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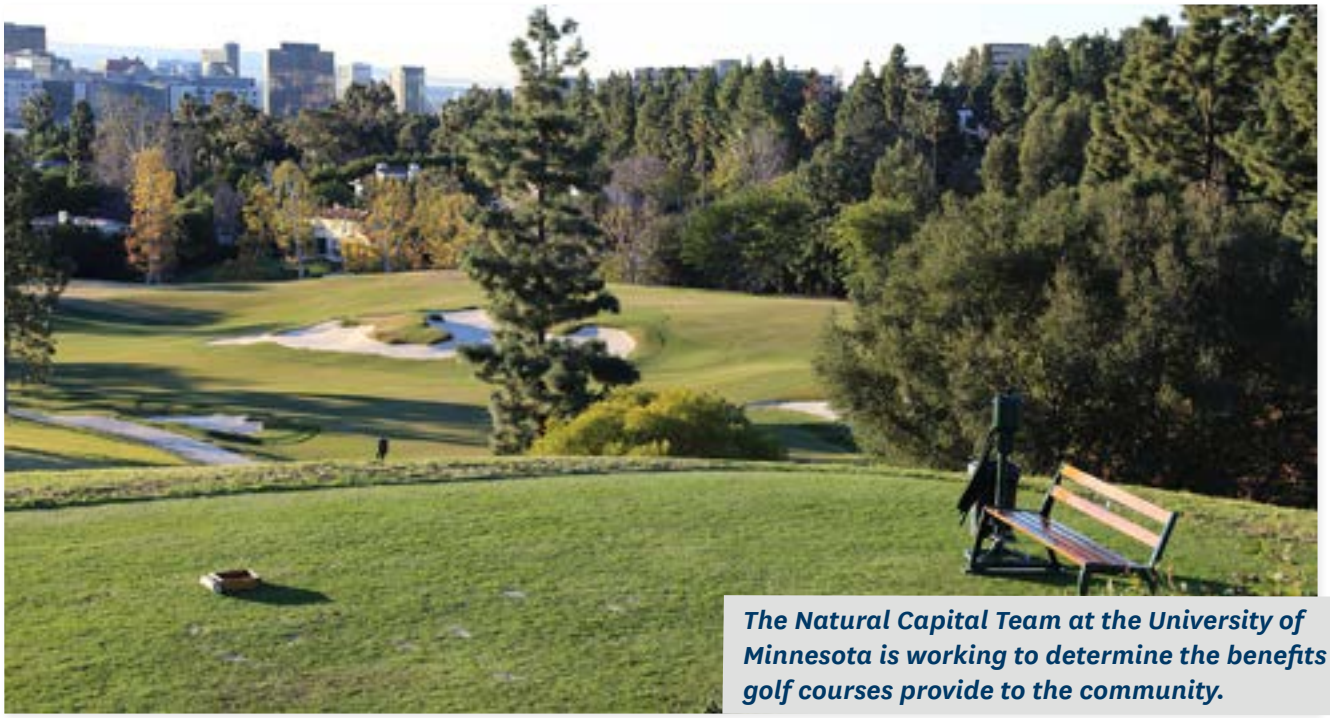

The Natural Capital Team at the University of Minnesota is working to determine the benefits golf courses provide to the community.

ECOSYSTEM SERVICES PROVIDED BY GOLF COURSES

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Key Takeaways

- Researchers at the University of Minnesota quantified the ecosystem services provided by the 135 golf courses in the Twin Cities metropolitan area.
- The research also analyzed how ecosystem services from golf courses might change if the golf courses were converted to one of five other land uses.
- Urban ecosystem service assessments are critical to ensuring that the value of nature becomes a standard component of urban planning and a more recognized and understood set of benefits provided by golf courses.
- Golf courses provide the greatest amount of cooling as compared to other land uses and are more supportive of pollinators than residential and industrial areas.
- Natural areas and city parks export less nitrogen and phosphorus than golf courses, while suburban and urban residential developments export more nitrogen.

It is likely that even someone in your community who hasn't played golf would still be able to describe what a golf course looks like. However, it is unlikely that someone who plays golf would be able to describe the benefits a golf course provides to the surrounding community beyond recreation. Much like a park, a golf course is part of a community's green space and supports the public in many more ways. With support from the USGA, the Natural Capital Project team at the University of Minnesota is working to better understand the benefits golf courses provide to the community - i.e., - the value of ecosystem services provided by golf courses.

Ecosystem services are the benefits that humans receive from the environment, such as carbon sequestration, storm water nutrient retention, and pollination services. Ecosystem services have been modeled and assessed in broader spatial planning contexts in rural and agricultural landscapes. Until recently, they were largely ignored in urban landscapes where there are more variations in the supply of ecosystem services stemming from buildings, pavement, and particular management of open spaces. To date, a straightforward, replicable approach to quantifying multiple urban ecosystem services has yet to emerge. There has been an increasing interest in integrating ecosystem services into urban planning decisions, but their inclusion in urban planning remains limited.

As the world transitions to a more urban lifestyle, it is critical we understand the consequences of development decisions on urban green spaces. Development pressures and municipal policies often influence the fate of ecosystem services from urban green spaces and as an urban green space, golf courses acutely feel these pressures. With an increasing number of people moving into urban areas, this pressure is growing. Golf courses currently represent a substantial part of urban areas in the United States, with approximately 14,200 courses comprising nearly 2.3 million acres as of 2015. Examining the environmental and societal impact of changing a golf course's land footprint to a different land cover type can help to assess the impacts of that decision on the ecosystem services provided from that land area to the surrounding region. Many golf courses are located in urban areas and the potential pressures to develop them are rising, quantifying the ecosystem services they provide in urban environments is an important area of research needed for urban planning.

Research Methodology

Our research team quantified ecosystem services provided by each of 135 golf courses in the Twin Cities metropolitan area that includes St. Paul, Minneapolis and the surrounding suburbs in seven counties: Anoka, Hennepin, Carver, Scott, Ramsey, Dakota and Washington. This metropolitan area currently supports a population of more than three million people and contains a mix of land cover, ranging from rural farmland to dense urban centers. The potential for landscapes to provide ecosystem services results from a combination of land cover and land use management, with the former generating services that are altered by the latter. For example, the fertilization and mowing frequency of grass cover within urban areas will vary among golf courses, home lawns, city parks and cemeteries.

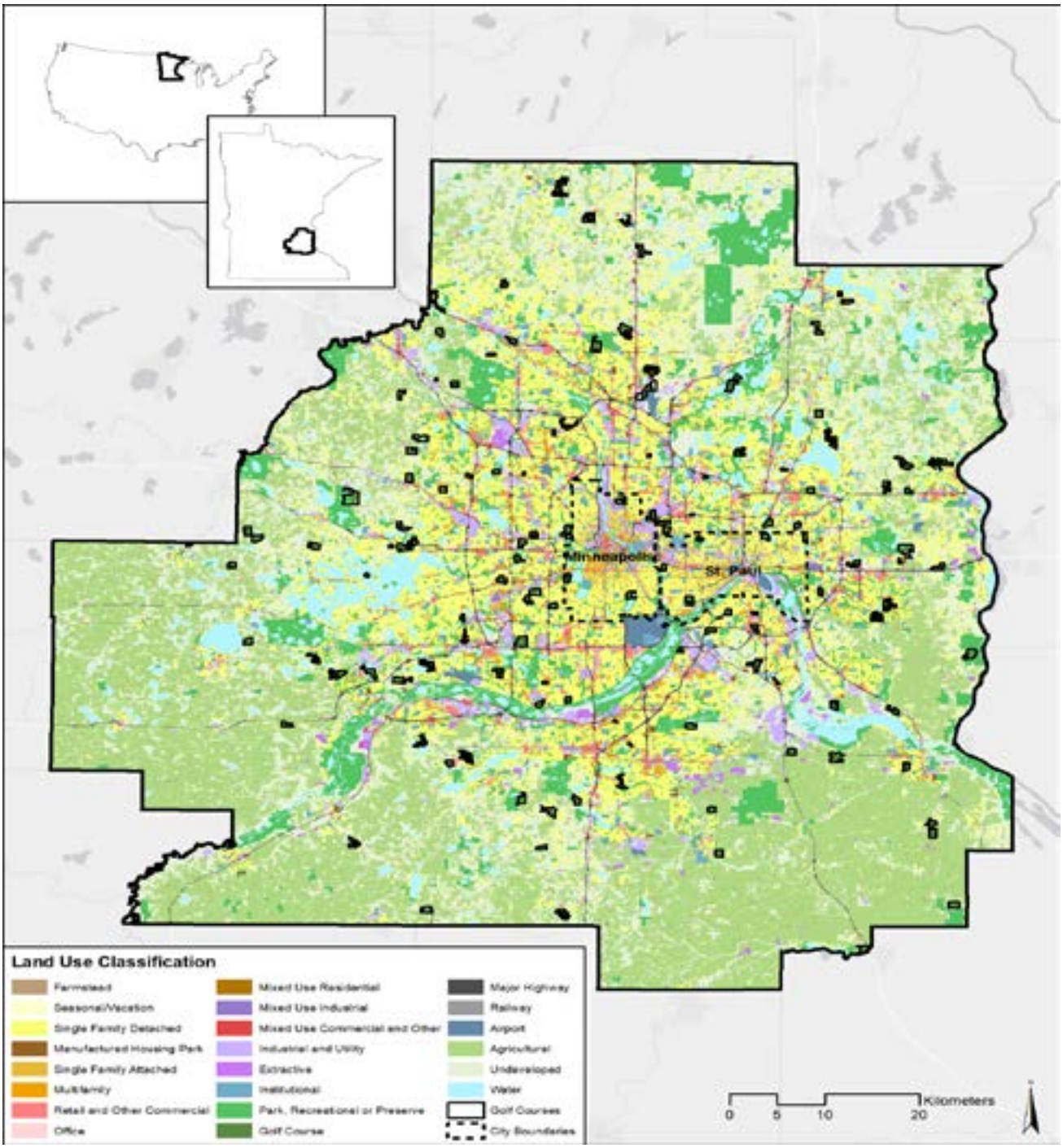

Figure 1. *The location of the Twin Cities metro area and its generalized land use zoning classifications, with golf courses and primary municipalities outlined.*

We also examined how the ecosystem services provided from golf courses might change if the land footprint of golf courses were changed to one of five other land uses below:

1. Natural area
2. City park
3. Suburban residential
4. Urban residential
5. Industrial park

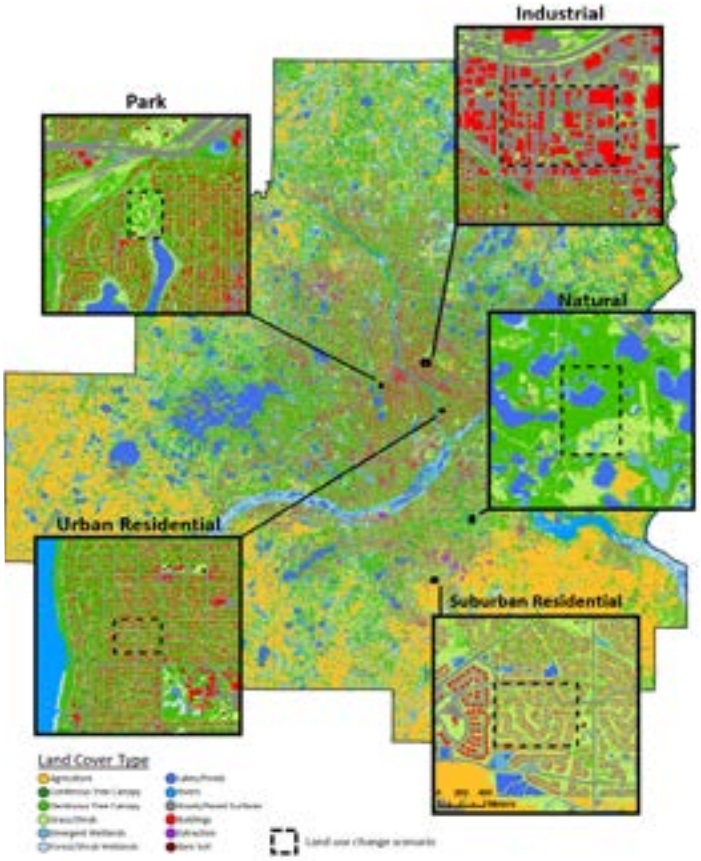

Figure 2a. *Land use change (LULC) scenario to assess changes in ecosystem services (1m resolution). LULC scenarios were clipped to outlines (dashed) to create source 'tiles' for scenario generation (see Figure 3).*

To evaluate how ecosystem services might change, we analyzed three specific ecosystem services provided by vegetative land cover were analyzed including:

- Urban cooling (reduction in temperature from the urban heat island)
- The retention of nutrients (nitrogen and phosphorous) from stormwater runoff

Our researchers parameterized previously developed predictive models specifically for use in urban areas, accounting for management practice as a function of land use. The golf course land type was used as a baseline for comparison.

Results

In general, golf courses provided an intermediate amount of services compared to other five land use options (Figure 3). When compared to more intensive land uses, golf courses provide greater ecosystem services but with the exception of urban cooling, they provide reduced. Our analysis suggests that golf courses provide the greatest amount of cooling as compared to other land uses. The cooling services provided by golf courses likely arises from the large, contiguous mixes of managed grass and trees found on courses.

"Our analysis suggests that golf courses provide the greatest amount of cooling as compared to other land uses."

The cooling green spaces on golf courses are similar to those in city parks and natural areas, resulting in similar levels of urban heat island mitigation. The urban heat island model predicted that if a golf course were developed into residential housing, the nighttime temperature experienced by homes within 1/3rd of a mile of the development would increase by 0.17 to 0.23 degrees F per evening—increases which are even higher for houses immediately adjacent to the former golf course.

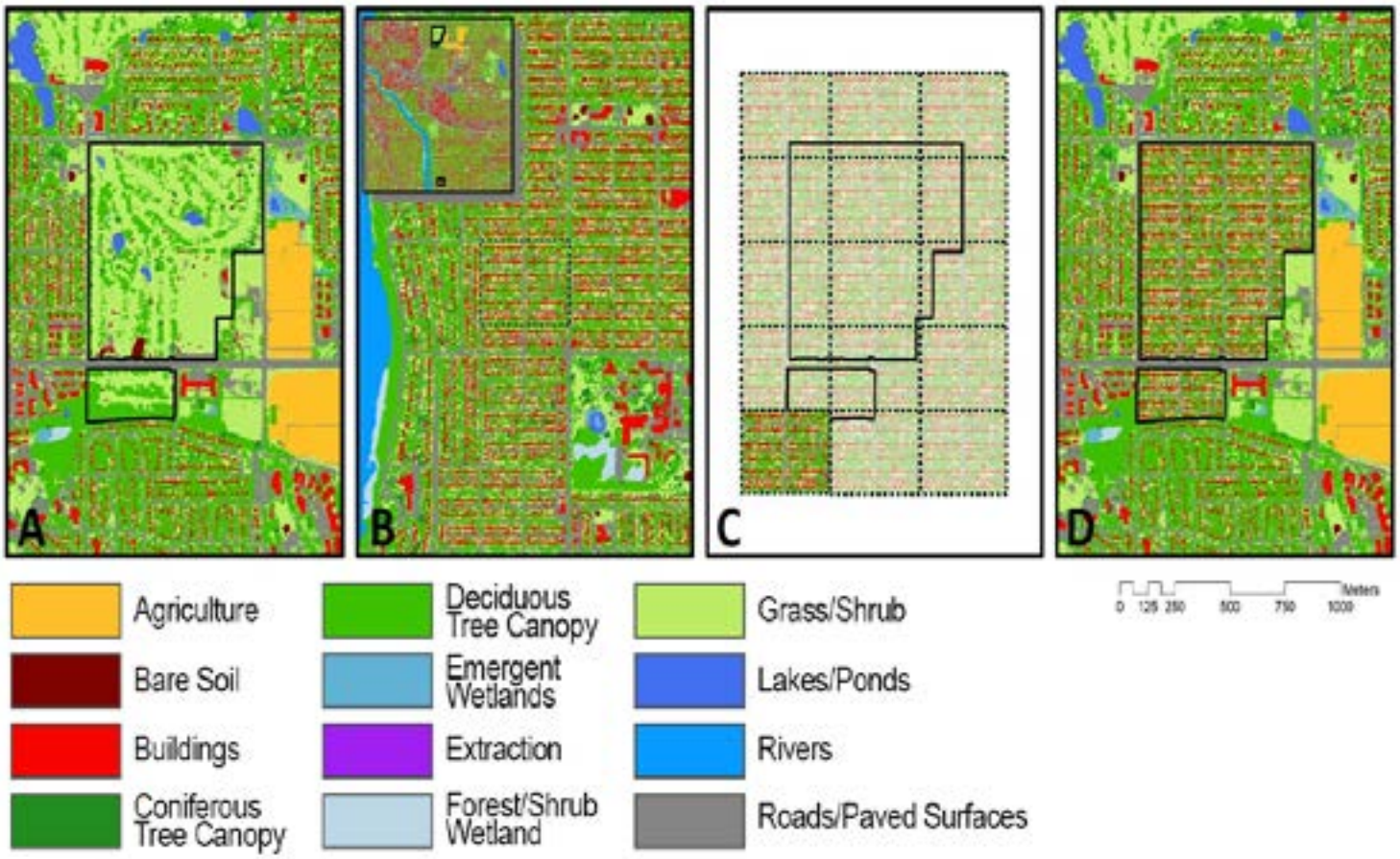

Figure 2b. The wallpapering method takes a user-inputted 'tile' (b) representing some urban typology (urban residential development), repeats that tile (c) to 'wallpaper' to encompass some parcel (a), and applies that to the original parcel to predict LULC change (d).

Our results suggest that golf courses are more supportive of pollinators than residential and industrial areas (Figure 3). While the greens, tees, fairways and rough do not provide suitable habitat for pollinators, there are often natural areas within courses that can provide good habitat. This is similar to suburban residential areas which have unsuitable habitat mixed with habitat that provides good nesting and floral quality. With more pavement and buildings, which provide no nesting or foraging habitat, our analysis suggests that urban residential developments and industrial areas reduce pollinator habitat and abundance accordingly when compared to golf courses.

Golf courses fall squarely between more naturalized green spaces and more managed urban areas in terms of predicted nutrient export. Our results suggest that natural areas and city parks export less nitrogen and phosphorus than golf courses, while suburban and urban residential developments export more. This can be attributed to the balance between fertilization and vegetative nutrient uptake – i.e., retention - as well as the spatial patterns in more developed landscapes. Golf course playing surfaces are fertilized throughout the growing season, with nitrogen and phosphorus. However, turfgrass on golf courses is also highly effective at utilizing and retaining nutrients, retaining 90% of nitrogen and 92% of phosphorous applied, similar to or better than vegetative cover on residential lawns, 93% and 44%, respectively (Rice and Horgan 2013). Higher retention is not enough to entirely offset the estimated volume of nutrients

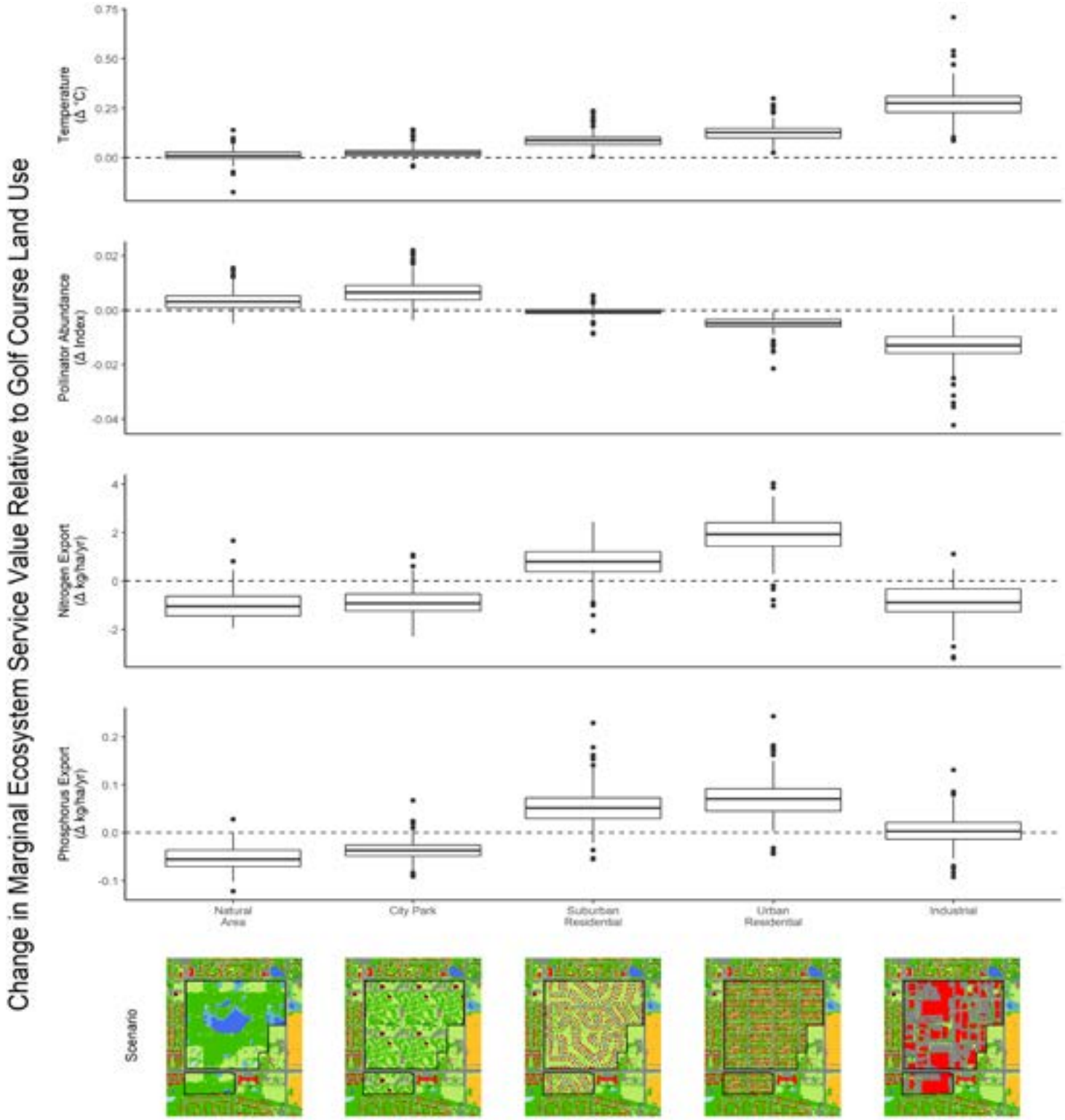

Figure 3. In general, golf courses provided an intermediate amount of services compared to other five land use options.

placed on the landscape, causing golf courses to provide a disservice compared to unfertilized natural areas and city parks.

When insights from past research on application and retention rates are applied to a landscape, we find that residential areas with high homeowner inputs and impervious surfaces have higher net nutrient export than golf courses. Although golf course fertilization rates are on par with residential lawns, golf courses provide additional areas of green space mostly free from paved surfaces and potential runoff problems. In residential and other urban development, nutrient retention is generally reduced by pavement and connected elements of drainage networks e.g., streets and storm drains - which efficiently carry runoff from the landscape downstream and provide little opportunity for further retention without the aid of stormwater management practices like ponds and rain gardens. Further, leaf litter entering streets from nearby trees can contribute substantially to nutrient export by street runoff.

Examining the ecosystem services provided by golf courses can highlight environmental benefits to communities and can help guide golf course management of out-of-play-areas. For example, as a part of the urban green space network, golf course management goals could include the support of local biodiversity, migratory biodiversity, semi-aquatic and wetland-dependent species, in addition to the maintenance and improvement of a variety of ecosystem services we studied.

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Beyond golf courses, this work also can provide insights for urban planners interested in exploring public consequences of land cover changes in cities. As a portfolio of expected ecosystem services from different urban land uses, our results allow both public and private entities to better weigh the costs and benefits of different urban development schemes by illuminating previously unquantified environmental consequences for the surrounding community. The increase of urban development is an inevitable process in a rapidly urbanizing world. Our work supported by the USGA provides an opportunity to assess the impact of alternative development scenarios on multiple ecosystem service benefits. While our analysis centered on possible futures for golf courses in the Twin Cities metro area, we are replicating our analysis in Atlanta, Dallas, Detroit, Phoenix, Philadelphia and the San Francisco Bay Area to better understand how ecosystem services are influenced by different ecological and climatological situations. It is clear that urban ecosystem service assessments are critical to ensuring that the value of nature becomes a standard component of urban planning and a more recognized and understood set of benefits provided by golf courses.

REFERENCES

Rice, P. J., and B. P. Horgan. 2013. Evaluation of nitrogen and phosphorus transport with runoff from fairway turf managed with hollow tine core cultivation and verticutting. Science of the Total Environment 456:61–68.

