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Transit-oriented smart growth can reduce life-cycle environmental impacts and household costs in Los Angeles

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ABSTRACT

The environmental and economic assessment of neighborhood-scale transit-oriented urban form changes should include initial construction impacts through long-term use to fully understand the benefits and costs of smart growth policies. The long-term impacts of moving people closer to transit require the coupling of behavioral forecasting with environmental assessment. Using new light rail and bus rapid transit in Los Angeles, California as a case study, a life-cycle environmental and economic assessment is developed to assess the potential range of impacts resulting from mixed-use infill development. An integrated transportation and land use life-cycle assessment framework is developed to estimate energy consumption, air emissions, and economic (public, developer, and user) costs. Residential and commercial buildings, automobile travel, and transit operation changes are included and a 60-year forecast is developed that compares transit-oriented growth against growth in areas without close access to high-capacity transit service. The results show that commercial developments create the greatest potential for impact reductions followed by residential commute shifts to transit, both of which may be effected by access to high-capacity transit, reduced parking requirements, and developer incentives. Greenhouse gas emission reductions up to 470 Gg CO_2-equivalents per year can be achieved with potential costs savings for TOD users. The potential for respiratory impacts (PM_{10}-equivalents) and smog formation can be reduced by 28–35%. The shift from business-as-usual growth to transit-oriented development can decrease user costs by $3100 per household per year over the building lifetime, despite higher rental costs within the mixed-use development.

1. Integrated transportation and land-use planning and environmental assessment

Transit-oriented development (TOD) is an urban planning strategy which can be paired with regional policies to enable reductions in energy use and environmental impacts of urban living and transportation (Chester et al., 2013a, Kimball et al., 2013). Recent studies have challenged whether density is by itself an enabler of these reductions and find that mixed-use designs, access to high-capacity transit, jobs-housing balance, incentives for development, and balanced parking policy are each important underlying drivers (Chatman, 2013, Churchman, 1999, Echenique et al., 2012, Loukaitou-sideris, 2010, Cervero and Duncan, 2006, Tumlin and Millard-ball, 2003). Creating TOD can encourage behavioral changes which lead to environmental benefits. For example, mixed-use developments can reduce travel distances for residents, favorable land parcel zoning can entice developers to act with reduced permits and special approvals, and parking restrictions correlate with increased biking, walking, and transit use. Some literature questions the ability to isolate a stimulus and response relationship, which can complicate the estimation of behavioral effects after TOD construction (Frank, 2000, Mokhtarian and Cao, 2008). While these factors can play a role in the success of TOD to reduce reliance on automobile travel and achieve energy use and environmental benefits, there are significant opportunities for improving the assessment of these benefits. Environmental life-cycle assessment (LCA), which calls for the inclusion of construction, use, maintenance, and end-of-life analysis, is a powerful framework for assessing the benefits and costs of TOD, yet its potential has not been fully realized in the increasingly important area of urban sustainability. Our intended contribution to this field is a novel combination of new integrated transportation and land-use LCA methods with behavioral assessment of neighborhood infrastructure changes over time.

TOD has potential value in the Los Angeles Metropolitan area (further referred to as LA) because of significant ongoing investment in accessibility through transit system deployment and state environmental legislation (CALIFORNIA AB32, 2006, California SB375, 2008). Senate Bill 375 (SB375) calls for the development of Sustainable Community Strategies which are in part plans for

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reducing greenhouse gas (GHG) and other air emissions through integrated transportation and land use planning. Within LA, an adaptive reuse ordinance is in place to expedite the redevelopment process for old and under-utilized buildings. Bond sales and tax increases have been allocated to help fund new transit operations, urban infill, and TOD (California prop1C, 2006, LAcounty measure R, 2008). Southern California Association of Governments' Compass Blueprint Strategy states that regional mobility, livability, prosperity, or sustainability should not be sacrificed as the region grows (SCAG, 2013). These policies, coupled with population growth projections, create a need for a comprehensive framework for assessing the environmental and economic outcomes of TOD.

The Gold Light Rail Transit (LRT) line opened in 2003 and the Orange Bus Rapid Transit (BRT) line in 2008, and both have been extended with follow-up projects after experiencing strong ridership growth and development near stations. Around the Gold Line, development has been spurred by incentives including public subsidies, reduced parking requirements, and changes to open space requirements (Loukaitou-sideris, 2010). Developers have recognized the demand for housing along the Gold Line and construction around the line has been aided by a low cost permitting process. New development has also occurred along the Orange Line corridor.

There has been no integrated transportation and land use environmental assessment framework that includes the impacts of deploying infrastructure, use of that new infrastructure, and the avoided behavior changes that may occur. To this end, an integrated transportation and land use life-cycle assessment (ITLU-LCA) framework is created building on the work of Kimball et al. (2013) and Chester et al. (2013a) to assess the environmental and economic impacts of targeted mixed-use developments around the Gold and Orange Lines. The framework uses traditional building and transportation environmental LCA methods, but also incorporates an estimate of household behavioral changes. The assessment provides an understanding of how upfront infrastructure, monetary, and environmental investments can be coupled with smart growth policies to produce environmental and economic benefits in the long-term.

2. A life-cycle framework for assessing TOD

An assessment of the potential development strategies around Gold and Orange Line stations is developed by starting with an available land assessment, next designing appropriate TOD for each station, then estimating the redevelopment impacts, and finally developing a household and transportation behavioral assessment. While some TOD has already occurred near both transit lines (including North Hollywood, Memorial Park, and Del Mar stations), the long-run nature of the new transit lines raises questions about how other land may evolve in the future, whether through market forces or policy incentives. This ITLU-LCA evaluates the land characteristics and availability around the stations of each line to estimate the long-run effects of land turnover from market forces, developer incentives, and adaptive reuse. The ITLU-LCA framework is used to assess proposed urban form changes around the Gold and Orange Line stations, the resulting changes in residential living, commercial activity, automobile travel, and transit use and the associated energy use, air emissions, and costs of the system (Kimball et al., 2013, Chester et al., 2013a). As LA's population is expected to grow from 9.8 to 11.6 million (CALIFORNIA DOF, 2013), shifting the next household into a new residential unit with walking access to high-capacity transit has the potential to change travel behavior and building energy use.

2.1. Scenario definition

Spatial analysis of current land use within 0.5 mile (0.8 km) of the stations is first performed to assess the land available for redevelopment, as shown in Fig. 1. Parcels are identified through one of two approaches: an *Underutilized (referred to as U-TOD)*

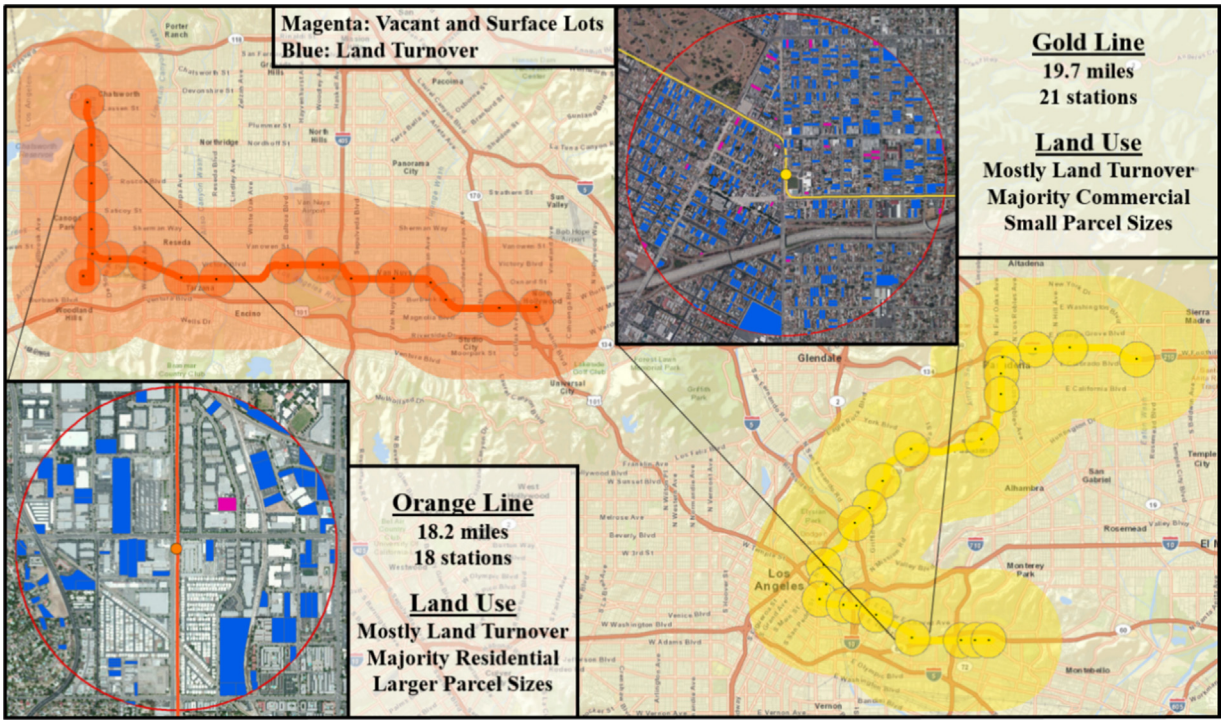

Fig. 1. Transit Location Map with Land-Use Assessment Diagrams. The locations of the Gold and Orange Lines are shown within Los Angeles. Around each station is a half-mile circle; the acceptable walking distance to a transit station. Using this radius, available land parcels are identified for development. Very few vacant lots exist and those present are generally small, which means that few opportunities exist for consolidated development efforts. Also shown is the 2-mile business as usual catchment area for each transit line.