August 2013

Geodesign in Practice: Designing a Better World

esri

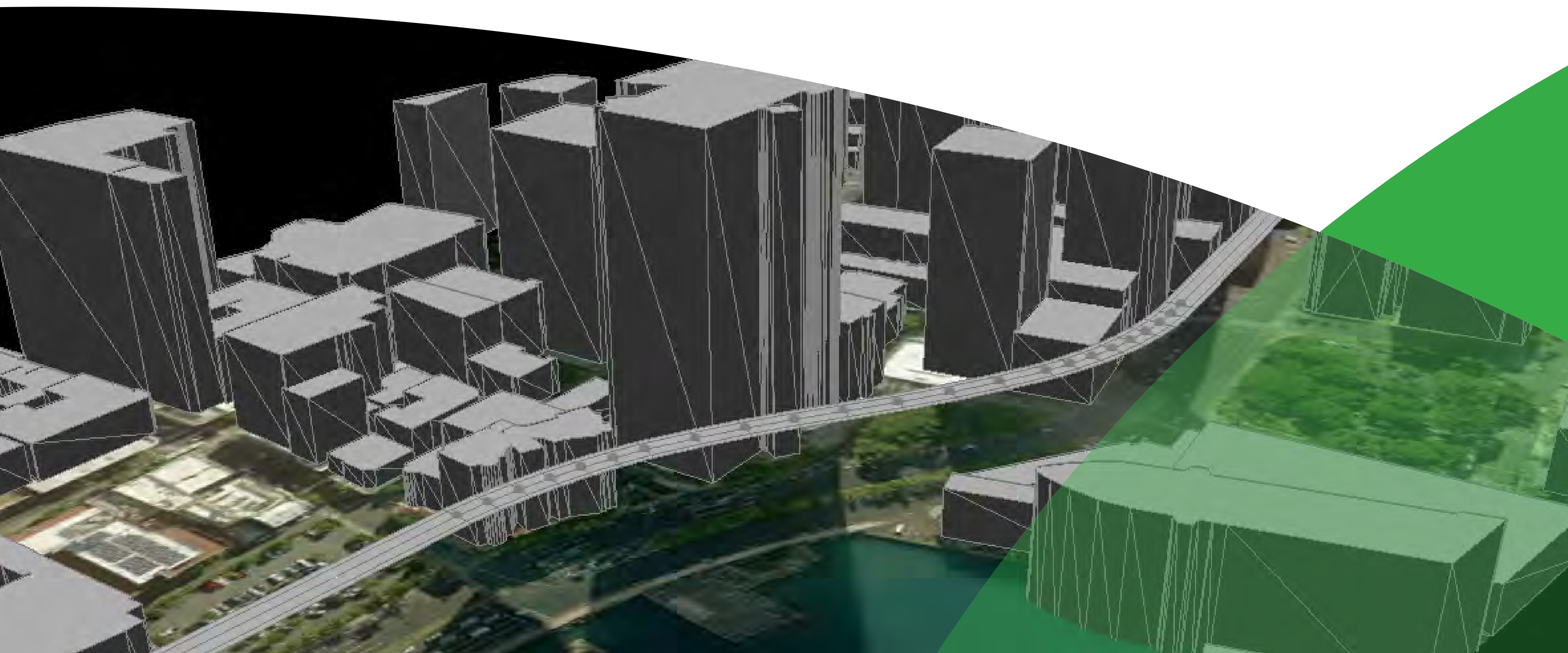


Table of Contents

Introduction

Our world faces serious challenges, and it's clear that we need to work together to collectively create a better future.

Geodesign offers an iterative design method that uses stakeholder input, geospatial modeling, impact simulations, and real-time feedback to facilitate holistic designs and smart decisions. It gives us a framework for understanding, analyzing, and acting, with the ultimate goal of creating a better future for us all. Geodesign tools and techniques offer what may be our best hope for transforming the way we interact with the world.

While there is still much more to do in order to transform geodesign into a full-fledged movement, the 12 articles in this e-book are proof positive we have already started to fundamentally transform how we think about making the world a better place. Geodesign is here to stay.

—Shannon McElvaney, Community Development Manager and Geodesign Evangelist, Esri

Geodesign and Wildlife Corridors

By Ryan Perkl, Assistant Professor, School of Landscape Architecture and Planning, University of Arizona

Over the last decade, wildlife corridors have become a cornerstone for promoting species persistence within conservation planning. While corridors have become an increasingly viable conservation strategy, issues still remain in translating modeled corridors beyond plans into implementable designs. Although modeled corridors result in the delineation of boundaries, they lack planning and design guidance for programming the appropriate vegetative types and patterns that may be desirable throughout the corridor. This represents a considerable implementation gap for practitioners interested in employing corridors as part of a conservation or land-use planning strategy.

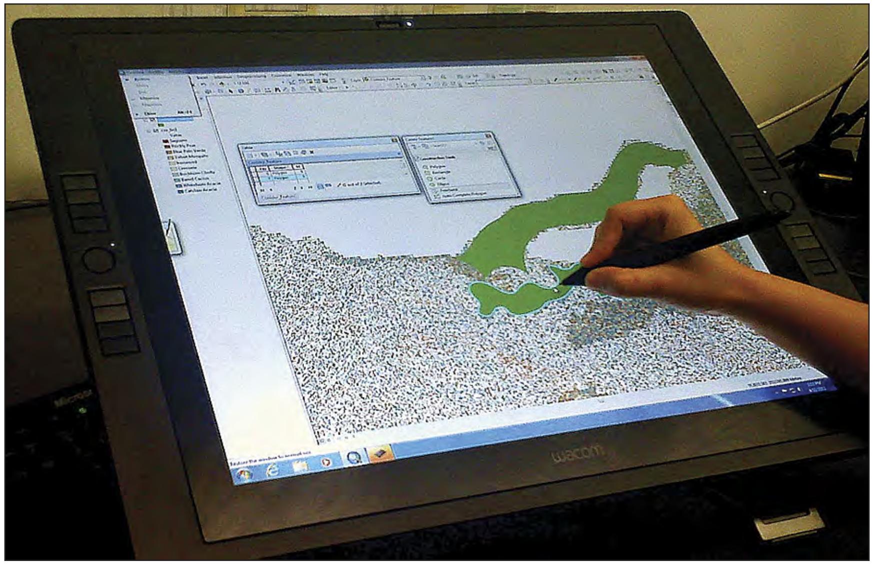
This University of Arizona team proposes that a modeled corridor by itself is not a design but rather a first step toward design. Design requires attention to site-specific characteristics; functions; and even more qualitative variables, such as aesthetics, as a means of informing the fine-grained decisions necessary for implementation. Further, the team believes that the growing field of geodesign holds promise in moving toward this end, as it strikes the needed balance between developing the analytically based methods required in conservation planning and the graphic and communicative language necessary for design

Saguaro and mesquite are among the many plants that should populate the corridors through the Sonoran Desert.

implementation. As a result, this article illustrates and discusses the development of a new tool while showcasing the marriage of geodesign with real-world applications in conservation planning and design.

A New Tool—ADM

The Automated Design Module (ADM) described here was used to inform the design of wildlife corridors within the Sonoran Desert, an incredibly biologically diverse region that spans southern Arizona and California in the United States and Baja California and Sonora in Mexico. Corridors were modeled between Saguaro National Park east and west. Located adjacent to the city of Tucson, Arizona, Saguaro National Park comprises two distinct districts, which are separated by the city. The wildlife in this area includes the mountain lion, bobcat, bighorn sheep, mule deer, javelina, gila monster, desert tortoise, red-tailed hawk, and the charismatic pygmy owl, among others.



Landscape elements are digitized using a Wacom monitor and incorporated as part of the pattern generator process within the Automated Design Module (ADM). Integrating such an interface allows vegetation clustering and linearity to be addressed in the final corridor designs and represents the inclusion of geodesign-based methodologies.

The ADM was created using Spatial Modeler within ArcGIS 10. The ADM starts by evaluating the landscape's capability to support various species of native vegetation specific to the Sonoran Desert. Vegetation species include the iconic saguaro cactus, palo verde, agave, cholla, cottonwood, creosote bush, prickly pear, and velvet mesquite, among others. Individual capability models were developed utilizing a standard raster-based overlay process that parameterized landscape characteristics and factors known to impact the distribution and persistence of each plant species. The resultant output of each model yields a capability surface that delineates the portions of the landscape most capable of supporting each plant type. The end result of this process yields a library of scored capability surfaces for each plant type.

The ADM then employs a selection algorithm that identifies the plant type from the library that exhibits the highest capability score for each cell within the corridor. This results in the selection of the plant type that is most appropriate for each cell. An additional query is then initiated to identify the next best plant type for each cell, and a corresponding dataset for each of these processes is derived. Where cells are equally capable of supporting multiple plant types, a random selection generator is employed to break ties. Together, these surfaces are utilized as the foundation for populating the modeled corridor's interior with the most appropriate site-specific vegetation.

The selection process can be further refined based on the requirements of the focal wildlife species for which the corridor

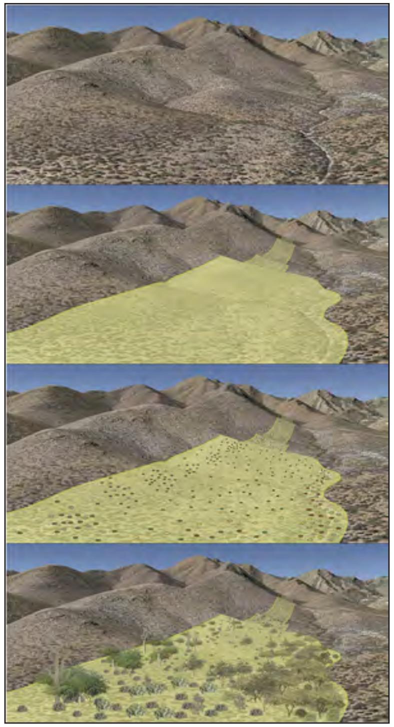
The desert tortoise is among the many animals that would negotiate the corridors.

is being designed. Individual wildlife species may require varying levels of vegetation diversity and/or density to facilitate movement. As such, vegetation diversity is a parameter within the ADM that can be used to populate the modeled corridor with the desired level of variation among plant types. For focal species, such as the pygmy owl, which requires the presence of saguaro cacti, the ADM can be parameterized to select the most optimal plant type for each cell while still meeting the desired criteria of the focal species. For species like mountain lions, however, which prefer more diverse conditions, the ADM can derive more assorted assemblages of vegetation through employing a random selection algorithm across all optimal and second-best plant types for each cell until the desired level of vegetation diversity is achieved.

The ADM employs a similar selection algorithm for determining the relative density of vegetation within the corridor. For example, the pygmy owl prefers more densely vegetated conditions. When these conditions are desired, the ADM selects and populates all or most of the available cells. Bighorn sheep, on the other hand, are more comfortable with moving through less densely vegetated conditions. In these instances, the ADM drops cells from being populated to achieve the desired condition. Additionally, the ADM can link vegetation density with other modeled connectivity outputs, such as flows of wildlife movement. When linked with current-flow surfaces of species movement, for example, the ADM can be parameterized to populate the corridor interior with greater vegetation density in areas where greater species movement has been modeled, and vice versa.

Vegetation Patterns

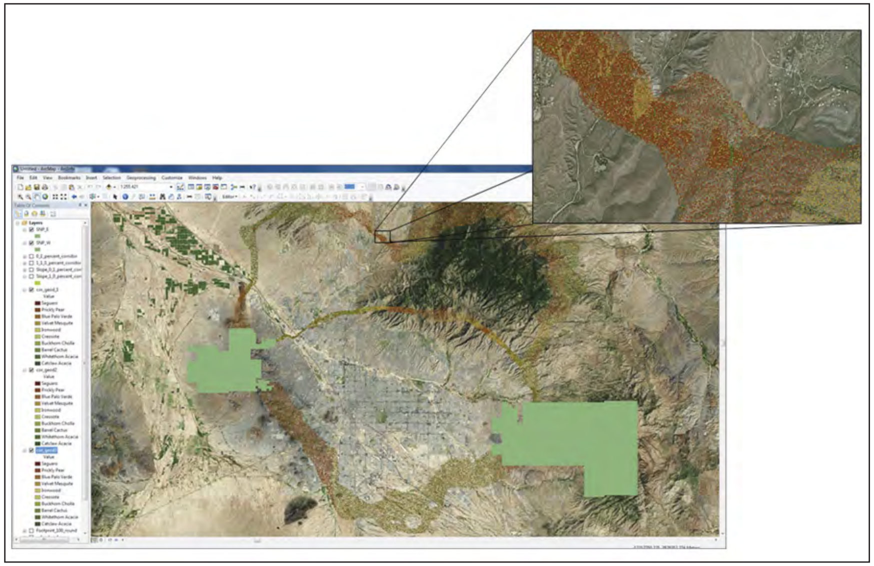
The ADM also has the ability to place vegetation in patterns that are known to either facilitate or impede wildlife movement. A series of pattern generators are employed to alter the relative



A typical Sonoran Desert scene (top), followed by a modeled wildlife corridor (second), followed by specific vegetation types and patterns generated by the ADM represented as points populating the corridor (third), and a final corridor design as derived from the ADM vegetation library (bottom).

dispersal, clustering, and linearity of the spatial locations of all vegetation assemblages to encourage movement where it is desirable throughout the interior of the corridor. Conversely, where movement is to be discouraged, the ADM can be parameterized to include linear patterns that have been documented to reduce species movement. Such patterns may be desirable along the periphery of the corridor, where species conflicts with adjacent land uses and mortality may be elevated. In this way, the ADM uses patterns to direct movement to where it is most desirable within the corridor and discourage it elsewhere, thus increasing the corridor's function through design.

Additionally, development of the ADM provides a more seamless design interface, allowing



The ADM populates the corridors with individual cells coded and arranged based on the optimal vegetation type and configuration for that location. This results in design guidance for both vegetation type and pattern integration, which can be utilized to create more functional wildlife corridors.

analysis, modeling, and design all to be completed within the ArcGIS environment without the need to export geospatial data to an alternative graphic design platform. This can be accomplished by using ADM-derived outputs within ArcScene. Additionally, this team believes that tools such as the ADM will aid in the development and design of functional wildlife corridors and contribute to the effectiveness of corridors as an increasingly viable conservation planning strategy. Further, the team believes that such developments will aid in spanning the gap between modeling, planning, design, and eventual implementation of wildlife corridors in a wide spectrum of planning applications.

About the Author

Ryan Perkl, PhD, is an assistant professor in the School of Landscape Architecture and Planning at the University of Arizona who specializes in environmental planning, wildlife connectivity modeling, and the emerging field of geodesign. Contributors to this work include Samuel Chambers, a doctoral student in arid lands resource sciences, and Brandon Herman, Wanyi Song, and Garrett Smith, all graduate students in planning at the University of Arizona.

Visit www.planning.arizona.edu to learn more about the Planning Master's Degree Program at the University of Arizona.

See also "The Importance of Connecting Protected Areas."

(This article originally appeared in the Summer 2012 issue of *ArcNews*.)

The Importance of Connecting Protected Areas

Given the recent trends of urban expansion, species decline, and habitat conversion and fragmentation, conservation planners have developed a wide spectrum of tools devoted to inventorying and analyzing environmental conditions, simulating and forecasting change, and identifying and prioritizing areas for conservation action. More recently, a subarea of conservation planning known as connectivity conservation has resulted in an emphasis on the importance of combating the negative effects of landscape fragmentation on species populations. Connectivity conservation recognizes the importance of setting aside natural areas for protection purposes but goes a step further by stressing the importance of connecting these areas so that they may function as larger systems rather than isolated units. It is believed that such an approach may hold the most promise for protecting the greatest number of species, given the shifting environmental conditions due to climate change.

The mountain lion is among the many animals that would negotiate the corridors.

As a result, connectivity conservation has yielded a number of tools and approaches for modeling landscape connectivity within ArcGIS and other platforms. All approaches make assumptions about how wildlife will move through the landscape, given their individual interactions with local landscape conditions. These interactions and subsequent movements are represented as the relative permeability of the landscape or as the cost of movement to the individual. While connectivity modeling tools vary greatly in their underlying methodological processes and employ different techniques to model permeability and cost, the most common output is the delineation of spatially explicit wildlife corridors that link user-defined locations. Such outputs result in linearly arranged polygons that represent either structural connections between locations with given landscape characteristics or functional paths through which individuals are expected to move. While useful for planning purposes, such outputs lack the specificity necessary for informing the physical design of their interiors upon implementation.

The Automated Design Module (ADM) is intended to provide additional insight and guidance in the physical design of a wildlife corridor's interior by populating it with vegetation arranged in patterns known to impact wildlife movement in desired ways. Developing such a tool sheds light on the suggested physical structure and design of the modeled corridor's interior, aspects that current tools do not address. Additionally, the automated nature of this tool allows large swaths of the landscape to be designed based on widely available data pertaining to landscape characteristics and considerations, such as soil, terrain, and vegetation, among others. Until now, designing such large portions of the landscape has been impractical due to the massive time constraints that are required to manually develop such designs. Finally, the ADM allows analysis, modeling, and design to all be accomplished within an ArcGIS environment without the need to employ other graphic design platforms, resulting in a more streamlined workflow.

See also "Geodesign and Wildlife Corridors."

(This article originally appeared in the Summer 2012 issue of *ArcNews*.)

Singapore's Sustainable Development of Jurong Lake District

The Republic of Singapore is a city-state composed of 63 islands off the southern tip of the Malay Peninsula. It is highly urbanized, with approximately 5.1 million people (as of 2010) living in an area that covers approximately 270 square miles. By comparison, the City of San Diego has a population of 1.3 million people living in an area of 340 square miles. Singapore has finite space, limited water supplies, and no natural resources. Nearly everything in Singapore is imported, whether it is for personal consumption, manufacturing, or construction. The government of Singapore has made sustainable development, the use of renewable energy, and the efficient use of resources primary considerations in all future planning efforts.

Skyline of Singapore's business district.

Every 10 years, Singapore reevaluates its long-term land-use strategies to ensure there is sufficient land to meet anticipated population and economic growth needs without damaging the environment. Given the high population density and amount of existing urbanization, a strategy of developing and rejuvenating existing buildings is encouraged.

In the *2008 Draft Master Plan* for Singapore, the Urban Redevelopment Authority (URA) heralded the Jurong Lake District (JLD) as an ideal place for such redevelopment, referring to it as "a unique lakeside destination for business and leisure." To help with this complex planning effort, URA would use GIS to model, visualize, and communicate the advantages of alternative scenarios.

JLD comprises two distinct but complementary precincts totaling 360 hectares: a commercial hub at Jurong Gateway and a vibrant world-class leisure destination at Lakeside. The 70-hectare Jurong Gateway is planned to be the largest commercial area outside the city center. As outlined in Singapore's *Blueprint for Sustainable Development*, unveiled by the Inter-Ministerial

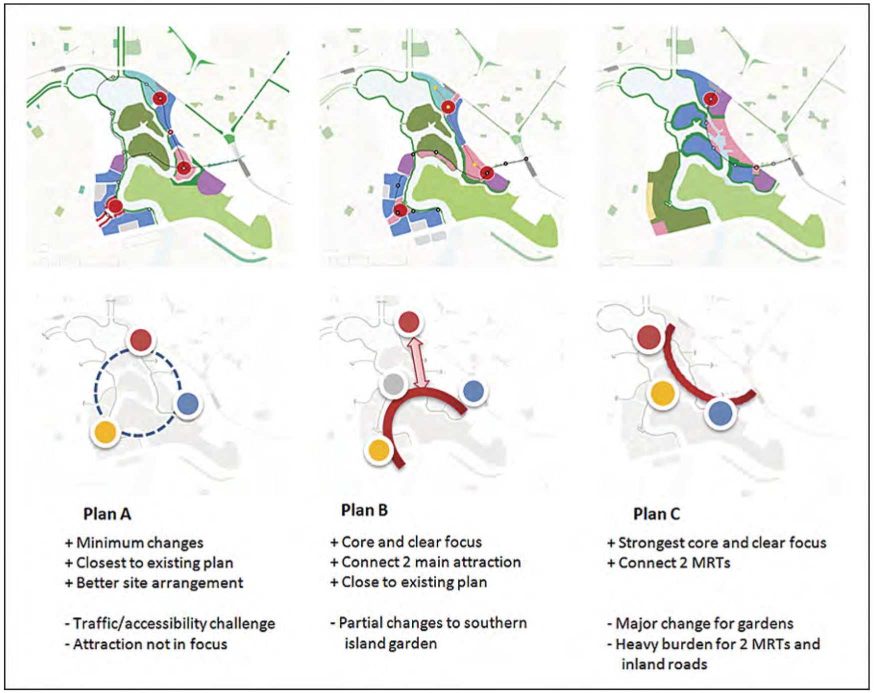
Committee on Sustainable Development, JLD will be developed as one of Singapore's new sustainable high-density districts. Overall, the aim is to formulate a holistic framework to guide the planning, design, and development of Jurong Lake District, one that considers the environment, the economy, and society concurrently during the decision-making process.

URA proactively included aspects of the sustainability blueprint in the JLD planning efforts, such as the incorporation of landscaped open space and pedestrian park connectors, to heighten the sense of greenery and closeness to nature and increase accessibility to existing transit, public facilities, and venues. Land sale requirements were also put in place to encourage developers to achieve higher Green Mark ratings (Platinum and GoldPlus) for new buildings.

Additional initiatives promote "sky rise" greenery—the addition of elevated parks, gardens, and green roofs on rooftops and skyways; the protection and enhancement of biodiversity; the reduction of resource use through building rehabilitation; and the increase of water catchment and treatment using natural systems whenever possible.

But how were these visionary goals going to be evaluated and translated into reality given the myriad of stakeholders, assortment of variables, and budgetary constraints?

To assist with this ambitious plan, URA enlisted the help of Esri Partner AECOM (headquartered in Los Angeles, California), which proposed the use of a geodesign framework using ArcGIS to help organize and address the complex sustainability needs for such a large-scale project as JLD.



An example of the positive and negative effects of three alternative plans, the last focusing on Singapore's Mass Rapid Transit (MRT).

The Sustainable Systems Integration Model

AECOM's Sustainable Systems Integration Model (SSIM) is a key component of the team's sustainability planning process, providing a platform for rationally evaluating, balancing, and costing a wide variety of sustainability strategies to determine the combination best suited to the economic, social, and business objectives of a given project. The model places ecological enhancement and service components side by side with energy, water, mobility, green building, and sociocultural strategies so that a truly integrated, balanced sustainability program can be measured and conceived. The result is a whole-system economic and GIS evaluation tool developed to work at multiple scales.

The model consists of many steps and techniques that allow users to select the themes and variables most befitting a given project's needs. The framework tracks a set of indicators including total energy use, water demand, waste produced, vehicle miles traveled, and total greenhouse gas (GHG) emissions that can be modeled to show the impact of a single building, block of buildings, or entire community. Various energy or water conservation strategies can be recombined and modeled to show the immediate carbon or water footprint, as well as initial development costs or ongoing maintenance and management costs of a given scheme for any point in the future.

Stage I—Urban Form and Master Planning

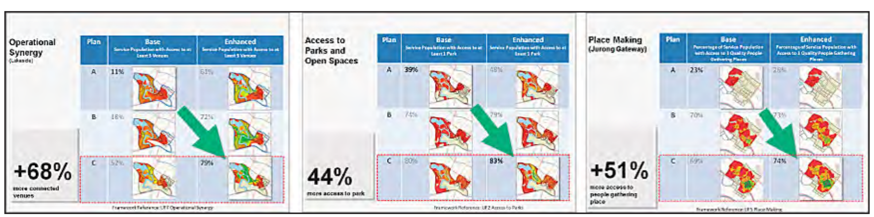
Urban form—the physical layout and design of a city, including land use and circulation patterns—has the largest impact on a city's energy use and GHG emissions. Stage I of developing a master plan seeks to identify the best mix of urban form, land-use density, and transportation network to achieve the highest trip capture and reduction in carbon emissions at the lowest cost.

The process started out with a visioning workshop at which all stakeholders and subject experts were brought together to help define and prioritize issues, metrics, and target goals. In this case, the stakeholders were the Building Construction Authority, Land Transport Authority, National Parks Board, National Water Agency, and URA, among others. Participants were encouraged to address problems beyond their field of expertise. The end result of this dynamic interaction and the sharing of views and perspectives across disciplines was an increased understanding among stakeholders of the complexity of key issues, enabling them to reach agreement on priorities.

To create a relatively accurate frame of reference, the team established definitions for business as usual (BaU) and baseline, to which the aspirational targets and all future scenarios could be compared to help the team understand improvements in performance, as well as associated costs (evaluation models). For JLD, BaU was defined as the original master plan in place for Jurong Gateway and Lakeside assuming conventional construction practices. The baseline was defined as the original master plan, combined with the existing sustainable development initiatives already implemented by URA, such as Green Mark certification, the proposed pedestrian network, and the greenery replacement program.

Once the BaU and baseline models were created, alternative master plans (change models) were "sketched" by participants using customized templates or palettes of predetermined land uses, building types, transportation modes, community facilities, and other amenities to help facilitate this process. Sketching was enabled through the standard ArcGIS 10 editing template functionality.

The model's GIS mapping and geoprocessing tools, developed as an ArcGIS for Desktop add-in using ArcObjects, were used to model accessibility to certain plan features, including land-use spatial allocation, internal and external connectivity, and access to key services and transit. A unique addition to the JLD project was the creation of tools to measure the accessibility of vertical components, such as elevated parks, skyways, and trams. These evaluation models, characteristic of a geodesign process, quickly evaluated design decisions, allowing participants to see the impact just by running the tools.



Example of the spatial analyses performed to show the impact of plan changes on different indicators important to the stakeholders. Heat maps created using ArcGIS for Desktop, showing colors from red to yellow to green, indicate good, better, and best for each plan. Plan C shows the highest benefit for each of these indicators.

Stage II—Infrastructure or Primary Systems Evaluation and Modeling

After a preferred master plan framework was selected, a more intensive evaluation of sustainability practices and measures took place, focusing more at a detailed infrastructure level of analysis. By tweaking certain measures—for example, selecting certain building materials or switching to low-flow faucets—additional improvements can be made in water consumption, energy consumption, or cost. This step seeks to answer three core questions for each theme: What energy reduction targets should be evaluated? Which combination of project design features are required to achieve each target? Which combination of project design features will achieve the reduction targets in the most cost-effective manner?

Just like in the evaluation of urban form in stage I, stage II requires the identification of a BaU and baseline for each system (the former being the minimum level of performance allowed by building and zoning codes, while the latter represents the level of performance required by URA in the existing plan). The primary difference between these two was in the amount of open space and green building requirements in the Gateway district. Three additional levels of performance (termed good, better, best), which had been earlier identified in the Sustainability Framework Matrix, were the basis for assembling "packages" of measures that would theoretically achieve each of the respective targets for each system. These packages were then modeled to test whether they in fact achieved the targets.

After identification of the packages of measures to be utilized in closing the gap between the aspirational targets and the current BaU case, each package of strategies underwent a cost estimating step and a cost-benefit analysis.

Stage III—Master Program Optimization

The goal of SSIM stage III is to combine the effects of multiple systems and strategies to create integrated sustainability programs across the entire project site for each of the alternative master plan scenarios refined in stage I. The Gameboard tool of SSIM facilitates this goal by allowing the selection of a performance package for each major system and simultaneously reporting various performance and cost indicators resulting from the package selections.

Gameboard is used to optimize the overall master sustainability program. In this context, *optimization* is the process of selecting unique combinations of sustainability choices that result in achieving the aspirational targets set out in stage I using a set of predetermined cost thresholds. The optimization process is assisted by a logic engine that solves for the set of constraints stipulated by the thresholds.

Conclusion

In the end, Singapore defined and evaluated three to five master sustainability framework programs. The variation between the programs included multiple combinations of good/better/best scenarios on all the systems. SSIM allowed URA to examine the theoretical 10-year life cycle analysis comparing net present value for each model run.

The savings from energy and water efficiency are expected to offset the investments in other sectors, such as parks, open space, public transportation, potable water infrastructure, and even social programs.

The refined sustainability framework matrix serves as the master checklist for achieving a holistic sustainability program for JLD. It is a living document that will be amended as time goes on and as adjustments need to be made in targets, due to changes in either technology, demographics, costs, or priorities.

(This article originally appeared in the Spring 2012 issue of *ArcNews*.)

Preparing for a Vibrant Future in the Township of Langley

Located in the heart of British Columbia's (BC) Lower Mainland, the Township of Langley is 45 minutes east of Vancouver and offers access to major transportation routes as well as the US border. Its central location, affordable land, young labor force, and diverse job opportunities make the township appealing to families and businesses. As one of the fastest-growing municipalities in BC, the township expects its population of more than 100,000 people to double in the next 30 years. To support this growth, it is implementing the principles of geodesign to plan sustainable community development and provide efficient services to residents.

Rich in fertile soil, 75 percent of the township's land is designated as provincial Agricultural Land Reserve (ALR). An ALR is a tract of land in British Columbia where agriculture is recognized as the priority use, and anything other than farming or leaving the fertile soil forested or vacant is not allowed.

Since most of Langley's land is designated as ALR, Langley Township staff face unique challenges to effectively developing the land that is available. While farming and agriculture remain important local industries, Langley has seen a steady rise in industrial and commercial development. In 2010 alone, the municipality issued nearly 1,000 building permits.

For a community that is used to a landscape of farmland and single-family housing, new proposed pockets of urban growth that include higher-density apartments and condominiums can be a bit jarring.

Since 1995, the township has used Esri technology to manage land information across its enterprise and enable geographic applications in various departments, including planning, finance, engineering, and protective services. It maintains GeoSource, a web-based GIS interactive mapping system that provides staff and the public with access to maps, land data, and aerial photography of the township. To stay at the forefront of GIS technology, the township upgraded recently to ArcGIS 10. The ability to create an interactive, shareable 3D model for the township that can be used for current and future needs was a major driver when adopting the technology.

Designing Tomorrow's Communities

To effectively plan new buildings and communities, the township uses ArcGIS with the ArcGIS 3D Analyst extension to view and analyze large datasets in three dimensions. This includes remotely sensed lidar data that provides highly accurate geographic positions of properties and assets whether they be buildings, utility poles, or trees. This data is being used to create a 3D model that will provide a current baseline against which the township can visualize alternative growth scenarios beginning with the Willoughby community, a growing, suburban area that is the new home of the civic facility.

3D modeling allows planners to visualize the impact of new buildings on the landscape.

An important characteristic of geodesign is the ability to measure the impact of a proposed change in a virtual world while in the design or planning stage. GIS allows township departments to conduct viewshed and line-of-sight analyses to see how new development—multifamily housing structures and mixed-use buildings, which are taller than single-family houses predominant in the township—might impact the current skyline or special views to landmarks. Taller buildings can also mean more shadow. GIS supports the visualization and estimation of the total amount of shadow that a new building might cast on adjacent properties, which could result in greater heating costs for the impacted property.

"Our planning department had always used print maps and traditional architectural scale models to envision how new communities would look," says Derik Woo, manager, Geomatic Services, Township of Langley. "Now, they're able to model a 3D virtual city that more accurately represents township properties and combine numerous data to visualize and analyze the impact of proposed projects. This helps them present evidence-based plans to council officials and makes it easier to communicate new development projects to residents."

Using the geodesign concept, township staff also conduct population and employment modeling to create projections by combining various data—including provincial land parcels (cadastral fabric) and land use, township neighborhoods, population, and employment values. Taking a holistic or cross-disciplinary approach to view all this data, along with the physical building model of the city, provides a powerful planning tool that can create, evaluate, and compare the cumulative impact of different alternatives, allowing decision makers to make the wisest decision possible given a projected growth scenario.

Managing Municipal Assets

For an integrated approach, the township also uses ArcGIS to obtain a clear picture of its infrastructure and assets. Recently, it completed digitizing videos of sewer inspections, which staff can access through the internal version of GeoSource. This has significantly increased efficiency and reduced costs. Previously, engineers needed to look up a proprietary database that lists all available recordings of the township's sewer pipes, then they had to manually find the disk or tape media to view the footage.

"In just a few clicks, our engineers can now easily view videos, photos, and documents related to our underground infrastructure through GeoSource," says Chad Huntington, GIS coordinator, Township of Langley. "This enables them to plan timely maintenance schedules and respond to requests for repairs more quickly."

The GIS also contains data about the township's infrastructure projects, thereby assisting in meeting Public Sector Accounting Board requirements.

Increasing Community Engagement Through Open Data

The township recently opened its data to the public to conduct their own research or develop commercial applications. In addition to providing an open data catalog on its website, the township contributes geographic content that is integrated into a free, national web basemap through the Esri Canada Limited (Esri's distributor) Community Maps Program.

The township was also selected to participate in the Community Maps Exchange, a pilot project that tested two-way data exchange between the township's database and ArcGIS Online, where the community basemap is hosted. This allows data to be automatically updated and helps ensure that information on the basemap is always up-to-date.

"This program reduces costs for people who regularly use township information," says Woo. "In the past, they had to pay a fee to obtain the township's topographical, infrastructure, and neighborhood data. Now, businesses planning to open a site here can access the data for free through the community basemap. The program also reduces our costs by allowing us to leverage outside resources to distribute information and encourage current and future residents to participate in improving our community."

In embracing GIS technology and the geodesign process as part of its corporate strategy, the township is well positioned to meet the needs of its growing population.

"GIS is an integral part of our information technology strategy," says Steve Scheepmaker, information technology manager, Township of Langley. "We've been using the technology for more than 15 years to increase efficiency in our business processes."

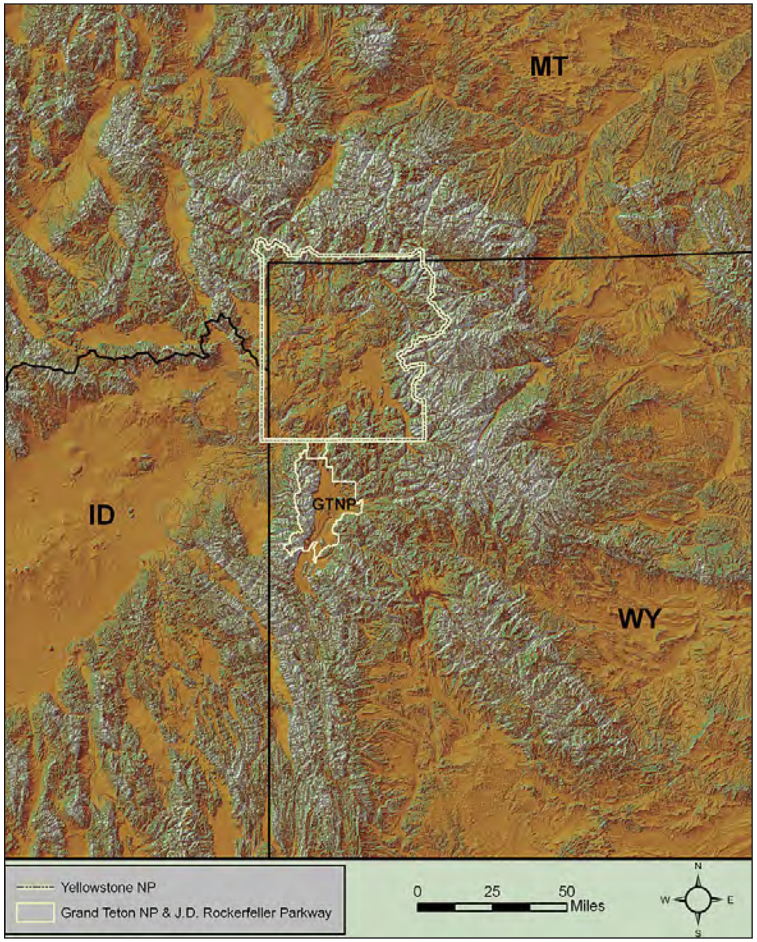
(This article originally appeared in the Spring 2012 issue of *ArcNews*.)

Where the Wild Things Are in Yellowstone Park

A Science-Based Approach to Collaborative Decision Making at Ecosystem Scales

The human history of the Yellowstone region can be traced back to an undesignated time in tribal oral history more than 11,000 years ago, when many groups of Native Americans used the park as their home, hunting ground, and source for gathering medicinal plants. These traditional uses of Yellowstone lands continued until the first explorers and trappers of European descent found their way into the region, recounting tales of a bountiful land full of natural wonders where "fire and brimstone" gushed up from the ground. In March 1872, President Ulysses S. Grant signed into law a congressional act making Yellowstone the first national park in the world, an area so extraordinary that it was set aside and protected in perpetuity for the enjoyment of future generations. Thanks to its early designation and protection, Yellowstone is one of the few remaining intact large ecosystems in the northern temperate zone of the earth.

In recent years, managing these ecosystems has become increasingly challenging. Drought, wildfire, habitat fragmentation, contaminants, invasive species, disease, and a rapidly changing climate have begun to threaten human populations, as well as native species and their habitats. To plan for this uncertainty, a dedicated group of ecologists is using ArcGIS, statistical analyses,



The greater Yellowstone ecosystem.

and a GeoDesign workflow to measure the impact of potential land-use change before it happens.

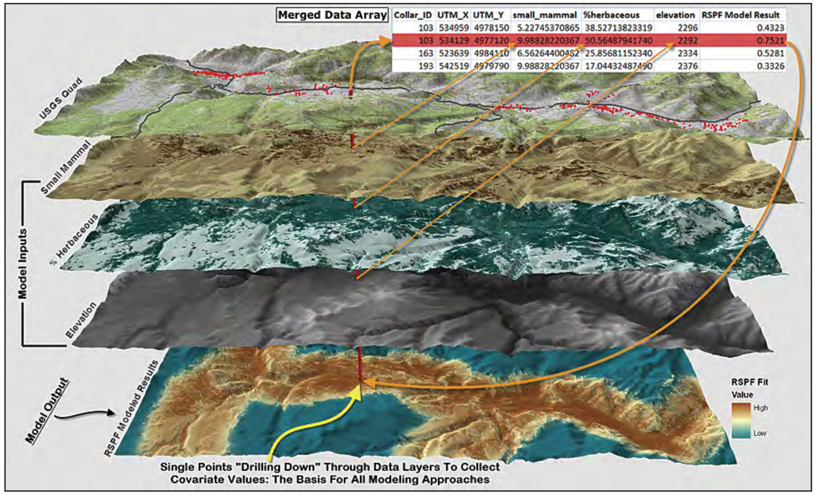
Ecological Forecasting

The Yellowstone Ecological Research Center (YERC), a private, nonprofit organization located in Montana, spends much of its time conducting long-term, large-scale, collaborative ecological research and education in concert with both public and private organizations. Historically, that work has relied heavily on ArcGIS to help organize, analyze, and visualize data on the health and status of native species and the land and water that sustain them.

Simulating ecological system dynamics is a complex undertaking. The sheer volume, variety, and complexity of geospatial data have grown exponentially in recent years, requiring the development of new tools and efficient workflows to help decision makers spend more time on the issues without having to sort through data. More importantly, decision makers need to be able to synthesize this data into standardized, transparent, and defensible information to support the management needs of today while preparing for the needs of tomorrow. And that means having a repeatable process, a core tenet of scientific inquiry.

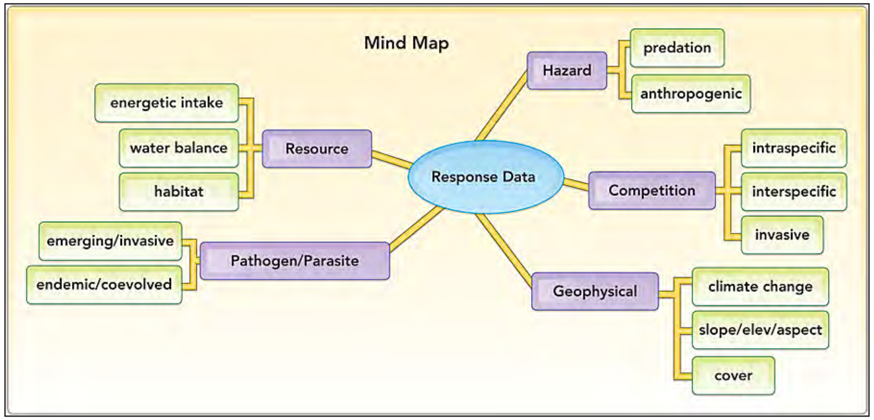
To support the entire process of ecological forecasting, YERC ecologists, statisticians, and GIS analysts created the Ecosystem Assessment, Geospatial Analysis and Landscape Evaluation System, known as EAGLES, which is essentially GeoDesign at an ecosystem scale. EAGLES is an integrative workflow architecture that organizes vast amounts of historic spatial data, some covering the entire United States, with modeling routines to create predictive ecosystem and species models. ArcGIS is a key component of EAGLES, providing a mapping platform to make the data easily understandable to decision makers.

The workflow begins with the assembly of experts having a strong knowledge of the organism of interest, including physiological drivers, feeding habits, predator/prey relationships, competitive interactions, and habitat. Additionally, this effort can integrate pathogens, parasites, or other hazards. These experts



When all data is referenced in a common coordinate system, the referential link gives the scientist or manager the ability to investigate all the various interdependencies of a single point to all other data, increasing the efficiency and quality of the inquiry.

help develop a conceptual model of key issues and management objectives. The conceptual modeling process begins with a verbal description of important relationships between the species of interest and its environment. The verbal description is then used to help select a set of hypothetical drivers to be considered for inclusion in the model. The environmental variables (i.e., covariates) and their relationship to the species of interest (i.e., response data) are referred to as a narrative model using a mind map.



A mind map is a quick way to display potential factors affecting variation in a focal species response, for example, the health and vitality of a population. The mind map could be based on present-day data or legacy datasets, either of which helps visualize the narrative model, which can get rather complex. The narrative model will eventually be used to create a quantitative model to support statistical analytics, which occur later in the workflow.

One of the park's pronghorn antelope.
(Photo courtesy of Hamilton Greenwood.)

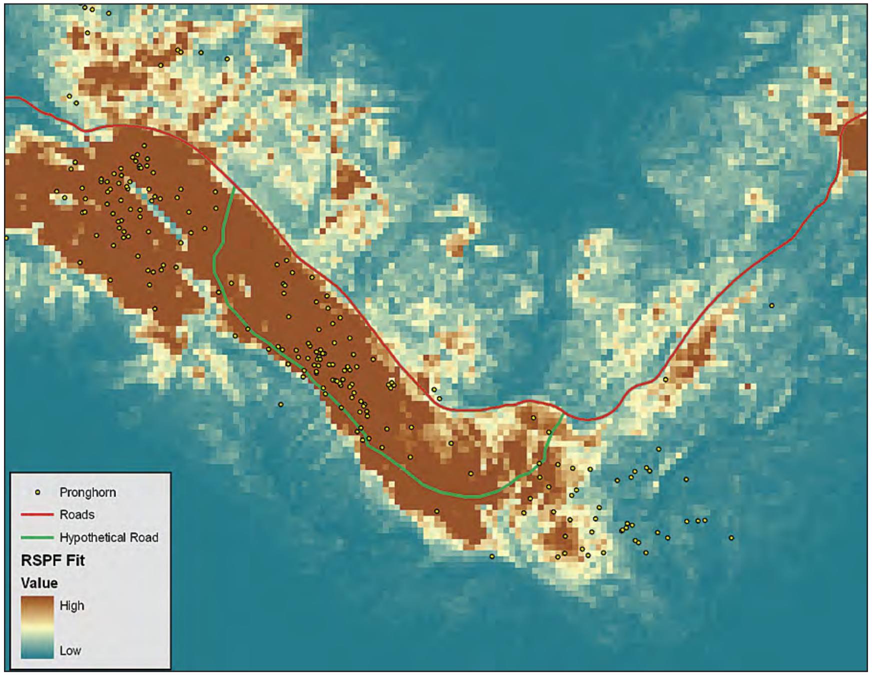
The Case of the Pronghorn Antelope

For example, the Yellowstone pronghorn antelope (*Antilocapra americana*) faces a suite of risks characteristic of small populations with geographic/demographic isolation, low abundance, and low recruitment. Decision makers need a management plan based on demographic monitoring of abundance, especially species vitality rates. This study focused on demographic monitoring, especially recruitment and survival; ecological interactions, especially predation rates and recruitment; and habitat assessment.

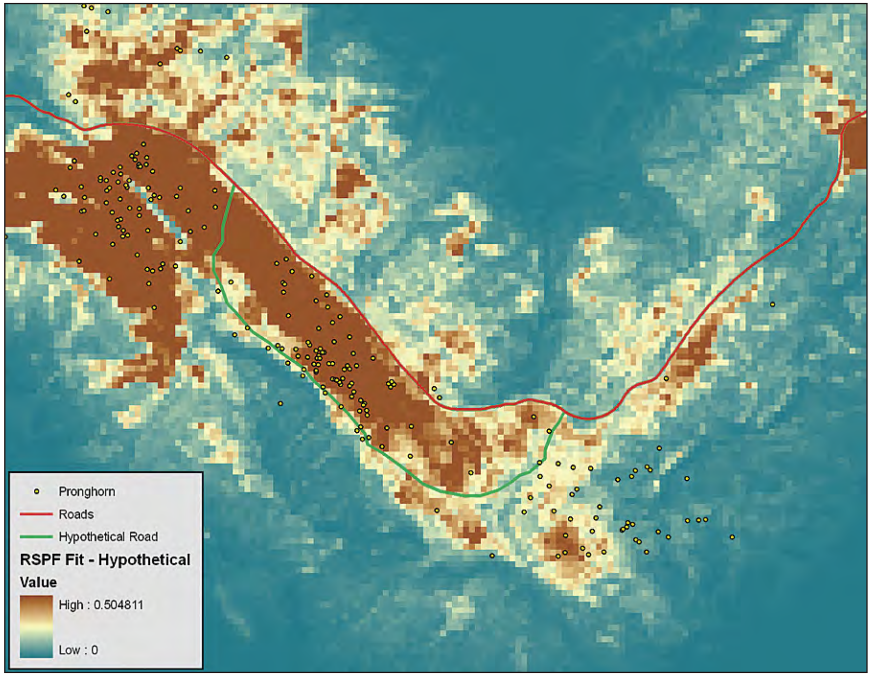
The issue assessment resulted in the creation of two narrative models, one representing birthing arenas and another for resource selection (involving the identification and use of viable habitats). In this case, species vitality could be explained by forage availability, predator intensity, geophysical context, and climatic variables. For example, the more rain, the more food, and the more newborns, the healthier the population might become.

Information Needs

Once the narrative models have been created, the next step is the identification and gathering of relevant datasets that could answer questions regarding road impacts, predator impacts, and range condition impacts on pronghorn antelope. A few of these datasets are elevation, topographic complexity, land cover, predation, and distance to roads.



The map on the left displays a portion of the original resource (RSPF) model showing predicted habitat use for pronghorn in Yellowstone National Park. The Swap tool was used to apply the resource model to a hypothetical road addition (shown in green).



The new prognostic RSPF model output for pronghorn (right map) indicates that pronghorn would be excluded from portions of their original selected habitats.

In the case of the pronghorn antelope study, the species observations included 762 telemetry fixes from 26 collared animals from May to July of 2005. The spatial extent of the analysis was defined by this data in combination with expert knowledge of known habitat use. The spatial resolution for all environmental data was a 100-meter grid produced by resampling the data as appropriate.

Analysts used various modeling techniques to create forage, herbaceous, sage, soil, and cumulative net primary production (NPP) layers (i.e., process models). Additional models using empirical field data created coyote and wolf intensity of use and small mammal biomass layers. Finally, available space layers were created using one-kilometer buffers around each pronghorn location in which points were randomly generated over that space to simulate potential habitat use. Since the spatial scale at which pronghorn select their habitat was unknown, this process was repeated at three kilometers and five kilometers for comparative analysis.

Examining Alternative Futures—Ecological Forecasting

EAGLES has a tool called the Swap tool that enables users to build alternative scenarios (i.e., change models) using an already constructed model and change only one attribute while holding all else constant to examine the effects of that change on the model. This approach allows a transparent investigation of the changes in levels of treatments, such as geophysical layer alterations, changes in forage availability, or more sophisticated modeled input layer substitutions. The goal is to apply a model that previously "fit" to observed data for a potential scenario in an effort to make projections about the ecological ramifications of a given landscape change (i.e., impact models).

For example, a forecast about the impact of building a new road through a habitat would rely on the input of a new layer that contains the proposed road. The user can then apply the fitted resource model to the new road layer (instead of the original layer) and view the response surface under the changed landscape. Such projections allow a measured assessment of habitat change. Visualization of the resultant surface occurs in GIS, and the resultant equations and models can be examined statistically, as well. The intent is to provide a utility for planning for landscape change.

Humans with Nature

The benefit of the EAGLES toolset is that it streamlines the finding, compilation, and integration of data by allowing the user to identify the geospatial data inputs, region of interest, scale, and a common data resolution—even a temporal resolution—to make it easier to assemble available national datasets into a common georeferenced coordinate system using ArcGIS. Applying such a workflow to standardized datasets across the United States would help propel the adoption of GeoDesign.

Finding solutions to major ecological challenges will require new ways of thinking. It is no longer humans against nature or humans in nature—it is humans with nature. Whether it's Yellowstone's pronghorn antelope, grizzly bear populations, or the collapse of Pacific Northwest salmon runs, science and GIS have lifted each of these issues—and many others like them—from subjective opinion and polarization to a place where decisions can be made based on facts.

For more information about the Yellowstone Ecological Research Center, visit www.yellowstoneresearch.org.

(This article originally appeared in the Winter 2011/2012 issue of *ArcUser*.)

Keeping Traffic Moving during Bridge Repair Project

By Matthew DeMeritt, Esri Writer

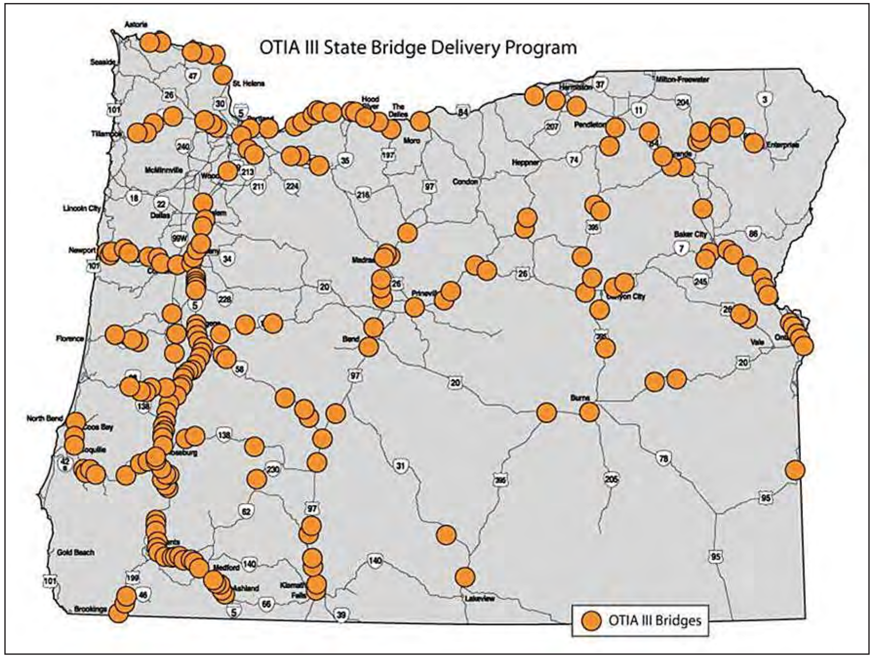
The Oregon Department of Transportation repaired the Snake River Bridge on Interstate 84 as part of the OTIA III State Bridge Delivery Program.

With 12 percent of US bridges declared structurally deficient by the Federal Highway Administration in 2006, bridge repair remains a top priority for most states. Three years before that, an extensive investigation of Oregon's bridges conducted by the Oregon Department of Transportation (ODOT) found that 365 of Oregon's bridges had structural problems that necessitated a large-scale bridge repair plan. Implementing that plan required that the department expand its GIS infrastructure and integrate a new traffic modeling application to ease congestion at multiple construction zones along the state's highway system.

Oregon Transportation Investment Act

From 2001 to 2003, Oregon passed a series of funding packages called the Oregon Transportation Investment Act (OTIA I, II, and III) to improve its highway infrastructure. For OTIA III, which included the State Bridge Delivery Program, ODOT turned to engineering consultants Oregon Bridge Delivery Partners (OBDP), a joint venture between HDR Engineering and Fluor Corporation, to create practices that would ensure the project finished successfully and within budget. One of the primary goals of the program was to reduce the impact on commuter and business traffic during large-scale construction on its road system.

Many of the bridges designed during the early development of Oregon's highway system used a reinforced concrete deck girder (RCDG) design specified in the regulations of that time.



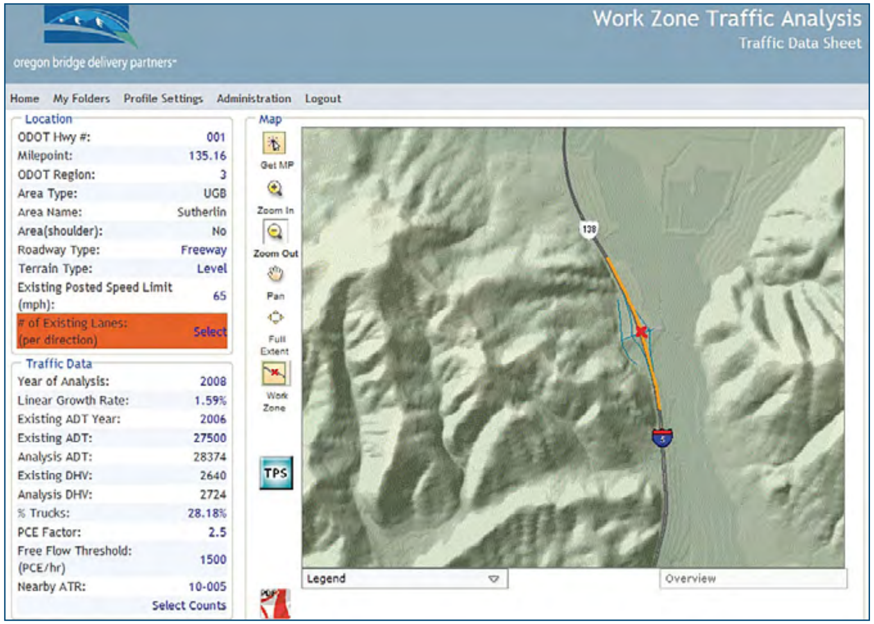
The OTIA III State Bridge Delivery Program is a 10-year, $1.3 billion program that will repair or replace hundreds of aging bridges on Oregon's highway system.

As specifications became more stringent in the 1960s, Oregon transitioned to pre-stressed and post-tensioned concrete bridges that improved structural integrity at a reduced cost. However, many RCDG bridges remained in service well past their expected decommission date and began to show signs of deterioration on deeper investigation. "In 2001, ODOT inspectors noticed that cracks identified in previous inspections had grown to the point of threatening structural stability," said Jim Cox, assistant manager of major projects at ODOT. "We immediately placed load restrictions on these bridges and started discussion on how to plan repairs with the least impact on commercial and commuter traffic."

GIS and Geodesign

Established in 2004, ODOT's GIS comprised the department's information-sharing infrastructure to plan and manage roadway projects. To integrate with ODOT's GIS, OBDP designed its system on the same ArcGIS platform for flexibility and scalability throughout the project life cycle and beyond. "We wanted easy adoption of tools and practices to smooth transition during project closeout and ensure usefulness beyond that," said Robb Kirkman, GIS Services manager for HDR Engineering. "GIS provided the foundation to start linking program systems, automate tasks, and better mitigate environmental impacts."

Before any construction work began, ODOT collected comprehensive environmental data on more than 400 of its bridge sites to identify nearby environmental resources. Standard ODOT practice involves consultation with experts such as biologists, wetland specialists, and archaeologists to get a better understanding of the effects of construction zones in ecologically sensitive areas. "We took a different approach for the OTIA III Bridge Program by conducting environmental fieldwork before we did any design," said Cox. "In ArcGIS, we drew a box around a bridge site and identified all the resources inside the box. This allowed the engineers to develop designs that minimized impacts on the surrounding environment."



The department can run traffic scenarios in a matter of minutes rather than hours—enabling ODOT engineers to modify traffic plans on the fly. Easy access to reliable data helped the agency determine how to stage projects with minimal delays.

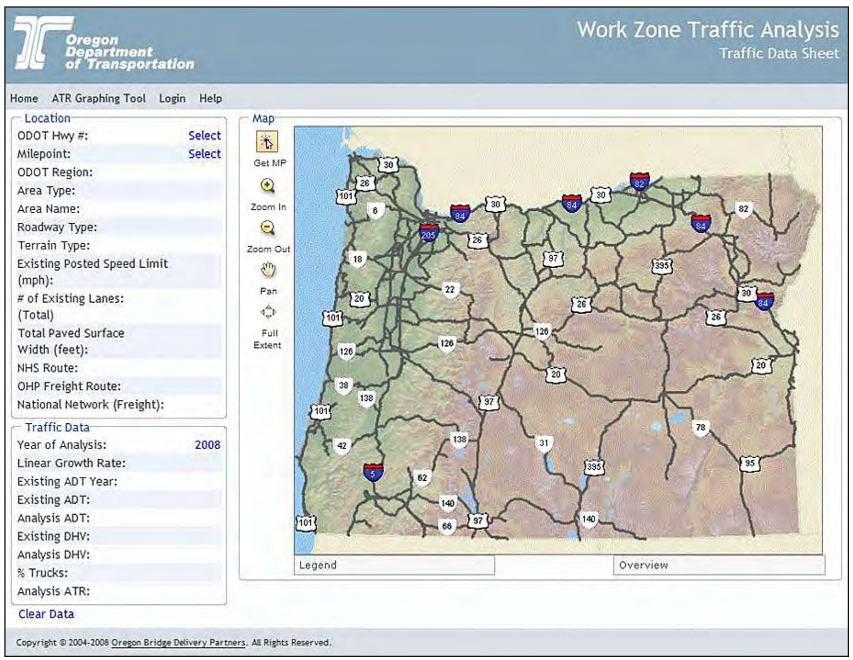
Improving Work Zone Traffic Analysis

Prior to its collaboration with OBDP, ODOT had been using spreadsheets containing traffic counts and automatic traffic recorder information from across the state to document and predict traffic impacts for its various road construction projects. That process could take up to four hours for each scenario because data had to be searched and collected from multiple databases within the agency and then inserted into a spreadsheet. "Gradually, that process evolved to incorporate GIS processes," Kirkman said. "Using macros and automation tools in ArcGIS, ODOT's traffic group was able to automatically populate the spreadsheets with information from the database."

Although much leaner, the spreadsheet-only approach experienced crashes as the database grew ever larger. The traffic team worked with OBDP to develop a more efficient GIS-based method for running traffic scenarios—one that tightly wove ODOT's geospatial data into a dedicated web-based analysis tool. Using common protocols, they worked on tying the datasets together to give ODOT staff direct access to the department's databases from a single interface. Called the Work Zone Traffic Analysis (WZTA) tool, the application allowed traffic scenarios to be run and shared in a web browser.

WZTA serves as a repository for information on traffic and road data that can be accessed and queried in a browser. The system allows users to view ODOT data to determine the effects on mobility created by lane closures related to construction and roadwork. Today, the department can run traffic scenarios in a matter of minutes, eliminating redundancy and enabling ODOT engineers to modify traffic plans on the fly.

Using a GIS-based interface also improved accuracy by allowing ODOT analysts to select the location and other information for a specific project site from the map itself rather than tabular lists. "Lookup tables using numbering systems aren't intuitive to all users," Kirkman said. "GIS enabled users to find exactly what they were looking for and verify the correct project information within a more appropriate map-based user interface where spatial relationships are more obvious."



Using a GIS-based interface, ODOT analysts can select the location and other information for a specific project site from the map itself rather than tabular lists. In 2007, WZTA received the Team Excellence Pathfinder Award from the American Association of State Highway and Transportation Officials.

Documented Return on Investment

In 2010, ODOT and OBDP documented their experience with the tools to evaluate the impact of ODOT's investments and determine if they should be used after completion of the bridge program. With the assistance of economic consultant Mark Ford, they analyzed every piece of software OBDP created for the OTIA III Bridge Delivery Program to determine the economic benefits and cost to the department. The study concluded that ODOT experienced a combined benefit-cost ratio of 2:1 for all enterprise IT investments related to management of the bridge program.

ODOT's GIS infrastructure alone returned a benefit-cost ratio of 3:1. "Integration of formats and standards proved to be important in generating value from the investment," said Ford.

In addition to these tangible benefits, ODOT experienced three types of intangible benefits. Migrating the data from disparate sources into a unified system allowed OBDP to employ consistent analysis methods, reducing the risk of calculation errors. The centralized database also made it easier for ODOT to maintain data integrity and reduce the risk that analysts working at different locations could use outdated information. "Systems like ODOT's GIS infrastructure generate accurate, consistent, and timely information for reporting and responding to inquiries," Ford said. "WZTA, and GIS in particular, has resulted in improved coordination with other agencies and interest groups, increasing the credibility of both ODOT and the bridge program in the eyes of the public and the legislature."

At the beginning of 2011, 351 of the 365 bridges in the OTIA III Bridge Delivery Program were free of construction zone delays. WZTA played a primary role in expediting the construction process by allowing the team to run lane closure traffic analyses in minutes as opposed to hours. The tool is now being used by ODOT on other roadway maintenance and construction projects to quickly determine impacts from lane closures across the state.

(This article originally appeared in the Summer 2012 issue of *ArcUser*.)

From Urban California to Rural Kenya

Applying the UPlan Model

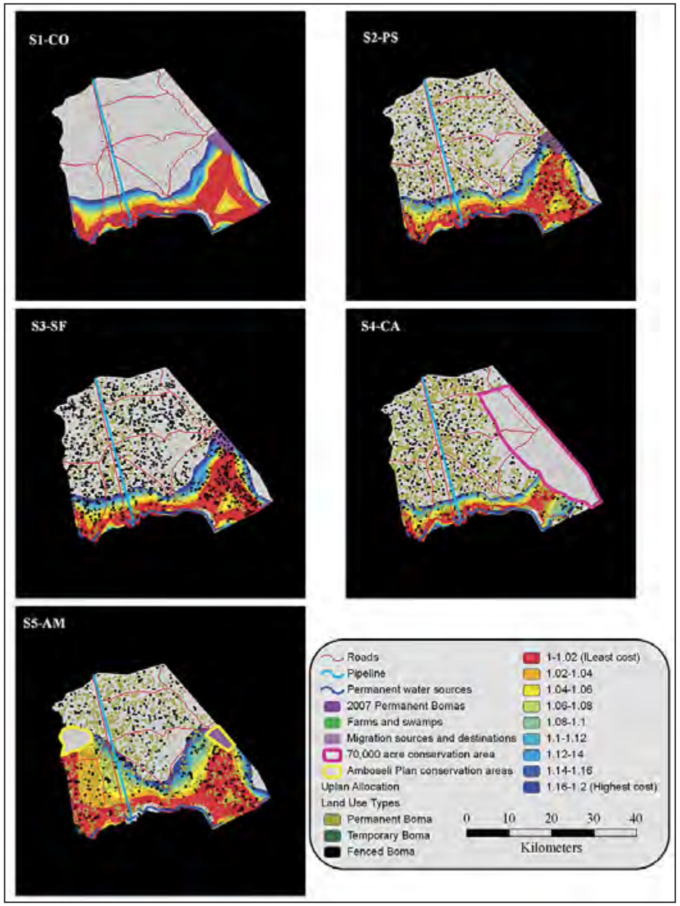
By Karen Beardsley, Managing Director, Information Center for the Environment, University of California, Davis

After centuries of a pastoral way of life, with livestock providing the basis for sustenance, many Maasai pastoralists in southern Kenya have been transitioning from communal land tenure to individual parcel ownership. The introduction of private landholdings frequently leads to a more sedentary, crop-based livelihood, and the land is often demarcated with fences. Effects of land subdivision go beyond the direct changes to people's landownership to include landscape-scale habitat fragmentation, reduced resistance to drought, and a decrease in wildlife populations. Some of the group ranches in southern Kenya have completely converted from communal lands to individual landownership, while others still have a choice in setting their land-use policies but are struggling with decisions about the future of landownership, subdivided or not.

There have been few if any systematic methods for estimating longer-term impacts of differing land-use scenarios on wildlife and other environmental resources in Africa. At the University of California, Davis, Information Center for the Environment (ICE), researchers endeavored to model and visualize some of the land-use issues facing the Maasai in Kenya with UPlan, an urban growth GIS modeling tool (see "How UPlan Works in California"). UPlan was developed to simulate growing urban areas of

A Maasai herdsman.

California and is widely used for long-range planning in rapidly growing cities. This would, at first glance, seem to have nothing in common with sparsely populated pastoral lands in East Africa. But the author, one of the ICE researchers, had been a Peace Corps volunteer in Kenya 20 years earlier and has connections (through the Society for Conservation GIS) with the [African Conservation Centre](#) (ACC) based in Nairobi, Kenya.



UPlan's output from five different Mbirikani scenarios, based on past trends, various degrees of fencing, and different management plans involving Mbirikani, will assist researchers and ultimately local ranch members with land subdivision decisions.

In summer 2007, the author spent three weeks in Kenya working with scientists at ACC visiting areas outside park boundaries, where ACC focuses most of its conservation efforts, and learning more about the issues facing the historically pastoralist communities. Potential land-use conflicts included a complex and interacting mix of livestock grazing lands, wildlife corridors, agricultural lands, and human settlements. Combining her knowledge of UPlan and ArcGIS with her interest and experience living in Kenya, she and ACC developed a plan for this collaborative work, adapting UPlan for use in a rural setting far away from its traditional applications in the cities of California.

In general, people prefer pictures or maps over reams of numbers to help them understand the world now and in the future. Geographic tools, such as ArcGIS, provide a visual framework within which to view the future or, better yet, a variety of possible futures. When dealing with the past or the present, scientists typically seek complete, unbiased data at the maximum resolution practical. This is not so when looking into an unknowable future. The UPlan urban growth model is an appealingly simple and easy-to-understand tool, built in ArcGIS, that has been far more instrumental in helping planners see what California's future might look like than similar, but more complex, models. The application of UPlan to rural Kenya explores some of the ways that ArcGIS can be designed to peer into the future at a low resolution and with multiple potential outcomes for a rural region experiencing rapid land-use change.

ICE researchers gathered existing data from many sources, including ACC, the United Nations Environment Programme in Nairobi, and several other researchers working in this part of Kenya. With very minor modifications to the urban version of the model, ICE scientists adapted UPlan to model different land-use choices in rural areas of southeastern Kenya. They modified UPlan to work within the Kenyan policy framework by developing five land-use scenarios for the Mbirikani Group Ranch in the Amboseli ecosystem in Kajiado District, Kenya. California projections use urban variables, such as general plan boundaries, distance to freeways and major arterials, residential/commercial/industrial land uses, and employment statistics. UPlan for the Mbirikani region includes temporary/permanent/fenced bomas (living areas), distance from water sources and villages, suitability of habitat types for farming and grazing, and proposed locations of new conservation areas.

The output from five different Mbirikani scenarios, based on past trends, various degrees of fencing, and different management plans involving Mbirikani, will assist researchers and ultimately local ranch members with land subdivision decisions. Taking this one step further, ICE researchers combined the pattern of human settlement from each scenario with possible wildlife migratory routes modeled across Mbirikani. Not surprisingly, the results pointed to the scenario with the highest level of subdivision and fencing having the most detrimental effects on migratory patterns of zebra and wildebeest in a landscape connecting some of the world's best-known wildlife areas.

Maasai cattle raising dust in the South Rift region of Kenya.
(Photos: Karen Beardsley.)

Californian city and county planners and Maasai group ranch leaders are not as different as one might think when it comes to interpreting maps and developing and evaluating alternative future scenarios. When applied to rural locations, such as southeastern Kenya, overlaying potential wildlife corridors with modeled future human habitation patterns using ArcGIS is a powerful method that can facilitate decision making in ways not previously envisioned. This study demonstrated the applicability of the UPlan model to rural Kenya and provided an example of how the model and its output can be used to evaluate different land-use options. Principal wildlife management stakeholders, including the local community, private conservancies, nongovernmental organizations, and the government, could work collaboratively (despite potentially opposing planning priorities) to determine a mutually agreeable way to plan for future uses of the land.

The goal in conducting this research was to develop the ideas and test the methods for applying UPlan in rural, group-managed lands in Kenya, recognizing all along that these methods and results should be taken back to the local people for their full value to be realized. The expectation is not that ArcGIS applications like UPlan be placed in the hands of Maasai herdsmen. Rather, local support organizations such as the ACC would manage the technical aspects of the process and work with local stakeholders to visualize and evaluate model results. ACC could operate the models, produce maps, and work directly with the local people using the Swahili or Maasai languages instead of English. An iterative process of developing alternatives, observing potential outcomes, and modifying parameters as needed to develop and evaluate new alternatives (following the geodesign paradigm) would keep people involved and engaged at all levels of the process. ACC has expressed a keen interest in moving forward with this work. The main obstacles, as is so often the case with international collaborations, have been time and funding.

It will be an informative experiment to take the next steps and make these methods and results available locally and see how they are used to support Maasai group ranch subdivision decisions.

About the Author

Karen Beardsley, PhD, GISP, has worked for the Information Center for the Environment, Department of Environmental Science and Policy, at the University of California, Davis, since its inception in 1994 and is currently the codirector of ICE together with professor James F. Quinn. She has a master's degree in geography from the University of California, Santa Barbara, and a PhD in geography from the University of California, Davis.

For more information, visit www.conservationafrica.org.

See also "How UPlan Works in California."

(This article originally appeared in the Summer 2012 issue of *ArcNews*.)

How UPlan Works in California

UPlan is a rule-driven, ArcGIS software-based urban growth model suitable for rapid scenario-based modeling. Originally developed by researchers at the Information Center for the Environment (ICE) at the University of California, Davis, more than 10 years ago, UPlan is continually maintained by ICE and has been widely applied in California and adapted to planning needs in other USA states, as well as several international settings, including China, Egypt, and Kenya (see "From Urban California to Rural Kenya"). Input parameters, including urban growth attractions, discouragements, masks, and planning datasets, are easily collected and configured using UPlan. While not an explicit economic model, UPlan uses "attraction" and "discouragement" factors that score the attractiveness of each modeling grid cell to each kind of potential development, generally based on economic factors understood to drive land-use decisions. UPlan uses a raster, cell-based environment within ArcGIS for Desktop with the Spatial Analyst extension. The model is available online and free of charge (ice.ucdavis.edu/doc/uplan/download).

The basic assumptions of UPlan are the following:

- Population growth can be converted into demand for land use by applying conversion factors to employment and households.
- Urban expansion (population growth) will conform to "general plans" (or an analogous land-use plan boundary defining allowable extent of growth) until demand exceeds the spatial capacity of the plan.
- Some cells, such as lakes, wetlands, publicly owned land, and existing development, will not be developed.
- Cells have different scores denoting attractiveness for development because of legal status (e.g., zoning in the United States); accessibility to transportation; infrastructure; and necessary resources, such as water.
- Other cells, such as high slopes or rare habitat types, will discourage new growth.

UPlan allocates growth into each land-use category based on demographic inputs, such as average household size, employees per household, and the percentage of housing development going into specified densities of residential or employment categories. Three primary factors determine where each land-use class will be allocated: city and county general plans (or comparable boundaries indicating where future growth types may be allocated), areas where growth is prohibited (masks), and site development attraction and discouragement factors. Attraction and discouragement factors are representations of physical, political, or economic effects that make a particular location either more or less attractive for future growth of a given land-use category. First, areas permitted to each land use under the general plan are identified. Then, areas with other growth prohibitions (lakes, very steep slopes, publicly owned lands, or existing development) are removed from the available space. Finally, the attraction and discouragement factor values are established for the remaining cells based on a location's potential suitability for growth. These values permit systematic prioritization of development within the UPlan model for each land use, resulting in an attraction grid. This is a purely additive process, with user-weighted attractions adding values and discouragements subtracting values. Population growth allocation occurs on a raster cell basis starting with the highest-value net attraction and working incrementally downward until either all the available land has been occupied or all the demand has been met.

Currently, about one-quarter of the 58 counties in California are using UPlan, many with technical support from ICE staff. In particular, rural counties rely on UPlan for their planning process as part of the California Rural Blueprints process, which is a long-term public visioning exercise run by counties and regional planners and funded by the California Department of Transportation. In California, UPlan has proved to be an effective and popular tool for visualizing future growth in part because it is adaptable, it runs quickly, and the assumptions are transparent. Problems in implementation have risen where political will is lacking, access to high-quality data is difficult, and personnel resources are limited.

UPlan lends itself well to the geodesign concept based on Carl Steinitz's framework. ICE is currently working with several counties to help them revise their planning process using a geodesign approach, with UPlan serving as a tool for developing alternative scenarios and iteratively evaluating the impacts of potential future growth outcomes on such features as wildlife habitat corridors, agricultural lands, water resources, and transportation needs.

See also "From Urban California to Rural Kenya."

(This article originally appeared in the Summer 2012 issue of *ArcNews*.)

From Maps to GeoDesign

Conserving Great Ape Landscapes in Africa

By Lilian Pintea, Africa Programs, The Jane Goodall Institute

The Jane Goodall Institute (JGI) has been very interested in the evolution of the new field of GeoDesign, which offers the vision and the infrastructure to bring people, disciplines, data, and technology together to not only better describe landscapes but also develop more successful conservation strategies and actions.

One practical application of GeoDesign has been the successful use of geospatial and conservation sciences to inform decisions in the Greater Gombe Ecosystem in Tanzania. JGI greatly improved village land use in this very sociopolitically difficult and historic setting. We were successful not only because of the technology we employed but also because the JGI staff understood human values and decision-making processes that influence landscape change in that particular region. We learned that helping develop the region (e.g., through working together to provide clean water sources, among many projects) opened the door to communities and motivated them to "buy in" to our efforts, creating a window of opportunity to apply conservation science to threatened ecological systems. Some of these programs are discussed in detail below.

At the core of JGI's applied conservation science program is using geography as a common framework to support our projects in Africa by connecting people, their values and activities, and conservation data and developing a shared understanding and vision of landscapes and how they should be changed. This in turn enables us to implement, monitor, and measure the success of those changes for both human and chimpanzee livelihoods.

Jane Goodall with Freud.
(Courtesy of The Jane Goodall Institute.)

We Need to Make More Enlightened Decisions

Time is running out for many endangered species, including our closest living relatives, chimpanzees. Chimpanzee and human populations are part of the same life support system, embedded in ecological systems that are intimately linked and dependent upon ecosystem services to survive. Unsustainable uses of natural resources by humans result in loss of those ecosystem services, with negative consequences for both chimpanzee and human livelihoods. The fundamental problem is that, despite advances in science and technology, we have not yet developed the methodologies to apply these to conservation and make more enlightened decisions about how to achieve a better balance between environmental and economic results.

Fifty years ago, on July 14, 1960, Jane Goodall stepped for the first time onto the shores of Lake Tanganyika and, through her groundbreaking discoveries about chimpanzees in what is now Gombe National Park in Tanzania, opened a new window to the natural world and to ourselves. This unique long-term research continues today with daily chimpanzee data collected by the JGI Gombe Stream Research Center and digitized, stored, and analyzed at the Jane Goodall Center at Duke University.

GIS and Imagery for Clearer Understanding

GIS has been used to georeference and digitize hundreds of thousands of chimpanzee behavior locations and analyze ranging and feeding patterns and relations with habitat characteristics as detected by remote-sensing and field surveys. The use of geospatial data for chimpanzee research was straightforward. Spatial tools and variables derived from GIS and remote sensing were directly used as part of research collaborations to test hypotheses. For example, a vegetation map derived from 4-meter IKONOS imagery helped demonstrate that chimpanzee hunts on colobus monkeys are more likely to occur and succeed in woodland and semideciduous forest than in evergreen forest, emphasizing the importance of visibility and prey mobility. JGI also worked with the Tanzania National Parks to improve the management of the park by using geospatial technology to visualize habitat change, map the park boundary, and support the development of the Gombe National Park Management Plan.

In addition to continuing Jane Goodall's pioneering research, JGI has been accumulating decades of experience and practical knowledge outside protected areas on how to successfully engage local communities and decision makers in the sustainable use of their natural resources. While the technology to map land cover inside and outside Gombe National Park was mostly the same, the way geospatial information was used to inform decisions was very different.

The use of geospatial information to inform decisions outside the park has been more complex. Gombe National Park was created in 1968. The park inherited a history of conflict with the local communities that started in 1943 when the colonial government established for the first time Gombe Stream Game Reserve. In 1994, JGI began working with the local communities outside Gombe through the Lake Tanganyika Catchment Reforestation and Education (TACARE, pronounced "take care") project to seek ways of arresting the rapid degradation of natural resources. TACARE project staff quickly learned that community buy-in was essential for success. Therefore, the TACARE project added agriculture, health, social infrastructure, community development, and clean water components to the range of interventions it employed. These interventions initially focused mostly on areas close to village centers.

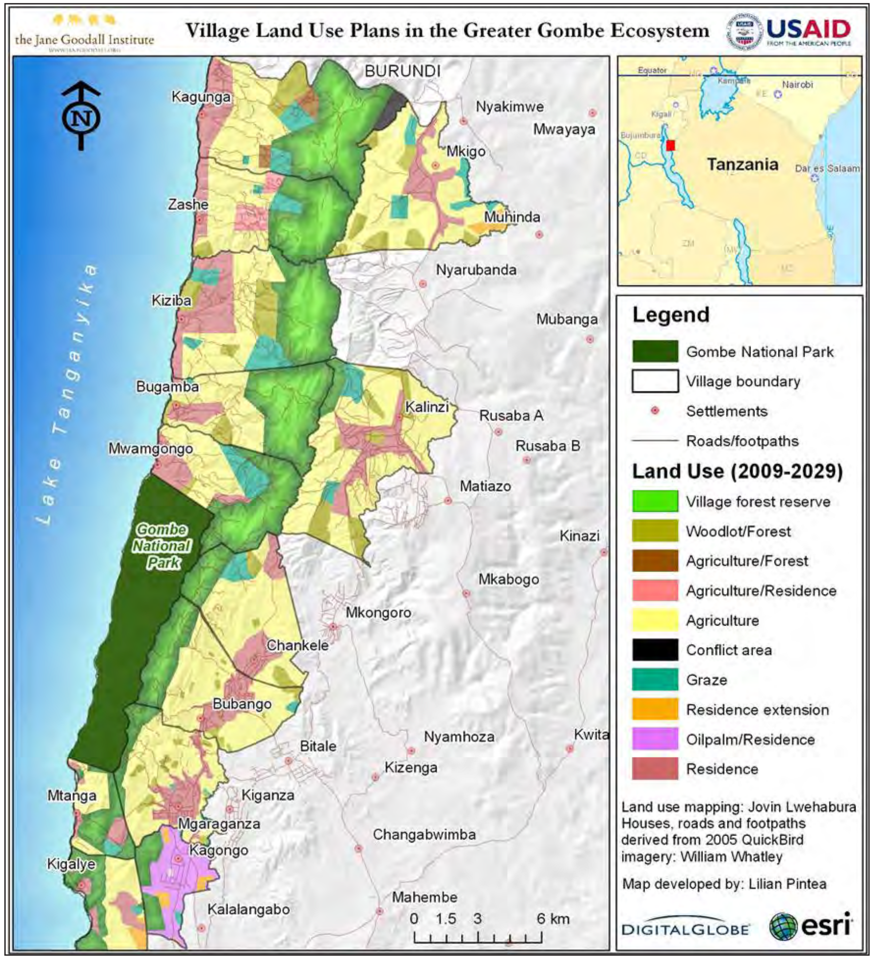
However, forest change detection using Landsat imagery from 1972 and 1999 showed that most chimpanzee habitats outside the park had been in areas away from the village centers and almost 80 percent of it converted to farmland and oil palm plantations. Remote-sensing and GIS analysis led to a landscape approach by focusing conservation efforts geographically on areas away from village centers and on forest patches with the most benefits to chimpanzees. In 2005, adopting the recommendations obtained through analysis of satellite imagery and with funds from the US Agency for International Development (USAID) and other donors, JGI and its partners embarked on a five-year Greater Gombe Ecosystem (GGE) project.

A Conservation Action Plan approach was developed to identify and prioritize conservation strategies. Village land-use planning was identified as one of the top strategies. GIS was used to overlay deforestation layers, historic distribution of chimpanzees and habitats, slope, footpaths, roads, streams, watersheds, density of human structures, and 60-centimeter QuickBird imagery to prioritize a conservation area that, if protected, would substantially increase the viability of chimpanzees inside and outside the park and stabilize the watersheds to support human livelihoods.

Participatory village land-use plans were prepared by the communities according to Tanzanian laws and with full involvement of government and community stakeholders. JGI facilitated the process and provided technical support, including maps and geospatial tools to record and manage spatial data. The planning process followed seven steps and required villagers to settle any existing land disagreements and agree on village boundaries and how land resources located within the villages should be used to meet specific human livelihood needs and environmental objectives.

At the end of the project in 2009, 13 villages within GGE completed their participatory village land-use plans, which became ratified by the Tanzanian government. Local communities voluntarily assigned 9,690 hectares, or 26 percent, of their village lands as Village Forest Reserves. These reserves are interconnected across village boundaries to minimize fragmentation and cover 68 percent of the priority conservation area identified by the GGE Conservation Action Plan.

With renewed financial support from USAID, JGI and partners are now engaged in facilitating community-based organizations, developing bylaws and building local capacity to implement these village land-use plans and restore and manage newly established Village Forest Reserves. The plan is



Participatory village land-use plans were prepared by the communities according to Tanzanian laws

(Courtesy of The Jane Goodall Institute.)

to use DigitalGlobe imagery continuously to provide detailed information on village land-cover change, such as increases in forest cover in Kigalye Village Forest Reserve, and monitor both new threats and conservation successes.

About the Author

Dr. Lilian Pintea brings more than 15 years of experience in applying remote sensing and GIS to the job of protecting chimpanzees and their vanishing habitats in Africa. As vice president of conservation science at JGI, Pintea directs the scientific department at the institute and conducts applied conservation research in Tanzania, Uganda, the Democratic Republic of the Congo, and the Republic of the Congo.

See also "Harnessing the Power of Our GeoDesign Vision."

(This article originally appeared in the Summer 2011 issue of *ArcNews*.)

3D Modeling Shows Off Elevated Rail System Landscape

Honolulu Uses Geodesign to Build Case for Rail Corridor

Being on island time conveys the aura that everything is as peaceful and slow traveling as an islander in paradise. In Honolulu, the islanders can boast they do travel slowly through their paradise, but maybe not so peacefully on their roadways, since Honolulu has claimed the top spot as the worst US city for traffic. Compounding the problem, citizens have moved to suburban areas in search of affordable housing, creating urban sprawl, which increases traffic demand when traveling to urban centers for work.

The City of Honolulu, shown here in CityEngine, shows the elevation levels of the downtown corridor, as well as the proposed transit-oriented development, giving citizens and planners a dynamic view of potential changes to the city.

For Honolulu, the effects of urban sprawl go beyond increased traffic demand and have negative impacts, such as environmental pollution, natural habitat reduction, loss of agricultural land, and even decline in human health and well-being. In an effort to help alleviate some of the traffic pressure on its roadways, the City and County of Honolulu have approved and begun construction of an elevated rail system connecting East Kapolei to Ala Moana Center. Not only will the new railway change the way citizens and tourists will travel through Honolulu, but the planning and development surrounding the rail corridor will be redefined through what is known as transit-oriented development (TOD).

Planners look to TOD as a common solution to accommodate future population growth, control urban sprawl, and decrease traffic demands on communities through the use of dense, mixed-use housing placed near transit. This creates mass-transit and walkable access to retail and amenities. This paradigm shift to TOD planned communities with medium- to high-rise development and a new feature in the landscape, the elevated rail system, can and has been met with opposition by some community members. Part of the planners' role is to persuade the citizens of the benefits of TOD for their community through a collaborative planning process where they share information and ideas about the development. The planners must tell the story of the future of the community from both sides of the coin. To do so, planners and consultants are using more sophisticated visualization tools, which can be very effective at shifting the attitudes about new and different development in this island paradise.

To tell the story of TOD, the City and County of Honolulu turned to GIS as a primary tool within the process. The city GIS department embraced and applied the concept of geodesign—that is, incorporating geographic knowledge into design—to more effectively analyze, compare, and visualize different scenarios of TOD for the key communities affected by the new development. To build the case for TOD, the GIS team needed to support the planners' goals to share with the public who would have safe access to rail; how changes to the zoning would visually redefine their community; and how the TOD would positively affect the community and region, preventing future urban sprawl.

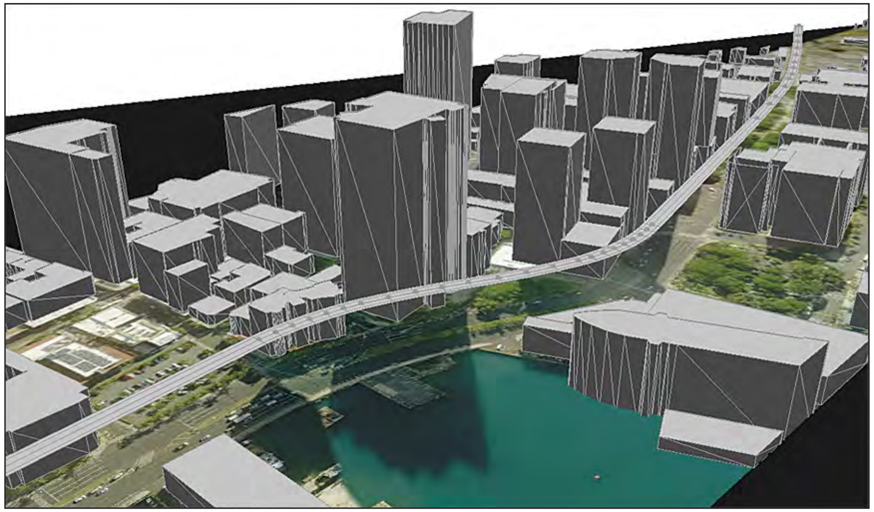
The team identified three core models that would be needed for the TOD geodesign process: walkability, urban growth, and densification models. As with any new GIS project undertaking, the GIS department first determined data resources needed to support the analysis and whether these datasets were available or needed to be developed. Most of the core data, such as roads, zoning, and buildings, was available in the rich geodatabase that Honolulu has been developing for years. Since visualization is a key component of geodesign and a powerful tool for persuasive planning support, a 3D model of the physical environment would be needed for the transit corridor. Honolulu had a good start to the city model with 3D geometries for the downtown area, including key landmark buildings with textures.

However, the model was not complete and needed to be enhanced in areas, since more than 3,000 buildings were without textures and some were mere footprints. The team used Esri CityEngine to improve the model by creating 3D geometry and applying textures based on a custom set of rules. Honolulu wanted to simulate the true look and feel of the city and accomplished this by collecting photos of real facades that were used to create a custom set of textures. These textures were applied based on the rules, instantly painting the remaining buildings. Rules were further applied to create 3D geometries by converting simple building footprints into complex structures with textures. The last component was the addition of the proposed evaluated rail, which was added from the existing engineering drawings, completing the 3D urban model of Honolulu.

The next step in the geodesign process was to analyze the effectiveness of a TOD and create alternative scenarios used by the planners to convey the benefits of TOD for a given community and the region. Utilizing the ArcGIS 3D Analyst and ArcGIS Spatial Analyst extensions and ModelBuilder, the GIS team developed reusable walkability, urban growth, and densification models in which data was run against changing variables to create different scenarios. A key factor of TOD is to provide the acceptable and safe walking or biking distance to a transit stop. The walkability model used Spatial Analyst geoprocessing tools to determine the travel distance from residences or work to a transit station.

From this analysis, stakeholders or citizens could determine the viability of transit for their use. Since the acceptance of TOD in a community must be more convincing than just ridership, the planners must convince members of the public that TOD will benefit Honolulu's future whether they utilize the rail or not. The GIS team supported the planners by creating scenarios based on the projected future with TOD and without. The TOD plans for each station were run against the urban growth and densification models using Spatial Analyst and 3D Analyst to perform the analysis.

Using CityEngine, the rules for creating 3D geometries and texture were applied to the resultant analysis, and new models were generated representing proposed build-out of the future with TOD. The 3D model showed urban growth concentration around stations with low- to medium-density buildings and ample undeveloped land. The same models were run against the existing zoning with no TOD, resulting in a sea of houses, showing a stark comparison of Honolulu's landscape in the future as urban sprawl. An incentive of geodesign for planners is to equip them with analytic outcomes that could be used to persuade the stakeholders and public that TOD will have a positive impact on the community. Honolulu approached the community engagement with unique visualization technologies, which included 3D holograms and simple web views of TOD scenarios. The GIS team worked with Zebra Imaging, a leading 3D visualization company and Esri Partner (Austin, Texas), to create visually captivating, true 3D views of the analysis in 3D holographic images.



Preparing this model for hologram printing and display is as simple as adding textures, saving the project, and loading the model into ArcGIS for use with the Zebra Imaging plug-in.

Through Zebra Imaging software, ArcGIS 3D Analyst, and Esri CityEngine, the holograms were sourced directly from the exports of 3D GIS data models representing TOD and rendered to capture thousands of unique 3D views. The 3D views of the

GIS were used to create a holographic grating that is recorded on film with lasers. When illuminated with an appropriate light source, what looks to be a flat piece of plastic reveals a 3D, full-parallax, color image reflected above the film's surface.

(This article originally appeared in the Spring 2013 issue of *ArcNews*.)

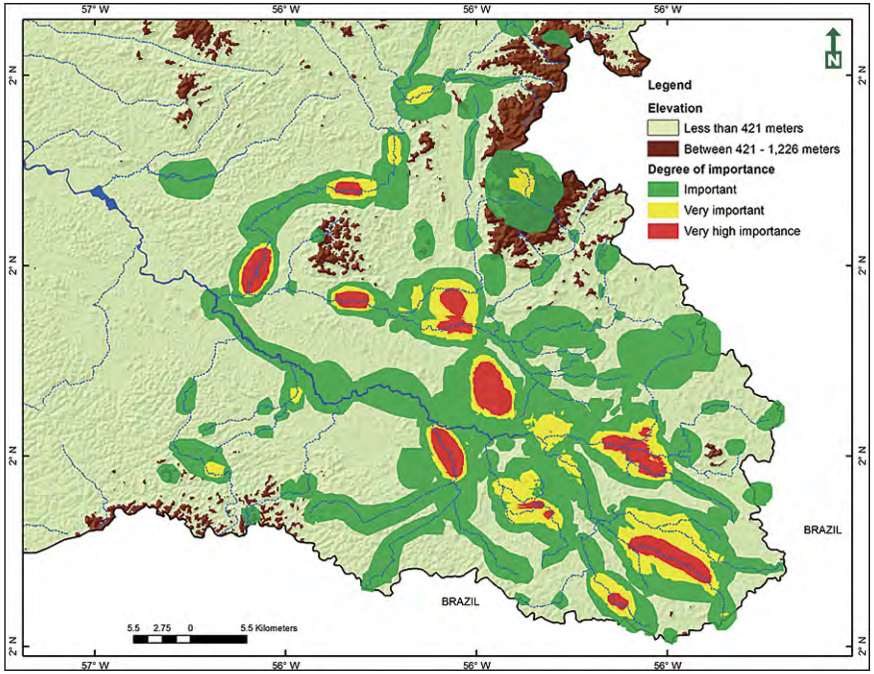
Participatory GIS

Indigenous Communities in Suriname Identify Key Local Sites

By Sara O. I. Ramirez-Gomez and Christian Martínez

The nation of Suriname is tucked up against the Atlantic Ocean in northeastern South America. Southern Suriname is covered with continuous tracts of unspoiled tropical forest, and it is the home of approximately 2,000 Wayana and Trio indigenous peoples. The area is currently remote, and economic development is practically nonexistent, which has helped it remain intact. However, several economic development projects for the area are becoming priorities for the national government, including mining, hydroelectric dams, and road construction. While these investments may benefit Suriname, they also pose a threat to Suriname's ecosystems and local communities' livelihoods, fundamentally in the lack of socioecological information. In the absence of reliable information, the decision-making process will fail to include local people's needs in terms of land and natural resources, bringing further inequity and poverty to vulnerable people in the country.

Conservation International Suriname (CI Suriname) is working with five indigenous communities in southern Suriname to produce maps depicting perceived importance for landscape services. Through this work, the organization is supporting the development of a visual tool for tribal communities to facilitate



Map of the Sipaliwini village's perceived importance of the landscape for subsistence, based on the count of overlapping locations.

their interaction with government planners and external institutions in all issues related to their territory.

To foster progress with informed decision making, CI Suriname is undertaking participatory mapping processes that produce spatial information to support a community bottom-up approach in the land-use decision-making process. To do this, the project team looked for a way to combine community mapping with GIS technology to put people's spatial knowledge into digital maps that could be incorporated into conservation planning. As a longtime user of Esri technology, CI Suriname chose ArcGIS to build a tool to effectively count the times that thousands of polygons were overlaid to produce maps showing the frequency of landscape services polygons as surrogates of importance; the more overlays, the more use of the area and thus the more important the landscape for the indigenous people.

To produce these maps, the development of an operational tool was needed to count the number of times that the landscape services polygons were overlaid. This tool combined several ArcGIS tools to effectively map intensity of use. The input data was obtained through social mapping workshops with community participants in five Amerindian villages of South Suriname. During the data collection process, people were prompted to individually indicate, by drawing polygons on a georeferenced landscape map, the areas that they use for four distinct landscape services. The services were distinguished by using different color markers: subsistence (red), income-generation-related services (blue), culture (orange), and life-sustaining services (green). The number of maps produced during the workshops coincided with the number of participants. The polygons in each of these maps were then digitized in ArcGIS, queried by the landscape service they represent, and prepared for the data analysis process. At this stage, thousands of polygons were processed.

A village woman drawing polygons on an elevation map.

Using the ModelBuilder environment in ArcGIS, a tool was developed to count overlapping polygons inside a shapefile, and a new shapefile was created with polygons whose attributes are the number of overlaps identified in that specific spatial unit. The developed tool has a simple user interface: it first asks for an input shapefile, which has all the polygons mapped in the area, and then it asks the name and location of the output shapefile. CI Suriname uses this tool to identify concentrations of important places for provision of landscape services according to the perceptions of local people.

ModelBuilder flexibility lets CI Suriname integrate available tools to create a new user-designed tool able to process a large amount of information and with a user-friendly interface. Identification of the areas important to local people is useful input to develop sustainable action plans and support decision making. Indigenous communities see the importance of the maps to facilitate dialog with outsiders. Some of the villagers highlighted the importance of the maps for tourism, while others highlighted their importance for future generations.

Kapitein Euka, the chief of Sipaliwini village, is a firm advocate of ensuring that the natural environment remains intact so that his village can continue to exist. At a meeting with CI Suriname, with whom villagers have created maps showing the areas and ecosystems they depend on, he said, "It is important for us to be able to show the government what parts of land are necessary for our way of life and are important to us." He added that he thinks the maps are vitally important to this cause, especially if future infrastructural development takes place. "It's good that everyone knows about these maps and is aware of how important this land is to our village."

About the Authors

Sara O. I. Ramirez-Gomez is South Suriname project coordinator for Conservation International Suriname. Christian Martínez is the land-use planning coordinator for Conservation International Ecuador.

(This article originally appeared in the Spring 2013 issue of *ArcNews*.)

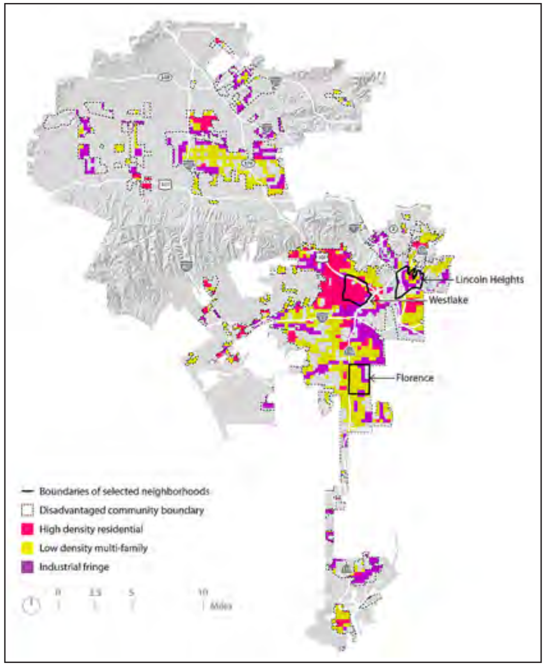
Turning Red Fields into Green Fields in Los Angeles

It's All Connected

Geodesign is about holistic design and communication. It is about easily linking seemingly disparate data into a cohesive graphic language that can tell a story far more powerful than its individual parts. Nowhere is this better illustrated than in the story of how something as humble and democratic as a park could help reverse the country's economic malaise.

Michael Messner, a Wall Street fund manager and cofounder of the Speedwell Foundation, proposed Red Fields to Green Fields (R2G), a plan for turning distressed properties (red fields) into parks (green fields). His argument is simple—remove the glut of overbuilt and foreclosed properties and redeploy that capital out of underperforming real estate and into green space. It would stabilize property values, strengthen banks, and create jobs. As Messner puts it, "Tearing down can create wealth. Land without buildings should be considered an asset by our financial system." He goes on to point out that the benefits are far more than financial.

In essence, parks benefit the "triple bottom line" by improving economic, social, and environmental health of communities. From New York City's Central Park to the City of Boulder's greenbelt, history has shown that parks and open space tend to increase



ArcMap, 2000 Census data, and land use data from both Esri and the Southern California Association of Governments (SCAG) were used to identify three areas that were both park-poor and economically disadvantaged (outlined in black).

(From Dakotah Bertsch, Michael Boucher, Eran James, and Abby Jones. Red Fields to Green Fields Los Angeles, Pomona: California State Polytechnic University 606 Design Studio, used with permission.)

nearby property values; attract tourists and residents who contribute to local commerce; increase public health by providing opportunities for physical recreation and mental relaxation; and perform vital environmental services, such as treating storm water, reducing heat island effects, and improving air quality.

Los Angeles was one of 11 cities selected to test the viability of the R2G concept. The Red Fields to Green Fields Los Angeles (R2G-LA) case study was developed by the Verde Coalition with the help of several agencies, including Occidental College's Urban and Environmental Policy Institute; Parks for People; the Trust for Public Land; and California Polytechnic University, Pomona's Landscape Architecture Department 606 Studio (606 Studio). 606 Studio played a significant role in developing the R2G-LA case.

City of Angels—Defining the Issues

Los Angeles is the third richest city and fifth most powerful and influential city in the world. It is also recognized as the most diverse metropolitan area in the United States. However, compared to other large cities within the United States, Los Angeles's parkland falls short both in terms of its percentage of the city's land area and in terms of park acres per resident. While a few large tracts of parkland do exist, parks are not distributed equally throughout the city, being especially deficient in lower-income neighborhoods.

Lack of parks is not the only disparity. Food deserts, obesity, asthma, and other ailments associated with lack of open space and low income dominate in these areas. Poor environmental quality is also highest in these communities. During the recession, property values plummeted everywhere, but disadvantaged communities were hit hardest.

Lincoln Heights aggregated capability bar chart map.

(From Dakotah Bertsch, Michael Boucher, Eran James, and Abby Jones. Red Fields to Green Fields Los Angeles, Pomona: California State Polytechnic University 606 Design Studio, used with permission.)

Working Across Scales

Geodesign is also about discovery. It is about reading the landscape to tease out what is most important. It involves assessing the condition of a place and its people working across scales to determine how one region, neighborhood, or number of sites might affect another. Since it is holistic in nature, it requires gathering diverse geographic data covering the natural, cultural, and built environments.

To begin the study, data inventories had to be collected and/or created for each level of investigation to meet the informational demands of each scale from the region to the neighborhood to the site. ArcGIS played a significant role by providing the data storage framework necessary to store, analyze, query, and visualize economic, environmental, and social data across multiple scales.

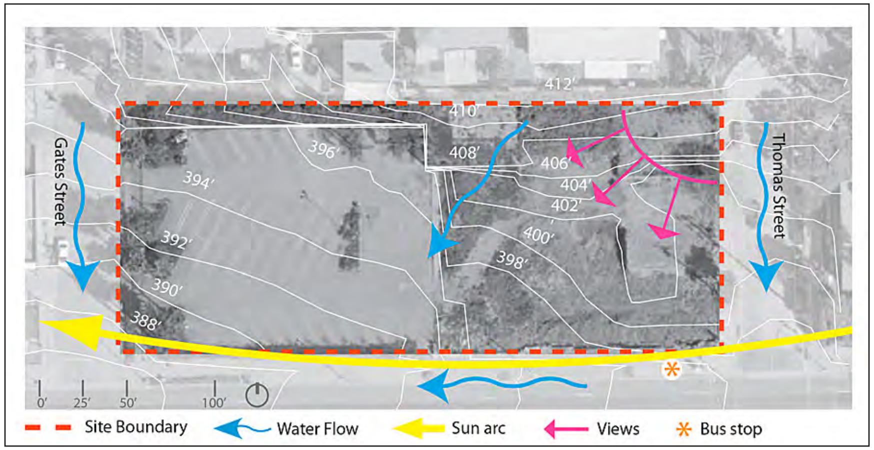
Identifying Neighborhoods

To begin the study for Los Angeles, researchers examined the geographic context of the region to determine the highest-need neighborhoods that could most benefit by the improved environmental, social, and economic health resulting from converting distressed properties to open space.

Two criteria were chosen, which were based on California Proposition 84 funding standards that have been instrumental in providing funding for parks and nature facilities in California:

- Identify the most park-poor areas, defined as having three acres or less of parkland per 1,000 people based on census tract data.
- Identify disadvantaged neighborhoods, defined as census tracts with a median household income that is 80 percent of the state median household income.

At the regional scale, these two criteria formed the basis of the geodesign evaluation models that would result in the identification of three neighborhoods most in need: Lincoln Heights, Westlake, and Florence.



A simple map/graphic diagram illustrates the key opportunities and constraints of the Lincoln Heights Local site analysis. Arrows represent direction of movement, flow, or views. Just enough detail to support the development of various design program elements.

(From Dakotah Bertsch, Michael Boucher, Eran James, and Abby Jones. Red Fields to Green Fields Los Angeles, Pomona: California State Polytechnic University 606 Design Studio, used with permission.)

Red Fields

Red fields are parcels of land that, for various reasons, are not functioning at their highest civic capacity. Many are vacant lots, brown fields, foreclosed properties, and run-down or collapsing buildings. Commercial real estate data helped narrow the search down to individual parcels; however, early site investigation showed that many vacant lots and distressed properties were missing from the data. The Studio 606 team surveyed all three neighborhoods to locate, ground truth, and inventory site characteristics for all available red fields. The site inventories provided a much more in-depth understanding of red field conditions and their community context, invaluable for later site design. The total number of red fields found in all the neighborhoods was 138 sites, with a total area of 67 acres.

The inventory included relative sun exposure; size; commercial use or zoning; average slope; buildings present; land-use designation; ownership; proximity to the network of planned bike lanes; and proximity to Metro stations and major commercial intersections (nodes), either of which are indicative of higher-than-normal pedestrian use.

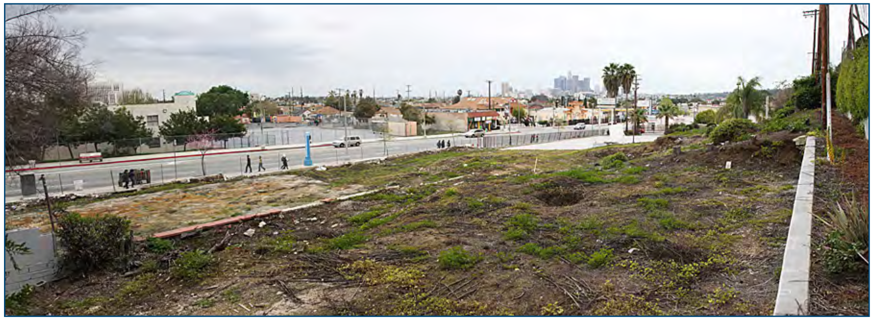
Green Fields

Green field types were developed that address the social, environmental, and economic needs of local Los Angeles communities. The four broad categories of green field types included urban agriculture, recreation, community, and ecology. Urban agriculture green field solutions support food production in the context of the urban environment through community gardening, farming, composting, or production of value-added products from agriculture. Recreation green field solutions refer to parks, sports fields, trails, or other facilities that promote active or passive physical activity. Community green field solutions focus on building community capital through social, cultural, educational, or artistic exchanges by creating plazas or space for community interaction. Ecology green field solutions provide ecological function and opportunities for people to connect with nature, for example, through engineered wetlands, reintroduction of native vegetation, etc.

Site Selection

Having identified the neighborhoods of highest need, the next step was to narrow selection down to individual parcels using a suitability analysis. One highly suitable site for each green field type was chosen from the list of suitable sites.

However, for the purposes of this article, only one site will be focused on to illustrate how a red field might be converted to a green field—the Lincoln Heights Local red field site. For the rest of this article, Lincoln Heights Local will be used for the green field site development discussion.



Lincoln Heights Local site selection.

(From Dakotah Bertsch, Michael Boucher, Eran James, and Abby Jones. Red Fields to Green Fields Los Angeles, Pomona: California State Polytechnic University 606 Design Studio, used with permission.)

Lincoln Heights Local—Site Analysis

Lincoln Heights Local, a large red field, is a sloped, vacant lot located on Broadway, a busy commercial street in one of the oldest neighborhoods of Los Angeles. Multiple schools surround the site, including a high school, elementary school, preschool, and kindergarten. An adjacent bus stop on Broadway is heavily used by high school students and other residents.

The site has steep topography on one side, providing views of buildings in downtown Los Angeles, and a relatively flat parking lot on the other side. It has high visibility, good accessibility, and a stream of pedestrians passing by—particularly at the beginning and end of the school day. The south-facing site receives full sunlight. Other factors to include in any determination are the following:

- Site area: 1.1 acres
- Neighborhood density: 10,602 people/square mile
- Surrounding uses: schools, residential, commercial
- Adjacent bus stop
- Sloped topography with views of city
- Pedestrian traffic from high school
- Water drainage needs handling
- Possibility of site needing terracing

Program Development

A detailed suitability analysis was performed that showed that a community garden and a farmers' market plaza, representing urban agriculture and community green field types, respectively, were the best fit for this red field, both programmatically and physically, given the opportunities and constraints of the site.

Lincoln Heights Local would focus on promoting healthy food options and building community. The community garden would provide plots to surrounding schools as well as other members of the community. The top floor of the community building would serve as an outdoor classroom, while the bottom floor would house garden tools.

The farmers' market plaza, with a large oak tree, would host weekly farmers' markets, as well as other community events, such as health fairs, arts and crafts fairs, and flea markets.

Built-in seating would enhance the functionality of the plaza and provide people with the option of dining on-site after purchasing healthy food at the farmers' market or meet with friends.

Site Design

Using ArcGIS, CAD, Illustrator, Photoshop, and sketching tools, design renderings of the proposed Lincoln Heights Local green field were produced to better illustrate the design concepts that had been developed for each site. Care was taken to ensure that the designs were appropriate applications of green field solutions to the specific site conditions, as well as to the neighborhood context and regional objectives. Photorealistic renderings backed by GIS analyses and hard data help community members, government officials, and special interest groups understand the consequences of a particular design so they can make better, more informed decisions.

The photorealistic design rendering.

(From Dakotah Bertsch, Michael Boucher, Eran James, and Abby Jones. Red Fields to Green Fields Los Angeles, Pomona: California State Polytechnic University 606 Design Studio, used with permission.)

The Big Picture

This study has shown that if all the area of need's red fields were converted to green fields, park space would more than double in the disadvantaged communities of Los Angeles. A $7.2 billion investment would allow Los Angeles to rebuild disadvantaged neighborhoods, add vital park space, and improve economic conditions citywide. Converting red fields to green fields would reduce disparities between communities and strengthen the city's social, economic, and environmental health. Key impacts would be the following:

- Create 77,000 new jobs.
- Remove 1,300 acres of distressed real estate from the market.
- Add 1,100 acres of small and walkable parks and increase the ratio of parks per thousand people by 48 percent in disadvantaged communities.

- Restore 400 acres of habitat in the Santa Monica Mountains National Recreation Area.
- Create 200 acres of park space along the Los Angeles River.

Moving Forward

At this time, the results of this analysis are being used to help government officials and other stakeholders build support to fund some of the proposed R2G-LA strategies. Community advocacy groups, environmental nonprofits, and others, are now working with LA officials to find ways to move forward with this integrative approach to solving multiple issues.

For more information on how to put geodesign into practice, visit esri.com/geodesign.

This article is adapted from "Chapter 8: Red Fields into Green Fields" from *Geodesign: Case Studies in Regional and Urban Planning* by Shannon McElvaney, Esri Press, ISBN: 978-1-58948-316-3. Visit esri.com/esripress.

(This article originally appeared in the Winter 2012/2013 issue of *ArcNews*.)

Understanding our world.

Esri inspires and enables people to positively impact their future through a deeper, geographic understanding of the changing world around them.

Governments, industry leaders, academics, and nongovernmental organizations trust us to connect them with the analytic knowledge they need to make the critical decisions that shape the planet. For more than 40 years, Esri has cultivated collaborative relationships with partners who share our commitment to solving earth's most pressing challenges with geographic expertise and rational resolve. Today, we believe that geography is at the heart of a more resilient and sustainable future. Creating responsible products and solutions drives our passion for improving quality of life everywhere.

Contact Esri

380 New York Street
Redlands, California 92373-8100 USA

1 800 447 9778
T 909 793 2853
F 909 793 5953
info@esri.com
esri.com

Offices worldwide
esri.com/locations

esri.com/ebooks

Printed in USA

G60023 ESRI8/13ek