ORIGINAL: Incorporating land use change and development into landscape planning and ecological assessments in the Upper Deschutes area, Oregon (USA)

PROPOSED: Challenges in providing land use change analyses to support landscape planning and ecological assessments: experiences from Oregon (USA)

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Challenges in providing land use change analysis to support landscape planning and ecological assessments: experiences from Oregon (USA)

Abstract

Policymakers and public lands managers need ways to evaluate and display the likely outcomes of policy and management alternatives while accounting for exogenous socioeconomic and other changes. Of particular interest are the role of land use change and development and their role in landscape change. Landscape planning and ecological assessments are fraught with challenges involving the availability of data, the units and scales of analysis, uncertainty about what socioeconomic and ecological processes must be represented, and the need to coordinate and fund a diverse team of scientists to fulfill project objectives in a timely and affordable manner. This paper provides an overview of these challenges with a focus on how they relate to providing land use information to multidisciplinary projects. The paper draws on our experiences participating in several multidisciplinary multi-agency landscape planning and ecological assessment efforts in Oregon.

Keywords: Ecosystem interactions, multidisciplinary and integrated planning and assessments, public and private lands management.

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INTRODUCTION

Policymakers and public lands managers desire ways to evaluate and display the likely socioeconomic and ecological outcomes of policy and management alternatives on public and private lands. The most helpful tools are easy to understand, usable by a wide range of interested parties, and reasonably represent the implications of regional land use changes, natural and human-caused disturbances, vegetative succession, and other factors that may influence likely outcomes. In practice, however, landscape planning and ecological assessment efforts are fraught with challenges involving general lack of data, disagreement among analysts regarding the units and scales of analysis that are conceptually appropriate and computationally feasible, uncertainty about the socioeconomic, ecological, and other factors that must be represented, and the need to coordinate and fund a diverse team of scientists to deliver on project objectives in a timely and affordable manner. These challenges extend to analysts tasked with providing land use information to such multidisciplinary efforts. Prevailing land uses and changes among land uses often are critical information for landscape planning and ecological assessments. However, inconsistency in data available for land use analysis and the variety of objectives analyses must serve impedes adopting any universal approach. A common necessity among land use analysts involved in landscape planning and ecological assessment is adaptation and innovation.

By landscape planning and ecological assessments, we mean projects that involve teams of scientists of different disciplines (e.g. ecology, economics, hydrology, wildlife and aquatic biology) to examine potential outcomes of landscape-level policies and management actions.

Interest in such efforts among policymakers, managers, and researchers arises from recognition that ecological processes rarely take place absent human disturbance. Many socioeconomic and ecological processes are interconnected, and interact to produce a changing flow of ecosystem goods and services over space and time. With population growth and development, those interconnections gradually affect a broader landscape extent such that active management often is seen as necessary for maintaining sufficient flows of ecosystem goods and services in the face of continued socioeconomic change. Given the extent of lands owned by federal agencies (e.g. Bureau of Land Management, Forest Service) and their mandate to conserve and manage natural resources in the public interest, landscape planning and ecological assessments often arise to serve federal land management and planning needs (e.g. Haynes and Quigley 2001). Similar efforts also address regional environmental issues and objectives—watershed management, for example—where private landownership predominates (e.g. Voinov et al. 1999).

The role of land use analysis in such studies typically is to define the boundaries of lands assumed to contribute to maintaining ecological processes and providing outputs of ecosystem goods and services—the extent of forest land, for example. However, in addition to the sheer loss of forest and other open space lands to development, studies show that resulting landscape fragmentation can be associated with changes in private forest management (Wear et al. 1999; Munn et al. 2002) with associated reductions in forest stocking, thinning, and post-harvest tree planting (Kline et al. 2004). These effects have the potential to alter the ecological conditions of remaining forest lands through changes in forest structure, species composition, and succession (Kline and Alig 2005). These secondary effects of land use change provide additional challenges regarding how best to accurately reflect the implications of land use change for ecosystem processes of interest. Despite a prevalence of papers describing "land use change analyses" in journals, conference proceedings, and other outlets, few universally accepted protocols exist for providing land use information to multidisciplinary studies. Rarer still is an owning up by study participants to the inherent messiness of the state-of-the-art.

Successful landscape planning and ecological assessments depends on the involvement of talented people with different skills, appropriate data of a high quality, technology that is up to analytical tasks at hand, and organizational commitment in the form of effective project leaders and sufficient funding and resources (Bettinger and Boston 2001). Although land use analyses conducted in support of multidisciplinary projects often are published as stand-alone papers that document methods and findings (e.g. Bockstael 1996, Kline et al. 2003), rarely do land use analysts afford time to reflect on ways in which they feel their attempts to incorporate land use information into such efforts succeeded or failed. Such reflection could benefit other land use analysts by pointing out potential pitfalls, providing solace to those immersed in ongoing studies, and revealing fruitful areas for future research. In this paper, we review some of the challenges we have experienced in attempting to provide land use information to landscape planning and ecological assessments over the past 10 years. We highlight those challenges by describing our experiences with two past projects and one ongoing project all aimed at evaluating how forest management might influence socioeconomic and ecological conditions and processes in select study regions of Oregon. Our intent is to share some of the lessons we have observed to help other analysts better anticipate the challenges they may face in similar efforts, as well as initiate discourse among practitioners regarding how best to meet those challenges.

LANDSCAPE PLANNING AND ECOLOGICAL ASSESSMENT CHALLENGES

The landscape planning and ecological assessments we have been involved with in

Oregon were motivated by a need by federal (Bureau of Land Management, Forest Service) and state (Oregon Department of Forestry) lands management agencies for information about the likely consequences of federal and state policies and management actions affecting public and private forest lands. These projects sought to inform efforts to protect habitat for threatened or endangered species, mitigate the threat of wildfire and other forest health issues, and maintain commercially viable opportunities for the production of timber and other forest commodities. Within these policy contexts, land use plays an important role by influencing the amount and characteristics of land available to meet resource management objectives. Landscape planning and ecological assessments require land use information to: (1) account for overall changes in land use supporting the production timber, forage, and other resource outputs on private lands augmenting similar outputs on public lands; and (2) account for secondary effects that land use changes may bring about for ecosystem conditions and processes and their socially valued outputs of ecosystem goods and services. We have found that providing usable land use information to such projects involves several challenges, some of which arise from demands for information at fine spatial scales and some of which arise from broader difficulties inherent in multidisciplinary work.

One of the first challenges potentially faced by economists specializing in land use is simply getting invited to participate in landscape planning and ecological assessment projects. In our experience, an appreciation for the human role in ecological change and the need to account for it in landscape models is not universal among ecologists and biophysical scientists. Some project participants may not appreciate the potential inevitability of future land use changes and so may not see land use as a factor that must be considered. Others may prefer to focus on ecological and biophysical processes taking place on landscapes far removed from human disturbance other than forest management actions to be evaluated. Professional skepticism of the need to include land use analysis can task land use analysts with arguing a case for inclusion. Even in the most earnest multidisciplinary efforts, there also can be genuine uncertainty about what socioeconomic and ecological processes must be represented. Landscape planning and ecological assessments by necessity require a balancing of multiple policy and management interests, conceptual rigor, analytical capabilities, time, and funding. Project participants must weight at the start the necessity and merits of including or excluding any and all analytical components under consideration. Just as projects can err in omitting components that may be relevant, projects also can err in including other components that may be less relevant than initially thought, especially if those components overtax scarce project resources.

Once invited to the table, economists face must locate appropriate data with which to describe land use change. Nationwide land use data generally are limited to just a few sources, such as the NRCS National Resources Inventory (e.g. Nusser and Goebel 1997), the USDA Forest Service's Forest Inventory and Analysis program (e.g. Frayer and Furnival 1999), and the National Land Cover Database (e.g. Homer et al. 2004). Some analysts also have begun to use population and housing data from the U.S. Census (e.g. Radeloff et al. 2000, Theobald 2005) from which land use classifications can be developed. Some landscape studies invest in procuring or developing their own land use data based on surveys or inventories of satellite imagery, aerial photographs, and other sources, but these efforts can be time-consuming and costly. In some cases, analysts can draw on regional, state, or local sources that may produce custom land use data for other uses. In locating land use data for analysis, analysts must consider spatial and temporal coverage and scale, and whether the specific classifications used to delineate "land use" are appropriate to meeting the objectives of the project at hand.

First and foremost, land use data must be relevant to the geographic and time scope of the project for which land use analysis must serve. After that, analysts must grapple with spatial scale. Up until the past, say, ten years, economists largely have been content examining land use changes at no finer than the county level and this has sufficed to meet the objectives of national resource assessments, such as the USDA Forest Service’s Resource Planning Act assessments, for which most such land use analyses have served (e.g. Alig 1986, Lubowski et al. 2006). However, the county-level spatial scale of such analyses typically attract little interest from ecologists and biophysical scientists involved in landscape planning and ecological assessments, because most aspire to work at much finer spatial scales—the 30 meter pixel, for example. Such fine spatial scales, whether rightly or wrongly, can be viewed by some project participants as absolutely necessary to the analysis of one or another ecological or biophysical process of interest. In addition to complicating the simple act of locating appropriate land use data, such fine spatial scales can also tax empirical land use modeling as typically practiced by economists.

After resolving the issue of spatial scale, land use analysts need consider whether available land use data delineate specific land uses relevant to the socioeconomic and ecological processes to be evaluated by the broader multidisciplinary project. Most land use data sources define thresholds of land use—discrete forest, range, agriculture, and urban categories. Although discrete land use categories often can be sufficient for meeting project objectives, predicted probabilities of change among discrete categories can be difficult to interpret when projecting future land use changes. Discrete categories also will not suffice when a delineation of gradients of land use change is desired—treating the intensification of land use from forest to urban as a continuum characterized by a gradual increase in building rather than as a discrete conversion. Whether analysts need worry about describing land use gradients depends on whether such delineation it is necessary to meet project objectives or whether such information can even be used my other project participants. Many of the models used by ecologists and biophysical scientists to describe ecological and biophysical conditions and processes are not capable of using land use gradient information, but rather require discrete land use categories. Still, the level of abstraction implied in the treatment of land use as a set of discrete categories may be inappropriate for examining socioeconomic and ecological processes of interest or miss important nuances in change processes. In many cases, analysts will have little choice regarding what land use data to use and likely will have to work with whatever is at hand.

A secondary data challenge arising from spatial scale involves the way most economists approach land use analysis. This typically involves estimating an econometric model based on a conceptual framing of land use change as a function of socioeconomic, geographic, and other factors hypothesized to influence land rents (e.g. Bockstael 1996). This econometric approach demands socioeconomic, geographic, and other data for constructing proxy explanatory variables with which to represent land rents at the spatial scale of analysis. When land use modeling at broader spatial scales, such as the county level, reasonable explanatory variables often can be constructed from US Census and other data sources. At finer spatial scales, however, data for constructing explanatory variables often are lacking. Timber prices and the value of agricultural commodities sold—two data series sometimes used to construct proxy variables for forest and agricultural rents—typically are only available at regional and county levels respectively. Barring significant creativity on the part of analysts in devising ways to weight such data to provide variation across finer spatial scaled observations, lack of data often means that more spatially refined econometric land use models must be deliberately mis-specified owing to the omission of key explanatory variables. Analysts involved in landscape planning and ecological assessment projects may find necessary tradeoffs between conceptual rigor and empirical expediency if land use change information is to be provided at the spatial scales often deemed necessary in multidisciplinary work.

A final challenge involves broader difficulties inherent in working with multidisciplinary groups. Admittedly frustrating at times, meeting this challenge also can be among the most professionally rewarding outcomes of multidisciplinary work. An emerging trend in landscape planning and ecological assessments is to convene a group of individuals representing social science (e.g. economics), ecology, aquatic and wildlife biology, hydrology and other disciplines. Coordinating work among these disciplines to meet a common research objective can make for slow progress. Participants often find that simply learning each other's professional language takes time, followed by a need to gain rudimentary literacy in some of the basic concepts from each other's particular discipline. Achieving consensus on project objectives, conceptual framing, analytical approach, and the spatial and temporal scope and scale of analysis can be a painstaking process that involves having to learn the capabilities and limitations of each discipline involved. Part of this process also involves building trust among participants that each participant is versed in the state-of the art of their respective discipline. Participants must resist the temptation to view the project from their own discipline-centric perspective.

Along with meeting these challenges, participants need to be aware of potentially differing expectations and perspectives regarding the work involved and its potential rewards. For some participants, the specific way in which a landscape planning and ecological assessment projects are carried out can provide opportunities to do cutting-edge research within their own discipline. For other participants, conceptual framing, data limitations, and other factors may limit the importance of their own contribution within their own discipline unless there are clear rewards for participating in multidisciplinary work. Participants also may have differing expectations regarding the timing and ultimate quality of project work. When and will participation result in a peer-reviewed journal article or an agency research report, for example? There may be differing views on how much project results should be generalized to other regions or how far into the future model projections reasonably can be made. Projects in which we have been involved have sought land use projections spanning 100 years—well outside the comfort zone of most economists. Policymakers and managers involved in projects also can have distinctly different views from researchers regarding the necessity of meeting deadlines and providing practical information. Most policymakers and managers want timely information that is accurate and can be used to resolve specific issues of concern. Many researchers are content finding results that are merely interesting and that lead to other interesting research questions.

Finally, projects must address difficulties in coordinating the development of multiple data sets and models, the temptation to expand model complexity, and the expectation that eventually seemingly disparate and potentially discipline-centric project components must be woven into an integrated whole. The analytical demands of running multiple models that draw upon sizable and detailed spatial datasets characteristic of multidisciplinary work at fine spatial scales can make for slow progress at best. The unwieldy nature of resulting model structures and data sets can preclude ever using resulting models to adequately address applied research questions. Keeping projects sufficiently simple to be useful to policymakers and managers can be the single greatest challenge researchers may face. It is natural for scientists to want to do their best work, especially when surrounded by peers from different disciplines. However, our experiences suggest that excessive complexity can hinder integration of disparate analytical parts and delay the delivery of end products on time and within budget.

THREE EXAMPLES

These challenges can be illustrated by our experiences working to provide land use information to three different landscape planning and ecological assessments projects in Oregon over the past decade. Each project was envisioned in response to requests from policymakers and managers for information about the socioeconomic and ecological consequences of forest policy and management actions conducted primarily on federal lands, while recognizing key landscape-level interactions with private lands. In the Pacific Northwest, specific issues of concern have included wildfire and forest health, wildlife habitat, water quality, timber, and recreation, among others. Policymakers and managers also have increasingly acknowledged the importance of accounting for forest, agricultural, and range land development resulting from population and income growth and the growing popularity of second homes in scenic forest and range land settings. Our role in each project has been to describe what land use changes are likely to occur over the course of the assessment horizon and assist other project participants in evaluating the potential socioeconomic and ecological implications of those changes.

The land use data we have had available for this purpose in many respects is enviable. Over the past ten years, the Oregon Department of Forestry often in collaboration with the USDA Forest Service's Forest Inventory and Analysis program has developed and periodically updated spatially referenced data describing several discrete categories of land use as well as building (or structure) counts on nonfederal lands throughout the state (Lettman 2002, 2004). The data are gathered from aerial photographs spanning the early 1970s to the present. Building counts document the number of buildings of any size or type within 80-acre circles surrounding sample points located on aerial photos. By tracking individual sample points from one sample period to the next, the data documents changes among predominant land use categories and increases in building counts over time. With 37,000 sample points statewide and three to four sample periods depending on region, the data set provides a unique resource for observing rates and patterns of land use change in Oregon in support of landscape planning and ecological assessment efforts conducted there. In the following examples, we briefly describe three projects in which we have been involved, the ways in which we provide needed land use information, and the degree to which we successfully addressed various challenges encountered.

Coastal Landscape Analysis and Modeling Study (CLAMS)

The Coastal Landscape Analysis and Modeling Study (CLAMS) was a multidisciplinary research effort to analyze the aggregate ecological, economic, and social consequences of forest policies in western Oregon's Coast Range mountains (Spies et al. 2007). The study area borders the Pacific Ocean on the west and the Willamette Valley on the east. Forest policies there try to achieve a mix of forest goods and services by spatially distributing different forest practices over watersheds and landscapes, and ownerships. Two policy concerns motivating the study were ensuring sufficient habitat for spotted owls (*Strix occidentalis caurina*) and coho salmon (*Oncorhynchus kisutch*). The project was intended to provide quantitative analyses testing the assumptions of existing forest policies to determine if projected future outcomes would be consistent with current policy goals. The project spanned 1996 to 2005 and involved landscape and forest ecologists, aquatic and wildlife biologists, hydrologists, economists, and several research assistants and geographic information systems analysts. The approach was to build high resolution spatial models of current biophysical conditions (e.g. vegetation, topography, streams) using Landsat TM satellite imagery, Forest Inventory and Analysis sample plots, and other GISbased data sources, and simulate expected changes in forest structure and composition under different management scenarios over 100 years using forest stand dynamics models. Several other linked models evaluated habitat suitability for select terrestrial and aquatic species, landslide and debris flow potential, and geomorphic dynamics, among other factors (Figure 1).

From the start policymakers involved with CLAMS wanted to account for the potential influence of future land use changes on forestry outcomes evaluated. Oregon's population had grown by 69% from 1970 to 2003, with much of that growth in the Willamette Valley. Initial land analysis developed for the study relied on readily available plot-level data describing historical changes among discrete forest, agriculture, and urban land-use categories provided by the USDA Forest Service's Forest Inventory and Analysis Program (Kline and Alig 1999, Kline et al. 2001). These data were used to estimate econometric probit models describing the probability that forest and agriculture plots converted to urban uses in western Oregon and western Washington. However, the forestry focus of the data meant that it comprised few observations of forest land conversions to urban uses, leading to poor explanatory power of estimated models. Integrating projected probabilities into other CLAMS models also presented difficulties. A specific need was the delineation of future forest land area at each modeling time interval. In western Oregon, the proportion of land in forest use historically has been quite high relative to urban lands, causing resulting predicted probabilities describing the likelihood of future forest land conversions to urban uses to be quite low and of little use in locating forest lands likely to convert. At the time, state policymakers also were becoming more concerned about the potential effects of low-density development—dispersed residential uses throughout existing forest lands. This new concern motivated the gathering of building count data and a second phase of land use modeling.

Once available, building count data provided greater variation in land use change through time and enabled estimating negative binomial models describing increases in building counts as a function of land's development potential, existing building counts, slope, elevation, and land use zoning mandated by Oregon's statewide land use planning program (Kline 2003, Kline et al. 2003). The desired 30-meter spatial resolution of eventual land use projections precluded including many of the explanatory variables typically used to econometrically model land use change, such as proxy variables representing forest and agricultural land rents. Population density reported in the US Census and often used as a proxy variable for urban land rents was deemed inappropriate given that our dependent variable was essentially "building density." As an alternative, we assumed that forest land development ultimately would be influenced most significantly by land's commuting proximity to work destinations in cities of the Willamette Valley. We constructed a proxy variable representing the development potential of land using a gravity index computed as the sum of populations of all cities within a 60-minute commute, weighted by the estimated driving time to each city's edge. The econometric specification yielded gravity index estimated coefficients of high statistical significance. By computing new gravity indices based on population projections for included cities, we used the estimated model coefficients to estimate and map projected pixel-level changes in building densities for each CLAMS modeling interval (e.g. Figure 2). Validation tests evaluating the accuracy and precision of model projections suggested that they suited CLAMS needs (Kline et al. 2003).

Other ecological and biophysical models were unable to input development gradient information such as building densities. Rather, building density projections were incorporated into other CLAMS models based on thresholds, assuming that timber production ended at 64 buildings per square mile and habitat viability ended at 640 buildings per square mile. Also, for habitat viability modeling, ¼-acre open vegetation patches (or building footprints) were assigned to each projected new building to account for the vegetative impacts of development on habitat. Projections suggested a 10% loss in forest land to development over 100 years, with the most substantial losses on non-industrial private forest lands (-35%), oak woodlands (-22%), and on gently sloping valley bottoms along the margins of the Coast Range (Johnson et al. 2007, Spies et al. 2007). Although forest land development clearly had the potential to influence future habitat, the sensitivity of habitat viability to different levels of projected development was not evaluated. The complete suite of CLAMS models proved too cumbersome and involved such lengthy processing times that only a select few scenarios could be evaluated, and those focused on forest policy effects. The most significant difficulty we encountered in our land use analysis approach involved the gravity indices which required significant computer processing time to construct at 30-meter resolution. Although effective as an explanatory variable, especially given our lack of other suitable data, these computational difficulties were a significant obstacle to providing much more than a base set of development projections given time and funding constraints. Despite this shortcoming we feel that the analysis reasonably depicted future forest land development, prompting greater consideration of potential ecological implications.

Interior Northwest Landscape Analysis System (INLAS)

The Interior Northwest Landscape Analysis System (INLAS) was conceived in 2000 to evaluate projected outcomes of alternative land management scenarios at intermediate spatial scales (Barbour et al. 2007, Wondzell et al. 2007). A hope among many participants was to find a more streamlined and functional approach than that taken by CLAMS, to produce computer simulations and other tools to better aid public land managers in their planning efforts. Like

CLAMS, INLAS was intended to account for interactions between management activities, forest succession, and natural disturbances. After large fires in the US burned 8.4 and 6.9 million acres during 2000 and 2002, INLAS refined its focus include wildfire. INLAS scientists selected a study area of mostly forested public and private land in the upper Grande Ronde River watershed in northeastern Oregon. The project was organized around discipline-specific modules each focusing on key processes deemed relevant to evaluating forest policy effects, such as forest succession, grazing, timber and wood utilization, and habitat viability. This parsing of analyses by discipline enabled individuals and groups to work independently in developing each module with the intent of eventually linking them through common variables. At the center of analysis was a vegetation module (Hemstrom et al. 2007) that tracked changes in vegetation over the modeling time horizon using a state-and-transition model (Figure 3). Several modules were eventually linked to this vegetation module. Direct linkages were not possible with other modules owing to differences in geographic scope, lack of common variables, or other factors.

One module that was not linked to the core vegetation model within time constraints of the study was land use, owing to delays in the development of building count data for the study region. However, had data been available sooner linking land use projections to INLAS' core vegetation model would have faced difficulties. Our expectation was follow our INLAS land use model on our CLAMS approach by estimating a spatial econometric model of building count changes that could be used to project and map future land forest and range land development. However, where as the CLAMS study area bordered a populous and growing region in western Oregon, the INLAS study area was fairly isolated and sparsely populated. Even driving access to LaGrande—the nearest town of significant size (population 12,327 in 2000)—is limited in many parts by a lack of roads. The population of Union County, where most of the study area is located, had only increased by 53% since 1900. Econometric approaches to modeling land use change depend on estimating an empirical model describing past rates and patterns of change and projecting them into the future based on assumptions about the future values of key explanatory variables. In the INLAS case, lack of significant past change confounded model estimation. Also, the relatively small size of the study area (688 square miles) and the predominance of federal land ownership (69%) meant that only about 132,000 acres of private lands were even available for potential development, and much of that land was owned by just a few individuals focused on industrial forestry and ranching. These factors led some INLAS participants to openly question whether land use change was even relevant to the study.

Our approach was to broaden the geographic scope of land use analysis to include a four-county region. Although we anticipated that any projections we might provide likely would indicate little future development within the INLAS study area itself, our intent was to portray a broader socioeconomic context for the study by projecting future development throughout the surrounding region. Two methods for modeling forest and range land development were tested (Kline et al. 2007). One method involved estimating a negative binomial model describing building counts at given locations and dates as a function of county population density, distances to major regional towns, slope, and zoning, and predicting future building counts based on projected population density increases. We used population density as the “driving” variable of development in our INLAS models after finding that gravity indices emulating those used in CLAMS had generally poor explanatory power in this less populated region. The second method involved estimating a tobit model describing average annual changes in building counts observed between subsequent sampling dates as a function of county population density changes and other explanatory variables. Future building count changes were computed based on projected future changes in population densities and then added to existing building counts to project future building densities. Unlike our CLAMS land use models that relied on aggregate changes in building counts observed from one sampling date to the next as the dependent variable, this INLAS model relied on average annual changes in building counts, because the length of time between subsequent sampling dates varied across observations owing to irregular sampling dates.

As we suspected, the recent history of limited population growth and development in northeastern Oregon led to statistical insignificance of the explanatory variable describing county population density changes in the tobit model describing average annual changes in building counts. Although within sample validation tests suggested that the model was able to predict coarse ranges of past building densities with a chance-corrected prediction accuracy of 78% (Kline et al. 2007: 328), the model lacked a statistically significant dynamic explanatory variable with which to support out-of-sample predictions of future change. Future changes would be based solely on static explanatory variables such as the distances to major towns, slope, and zoning. Alternatively, the negative binomial model describing building counts at given locations and dates did yield a statistically significant estimated coefficient for population density, but within sample validation tests suggested that the model was able to predict coarse ranges of past building densities with a chance-corrected prediction accuracy of just 8% (Figure 4). The results of the two modeling approaches reveal the tradeoff land use analysts face when having to choose between models that are conceptually more proper versus models that are less proper but more expedient in prediction. Time constraints, which prevented us from attempting to link our land use analysis to the vegetation model, precluded us having to make a final choice. Although not directly integrated with the larger effort, our INLAS land use analysis enabled us to test alternative model specifications and consider weaknesses in our econometric approach.

Interagency Mapping and Analysis Project (IMAP)

The latest landscape planning and ecological assessment currently underway in the Pacific Northwest is the Interagency Mapping and Analysis Project (IMAP). IMAP is a partnership of federal and state agencies and non-government organizations intent on sharing in effort to generate landscape-wide vegetation data, landscape models, and related information with which to evaluate the integrated effects of natural disturbances and management activities on natural resource conditions in the Pacific Northwest. The intent is to simultaneously address many of the persistent challenges that similar landscape planning and ecological assessment projects have faced, namely (1) limited funding, (2) lack of skilled people to perform landscape analyses, (3) desire to avoid conflicting answers across ownerships and interests, (4) the need for integrated analyses of management and natural disturbance effects across a broad range of ownerships and vegetation conditions, and (5) a desire for relatively simple and understandable approaches to landscape analysis and policy evaluation. Key concerns of managers involved with IMAP are wildfire risks, wildlife habitats, and maintaining timber output. Current efforts are focused on a 680,000-acre pilot study area in central Oregon consisting of 534,000 acres of federal forest, reserves, and wilderness, and 146,000 acres of private lands (Figure 5). IMAP eventually will be expanded to include all of Oregon, and perhaps Washington as well.

Similar to INLAS, IMAP is sturctured around a state and transition vegetation model that treats vegetation as a few combinations of cover type and structural stage. These states are linked through time by transition probabilities that describe the transition of lands possessing particular vegetation characteristics to other characteristics as a result of growth, management, and fire and other natural disturbances. Vegetation cover types and structural stages at each modeling interval are used to inform ecological and biophysical models describing habitat, wildfire risk, and other factors. Although projections of future vegetation can be mapped by tracking the locations of lands possessing particular characteristics through time, state and transition models are inherently non-spatial, and project future vegetation based on past characteristics and the transition probabilities. Results describing vegetation, habitat, wildfire risk, and other factors are summarized at a (HUC5) watershed level, providing information about the spatial distribution of landscape characteristics likely to result from management actions without implying pixel-level accuracy. This model simplicity and coarsness in spatial scale is designed as a compromise between analytical detail sufficient to address management issues of interest and functionality necessary to make resulting models usable to managers.

As with CLAMS and INLAS, policymakers and managers involved with IMAP are eager to account for future forest and range land development, and its management implications regarding wilfire risk, timber supply, and habitat. Specifically, the likelihood that forest and range lands will be lost to development is envisioned as another transition probability acting upon the different states included in the core vegetation model. Many of the challenges involved in providing land use conversion probabilities to IMAP are similar to those faced in CLAMS and INLAS. But perhaps the most vexing challenge involves the spatial scale of analysis—the hydrologic unit code-five (HUC5)—which in Oregon average about 19,000 acres in size. This spatial scale means that land use analysis either must be done at a HUC5 observation scale—using an area base approach, for example—or must be done at a finer spatial scale with projections aggregated up to HUC5 watersheds. Given the difficulty in creating explanatory variables aggregated to HUC5 watersheds, constructing an area-base econometric model based on HUC5-level observations would be difficult. But working at a finer spatial scale also presents challenges. The central Oregon pilot study region is comprised of 35 HUC5 watersheds for which there are 2,067 points on which land use through time has been recorded, for an average of 59 observation points per watershed. Many watersheds comprise very little private land and so have very few point observations of land use on which to base watershed-level projections.

We see our land use modeling options as either: (1) developing a spatially explicit econometric model of land use change following on our approach in CLAMS; or (2) providing a much simpler analysis based on simply extending past trends aggregated to HUC5 watersheds. Given funding and time constraints and the history of relatively slow population growth within much of the central Oregon pilot study region, we have to date opted for a simple approach. We are using the discrete land use categories included in our land use data as a basis for a simple Markov analysis of forest, range, and agricultural land conversion to low-density or higher intensity development in 1982—the year land use zoning generally was fully implemented in the region—to the present. Rather than providing customized Markov projections for individual HUC5 watersheds, we are instead providing projections for combinations of key IMAP "strata" which define discrete land characteristics deemed relevant to forest and range land management. Key strata include industrial versus non-industrial private ownership, east Cascade versus west Cascade location, and zoning designated under Oregon's by statewide land use planning program (Table 1). Although the Markov projections are not linked to actual or projected population growth or other socioeconomic variables, the strata combinations for which projections are provided have been found to be statistically significant variables in past CLAMS and INLAS econometric land use models. This simple Markov approach does not preclude using other more intensive spatial econometric methods for other regions, such as in western Oregon, once IMAP's focus shifts to those areas. For now a simple approach would seem to suffice.

ADVICE FOR THE ENLISTED

Opportunities for managing public lands depend on varying vegetation conditions, natural disturbances, and the varying objectives of neighboring private landowners, among other factors.   Despite the best intentions, uncertainty persists in the likelihood of natural disturbances, unforeseen management consequences, and changing political, social, and economic factors. Given these challenges, policymakers and public land managers will continue to call on the research community to evaluate the likely short and long-term consequences of different management alternatives under consideration. As a principal agent of landscape disturbance, land use change is increasingly relevant to landscape planning and ecological assessment efforts as human populations expand into forested settings and demand more from their public forests. Whether or not land use analysts want to be involved, opportunities to participate in multidisciplinary projects needing information and analysis about land use change will persist. Land use analysts acting on such opportunities could find themselves facing new challenges in attempting to apply the concepts and methods of their own discipline to inform multidisciplinary research. We have attempted to illustrate some of the challenges we have experienced in providing land use information to multidisciplinary landscape planning and ecological assessment projects, and offer the following lessons to those embarking on similar efforts.

Within multidisciplinary groups, we first suggest groups indulge in learning about each others disciplines before settling on a particular research approach. Openly discuss how each participant might approach the study from their own disciplinary perspective. Depending on participants' past interests and experiences, it can take considerable time to learn each others' professional language. Second, consider what issues are to be studied and where, whether they are motivated by research questions or on-the-ground policy and management questions, and what disciplines are necessary to adequately address them. Consider what is feasible within time and budget constraints. Accept that some initial participants may not in the end be needed to meet specific project objectives as they emerge. As we found in CLAMS and then INLAS, choice of a specific study area can greatly influence what work can be done by particular disciplines regarding particular issues. Third, only after those extensive early discussions should groups develop an integrated conceptual framework to address project objectives. This can be a significant challenge. There is a tendency to develop multidisciplinary conceptual frameworks by simply delineating separate disciplines as circles or boxes and connecting them with lines or arrows. Cynics call this "integration by stapler," because such projects typically result in several individual reports sourced to separate disciplines that are in the end "stapled" together to make a whole. Ideally, work on project components should involve groups of individuals from different disciplines working together. Participants of like disciplines working in isolation from other disciplines often indicate poor integration of one or more project components.

Fourth, consider the necessity of particular spatial and temporal scales; they will influence what issues can be reasonably or comfortably addressed and different disciplines. Spatial scale in particular also will greatly influence model complexity and computer processing times. The 30-meter spatial resolution of CLAMS translated into cumbersome models requiring lengthy computer processing time, and ultimately constrained the number of scenarios that could be evaluated and limited the functionality of the final product. Fine spatial scales may be appropriate and necessary for addressing particular issues, but they must be weighed against the value of gaining timely and potentially more abundant information. Fifth, similarly consider the necessity for complex models versus simpler analyses. Although many researchers desire and even thrive on complexity, policymakers and managers often are willing to accept models and analyses that are imperfect if that would result in more timely and practical guidance on the complex issues they face. Alternatively, policymakers and manager should not expect “push-button” answers to difficult questions. Ideally there is an optimal spatial scale and complexity for addressing issues of interest in a cost-effective and timely manner. For some disciplines, that ideal may not always translate into doing cutting-edge research. When gauging their own interest in particular projects, participants must weigh potential within-discipline rewards against other professional rewards arising from participation in multidisciplinary projects, the timing of which may depend on other project components and completion of the whole.

Analysts tasked specifically with providing land use information to landscape planning and ecological assessments may find that the parameters of multidisciplinary projects—spatial scale, for example—often defy what might be considered appropriate economic conceptual framing and econometric specification of land use models. This can present problems when objectives call for evaluating policy instruments intended to directly influence land use, but is less problematic when all that is desired is a reasonable depiction of future land use to control for those effects in ecological and biophysical models. Landscape planning and ecological assessments typically do not focus on evaluating land use issues. Rather, they focus on evaluating the effects of forest management actions. Analysts need not condone work of poor quality. But remember that most applied work in economics calls for making the most of the data and study constraints at hand, acknowledging potential problems, and examining the potential implications of those problems. For land use analysts, success in multidisciplinary research projects often will have less to do with creating the perfect model, and more to do with simply getting policymakers, managers, and other scientists who may not have thought much about land use to see its relevance to their own work and its future resource management implications. With that greater appreciation among others for the role of land use in ecological change may also be renewed appreciation among land use analysts for the potential limits of prevailing economic method, which inspires developing new concepts, data, and method.

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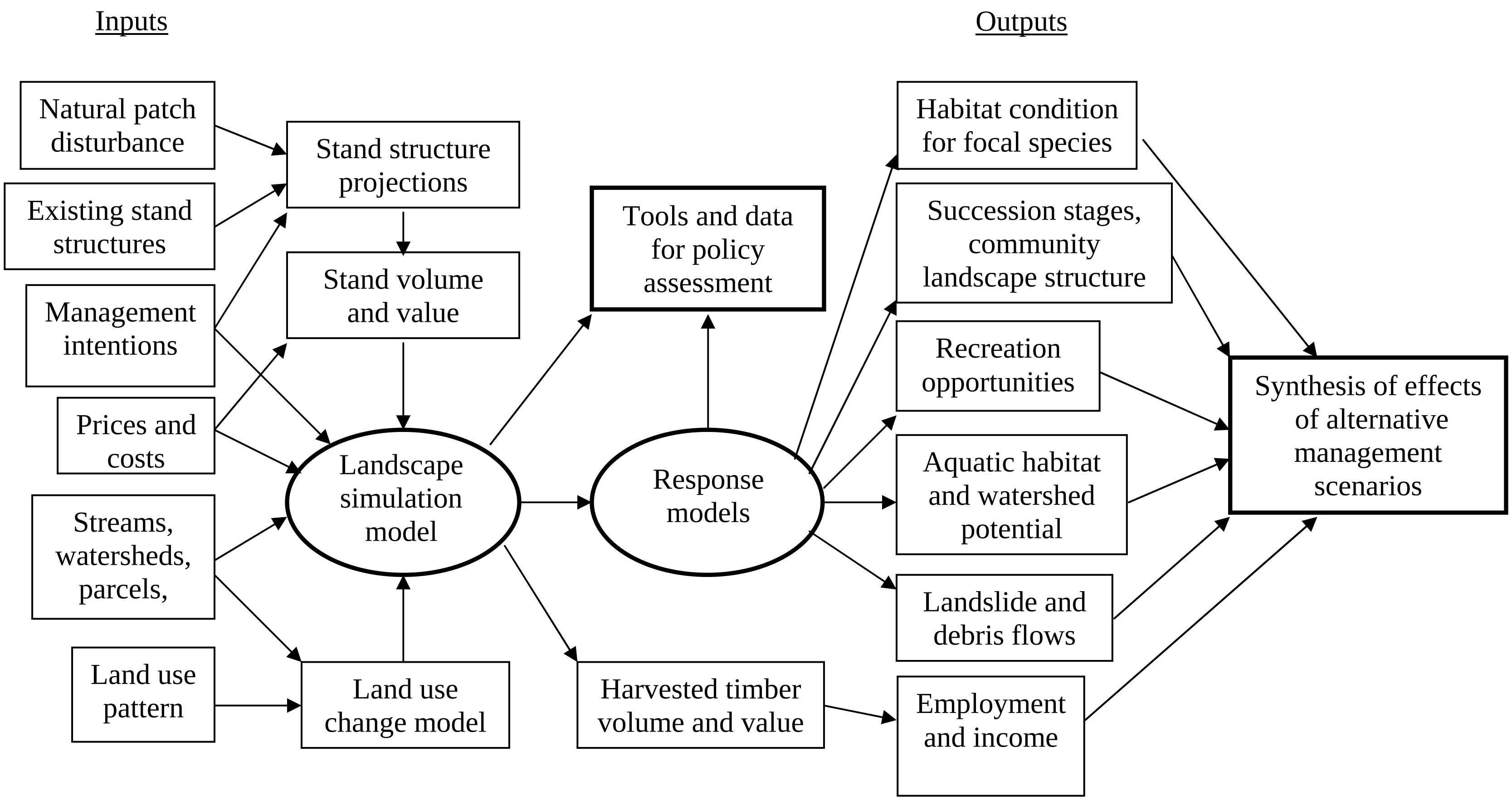

Figure 1. Schematic of CLAMS inputs, models, and outputs.

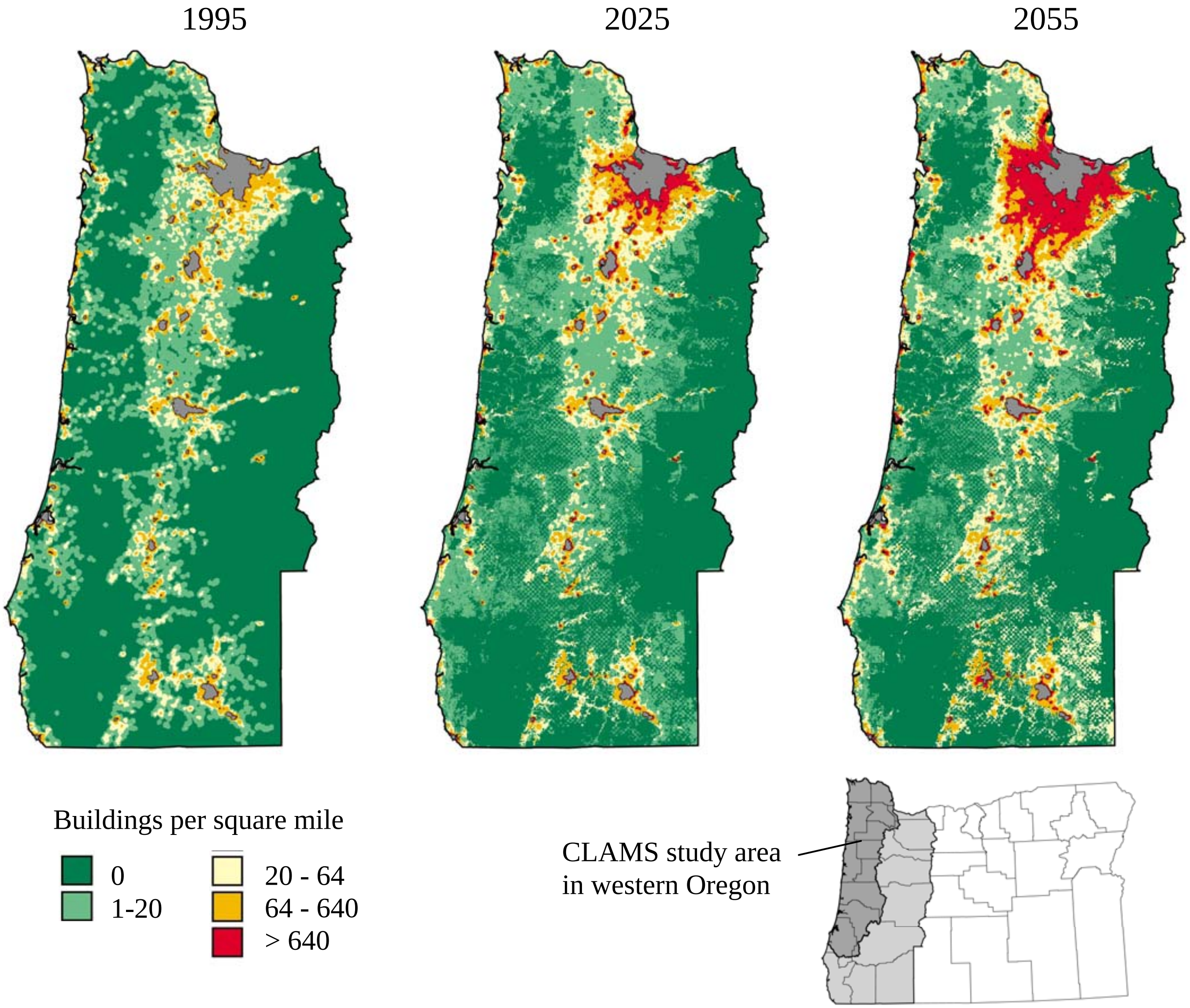

Figure 2. Projected building densities for western Oregon including CLAMS study area.

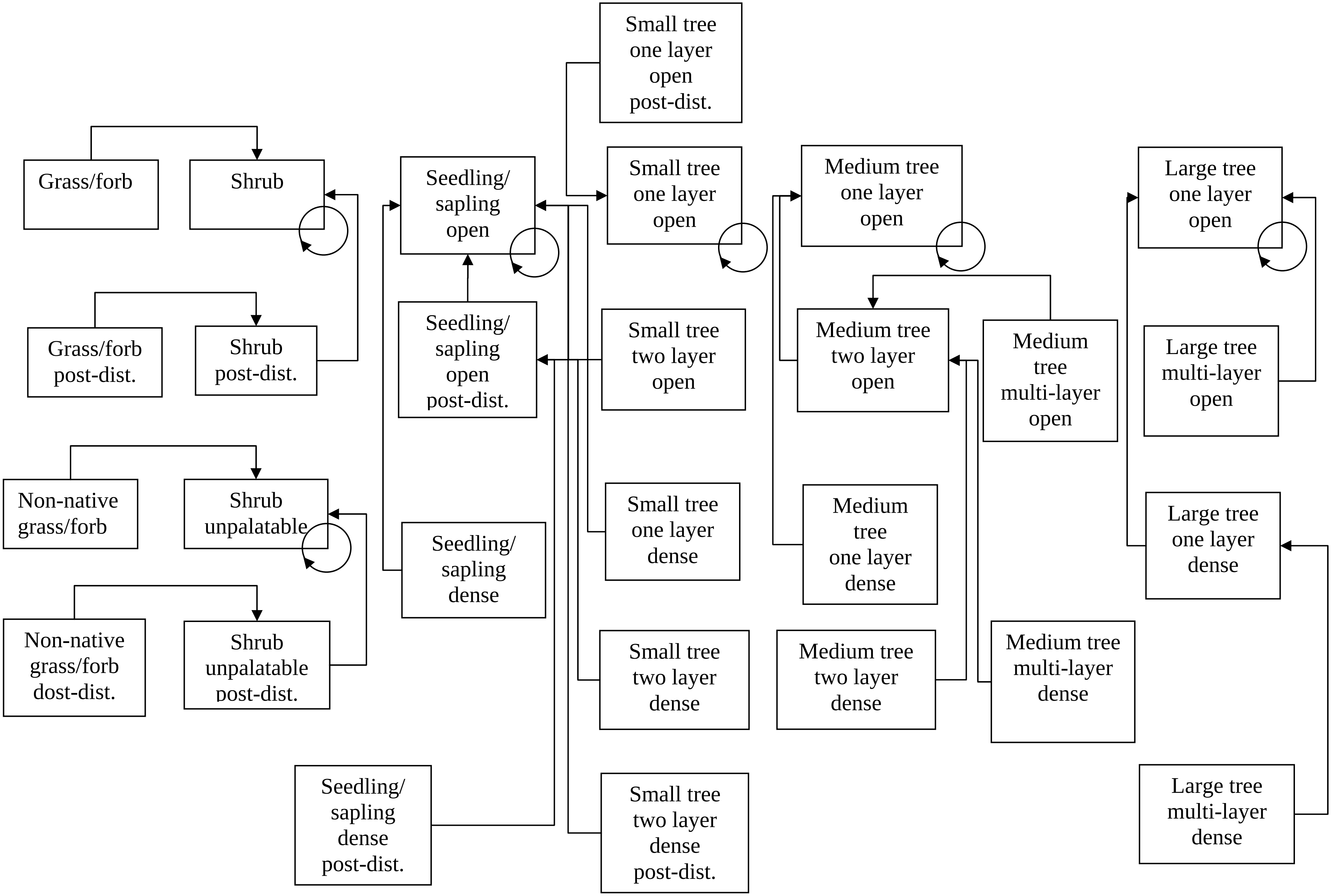

Figure 3. Example INLAS state and transition model for surface and mixed-severity wildfire (from Hemstrom et al. 2007)

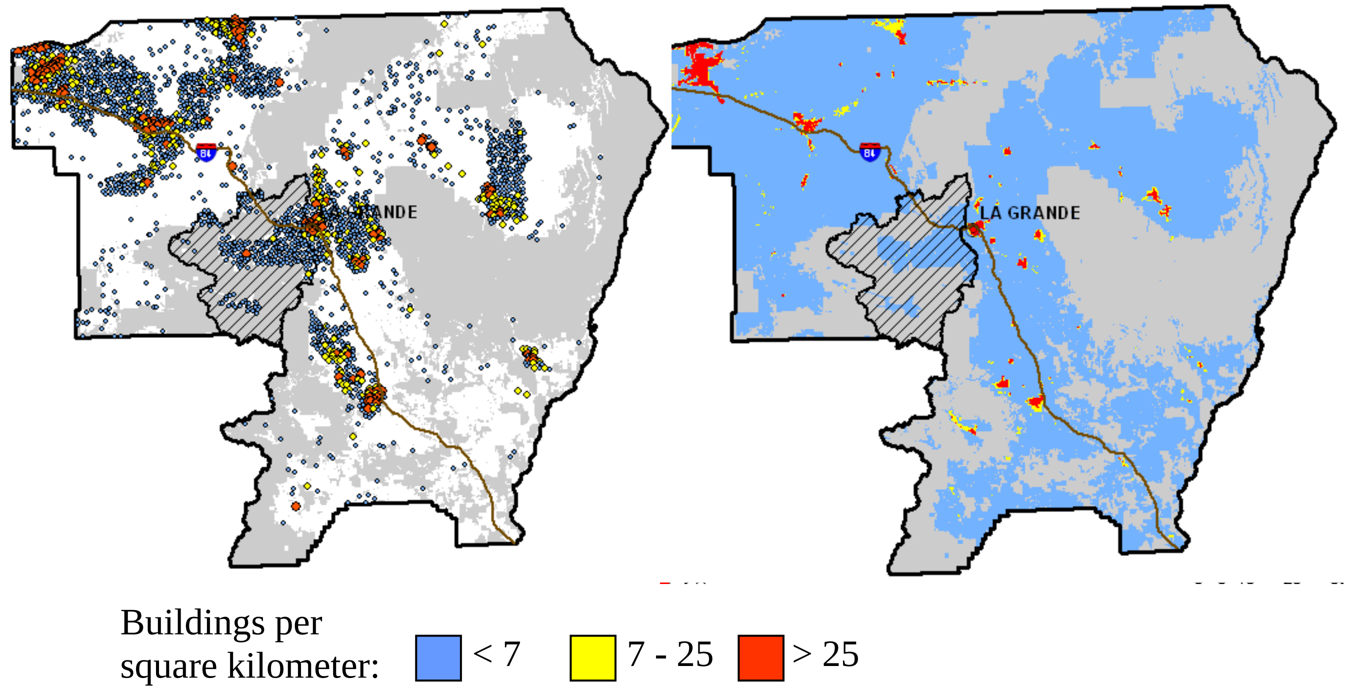

Figure 4. Actual building counts (per square kilometer) observations and projected pixel-level building counts for four county region surrounding INLAS study area (from Kline et al. 2007).

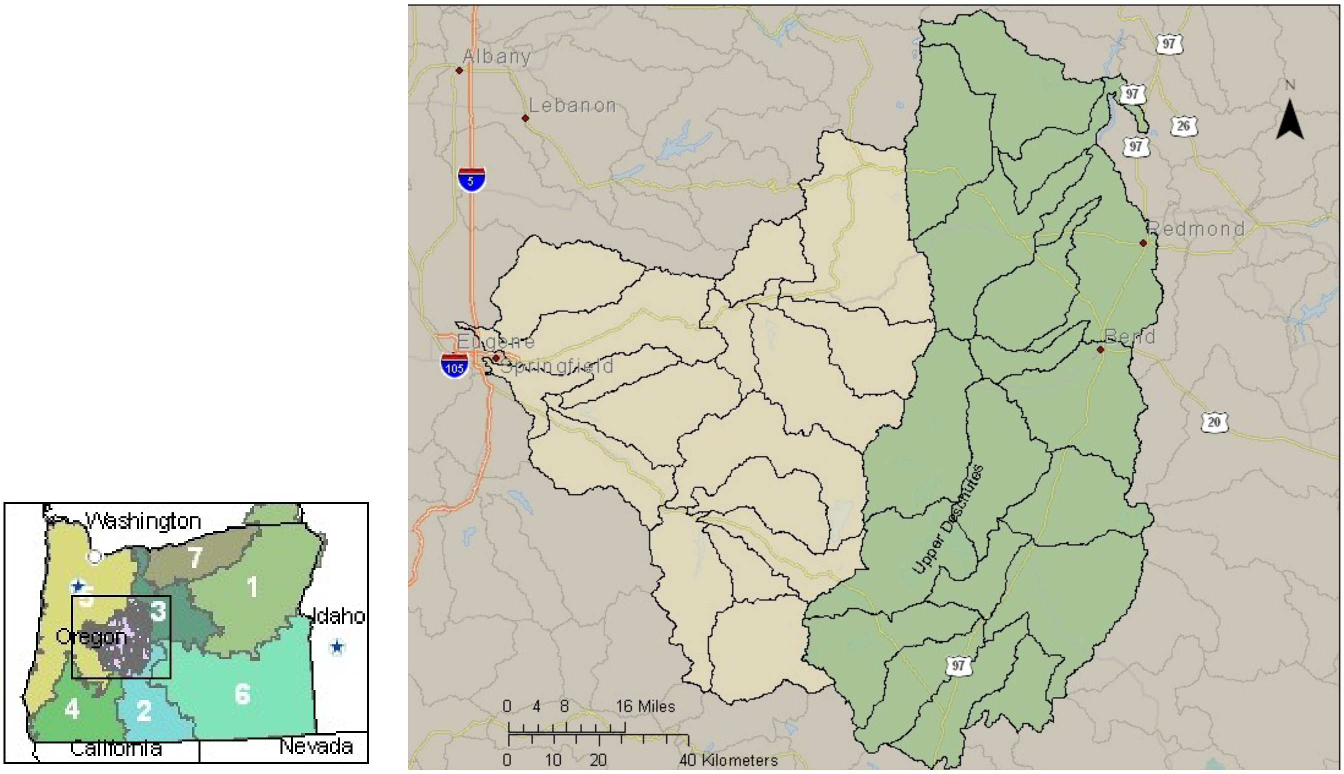

Figure 5. Central Oregon pilot study area for IMAP showing HUC5 watersheds and east and west sub-region delineation.

Table 1. Example Markov forest, range, and agricultural land annual conversion probabilities to low-density or higher development for key strata combinations for central Oregon IMAP pilot study area.

Initial land use	Owner[a]	Zoning[b]	Sub-region[c]	Annual conversion probability to low-density development
Forest	Industrial	All	East and west	0.0000439
	Non-industrial	Developable	East and west	0.0180947
	Non-industrial	Resource land	West	0.0004803
	Non-industrial	Resource land	East	0.0029952
Range	Industrial	All	East and west	--
	Non-industrial	Developable	East and west	0.0349532
	Non-industrial	Resource land	West	--
	Non-industrial	Resource land	East	0.0067374
Agriculture	Industrial	All	East and west	--
	Non-industrial	Developable	East and west	0.0063527
	Non-industrial	Resource land	West	0.0011002
	Non-industrial	Resource land	East	0.0065361

[a] Industrial owners are companies who grow timber for industrial uses, including those with and without wood processing facilities. Non-industrial owners include farmers and other private owners.

[b] Developable zoned land includes urban growth boundaries, rural residential, and zones where development generally is allowed under Oregon's land use planning program. Resource lands include forest, range, and agricultural zones where development is greatly restricted.

[c] East and west sub-regions are delineated by the crest of the Cascade Range.