Planning Support Systems for Fiscally Sustainable Planning

Scott N. Lieske[1], Roger H. Coupal[2], Donald M. McLeod[2], Anna M. Scofield[2] and Jeffrey D. Hamerlinck[3]

[1] Sustainability Research Centre, University of the Sunshine Coast, Maroochydore DC, Australia; slieske@usc.edu.au
[2] Agricultural and Applied Economics, University of Wyoming, Laramie, Wyoming, USA; Coupal@uwyo.edu; DMcLeod@uwyo.edu; ascofiel@uwyo.edu
[3] Wyoming Geographic Information Science Center, University of Wyoming, Laramie, Wyoming, USA; jhamerl2@uwyo.edu

Abstract

Local government's need for accurate assessments and projections of the fiscal consequences of development is well established and persistent. This analysis demonstrates the use of a geographic information science-based planning support system to project residential growth and the fiscal consequences of development. The cornerstone of the analysis is a spatial index of urban form which captures clustering and dispersion of the built environment. A regression model indicates the spatial index to be a statistically significant determinant of expenditures on policing services in the study area. Modeled future growth was spatially and temporally disaggregated to indicate future residential growth at different planning horizons. Spatial indices were calculated for these planning horizons and incorporated into the econometric model for *ceteris paribus* evaluation of the effect of change in urban form on public service expenditures. Results demonstrate planning informed by PSS modeling has the potential to realize savings on public service expenditures.

1. Introduction

Sustainability, from the perspective of local government finance, is in part a situation where the costs of providing a public service are minimized rather than exacerbated by development decisions. Emerging research in local government fiscal modeling demonstrates a statistically significant relationship between increasing dispersion of the built environment and increasing costs of public service provision. The goal of this research is to inform public service decision making and support sustainable planning and urban development by making clear the fiscal implications of a local government land-use planning and regulatory framework. The approach taken is to use a geographic information science-based planning support system (PSS) to link a public service expenditure model with a growth model. The growth modeling technique employed here is a straightforward build-out analysis based on future land use and density requirements specified in a developing comprehensive plan. Build-out rather than a more sophisticated growth model is preferred as it ties clearly and directly to the existing planning and regulatory framework in the study area. Zoning, along with subdivision control law and to a lesser extent growth control laws and building codes are the primary regulatory tools associated with land development in the study area. In order to compare and contrast the impacts of differing land-use patterns a base scenario emerging from the comprehensive planning process is contrasted with an alternative land-use scenario. The alternative land-use scenario has decreased densities in outlying areas and a larger urbanized area. The hypothesis is the alternative land-use scenario, with a more concentrated built environment, will offer greater efficiency than the base scenario. Given plausible results (indicating the econometric modeling, growth modeling, and the linking of the two are valid), the degree of economic efficiency realized, the magnitude of fiscal change and change in efficient area across scenarios may be used as a cornerstone for proactive fiscally sustainable planning.

PSS operationalize various tools needed to develop this analysis including scenario planning, build-out analysis, spatial and temporal growth modeling, and impact assessment. By using PSS to critically evaluate land-use and density specifications within the context of future growth it may be possible to more clearly demonstrate the future impacts of current policies and regulations including whether mechanisms in place help to realize or conflict with a community's vision. Van Eck and Koomen (2008) describe this approach as "ex-ante evaluation of the spatial effects of planning measures" (p. 124) and note the importance and need for tools to do this. By enabling ex-ante evaluation of the potential impacts of extant planning policies and regulations it is hoped to be able to realize broader impacts from this research including conclusive impact and benefit from PSS, spatial modeling and spatial planning.

2. Background

This research used the CommunityViz® PSS to evaluate the long-term (25 year) influence of changing urban form on expenditures for policing services in Laramie County, Wyoming, USA. Developed by the Orton Family Foundation (Rutland, VT), CommunityViz is a modular system built on the ArcGIS platform (ESRI, Inc.; Redlands, CA). CommunityViz includes two integrated components: Scenario 360 and Scenario 3D. Scenario 3D allows display of three-dimensional landscape and structure information with real-time movement and object manipulation in a semi-realistic setting. Scenario 360 provides functionality for assessing the potential impacts of specific, proposed land use actions. CommunityViz Scenario 360 is used here to develop a build-out analysis, distribute modeled dwelling units spatially and temporally across the study area, and evaluate the fiscal and related impacts of alternative land uses using a scenario analysis and series of indicators.

Local government expenditure modeling

The fiscal implications of differing urban forms are important considerations for local government financial health and as evaluation criteria in planning processes. Burchell and Listokin (1978) articulate the need for fiscal analysis stating that municipalities, "...must be aware of the public costs associated with private development, major rezonings, annexations, or alternative land use plans" (p. 1). Fiscal analysis may be used to predict budget deficits, allow local governments to quantitatively consider land-use policy decisions, levels of service, capital improvement plans and long term financing needs including current and future revenue streams. Fiscal analyses are helpful in short and long-term land-use policy and financial planning (Tischler, 2002a). For comprehensive planning, Tischler recommends evaluation of different plan alternatives early in the planning process, prior to making the plan. This allows planners, "…to determine if land use … and location assumptions generate net revenues or net costs to the jurisdiction" (Tischler, 2002b, p. 4). Goetz (2007) further emphasizes the importance of the issue when he juxtaposes the need for the fiscal evaluation of planning alternatives with the idea of planning as a nonrepeatable experiment. Once constructed, residential land-use patterns are "largely irreversible" (p. 20).

Important research in local government expenditure modeling includes Davenport (1926), Fabricant (1952), Hirsch (1970), Borcherding and Deacon (1972) and Heikkila (2000). These works demonstrate the use of econometric techniques to model local government expenditures on public services as a function of determinants including factor inputs and neighborhood characteristics. Examples of the latter include population, income, density and urbanization. Often, but not always, low density is associated with higher per capita costs of public service provision and higher density is associated with lower per capita costs of service provision. Lieske *et al.* (2012) add to this body of literature by developing a spatial index of urban form that was a statistically significant determinant of local government expenditures. The econometric model put forward here is based on the tradition of local government expenditure modeling from the 20th Century augmented with the methods of Lieske *et al.* (2012) for quantifying urban form.

Scenario planning

In planning contexts, scenarios may be viewed as different plausible development alternatives. Scenarios can serve as thinking tools, communication tools and evaluative tools. As thinking tools, the construction of scenarios "…requires people to uncover and cope with forces that are driving change in their environment" (Avin and Dembner 2001, p. 22). Observing different patterns allows consideration of the driving forces behind those patterns (Veeneklaas *et al.*, 1995). Implicitly and explicitly tying driving forces to scenarios allows consideration of different assumptions and stimulates critical thinking (Xiang and Clarke, 2003). Scenarios change and improve thinking because the discussion moves from "What do you think might happen?" to "What else might happen?", "Why might this happen?" and "How might this happen?" (Avin and Dembner 2001, p. 22). As a communication tool, scenarios serve a bridging function, allowing an exchange of information between scenario creators and scenario users (Xiang and Clarke 2003). This exchange of information means scenarios are useful as a communication and education tools between planners and their audiences. Finally, as evaluative tools, scenarios allow the answering of "What if?" questions quantitatively, qualitatively and visually. Evaluation of scenarios brings about the key benefit from scenario planning, "…the knowledge that, having explored many alternatives well, the selected course of action is defensible and prudent" (Avin and Dembner, 2001 p. 20).

Build-out

Build-out analysis is a calculation of the development capacity of land based on current or proposed zoning regulations and associated density values. Walker and Daniels (2011) call build-out analysis "…the most common and basic type of growth projection" (p. 76). Build-out analysis enables a community to illustrate and evaluate the impacts of their zoning regulations including lot size, floor area ratio, lot coverage, building height, number of stories, setbacks and density. On one hand the analysis may appear somewhat hypothetical because it specifies the very upper limit of legally allowable growth. On the other hand, it is critical for decision makers and citizens to know the long-term impacts of their land-use regulatory framework and if that framework helps realize or conflicts with the vision of the community. For example:

> Often, a build-out analysis presentation shocks audiences. By showing a map or 3-D model of what the community would look like if it were built out, you can draw the public's attention to the negative effects of poorly planned growth and weak zoning (Walker and Daniels 2011, p. 77).

Spatial and temporal growth modeling

CommunityViz® TimeScope™ functionality allows mapping and analyzing temporal change by enabling the storage and presentation of historical data as well as modeling future growth by specifying build rate details including growth rate and growth rate type (e.g. linear, exponential etc.). TimeScope also allows specification of the order in which features are built over time, for example based on development criteria such as suitability. "TimeScope calculates where and when new development will occur based on assumptions that you provide about growth rates and growth patterns" (Walker and Daniels, 2011 p. 80).

Impact assessment

Impact analysis involves quantifying outcomes from different spatial patterns and their interaction with any related non-spatial drivers. Impact analysis is premised upon and directly supports the rational planning process where data are transformed into conclusions and recommendations

(Hanna and Culpepper, 1998). As a tool that is both evaluative and communicative, impact analysis helps people understand the implications of discrete design and policy choices on the larger community (Snyder, 2003).

The quantification of impacts is accomplished by creating indicators. Indicators are calculated values which measure impact or performance (Walker and Daniels, 2011). Indicators can be used to represent nearly anything quantifiable within a planning process. They can be as simple as counting features or measuring the size of an area or as sophisticated as the user cares to develop. Indicators facilitate direct comparison of criteria before and after events and/or among scenarios. Van Eck and Koomen (2008) recommend indicators be understandable to policy makers, accurately present modeling results, and allow one to discern differences between scenarios.

3. Methods

Laramie County, Wyoming was selected for study because county planners were recently using CommunityViz® to develop a build-out analysis as part of a comprehensive plan update. The county is an example of a fast-growing community with considerable development occurring beyond the urban fringe. The county seat, Cheyenne, is the state capital of Wyoming and primary node and source of service provision in the area. Growth in Cheyenne and Laramie County has been spurred by the northern expansion of the front range of Colorado, the proximity of Cheyenne to the junction of two major interstate highways, and oil and gas development.

Scenarios

Two scenarios are developed, a base scenario and an alternative land-use (Alt. LU) scenario. The base scenario captures anticipated future land uses and associated densities that are part of the current planning effort. The alternate land-use scenario attempts to ascertain if changed land use and density values can lead to lower costs of public service provision. The alternate land-use scenario represents a slight expansion of the urbanized area of the county and the establishment of agricultural (Ag) zoning where development is restricted to one dwelling unit per 640 acres.

Build-out

Preliminary econometric modeling did not indicate the pattern of commercial or industrial development to be a statistically significant determinant of policing services expenditures. The emphasis of the build-out analysis is therefore residential rather than commercial or industrial development. Commercial development is included only to the extent needed to have a reasonable certainty that there is not an over estimation of residential development due to the complete exclusion of commercial development.

Steps in developing a build-out analysis are to (1) chose a land-use analysis layer, (2) specify density rules and (3) specify any additional development parameters based on both the regulations of the study area and the desired accuracy and level of detail of modeled output. The analysis layer used here is a grid with cells one square kilometer in size that covers the study area. CommunityViz® build-out functionality allows one to enter settings for densities and additional parameters through an interactive wizard-type series of input windows. Build-out parameters used for the two scenarios are identical and presented in Appendix I. CommunityViz offers both numeric and spatial build-out functionality. Numeric build-out calculates building capacity based on area and density rules. Spatial build-out generates data by creating a GIS layer of building points. The land-use layers used to develop the build-out analyses for the two scenarios are presented in **Figure 1.**

One of the additional parameters that may be specified in a build-out model is development constraints. Constraints incorporated here include public lands managed by the U.S. Bureau of Land Management, State of Wyoming owned lands, lands under conservation easement, oil and gas wells indicated as permitted by the Wyoming Oil and Gas Conservation Commission as of April 2012 with 350 foot buffers, Western Area Power Authority power transmission lines buffered to 120 feet, county road rights of way, distributed U.S. Department of Defense sites, areas with slope greater than ten per cent, 100 year floodplains, and petroleum pipelines from the Wyoming Pipeline Authority buffered to 120 feet on each side. As seen in **Figure 2** development constraints in the county are extensive and widely distributed. Identical constraints were incorporated in each scenario.

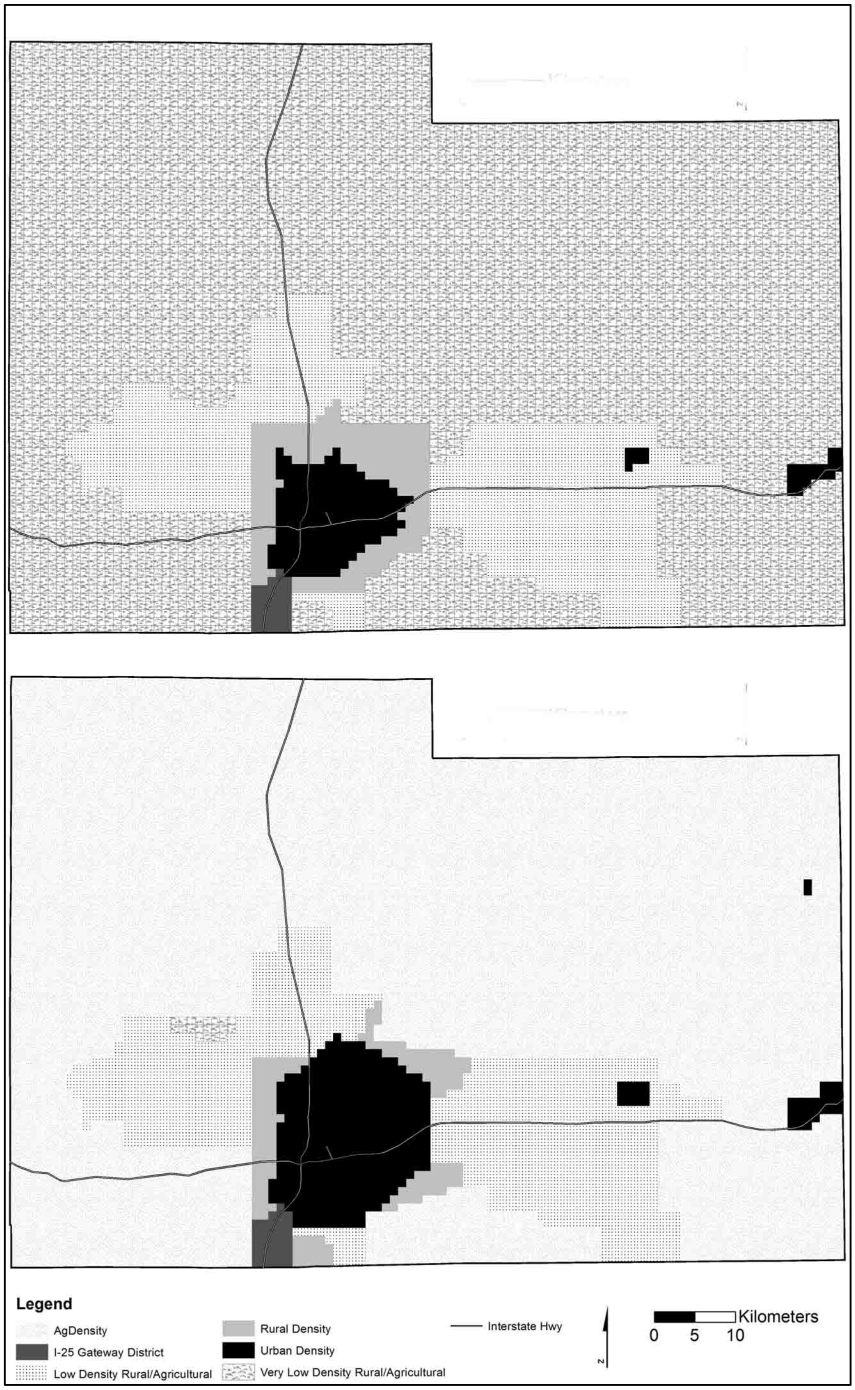

Fig. 1. Land uses for the Base Scenario (above) and Alternate Land-use scenario (below)

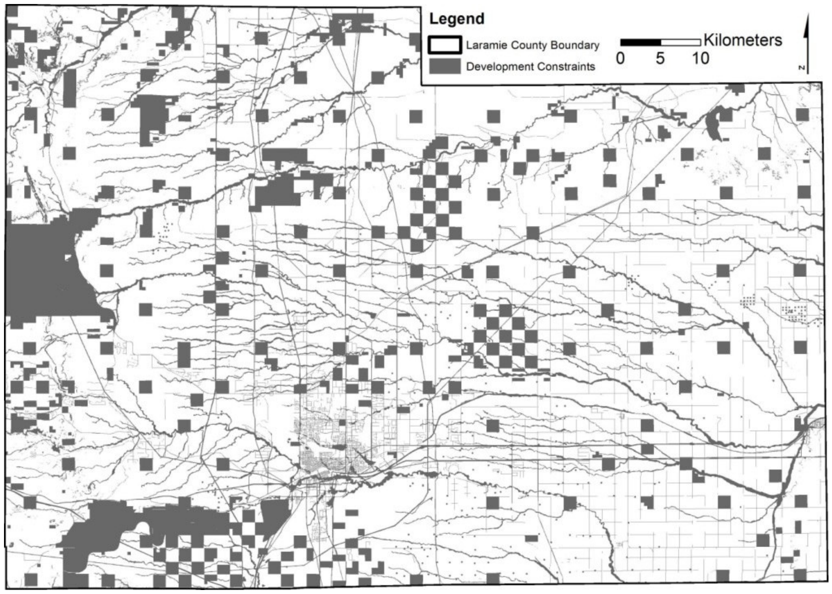

Fig. 2. Laramie County, Wyoming development constraints

Spatial and temporal growth modeling

CommunityViz® Timescope™ functionality was used to temporally and spatially disaggregate build-out results. Critical Timescope parameters are start and end date, growth rate and build order. Build order specifies where features are more and less likely to be built over time. The Timescope start date was set to 2010, the year of the latest data incorporated into the fiscal modeling. The Timescope end date was set to 2037 establishing a 25 year planning horizon from the 2012 update to the Laramie County comprehensive plan. Growth rate is indicative of development pressure (Theobald and Hobbs 1998) and set at two percent annually. While census data indicate a 1.2 per cent annual increase in population and 1.6 per cent annual increase in housing units for the time period 1990 – 2010, Timescope will only accept integer values for growth rate. Two percent was selected rather than one percent as two percent more closely tracks the pace of residential development in the study area. Preliminary efforts at developing a spatial regression-based development suitability model were inconclusive therefore build order was specified based solely on proximity to existing residential development. Statistically, proximity to existing buildings is the best indicator of desirability (Walker and Daniels 2011), and presumably, the location of future growth. Using Timescope, build-out results were temporally disaggregated to indicate modeled future growth in 2012, 2022, 2032 and 2037. These years correspond to planning horizons relevant to the Laramie County comprehensive plan update where 2012 represents current conditions, 2022 a ten year planning horizon, 2032 a twenty year planning horizon and 2037 a twenty-five year planning horizon.

The fiscal model

Based on Hirsch (1970), Borcherding and Deacon (1972), Heikkila (2000) and Lieske *et al.* (2012) a per service aggregate expenditure function is presented as follows:

$$E = f(\mathrm{N_x}, \mathrm{M}, \mathrm{I}) \quad (1)$$

where,
E represents total annual per service local government expenditures on inputs in dollars,
$\boldsymbol{f}(.)$ represents an allocation of resources for service provision,
$\mathbf{N_x}$ represents a combination of neighborhood characteristics relevant to expenditures,
M is a spatial index that captures urban form by land use; and,
I is a vector of essential inputs related to ***E***.
The dependent variable in the model is operating expenditures of the Laramie County Sheriff's department. This and the explanatory variables incorporated in the econometric model are summarized in **Table 1**. All data are time series covering 21 years from 1990–2010. In all cases data represent 21 observations (n=21).
Following Lieske *et al.* (2012) results of the regression model may be used to calculate a spatially defined service-based impact for each grid cell in the analysis. A property tax revenue model may also be developed. By contrasting the spatially defined service-based impact with revenue for each cell, fiscal efficiency (whether a cell contributes more in tax payments than it demands in services) and inefficiency (where the modeled demand for service is greater than revenue) may be mapped in a spatially explicit fashion.

Table 1. Definition of Variables.

Included Variables	Definition	Units
LE_{EXP}	Operating Expenditures of the Laramie County Sheriff's Dept.	Millions of $USD 2010
Res	Spatial index representing residential urban form	Spatial Index
Rural Pop	Population of unincorporated Laramie County	Individuals
LEO	Officers in the Albany County Sheriff's Dept.	Individuals
t	Time	Years

Extension of the base (2010) fiscal model to incorporate the results of the spatial and temporal growth modeling relied heavily on CommunityViz® dynamic attribute functionality to calculate new spatial indices for the planning horizons of interest. Dynamic attributes are formula-driven attributes of a GIS layer, much like formula-based cells in a spreadsheet, which automatically re-calculate when inputs change. After running the build-out and Timescope models, the first step in extending the expenditure model was to use a dynamic attribute to count the number of buildings in each grid cell indicated by Timescope as having been built. The sum of the building value for each cell was determined by a dynamic attribute that calculates the mean residential building value in the current or nearest cell where mean residential building value is greater than zero, multiplying this value by the count of new dwelling units in the grid cell, then adding this modeled building value to any building value from existing residences located within the cell. The next step was to calculate local Moran's *I* values for each cell based on the sum of building value within that cell. As detailed in Lieske *et al.* (2012), the spatial index is calculated as the average of these local Moran's *I* values for cells where the sum of building value is greater than zero. This process was repeated in order to develop a spatial index for each planning horizon. Following the governmental expenditure projection methods of Hirsch (1961), calculation of a spatial index for each planning horizon allowed *ceteris paribus* evaluation of the change in urban form in each planning horizon on expenditures.

The revenue model required similar adjustments in order to incorporate the outputs of the build-out and Timescope spatial and temporal growth modeling. The first step in expanding the revenue model was to count the number of buildings in each grid cell indicated by Timescope as having been built. Dynamic attributes where used to determine lot size and value per acre. Lot size was assigned based on zone. Value per acre was calculated similarly to mean building value where the value per acre per cell was taken from that cell if it was greater than zero or from the nearest neighboring cell if the original cell was undeveloped. Given the count of residential buildings, lot size, land value per acre and mean building value for each cell it was a simple matter of following the Laramie County assessor's formula to model assessed value. Property tax for modeled buildings was determined by multiplying assessed value per cell by the appropriate tax rate. In order to determine the property tax paid for each cell the property tax for modeled residential buildings was simply added to the property tax paid by existing residences. Spatially explicit revenue models where developed for each planning horizon.

Property tax may be contrasted with the revenue model on a cell by cell basis to estimate fiscal efficiency in a spatially explicit fashion. The annual share of overall property tax dedicated to the provision of policing services is approximately 8 per cent over the time period of the study. Evaluation of fiscal efficiency is accomplished by multiplying property taxes by 8 percent to indicate the portion of property taxes applicable to policing services. An if/then dynamic attribute formula is used to calculate a Boolean value indicating whether or not a grid cell contributes more in revenue than the value of the service-based impact of the cell, or *vice versa*.

Impact analysis

Fiscal impact evaluation is both map and indicator based. Maps may be used to indicate areas of efficient and inefficient residential development. Indicators may be used to summarize the impacts of different development patterns on revenues, expenditures, dwelling units, area impacted by efficient and inefficient development, and the spatial index of urban form. Like dynamic attributes, CommunityViz® indicators are formula driven and update automatically when inputs change.

4. Results

The mapped build-out results for 2037 shown in **Figure 3** illustrate the differing future land uses presented in **Figure 1** yield substantially different patterns of residential growth. Both scenarios result in an increase in residential development in and around the core urban area of the county, the City of Cheyenne. The alternate land-use scenario sees substantially increased residential development in the area northeast of the present municipal boundary of Cheyenne and substantially less residential development scattered throughout the remaining areas of the county. It is important to note the number of dwelling units accommodated in the alternate land-use scenario is slightly more than the base scenario in each planning horizon. In 2037, the year of maximum difference, the alternate land-use scenario allows 3,000 more dwelling units than the base scenario.

Mapped and indicator-based results for this analysis are presented for 2012, 2022, 2032 and 2037. The presentation of results across several years both helps one understand and communicate the continuous nature of temporal change and, according to Walker and Daniels (2011) generates more interest and a greater call to action than the theoretical maximum that is the more usual output of a build-out analysis.

Urban form quantified as a spatial index allows one to quickly ascertain the changing character of the built environment across the time period of the study. Because the spatial index is based on the Moran's *I* measure of spatial autocorrelation a larger spatial index indicates greater clustering in the built environment and a lower spatial index indicates decreased clustering of the built environment. As shown in **Figure 4** changes in the spatial index over the time period of the study indicate de-clustering of the built environment over the time period of the study for both scenarios, but greater dispersion for the base scenario and relatively greater clustering for the alternate land-use scenario.

Results of the econometric modeling (**Table 2**) show a statistically significant relationship between urban form as quantified using the spatial index and law enforcement expenditures. Urban form is specified with standard and the quadratic form of the spatial index (Res and Res^2). The sign on the standard form of the spatial index is negative, indicating that as the built environment becomes more dispersed expenditures on policing services increase. The positive relationship between expenditures and the square of the spatial index demonstrates that as clustering decreases expenditures increase at an increasing rate.

Fig. 3. Build-out results through 2037, base scenario (top), alternate density (bottom)

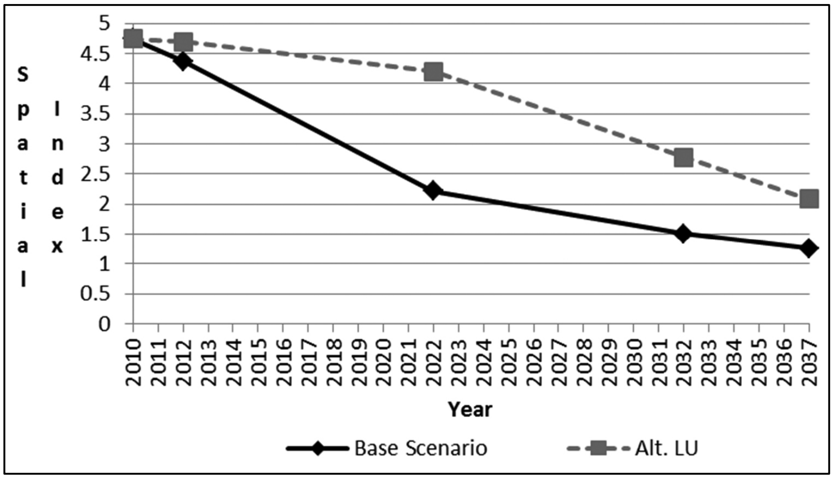

Fig. 4. Change over time of the spatial index of urban form

Table 2. Regression Model Coefficients

Parameter	Coefficient	Standard Error	t	P	Lower 95% CI	Upper 95% CI
Constant	17.256	5.49	3.14	0.007	5.48	29.03
Res	-6.802	2.097	-3.24	0.006	-11.3	-2.3
Res^2	0.522	0.126	4.15	0.00 1	0.25	0.79
Rural Population	0.000	0.000	1.06	0.307	-0.000	0.000
Officers	0.063	0.29	2.17	0.047	0.001	0.124
$Officers^2$	-0.000	0.000	-2.17	0.048	-0.001	-0.000
Time	-0.135	0.213	-0.62	0.543	-0.599	0.33

The positive sign on rural population indicates expenditures increase commensurately with population. The positive sign on officers and negative sign on officers squared indicates that increasing the number of law enforcement officers increases expenditures at a decreasing rate.

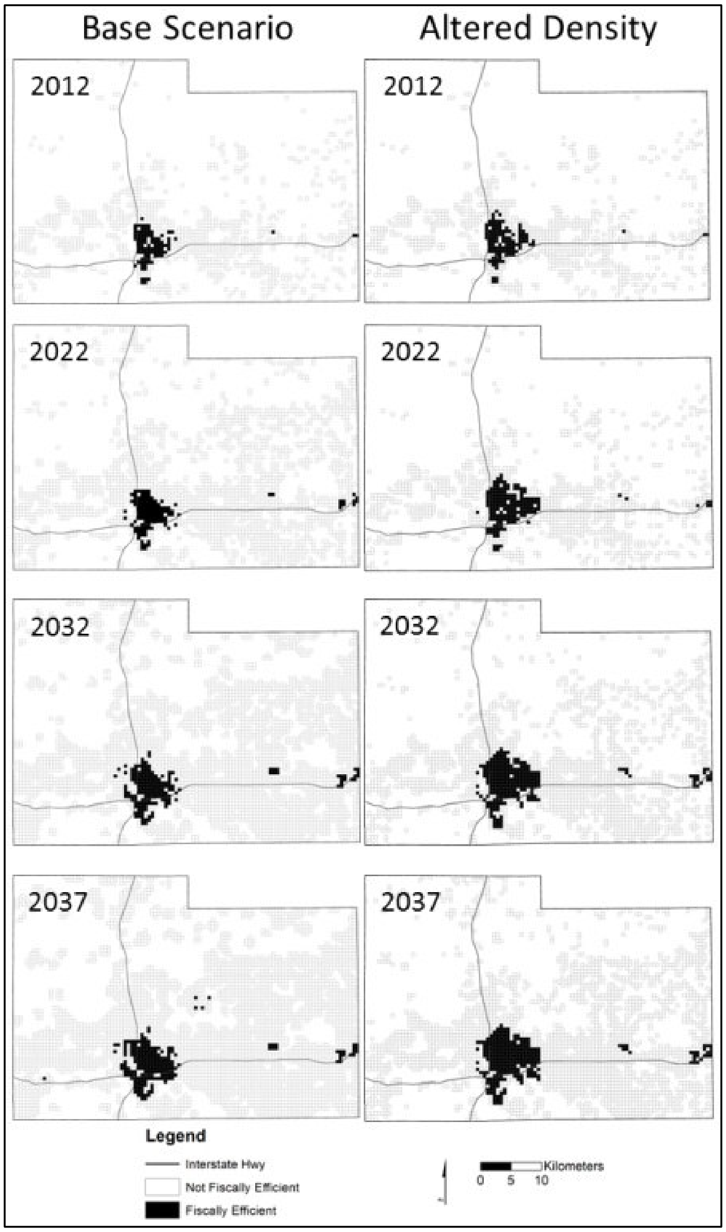

Fig. 5. Modeled fiscal efficiency for the provision of county policing services by year: 2012 – 2037

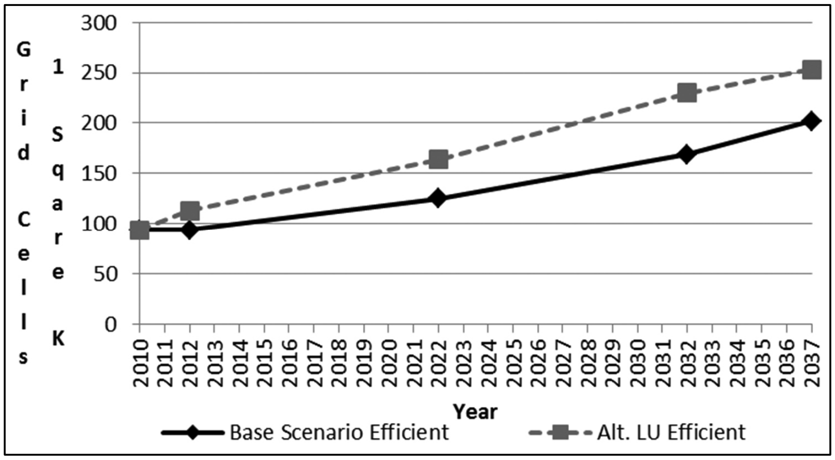

Fig. 6A. Numbers of efficient one square kilometer grid cells in each scenario

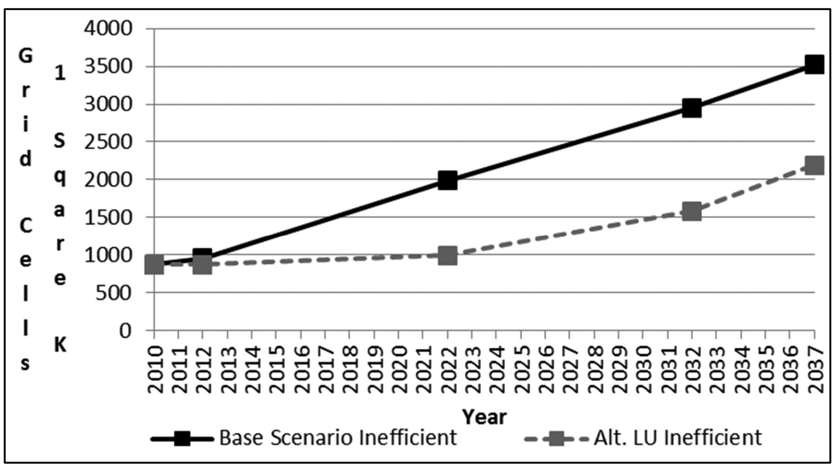

Fig. 6B. Numbers of inefficient one square kilometer grid cells in each scenario

Maps indicating residential areas of Laramie County that are efficient and inefficient for the provision of policing services for the planning horizons of the study are presented in **Figure 5**. Looking at the maps in **Figure 5** and the number of efficient (**Figure 6A**) grid cells, it is apparent both scenarios result in increases in fiscally efficient cells around the large urban center of the county, Cheyenne. Although, there are more grid cells that are fiscally efficient in the alternate land-use scenario than in the base scenario across the time period of the study. The effect of the Agricultural District zoning can be seen in the number of inefficient cells **(Figure 6B)** which is considerably less in the alternate land-use scenario than the base scenario.

In addition to the mapped outputs and counts of efficient and inefficient grid cells, fiscal impacts may be gauged by looking at the revenues and expenditures associated with each scenario. As shown in **Figure 7** expenditures for the base scenario increase both more rapidly and to an overall higher annual level than for the alternate land-use scenario. Revenues for both scenarios remain approximately equal throughout the time period. While both scenarios indicate residential property taxes allocated to policing services are insufficient to cover the cost of policing services, the alternate land-use scenario requires smaller expenditures and therefore performs better over the course of the modeling than the base scenario.

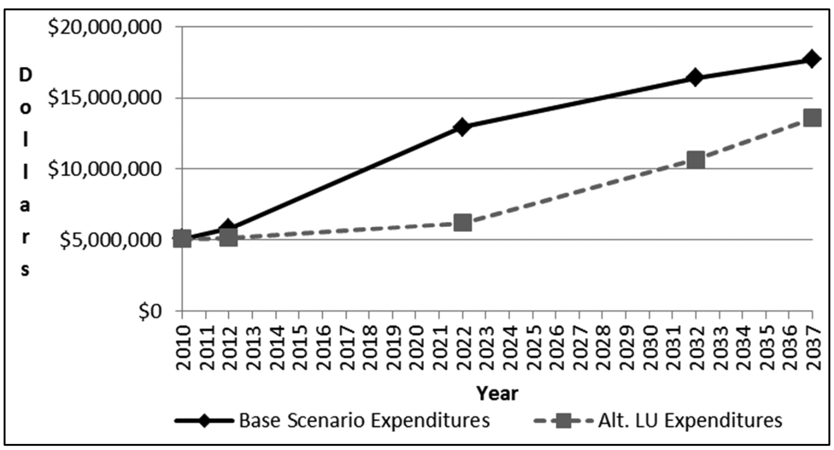

Fig. 7. Modeled annual expenditures associated with the provision of county policing services

5. Discussion and conclusion

This paper demonstrates an econometric model of public service expenditure that incorporates urban form can be linked with a growth model in such a way that produces plausible results for public service expenditures. Fiscal modeling and growth modeling are linked via land use and density specifications that are key components of the regulatory and policy framework of the study area. These links make clear the direct connection between those frameworks and potential future expenditures on public services. Results, both mapped and numeric, are in turn useful for local government planning and decision making.

In a discussion of land resource economics, van Kooten (1993) posits that demonstrating inefficiency is insufficient justification for planning; planning must lead to efficient land use. Given that benchmark, neither the base or alternate land-use scenario meets the standard needed for government intervention to bring about improved outcomes. The fact that neither scenario closes the gap between revenues and expenditures leads to the question if there is a way to further optimize results. What the scenarios suggest is further research on the relationship between urban form and public service expenditures to see if urban form can be manipulated to bring about substantially greater efficiencies in the costs of public service provision.

From the benchmark provided by van Kooten it would be desirable to see, for example, if one could realistically model land use and density in a such a way that results in fiscal sustainability, where the gap between revenues and expenditures closes rather than widens as time passes. The econometric model results suggest it is necessary to alter urban form in such a way that it increases rather than decreases the spatial index. This would likely require further expanding the urban area, increasing residential densities in the urban core and the areas surrounding the urban core in the county, and decreasing residential densities in the more outlying areas. Theobald and Hobbs (1998) note that land-use change models are noticeably affected if "…even small clusters of moderate density are at some distance from an urban center" (p. 68). This is likely the case here. In addition to there being trade-offs between development in the urban core of the county and outlying areas there may be tradeoffs associated with levels of development within higher density clusters of development, specifically the two developing clusters of higher density indicated as fiscally efficient that lie east of Cheyenne as shown on the maps in **Figure 5**.

The modeling highlights a number of features of PSS including scenario planning, build-out, spatial and temporal data disaggregation and the quantitative assessment of planning alternatives with indicators. Given the largely irreversible nature of changes to the built environment, PSS enable an inexpensive and low-risk opportunity for ex-ante evaluation of planning regulations and policies. Another potential benefit of this modeling approach is that it could be incorporated into the day to day permitting work of a planning office. Having defined the relationship between trends of change in urban form and change in county revenues and expenditures for policing services over time it is a small leap to consider site specific additions to model inputs and resultant changes in model output. Furthermore, while the focus of this discussion is development of optimal solution(s) to a planning problem, it is noted there are no restrictions on integrating model outputs with a public engagement planning process in order to incorporate public values in fiscally sustainable planning and decision making.

Among the broader impacts of this work are support for spatial planning, spatial modeling and PSS adoption generally through promotion of the benefits of PSS using demonstration projects (Vonk *et al.* 2005) that meet the demands of planners and successfully address standard and desirable planning tasks (Vonk and Geertman 2008). By embedding the approach within an existing planning and regulatory framework and producing plausible results, this research may help address PSS bottlenecks including lack of awareness of the potential applications of PSS (Geertman and Stillwell 2009, Vonk 2005). The forward looking nature of the project also is well aligned with Klosterman's (2009) mention of the normative effort to move the planning profession toward planning and away from administration. Looking forward, in addition to further refining data inputs and modeling procedures, there are opportunities for research in demonstrating the positive communication, group cognitive, process impact and business case benefits of PSS and scenario planning for local government fiscal sustainability.

Acknowledgements

This work was supported by the United States Department of Agriculture National Institute of Food and Agriculture.

References

Avin U, Dembner JL (2001) Getting scenario-building right. Planning. November: 22-27

Borcherding, TE, Deacon RT (1972) The demand for services of non-federal governments. American Economic Review 62: 891-901

Burchell RW, Listokin D. (1978). The fiscal impact handbook: estimating local costs and revenues of land development. Center for Urban Policy Research, Brunswick, New Jersey

Davenport D (1926) An Analysis of the cost of Municipal and State Government and the Relation of Population to the Cost of Government, Net Taxable Income and Full Value of Real Property in New York State. J.B. Lyon Company, Albany, New York

Fabricant, S (1952) The Trend of Government Activity in the United States Since 1900. National Bureau of Economic Research.

Geertman S, Stillwell J (2009) Planning Support Systems: Content, Issues and Trends. In: Geertman, S, Stillwell, J (eds) Planning Support Systems: Best Practices and New Methods. Springer Science and Business Media B.V. pp. 1–26

Goetz SJ (2007) The Economic Case for State-Level Land Use Decision-Making. Journal of Regional Analysis and Policy 37(1):20-24

Hanna KC, Culpepper BR (1998) GIS in Site Design. John Wiley and Sons, Inc., New York

Heikkila E (2000) The Economics of Planning. Center for Urban Policy Research, New Brunswick, New Jersey

Hirsch WZ (1961) Projections: Governmental Expenditures, Economic Activity and Population. In: Bollens JC (ed) Exploring the Metropolitan Community. University of California, Berkeley, pp. 388 - . 368

Hirsch WZ (1970) The Economics of State and Local Government. McGraw-Hill, Inc. New York

Klosterman R (2009) Planning Support Systems: Retrospect and Prospect. In: Geertman, S, Stillwell, J (eds) Planning Support Systems: Best Practices and New Methods. Springer Science and Business Media B.V. pp. v – vii.

Lieske SN, McLeod DM, Coupal R, Srivastava S (2012) Determining the relationship between urban form and the costs of public services. Environment and Planning B 39(1): 155-173

Snyder K (2003) Tools for community design and decision-making Planning Support Systems in Practice. In: Geertman S, Stillwell, J (eds) Springer, Heidelberg, pp. 99-120.

Theobald DM, Hobbs NT (1998) Forecasting Rural Land-use Change: A Comparison of Regression- and Spatial Transition-based Models. Geographical & Environmental Modelling 2(1):65-82

Tischler PS (2002a). Analyzing the fiscal impact of development. TischlerBise, Bethesda, Maryland

Tischler PS (2002b) Fiscal Impact Analysis, Reader Beware: Some Caveats. TischlerBise, Bethesda, Maryland

Van Eck JR, Koomen E (2008) Characterising urban concentration and land-use diversity in simulations of future land use. Annals of Regional Science 42:123–140

van Kooten GC (1993) Land Resource Economics and Sustainable Development. University of British Columbia Press. Vancouver

Veeneklaas FR, van den Berg LM, Schoonenboom IJ, van de Klundert, AF (1995) Scenarios as a tool. In: Schoute J, Finke PA, Veeneklaas FR, Wolfert HP (eds) Scenario Studies for the Rural Environment. Kluwer Academic Publishers, Dordrecht

Vonk G, Geertman S (2008) Improving the Adoption and Use of Planning Support Systems in Practice. Applied Spatial Analysis 1:153-173

Vonk G, Geertman S, Schot P (2005) Bottlenecks blocking widespread usage of planning support systems. Environment and Planning A 37(5):909 – 924

Walker D, Daniels T (2011) The Planners Guide to CommunityViz: The Essential Tool for a New Generation of Planning. The Orton Family Foundation, Middlebury, Vermont

Xiang W, Clarke K (2003) The Use of Scenarios in Land-Use Planning. Environment and Planning B (30): 885-909

Appendix I Build-out Settings

For both scenarios

Polygon layer containing land-use information	LaramieGrid1K
Attribute specifying land-use designation	Zone
Unique Identifyer	OBJECTID

Density Rules

	Dwelling Units			FAR	
	Quantity	Measurement	Equivalence	Quantity	Measureme
AgDensity	0.011563	DU per acre	1 DU / 640 acres	0	FAR
I-25 Gateway District	1	DU per acre	1 DU / 1 acre	0.25	FAR
Low Density/Agricultural	0.02857	DU per acre	1 DU / 35 acres	0.1	FAR
Rural Density	0.1	DU per acre	1 DU / 10 acres	0.1	FAR
Urban Density	1	DU per acre	1 DU / 1 acre	0.1	FAR
Very Low Density Rural/Agricultural	0.02857	DU per acre	1 DU / 35 acres	0.1	FAR

Mixed-Use Land Are Percentages	Dwelling Units		Floor Area	
Designation	Percent	Measurement	Percent	leasurement
I-25 Gateway District	25	1 DU per acre	75	0.25 FAR
Low Density/Agricultural	97	.02857 DU per acr	3	0.1 FAR
Rural Density	98	0.1 DU per acre	2	0.1 FAR
Urban Density	93	1 DU per acre	7	0.1 FAR
Very Low Density Rural/Agricultural	93	.02857 DU per acr	7	0.1 FAR

Efficiency

Designation	Efficiency Percent
AgDensity	95
I-25 Gateway District	77
Low Density/Agricultural	100
Rural Density	90
Urban Density	77
Very Low Density Rural/Agricultural	100

Building Information	DU per	Building Footprints	
Designation	Building	Area sq feet	Floors
AgDensity	1	0	1
I-25 Gateway District	1	39204	1
Low Density/Agricultural	1	47916	1
Rural Density	1	47916	1
Urban Density	1	43560	1
Very Low Density Rural/Agricultural	1	47916	1

Constraints constraints11_floodplains_final_prj

	Layer	Value or Attribute specifying DU/bldg
Existing Buildings	Address_modified	1
	Value or attribute specifying floor area	
	0	

Spatial Layout Designation	Minimum Separation Distance feet	Layout Pattern	Road or Line Layer	Setback feet
AgDensity	60	Random	streets	30
I-25 Gateway District	60	Random	streets	30
Low Density/Agricultural	60	Random	streets	30
Rural Density	60	Random	streets	30
Urban Density	60	Random	streets	30
Very Low Density Rural/Agricultural	60	Random	streets	30

Spatial Buildings Designation	Building Type	Footprint Size
AgDensity	Points	0
I-25 Gateway District	Points	39204
Low Density/Agricultural	Points	47916
Rural Density	Points	47916
Urban Density	Points	43560
Very Low Density Rural/Agricultural	Points	47916

End of Spatial Phase

Set the number of times buildout will attempt to place a random building 18