas et al. 2016;

Walsh et al. 2016). Flooding effects are not limited to human-related impacts. Flood altered landscapes in South Texas have been shown to directly contribute to the decline of wild turkey (Perotto-Baldivieso et al. 2011) and case studies suggest numerous species may be significantly affected by border security fences and supporting infrastructure (Flesch et al. 200910).

Much of South Texas is occupied by a collection of plants and animals that collectively comprise an ecological zone known as the Tamaulipan thornscrub. As the name implies, this ecoregion stretches from far South Texas east across the Rio Grande/Río Bravo and south through much of the Mexican state of Tamaulipas. It is home to numerous endangered animal and plant species including the ocelot, several migratory birds, the star cactus, the Zapata bladderpod, and Walker's manihot. Ninety-five percent of the native Tamaulipan thornscrub has already disappeared over the last century due to economic development that follows the bulldozing or root-plowing of native vegetation (Schlyer 2018). Construction of a U.S.-Mexico physical barrier would constitute one more destructive action reducing the remaining Tamaulipan thornscrub habitat.

A similarly diverse and relatively pristine ecosystem is present in Texas in what is called the Trans-Pecos, the portion of the state lying west of the Pecos River. This complex area contains a variety of vegetation and animal communities spread across diverse habitats from desert flats to mountain slopes. Although the amount of economic development in West Texas is miniscule compared to South Texas, the potential for irreversible damage to the ecoregion as a result of a physical border barrier and supporting road network is just as significant. One example is the possibility that the proposed barrier would run through Big Bend National Park between the Chisos Mountains and the Rio Grande. The result could negatively affect the park’s population of black bears by cutting

them off from larger populations in Mexico. Restricted gene flow would lead to inbreeding and adverse genetic effects (Lasky et al. 2011). This phenomenon was recently described in populations of the Western Diamondback Rattlesnake (*Crotalus atrox*) divided by an interstate highway (Herrmann et al. 2017). Roadway-induced loss of genetic diversity in this species of rattlesnake found across the desert southwest suggests that more sensitive and threatened or endangered species may also be at risk.

There is concern about barrier construction projects being exempt from environmental review requirements (US Public Law 109-13, Section 102c). This is particularly troubling because much of the land along the border in South and West Texas is federally owned. Activities have already begun in preparation for the partial destruction of the Mission Texas Butterfly Sanctuary, a key stopover point the Monarch butterfly uses during its ~3200 km (~2000 mi) annual migration. There are several other parks/sanctuaries that could be affected including Bentsen-Rio Grande Valley State Park, Resaca de la Palma State Park, and Santa Ana National Wildlife Refuge. These areas are integral to our state and national heritage and as such, should be preserved from a societal point of view as well as for ecological reasons. The Texas Academy of Science echoes those suggestions proposed by Fowler et al. (2018) for any proposed border construction projects: (a) conducting an appropriate environmental review for each proposed barrier section, even if it is not required, (b) limiting the extent of physical barriers and associated roads, (c) designing barriers in such a way as to permit animal passage, and (d) substituting less biologically harmful devices, such as electronic sensors, for physical barriers.

The scientific ecological reasons for giving deep consideration to a physical barrier on the US-Mexico border are many. We should not lose sight of the fact that the impacts of the proposed physical barrier on the landscape and its ecology are irrevocable. Once inflicted, they cannot be undone – nature will either find a way to adapt – almost certainly in reduced numbers and quality – or perish. The final result will affect humanity on both sides of the border.

Literature Cited

ADEQ (Arizona Department of Environmental Quality). 2019. Arizona Border Trash. Available at https://www.azbordertrash.gov/about.html. Archived at https://web.archive.org/web/20190717163120/https://www.azbordertrash.gov/about.html on 17 July 2019.

Clark Barkalow, S. L & S. A. Bonar. 2015. Effects of suspended sediment on early-life stage survival of Yaqui chub, an endangered USA-Mexico Borderlands cyprinid. Transactions of the American Fisheries Society 144:345–351.

Cohn, J. P. 2007. Environmental impacts of a border fence. Bioscience 57:96.

Epps, C. W., P. J. Palsbøll, J. E. Wehausen, G. K. Roderick, R. R. Ramey II & D. R. McCullough. 2005. Highways block gene flow and cause rapid decline in genetic diversity of desert bighorn sheep. Ecology Letters 8:1029–1038.

Flesch, A. D., C. W. Epps, J. W. Cain III, M. Clark, P. R. Krausman & J. R. Morgart. Potential effects of the United States-Mexico border fence on wildlife. 2010. Conservation Biology 24:171–181.

Forman, R. T. T. & L. E. Alexander. 1998. Roads and their major ecological effects. Annual Review of Ecology and Systematics 29:207–231.

Fowler, N. L., T. Keitt, O. Schmidt, M. Terry & K. Trout. 2018. Border wall: Bad for biodiversity. Frontiers in Ecology and the Environment 16:137–138.

Granados-Olivas, A., L. C. Alatorre-Cejudo, D. Adams, Y. L. Serra, V. H. Esquivel-Ceballos, F. A. Vázquez-Gálvez, M. E. Giner & C. Eastoe. 2015. Runoff modeling to inform policy regarding development of green infrastructure for flood risk management and groundwater recharge augmentation along an urban subcatchment, Ciudad Juarez, Mexico. Journal of Contemporary Water Research and Education 159:50–61.

Haddad, N. M., L. A. Brudvig, J. Colbert, K. F. Davies, A. Gonzalez, R. D. Holt, T. E. Lovejoy, J. O. Sexton, M. P. Austin, C. D. Collins, W. M. Cook, E. I. Damschen, R. M. Ewers, B. L. Foster, C. N. Jenkins, A. J. King, W. F. Laurance, D. J. Levey, C. R. Margules, B. A. Malbourne, A. O. Nicholls, J. L. Orrock, D.-X. Song & J. R. Townshend. 2015. Habitat fragmentation and its lasting impact on Earth's ecosystems. Science Advances 1:e1500052

Herrmann, H. W., K. M. Pozarowski, A. Ochoa & G. W. Schuett. 2017. An interstate highway affects gene flow in a top reptilian predator (*Crotalus atrox*) of the Sonoran Desert. Conservation Genetics 18:911–924.

Ibisch, P. L., M. T. Hoffmann, S. Kreft, G. Pe'er, V. Kati, L. Biber-Freudenberger, D. A. DellaSala, M. M. Vale, P. R. Hobson & N. Selva. 2016. A global map of roadless areas and their conservation status. Science 354:1423–1427.

Jakes, A. F., P. F. Jones, C. Paige, R. G. Seidler, & M. P. Huijser. 2018. A fence runs through it: A call for greater attention to the influences of fences on wildlife and ecosystems. Biological Conservation 227:310–318.

Lasky, J. R., W. Jetz & T. H. Keitt. 2011. Conservation biogeography of the US-Mexico border: A transcontinental risk assessment of barriers to animal dispersal. Diversity and Distributions 17:673–87.

Laurance, W. F., G. R. Clements, S. Sloan, C. S. O'Connell, N. D. Mueller, M. Gossem, O. Venter, D. P. Edwards, B. Phalan, A. Balmford, R. Van Der Ree & I. Burgues Arrea. 2014. A global strategy for road building. Nature 513:229–232.

Liu, J., L. Baeten & K. Verheyen. 2019. Biodiversity on international borders requires solid inventories. BioScience 69:409.

Montgomery, D. R. 1994. Road surface drainage, channel initiation, and slope instability. Water Resources Research 30:1925–1932.

Norman, L. M., H. Huth, L. Levick, I. S. Burns, D. P. Guertin, F. Lara-Valencia & D. Semmens. 2010. Flood hazard awareness and hydrologic modelling at Ambos Nogales, United States-Mexico border. Journal of Flood Risk Management 3:151–165.

Perotto-Baldivieso, H. L., X. B. Wu, M. J. Peterson, F. E. Smeins, N. J. Silvy & T. W. Schwertner. 2011. Flooding-induced landscape changes along dendritic stream networks and implications for wildlife habitat. Landscape and Urban Planning 99:115–122.

Peters R., W. J. Ripple, C. Wolf, M. Moskwik, G. Carreón-Arroyo, G. Ceballos, A. Córdova, R. Dirzo, P. R. Ehrlich, A. D. Flesch, R. List, T. E. Lovejoy, R. F. Noss, J. Pacheco, J. K. Sarukahn, M. E. Soulé, E. O. Wilson, J. R. B. Miller, and 2556 scientist signatories from 43 countries (including 1472 from the United States and 616 from Mexico). 2018. Nature divided, scientists united: US–Mexico border wall threatens biodiversity and binational conservation. Bioscience 68:740–743.

Rocca, J. D., M. Simonin, J. R. Blaszczak, J. G. Emakovich, S. M. Gibbons, F. S. Midani & A. D. Washburne. 2019. The Microbiome Stress Project: Toward a global meta-analysis of environmental stressors and their effects on microbial communities. Frontiers in Microbiology 9:3272.

Sadasivam, N. 2018. The Texas-Mexico border wall comes with a dangerous, costly side effect: flooding. The Texas Observer. Available at https://www.texasobserver.org/the-texas-mexico-border-wall-comes-with-a-dangerous-costly-side-effect-flooding/. Archived by WebCite at http://www.webcitation.org/77DT3wRNu on 28 March 2019.

Schieffelin, S. 2012. Environmental impact of fences. National Border, National Park: A History of Organ Pipe Cactus National Monument. Available at https://organpipehistory.com/nature/environmental-impact-of-fences/. Archived by WebCite at http://www.webcitation.org/77DSep63v on 28 March 2019.

Schlyer, K. 2018. Borderlands Refuge: Saving an endangered ecosystem in the Lower Rio Grande Valley. American Forests 124(2):24–31.

Sorrensen, C. L. 2012. A history of transboundary storm water flows: Flooding, tunnels, and the spatial incongruity of the U.S.-Mexico border. Journal of Historical Geography 38:447–457.

Trombulak, S. C. & C. A. Frissell. 2000. Review of ecological effects of roads on terrestrial and aquatic communities. Conservation Biology 14:18–30.

USDHS, USCBP, USBP (United States Department of Homeland Security, U. S. Customs and Border Protection, U. S. Border Patrol). 2008. Environmental stewardship plan for the construction, operation and maintenance of tactical infrastructure U. S. Border Patrol Rio Grande Valley Sector, Texas. [Washington, D. C.] 190 pp.

USGAO (United States General Accounting Office). 2004. Border Security: Agencies need to better coordinate their strategies and operations on federal lands. GAO-04-590. ii + 56 pp.

Wagg, C., S. F. Bender, F. Widmer & G. A. van der Heijden. 2014. Soil biodiversity and soil community composition determine ecosystem multifunctionality. Proceedings of the National Academy of Sciences of the United States of America 111:5266–5270.

Walsh, C. J., D. B. Booth, M. J. Burns, T. D. Fletcher, R. L. Hale, L. N. Hoang, G. Livingston, M. A. Rippy, A. H. Roy, M. Scoggins & A. Wallace. 2016. Principles for urban stormwater management to protect stream ecosystems. Freshwater Science 35:398–411.