

DRAFT

Human Dimensions of the Mountain Pine Beetle Outbreak in the Greater Niwot Ridge LTER Landscape: Specifying Anthropogenic Feedbacks and Socio-Economic Impacts in a Coupled Human-Natural System

William Travis
Thomas Dickinson
Alex Durant
Kevin Sharp
Department of Geography
University of Colorado
Boulder, CO 80309-0260

Abstract

We conducted an exploratory documentation of social response to the mountain pine beetle (MPB) outbreak underway in the central Rocky Mountains focused on a study area that includes the Niwot Ridge LTER site near the continental divide, and encompassing a west slope zone (Grand County) in which the outbreak is almost total, and the east slope (Boulder County) into which the outbreak is still invading. Our overall goal in this exploratory research was to illuminate the nature of institutional and individual reaction to dramatic change in a forest ecosystem spanning several different land ownership and management regimes while the event was underway and to establish approaches for further analysis of the human dimensions of the outbreak as it evolves. Of special interest are responses that physically affect the ecosystem and thus set up feedbacks between natural and human systems. The human dimensions element of this project is framed within the context of “coupled human and natural systems” (CHNS) and the Integrated Science for Society and the Environment (ISSE) model developed in LTER. Responses are a factor of individual and collective perceptions of ecosystems, and institutional structures like land ownership, technology, economics, and land use and health and safety regulations that set the range of options.

We started by building a propositional inventory of the perceived effects of the beetle outbreak and associated forest death drawn from media coverage and public meetings and interpreted via the theory of risk perception. Next we created a roster of potential human responses that would feedback to the forest landscape. We then characterized the study area landscape in terms of forest cover, beetle impact, ownership, and management, with the goal of developing GIS data for future analysis and predicting the spatial pattern and intensity of human response (forest treatments). We found the east side forest to be much more fragmented in terms of both physical cover and ownership, suggesting a more fragmented pattern of physical treatments. We explored two approaches, agent based modeling and fuzzy sets, to making such predictions (though we have not carried out this analysis). Finally we collected economic data that, according to the propositional inventory, should show beetle impacts, and examined them for any effect (this was conducted at a larger scale of several counties in keeping with data resolution and for comparison to areas with and without significant beetle impact). With one possible exception we found no evidence of the cited economic effects.

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Introduction

A significant mountain pine beetle (MPB, *Dendroctonus ponderosae*) outbreak is dramatically altering the forest landscapes in the western United States and Canada, especially the region's extensive lodgepole pine (*Pinus contorta*) stands. Interaction of a large suite of conditions, including natural and anthropogenic factors, appears to have occasioned the largest MPB outbreak in recorded history (Raffa et al., 2008). Forest mortality across large landscapes in the Rocky Mountains has evoked strong social responses, including grave concern over heightened wildfire hazard, attempts to intervene with mechanical and chemical treatments, worry about potential (but yet un-measured) economic loss and mitigation costs, and grief over lost aesthetics. While already at unprecedented geographical scale, the outbreak at this writing was still expanding into thus-far unaffected forests. This paper examines key social dimensions of the MPB outbreak, both theoretically, drawing on the concepts of coupled human-natural systems (CHNS; Liu et al., 2007) and empirically, based on initial observations and impacts data from a study area in the Colorado Rockies centered on the Niwot Ridge LTER site.

Mountain Pine Beetle in Couple Human-Natural Systems Perspective

The MPB is an eruptive insect prone to semi-periodic outbreaks occasioned when two or more factors, like temperature, forest host conditions, and beetle populations, exceed some threshold past which positive feedbacks dominate until appropriate host forest stands are depleted, or some exogenous event like a significant cold spell intervenes (Raffa et al., 2008). Some of these contributory factors evince anthropogenic signals (e.g., forest stand structure, warmer temperatures), and humans respond to outbreaks in complex ways, including attempts to intervene physically and to alter forest management to affect current and future outbreaks. Thus MPB outbreaks offer an excellent opportunity to study CNHS dynamics magnified by a dramatic disturbance event that some people see as a catastrophe.

Conceptual and operational models developed in projects like the Global Land Project (2005), coupled human-natural systems (Liu et al., 2007), and land change science (Rindfuss et al., 2004; Turner et al., 2007) provide common touch-points and analytical schema for human dimensions researchers to link both process and case to a larger framework, and allow comparisons across space and time via coordinated case studies and meta-analysis (Lambin et al., 2001; Liu et al., 2007; Raquez and Lambin, 2006). The various conceptual models are roughly similar, derived from early global systems diagrams and universally casting the interactions of social and physical systems as iterative feedbacks. The beetle outbreak would seem to be almost a perfect example of CNHS as conceived in the Integrated Science for Society and the Environment (ISSE) model (fig. 1) proposed within the U.S. Long Term Ecological Research Network (LTER, 2007).

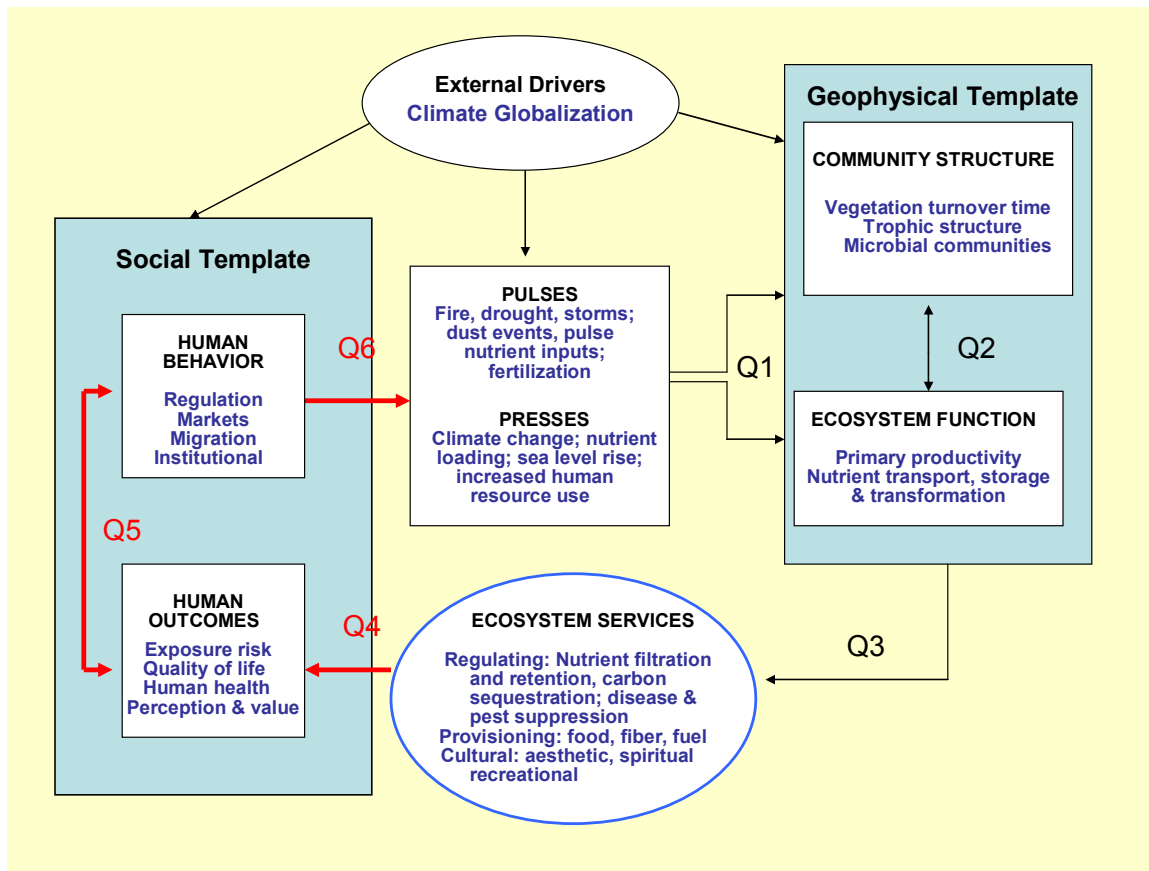


Figure 2: A version of the LTER ISSE conceptual model modified for this study.

A CHNS Model of the MPB Outbreak

Here we apply a slightly modified version of the ISSE framework (figure 2), focusing on the three broad questions stemming from that model's Social Template:

Q4: How do changes in vital ecosystem services alter human outcomes?

Q5: How do perceptions and outcomes affect human behavior?

Q6: Which human actions influence the frequency, magnitude, or form of *press* and *pulse* disturbance regimes across ecosystems, and what determines these human actions?

The analyst can start at any point of interest within this chain of linked questions (we start with questions of how people perceive the outbreak), but there is an implied obligation in CHNS studies to attempt to follow the causal chain through at least one feedback cycle. In the MPB case, the ISSE model questions can be elaborated as:

Question 5: How is the beetle epidemic assessed and framed?

- “Katrina of the West”—a true catastrophe with attendant social impacts
- w/i or w/o “range of natural variability”
- Bad land management
- Part of global warming

Sub-questions for Q5:

- Does it matter to the human response if the outbreak is interpreted as a “catastrophe”?

- Does it matter if it is seen as stemming more from natural vs. anthropogenic origins?

Question 4: Can we document any actual economic impacts, in particular: depressed tourism or property values?

Question 6: What sorts of new, policy-driven “pulses” (e.g., clear-cutting) and “presses” (e.g., demand for altered fire suppression policies or long-term forest treatment and logging patterns). Sub-questions for Q6 include:

- Are there identifiable thresholds for particular landscape interventions (pesticide spraying, prescribed fire, timber cutting)?
- What might be the scale, intensity and landscape pattern of these anthropogenic presses and pulses?
- What are the constraints (e.g., \$1000/ac treatment costs) on the social system’s ability to generate these new presses and presses?

The challenge, as described throughout this report, is especially to quantify the likely presses and pulses generated by the outbreak’s real and perceived effects.

But how might we predict human interventions? Since the current MPB outbreak is unprecedented, we might reasonably expect unprecedented social response. Yet we know very little about human response to complex environmental processes and changes like MPB eruptions that are characterized by cross-scale interactions, threshold processes, and both subtle and overt landscape effects. We struggle for analogs. Indeed, if the MPB outbreak is seen as catastrophic, then human response to the wildfire hazard might inform our analysis and expectations (indeed, the two processes are perceptually linked, as discussed below). And we can call on a large literature on human response to discrete natural hazards and disasters (Burton, et al., 1968; Mileti, 1999; Cutter, 2001), as well as to more subtle environmental processes like climate change (Parry et al., 2007); but we have few guides to know which findings from such work would illuminate social response to this landscape-changing event. For example, the MPB outbreak does not itself directly pose significant risks of human morbidity and mortality, certainly nothing like that associated with wildfires, hurricanes, or tsunamis. Yet the landscape change wrought by MPB is quite dramatic and, in this outbreak, quite fast, as compared, say, to global warming. In this sense, it is more like the drought hazard: large-scale, dispersed, moderately slow-onset, but nevertheless of potentially large ecological and economic consequence (Riebsame et al., 1992).

A Propositional Inventory of Human Response

Much of the forest cover in the Colorado mountains is being affected by pine bark beetles that attack and kill whole stands of lodgepole pine. The needles of dead trees turn red and thus signal dramatic landscape change to even the casual observer. The outbreak has already evoked widespread media coverage, agency response, and action by individual property owners. As the first stage of this analysis we began, in spring, 2008, to collect what Webb et al. (1966), in their guide to “unobtrusive measures”, called the “running record” of social responses, via three main sources focused on Colorado: news media coverage; agency documents; and presentations and discussions at public meetings. For an example, see Appendix 1, “Field Notes from a Public Meeting,” and Appendix 2: “Media Coverage: Selections from the Print Media.” Here’s our first cut of the propositional inventory:

- concerns that the outbreak represents a significant, even catastrophic, fire hazard
- lost aesthetics
- reduced property values

- loss of tourism and associated income and tax receipts
- tree-fall hazard
- pesticide spraying (costs, health effects, effectiveness, etc.)
- dead tree removal
- preventive logging
- arguments for long-term forest management aimed at reducing the next outbreak; to create “resilient” forests, and often cite bad land management.
- Arguments and efforts to re-program agency budgets, and create new legislation and new budgets, for “forest health”, typically including enlarged mechanical treatments.

The outbreak has occasioned a public debate about cause, management policy, and forest health, and will certainly evoke new, anthropogenic pulses and presses in the montane forest ecosystem, some of which may be quite unorthodox. We can hypothesize that the social response might send pulses of tree cutting, prescribed fire, and other disturbances across the landscape in certain patterns (e.g., cutting near houses, roads, facilities, and trails). This depends, though, on a set of economic factors and policy decisions.

A first approximation of human perception to the MPB outbreak can be gleaned by transference from the very limited research on other cases of forest die back. A similar outbreak (in spruce) has been studied in Alaska, where Flint (2007) uncovered a version of the “issue-attention cycle” (first laid out by Downs, 1972) in her analysis of the risk perception as residents of Homer, AK, experienced a landscape-changing spruce bark beetle outbreak. Although alarmed and depressed as the outbreak ensued, and laying blame on the land management agencies and lack of logging, they came to accept the new landscape in just a few years, especially after the much-touted fire danger did not pan out. Here’s one of Flint’s informants:

Had you asked me this 4 years ago my answer would have been much more “devastating!” I would’ve said things like, “it’s ripping at the core of the community.” Everybody’s done such a good job just rolling with the punch and dealing with it. When it first was coming in a mass, that’s what it felt like. The first time you were outside in the yard and more than 6 beetles landed on you at one time, it was terrifying. It was devastating. But, then you realized that we were all going through it and we all lived through it. All it does is change what your property looks like. I guess it’s not as devastating as I felt that it was originally. (quote from Flint, 2007, p. 1600).

Others worried about the fire hazard, and criticized the government’s poor management and the potential effects of salvage logging.

In terms of CNHS the existence of the issue-attention cycle (Downs, 1972) in MPB problems or forest health issues generally, is not as significant as the probability that the cycle’s most energetic phase (which Downs termed “alarmed discovery” and “euphoric enthusiasm” for solutions) might generate new, intense, more widespread (or all of these) presses or pulses on the landscape (e.g., increased logging, spraying, seeding, or fire suppression). Forest managers are clearly trying to avoid this in Colorado by starting most discussions and write-ups about the outbreak with statements about its natural roots and inevitability. They wish to defuse the public’s natural tendency to demand control.

We attended public meetings hosted by the US Forest Service (see Appendix 1), as well as meetings of the Colorado Governors’ Healthy Forest Task Force. Alarm at the beetle impact is expressed through a simple narrative of causality: beetles kill trees, dead trees are a fire hazard; the larger extent of beetle kill means larger, more devastating fires (Appendix 1). A more sophisticated, but not necessarily more accurate narrative has been offered by political leaders (Appendix 2),

especially the USFS regional forester who has argued in op-ed's and several presentations (two of which we attended) that not only do the standing dead trees portend more, larger, more catastrophic wildfires, but when they fall they create the conditions for intense ground fires that "sterilize" and create a crust on the soil that causes more runoff, which causes more erosion and sediment transport, threatening water supplies both locally and regionally (including all of the Colorado Basin as well as water users in California who export Colorado River water). In a 2006 speech, then Senator Ken Salazar referred to the MPB outbreak as the future "Katrina of the West" in the context of a massive wildfire threat (Erickson, 2006). The Regional Forester was described in the media to have: "Dismissed the findings of a recent Colorado State University study, which argued that Colorado's beetle epidemics are part of a natural process. The report, written by William Romme and his colleagues, said the widely held belief that massive insect outbreaks set the stage for extreme wildfires 'is not well supported and may in fact be incorrect.'" (Erickson, 2006).

But can we quantify the probability that public concern will cross some threshold that results in policy change and widespread impacts on the pre- or post-outbreak landscape? And can we give some parameters to the resulting presses and pulses? And, given the issue-attention cycle, when might we see relaxation such that the likelihood of new presses and pulses declines? Finally, of course, there is a small chance that federal policy will switch under public pressure for extensive logging, but the rapidity with which the issue lost salience in Flint's Homer, AK, study, suggests that time will not be sufficient to bring about large public land policy change.

Predicting Human Response-Induced Landscape Change: Multiple Approaches

Forest Clearing Behavior Based on Landscape Structure

The simplest approach to predicting how land managers will respond to the outbreak, and thus create the feedback envisioned in Q6 of the modified ISSE model, is to map the ownership and major landscape features that we can hypothesize from our roster of responses will actually play out physically on the landscape. Experience in our West Slope study area shows that some landscape-changing responses are likely.

Our focus will be on forest clearing. On public lands we can predict that pre- and early-outbreak logging will be conducted on a small subset of lands, near trailheads, campground and similar facilities; this could be easily mapped. Whether pressure to log on the up-swing of the issue-attention cycle will yield more widespread forest treatment is more difficult to say, but we can certainly rank the likelihood: greater now than anytime in the last two decades, and greater now than it is likely to be a few years after the outbreak (even though arguments for not letting the dead trees go to waste will surely be made, as they were after the 1988 Yellowstone fires). On private land we could posit that outbreak and post-outbreak logging will expand dramatically and could affect essentially all private lands. Almost certainly all residential lots (1-5 acres) affected by the MPB outbreak, will be logged, and larger, exurban lots up to perhaps 50 acres will be at least partially treated. The intensity will range from perhaps half the stems cut to all, the latter especially on smaller lots, and tempered by the potential for spraying to save some trees. The extent, frequency and effects of spraying are less easily discernible but may be transferable from the west slope.

The areal extent and intensity of private land treatment (especially logging) depends on two main factors: economics and policy. In this case, the traditional economic geography of logging will be inverted: smaller properties are more likely to be logged than large properties (e.g., lack of a market demand means no economies of scale, just the opposite); the steepness of this inverted cost curve might be lessened if markets can be developed, probably through subsidies, for the wood

products (as often proposed, e.g., for biofuels, furniture, etc.), though this depends on economic and policy factors. Tree removal is typically required by local ordinance, but the scale and effectiveness of this regulatory impact remains uncertain.

The main themes for Q5, then are: What sorts of beetle kill patterns and threats will evoke what sort of human response, and how will those joint influences yield a new forest structure? In a sense there are two “agents” in this landscape: beetles and land owners/managers. The beetles spread in annual time steps (modeled from actual spread on the west side and from the literature). The land owners observe the outbreak, or develop expectations of it (most believe that the MPB outbreak will kill most if not all of the lodgepole forests on their land). They can choose several response paths, including doing nothing, selective thinning and some clear-cutting to try to save some trees, or wholesale clearing, perhaps with some re-planting. Their ability to alter the forest cover is limited by costs and technical feasibility. And their actions are guided by formal requirements (municipal and county regulations, and differences between U.S. Forest Service and National Park Service regulations), incentives (if their land is included in a forest health or fire mitigation project), and informal expectations (neighbours expect them to deal with unsightly, dead trees). We expect their actions to play out over a five-year period, and to reflect similar responses taken on the West Slope (Grand County) where the MPB outbreak has already killed most of the forest cover (we’ll define these parameters via aerial photo analysis and field visits to Grand County).

Here is an example of the sorts of scenarios that might play out:

Most land owners clear significant amounts of forest, with those owning <35 acres clearing 100%, those in 35-160 acre class clearing half, mostly within 250m of roads and around buildings, and those with >160 acres clearing only around facilities (roads, building, utilities, campsites, trailheads and trails), but to a further extent, roughly 500m.

We developed preliminary results for this analysis by a GIS analysis of the intersection of land ownership (parcels) and lodgepole cover for Boulder (East Slope) and Grand (West Slope) counties (Tables 1 and 2).

Agent-Based Modeling

The simple, landscape structure approach suggests that much more clearing is likely on the West Slope compared to the East Slope, but that East Slope result might be a more finely grained patchiness. We then explored how we might, in the next research steps, improve this into a more detailed prediction (scenario?) based on increased information on landowner behaviour gained empirically or postulated by behavioural theory. This would be a modelling experiment that combines GIS analysis, agent-based modeling, and landscape metrics to test a set of hypotheses and scenarios of how the beetle outbreak will proceed as a coupled natural-human landscape event/change. For this project we need to borrow or create algorithms that yield measures of the resulting variables:

Type (e.g., forest clearing)

Intensity (e.g., clear-cutting)

Areal extent (e.g., square km)

Pattern (e.g., patches of certain average size and shape; altitude zonation, etc.)

Duration / time frame / speed of on-set (e.g., fast vs. slow variables—this may differentiate “press” from “pulse”)

These can be descriptive and analytical “now-casts” based on current conditions, “retro-casts” based on historical conditions, or “fore-casts” based on projected future conditions.

One approach to conducting this work in the post-SGER research is to develop an agent-based model of land use and land cover change in the forested landscape along the Colorado front Range in proximity to the Niwot LTER site, using the Recursive Porous Agent Simulation Toolkit (REPAST)

modeling framework (<http://repast.sourceforge.net/index.html>), which is designed well for spatial and landscape analysis and for displaying results in GIS formats. Key data needed here are ownership, parcels, property values, forest cover, slope, and likely (or actual) beetle damage (for the MPB outbreak case) and/or wildfire fuel status (for the fire mitigation case). REPAST allows me to assign rules of behavior to land owners and managers, including likely responses to the beetle outbreak or perceived fire threat in terms of rates and patterns of forest clearing or thinning, limited by the agents' geographical sovereignty (e.g., ownership parcels) and guided by costs and technical constraints, but also by legal requirements (e.g., land use regulations). We would model landscape outcomes for a variety of beetle and land manager interaction scenarios. The landscape outcomes can then be assessed for their outcomes in terms of forest structure (mainly fragmentation) via FragStats.

Socio-Economic Impacts: Real and Perceived

The West that depends on tourism, meanwhile, wonders what their customers will think about the dramatic change in scenery. Four million visitors a year come for sightseeing and recreation to Grand County in Colorado, where much of the forest is now dead. "What happens," said Ray Jennings, director of emergency management for Grand County, "if this becomes an ugly place to be?"

-New York Times 11/18/2008

The current Mountain Pine Beetle (MPB) outbreak has killed millions of acres of trees across the Rocky Mountain West. In its wake, whole forests have been left standing dead, red needles signaling their dead hosts. In Colorado, many stands in the Central Mountains have been decimated, and the very heart of the state's tourism economy seemed to be at risk. Fears have been expressed that the forest die-off would repel visitors and reduce mountain real estate values. We found no studies of these impacts, and this section looks for effects based in two areas frequently mentioned: tourism (measured by lodging, retail, and restaurant tax receipt) and property value. Local business operators assumed that since dead trees are "ugly" and people do not want to vacation in an "ugly" environment, the resort economy would collapse. Moreover, they feared that the subsequent intense wildfires would further blunt their economic livelihood. Many blame a depressed real estate market on lots covered in dead trees, but some also recognized that in 2007 onward the nation has been in a deep economic slump, which could override some of these hypothetical effects.

The commonly held belief that "ugly forests" or "dead forests" drive away visitors is not supported by experience. The widely reported, and widely decried, fires in Yellowstone national park in 1988 provide a possible analogue. Similar fears were raised by Yellowstone-area merchants in 1988: that the burned park would attract fewer tourists (and that bad land management had been responsible for the fires).

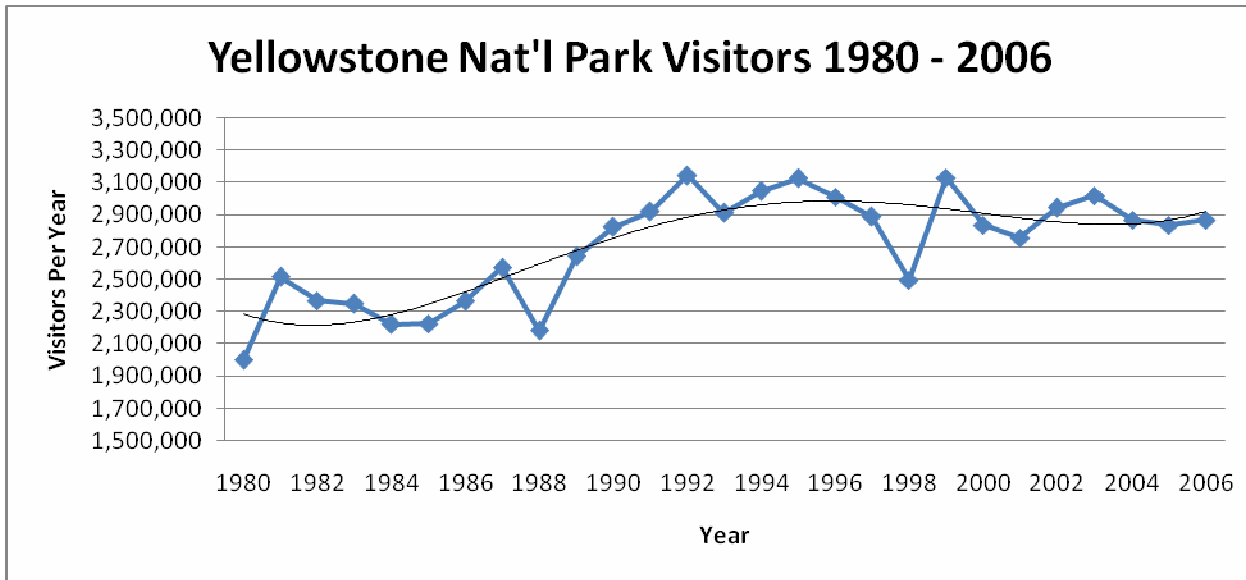


Fig 2. Yellowstone National Park Visitor Statistics, all entrances, 1980 – 2006

After the 1988 Yellowstone fires, which affected 36% of the park, visitor numbers kept increasing at their previous rate (Fig. 2)---despite the media firestorm. Park visits were, indeed, depressed in 1988 during the fires, because many areas were closed, the news media conveying an image of the whole park aflame, and fire-fighters clogged the roads, restaurants and lodging. But visitor numbers in 1989 picked up right where 1987 left off. Through 1992, visitor numbers increased steadily every year, before levelling off. During the post-fire period, only one year, 1998, had fewer visitors than 1987. Even with its recovering forests, Yellowstone still received more visitors per year than it had before the fires. This case at least, suggests that forest loss would not necessarily depress Rocky Mountain tourism.

The ski industry also feels at risk from forest change. The ski industry fears that bare slopes will not be able to maintain a snowpack as effectively as forested slopes, and that destination skiers will go to other western states without the beetle because of reduced aesthetics. One ski industry observer put it this way: “The resulting loss of shade will trigger an earlier spring melt... [large scale loss of trees means] fewer wind breaks, which will increase snow drift and, perhaps, snowmaking. Trees also buffer ski lifts, so there might be more wind closures.” (Tolme, 2009).

Tourism Impacts

To assess impacts on the economy, we expanded the study area to include other counties (though we still focus on the west slope area of our Niwot landscape), including areas in other parts of the state that are minimally affected by beetles. First, twelve areas of interest were selected. These areas ranged from locations heavily dependent upon winter recreation, such as Winter Park and Summit County, to areas more dependent upon summer use, such as Grand Lake. Areas also range from developed and structured recreation, such as sprawling ski resorts, to the undeveloped forests on the Grand Mesa. Beetle kill data were retrieved from the USFS Region 2 GIS data bank. Data from 1994 – 2008 were merged to represent a total kill area. This number was then normalized by the total area of each resort area polygon, providing beetle kill for the *entire* area, not just the forested sections. As a result, the percentage of dead trees within each forest is likely much higher in polygons

including large high alpine or water-covered areas. Simply stated, the beetle kill value is the percent of total area in the zone covered by dead trees, not the percent of forest. So in the Summit County Resorts zone, 22 – 40% of the *entire zone* is covered by MPB infested trees.

The results were then broken into three kill classes. Class one represents minimal MPB impact, with 15% – 22% of the RA having dead trees present. From the author’s travels and observations, beetle kill in these areas can be difficult for the casual observer to spot. Class two kill, 22% - 41% affected, will be noticeable to most observers. Class three kill, 41% - 60% affected, signals severe kill. Most of the trees in these areas are dead, and entire hillsides are red.

Let’s first compare two ski resort towns: one with of almost total beetle kill, Winter Park, and another with little beetle effect. Telluride is a destination resort. Winter Park is in Grand County, an area embattled by the Pine Beetle. In GIS analysis, this area is class three kill, with greater than 40% of the zone (all land-covers) covered by beetle infestation. In contrast, the South East corner of San Miguel County, high in the Northern San Juan Mountains, is a jagged patchwork of peaks and canyons. Tree line runs low in this area, which is class one kill, 15 – 22%, about half of the kill that exists in Winter Park.

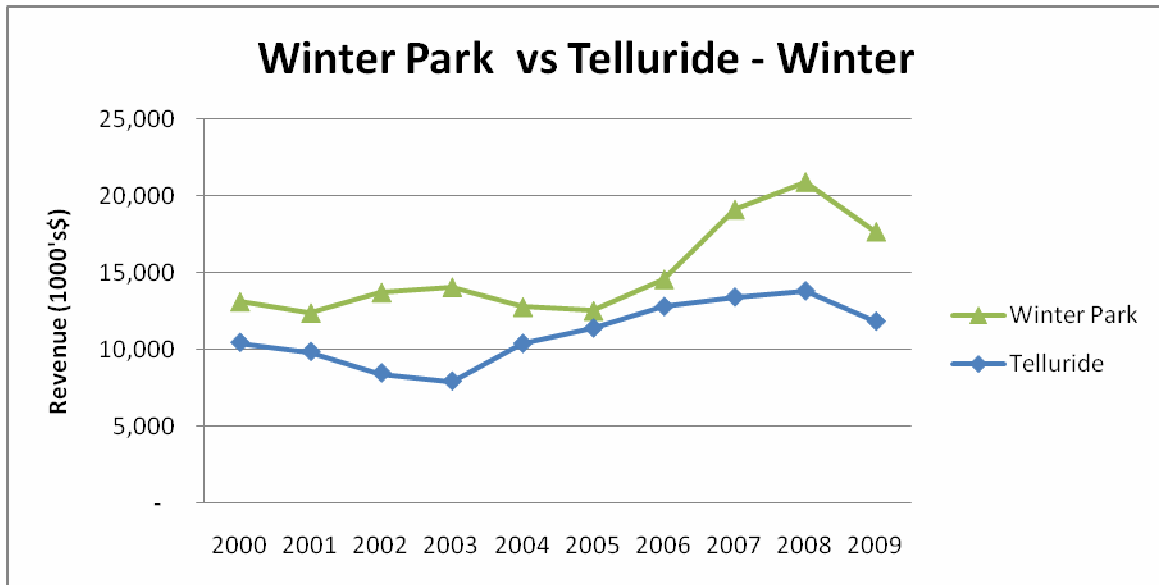


Fig 3: Winter Park vs. Telluride: Lodging + Restaurant Revenue

Over the past ten years, there have been two large economic discrepancies between them. In the post 9/11 economic decline, Telluride seemed to take a bit of a hit, while Winter Park actually had a boost. Winter Park most likely did better during this period because of its proximity to a larger population (near Denver, thus available to visitors driving rather than flying). The 2005 – 2008 period corresponds with the start of the beetle attack in Telluride, probably before there were even any visibly dead trees. However, there were already standing red pines in Winter Park. Winter Park had a substantial recreational spending increase during 2006 and 2007, while Telluride’s stagnant economy slowly recovered. During this period, there were noticeable swaths of dead lodgepole, and this area still had stronger growth than the lower kill Telluride area. Both areas felt the economic slump during the 2009 season, and while Winter Park had a slightly sharper decline, this pattern can be seen in the revenue curves for the other Front Range ski towns. Even though they are fundamentally different areas, they are representative of larger patterns. Ultimately, even if the clientele are different, Winter Park is growing during its red tree years. For Winter Park, and other Front Range resorts this shows that the economy is not negatively affected by the beetle (Fig. 3).

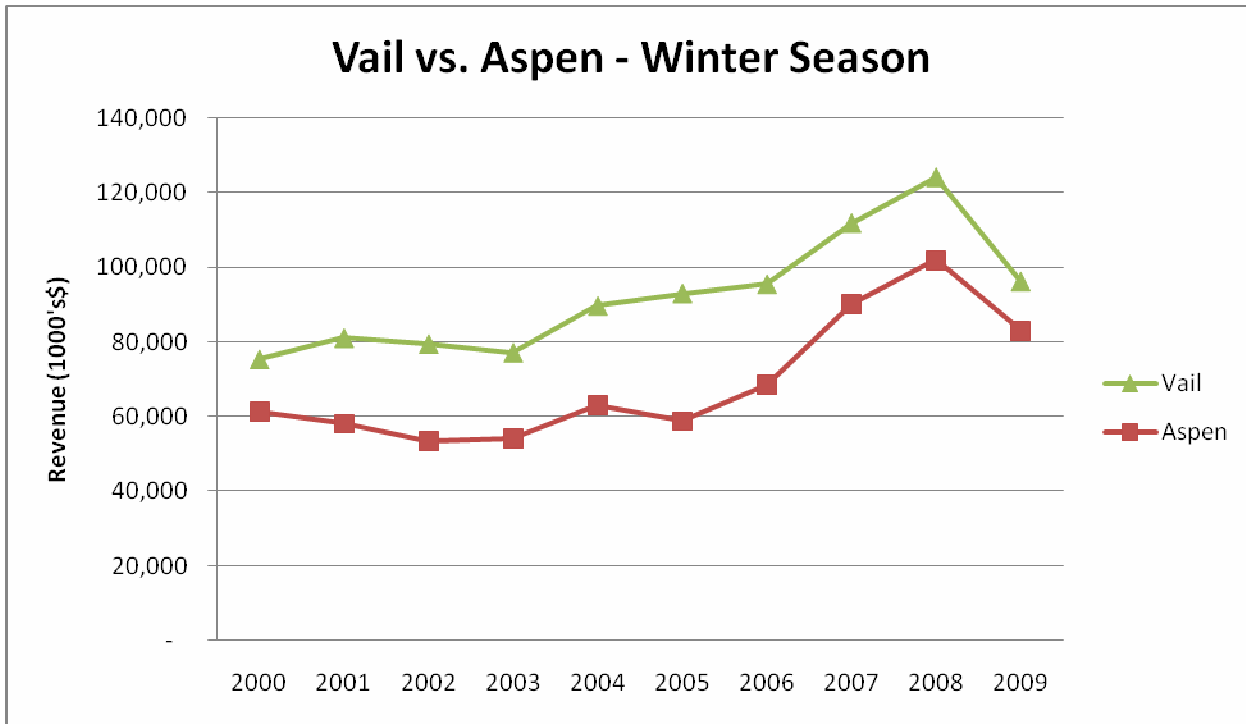


Fig 4: Vail and Aspen: Lodging + Restaurant Revenue

Unlike the stark contrast between Telluride and Winter Park, Vail and Aspen are comparable areas (Fig. 4). Both are renowned destination resorts, with multiple ski areas, luxury restaurants, and world class snow. These are ski areas that pride themselves on having the *highest* lift ticket prices; they are the two big hitters in the Colorado market. Due to its location, Vail does draw some of the Front Range crowd, but like Aspen, is a destination resort. However, one key difference between the two areas does exist. Vail Valley has class three beetle kill. Aspen and the rest of the Roaring Fork Valley have class one kill. Yet, the two tax curves almost mirror each other. These two areas are similar in all aspects except for one, the significant presence of beetle kill in Vail (the Town of Vail has spent \$750,000 on mitigation; Tolme, 2009). The similar curves clearly show that Mountain Pine Beetle has not had a significant economic impact.

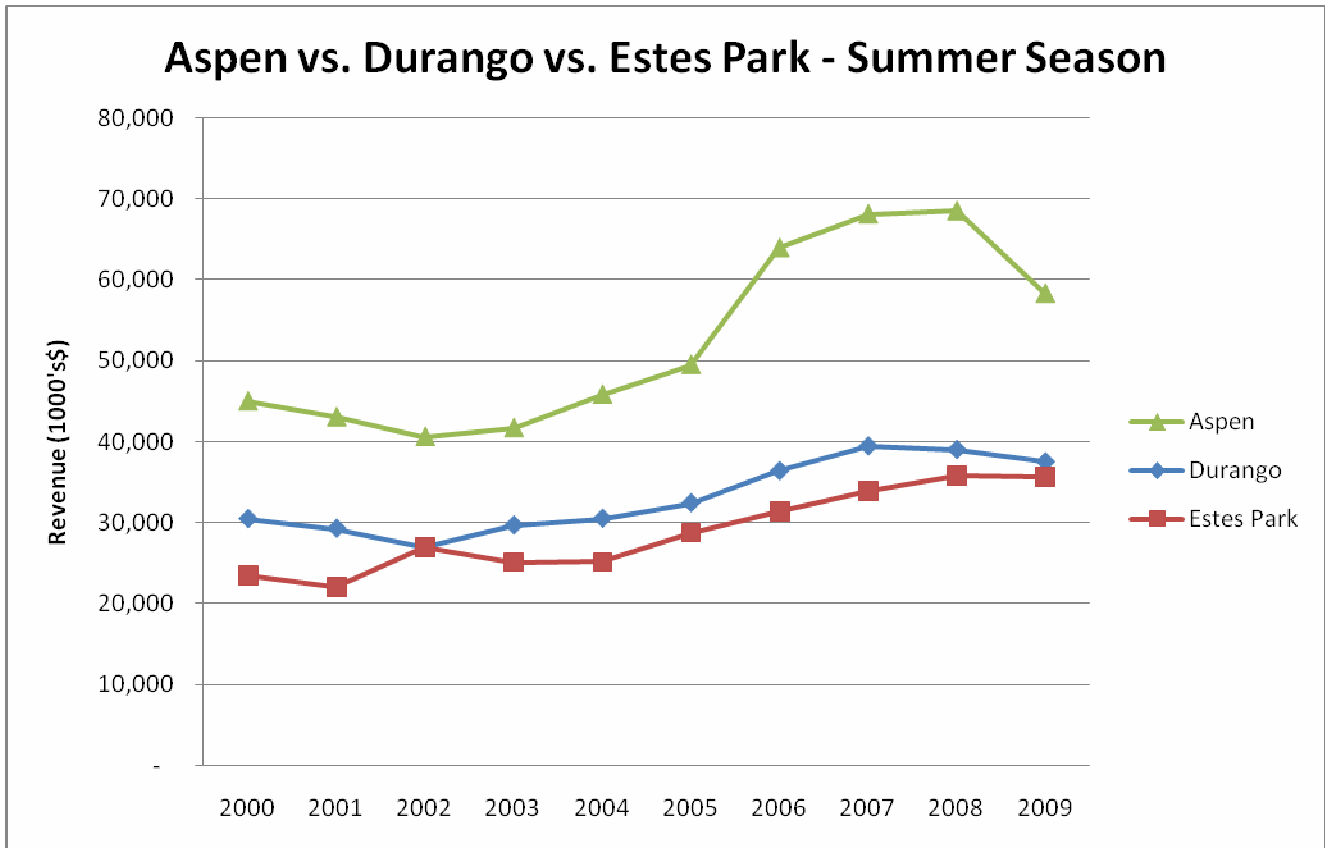


Fig 5: Aspen, Durango and Estes Park Lodging + Restaurant Revenue

Three different towns allow for a comparison of potential effects on summer tourism (fig. 5). Durango, in the southwestern corner of the state, is a gateway to the San Juan Mountains. It sits in a Class two kill area. Estes Park is on the eastern slope of Rocky Mountain National Park. Closer to Denver than the Grand Lake entrance, and full of restaurants, hotels, and shops, it receives much traffic bound for the park. Estes Park sits in the RMNP zone, which is class two kill. The continental divide bisects this zone, which shielded the eastern side of the park (and Estes) from the beetle. However, a recent push has sent the bugs over this barrier, with much of the forest in Boulder and Larimer Counties being attacked. Both of the class two kill areas have a similar tax curve, and saw their revenues flatten out around 2007. In stark contrast to these two towns, Aspen sits at the head of the Roaring Fork Valley, an area with very little kill. Much like Estes and Durango, after a small decline during 2000 and 2001, it enjoyed a slow recovery until 2005. A period of rapid growth ensued until 2007, when, like its counterparts, revenue began to flatten out. However, in the summer of 2009, the town experienced a rapid revenue decline. With no beetle kill, and a large destination resort, this decline can more easily be attributed to the larger economic downturn. Simply, if there is no beetle in the area, the town cannot have a negative impact from it. While Durango also saw a small decline, Estes Park, the beetle victim among these three, saw only a negligible decline – by far the smallest. This indeed was a case of areas with the beetle doing significantly better than an area without the beetle.

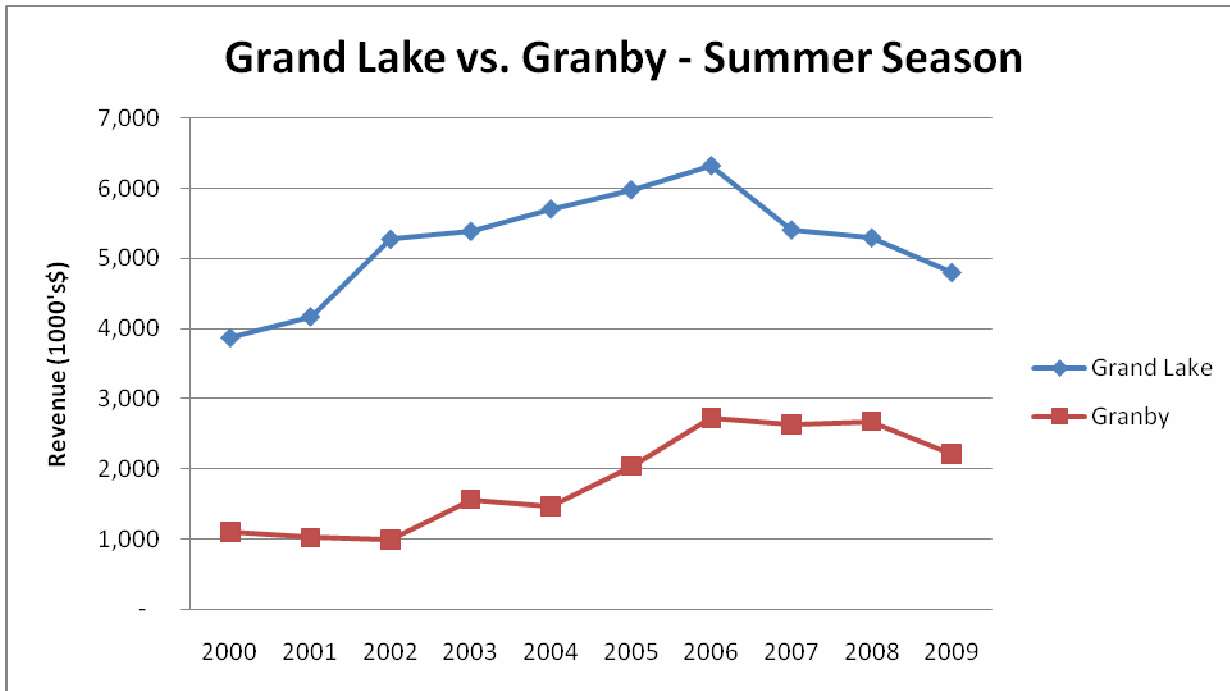


Fig 6: Grand Lake and Granby: Lodging + Restaurant Revenue

During the summer season only one area – Grand Lake – shows a significantly different revenue curve (Fig. 6). Unlike the more traditional economic profile, as seen in the Granby data, Grand Lake revenue abruptly started declining in 2007. However, during the summer of 2009, the slope of both profiles are roughly equal, signaling a uniform reaction to the larger economic downturn. While Grand Lake does show a downturn, and it is an area of very extensive and noticeable beetle kill. Yet, its neighboring areas, also with significant kill, show the more traditional revenue patterns. It may be that Grand Lake is uniquely sensitive to the beetle impacts, so we cannot be sure that this is not a beetle signal, but lack of signal in other parts of the county, also affected by the beetle kill, and no obvious reason to expect greater impacts in Grand Lake, make me doubt this explanation, but further work is warranted to explain the Grand Lake drop in values.

While an examination of tourism revenue shows that there has been an economic decline, there is little evidence that the pine beetle has played a role in it. In the first three examples, examining resort communities, often the locations which experienced beetle kill, such as Vail, Winter Park and Estes Park, fared just as well, if not better than the areas without significant kill, for example, Telluride and Aspen. While there was an unexplained downturn in Grand Lake, there is no evidence that it is related to the beetle. Simply stated, the tourist and real estate economies, as examined here, that were affected by beetles do not appear to exhibit trends unlike those with little or no beetle impact.

Real Estate Impacts

Except in the case of Grand Lake, a small resort town in the heart of the dead lodgepole forest, we detect no evidence that the beetle kill has affected real estate values as feared. In Grand County, which has long been viewed as the worst kill area in Colorado, property values are actually on the *rise*. Property values did decline during 2002-04 during a national economic down-turn, but from

2006 to 2008, during the worst, most visible expression of the outbreak, the sale prices of single family homes (SFH) increased by 15%, while condominiums (CND) increased 21% (Fig. 7).

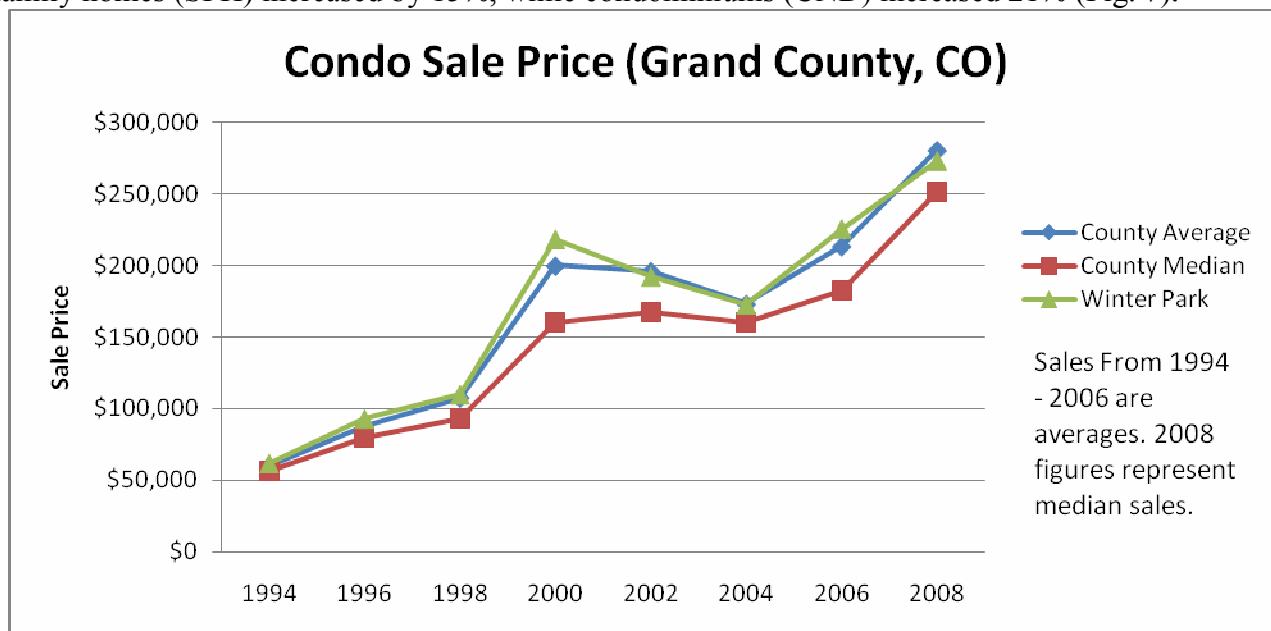


Fig 7: Average Sale Price, Grand County condominiums, 1994 - 2008

Forest Service records first show MPB presence in both Grand and Summit counties as early as 1994, and rangers at the Granby ranger station reported a noticeable presence of standing dead Lodgepoles from 2005 onward. While it was slow to start, the beetles have been attacking trees in this area for the same period in which the real estate data is charted. It is important to note the difference between home demand and sale price. Sale price is affected by a market saturated with new, more expensive properties. However, just the rapid increase in new properties, and corresponding price increases, needs to be recognized for its own implications. While the average sale price did drop, corresponding to the post 9/11 economic slowdown, the median sale price merely leveled off, before beginning a rapid increase – and an increase right through the beetle epidemic.

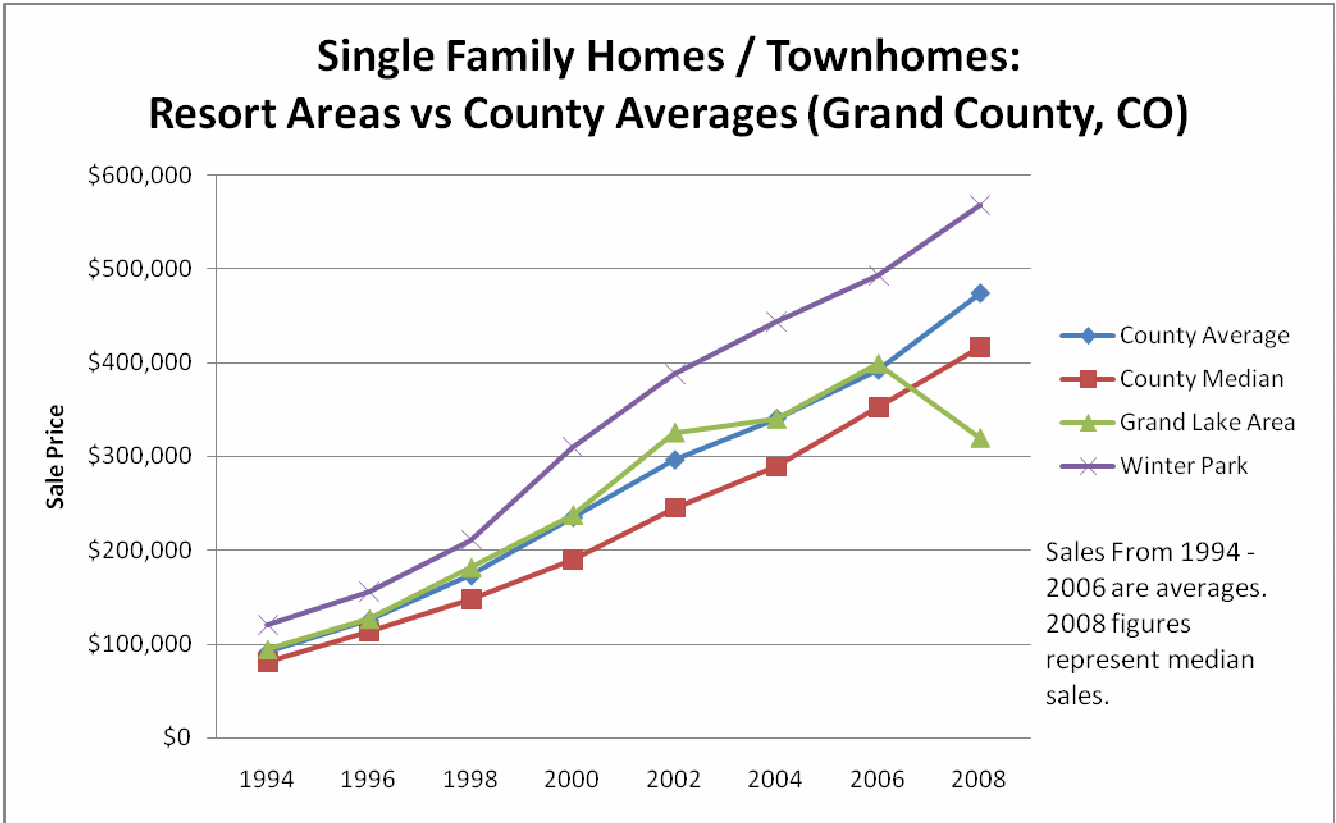


Fig 8: Average/Median Sale Price, Grand County single family homes and townhomes, 1994 - 2008

Despite the ongoing MPB epidemic, there are no indications that it has affected home values. In the 14 years of existing data for the single family home market, we only see three segments with negative slopes. Two of them are not in resort/kill areas. Only one, the recent drop in Grand Lake, can be considered a heavy kill area (Fig. 8).

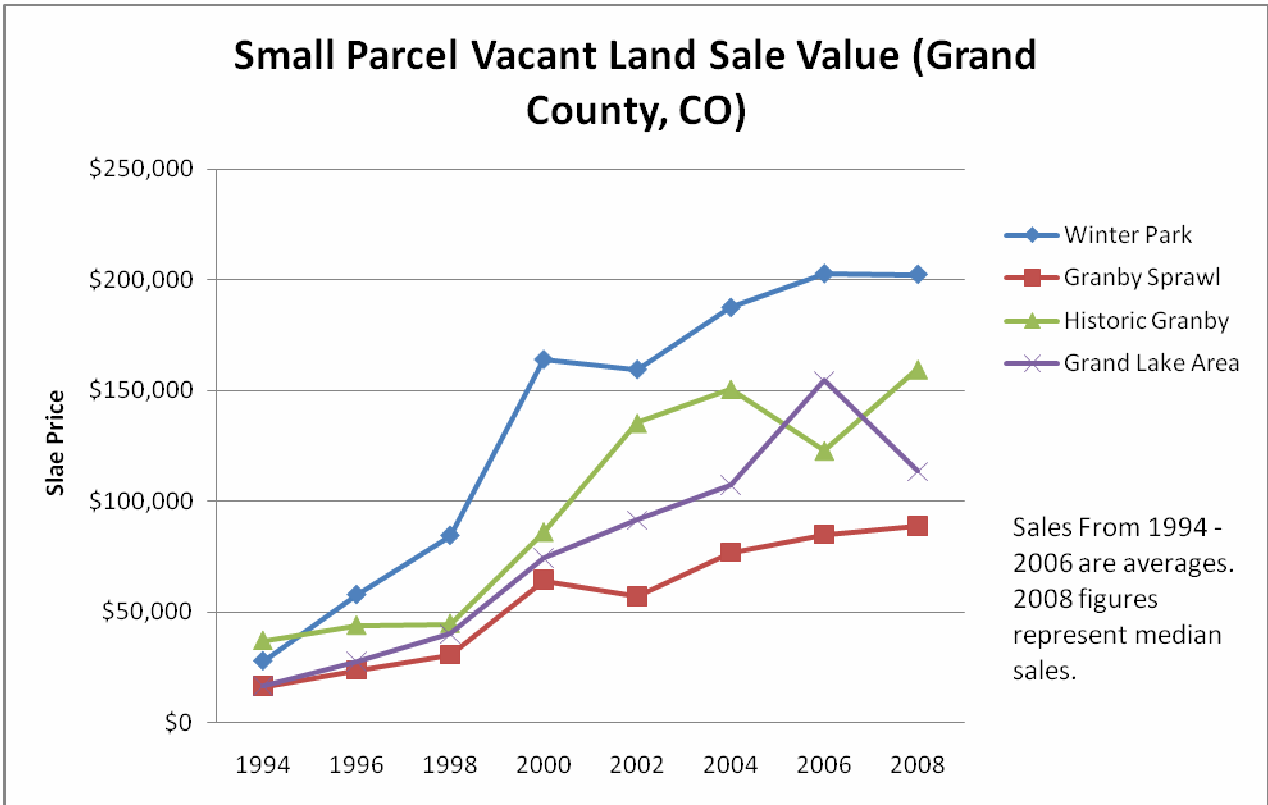


Fig. 9: Average Sale Price, Grand County Small Parcel Vacant Land, 1994 - 2008 Graph

Grand County MPB Kill 1994 - 2008

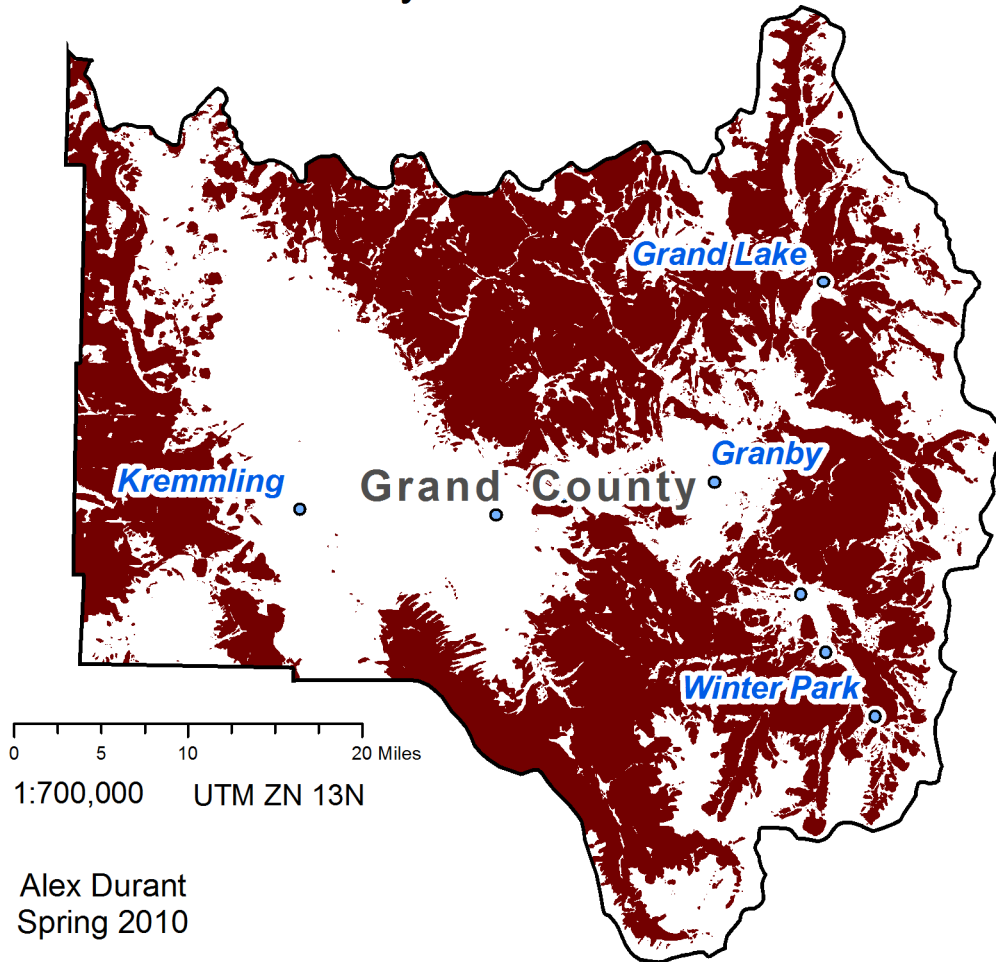


Fig 10: Cumulative Mountain Pine Beetle Kill, 199 –2008.

Vacant Land values have increased higher in the resort areas, generally forested, and within the kill zones. A 613% increase (resort zone average) during years of ongoing kill signals a clear disconnect between the beetle and home values. There are three critical factors in this increase. First, the cost of clearing dead trees, in accordance with county and municipality ordinances, is negligible. Many of the properties are unique, and a desired lot will be cleaned up, regardless of its beetle damage. Most lots could be cleared for under \$4000, a number that is probably on the conservative side to begin with. The county appraiser estimated this based on a \$100/tree removal, and we have seen advertisements for removal from \$35 to \$85 per tree.

Most of the smaller lots are already cleared, and while buyers may ask for a discount on lots that must be cleared, a \$5,000 removal fee would not prevent a family from purchasing \$570,000 house (2008 Winter Park median sale value) that they have been saving for. Second, removing trees can improve property values by opening up new views.

Any drop in home values in Grand County is likely due to the general economic downturn, with an uncertain role due to the insect outbreak. This downturn has played out very similarly to the late 1980's downturn, when there was no beetle outbreak. While it is too early to make a final

judgment on the real estate market (mostly because of the ongoing recession), it is very likely that any downturn in the Grand County market can be attributed to the economy and not the Mountain Pine Beetle.

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Table 1: Occurrence of lodgepole pine by landownership type in Boulder County (“East Slope” study area).

Owner	Area acres	Lodgepole acres	Pct Lodgepole	Pct of all lands
Federal	168,106.46	31,432.25	18.70	35.46
Bureau of Land Management	2,102.44	0.43	0.02	0.44
US Fish & Wildlife Service	6.02	0.00	0.00	0.00
National Park Service	27,423.13	3,513.37	12.81	5.78
US Forest Service	136,334.80	27,918.46	20.48	28.76
Other Federal (BOR, tribal, etc.)	2,240.07	0.00	0.00	0.47
State	2,539.71	328.53	12.94	0.54
Division of Wildlife	171.95	0.00	0.00	0.04
State Parks	1,041.87	0.00	0.00	0.22
State Land Board	1,324.90	328.53	24.80	0.28
Other State	1.00	0.00	0.00	0.00
Local	98,593.24	4,062.34	4.12	20.80
City	44,650.19	777.27	1.74	9.42
County	49,701.05	3,278.05	6.60	10.48
Joint City/County	4,219.31	7.02	0.17	0.89
Metro District	0.00	0.00	#DIV/0!	0.00
School District	22.68	0.00	0.00	0.00
Special District	0.00	0.00	#DIV/0!	0.00
Private/NGO	204,822.35	14,382.01	7.02	43.21
Land Trust	0.00	0.00	#DIV/0!	0.00
NGO	1,294.81	0.43	0.03	0.27
Private	203,527.55	14,381.58	7.07	42.93
Total	474,061.76	50,205.13	10.59	

Table 2: Occurrence of lodgepole pine by landownership type in Grand County (“West Slope” study area).

Owner	Area acres	Lodgepole acres	Pct Lodgepole	Pct of all lands
Federal	807,947.52	277,783.98	34.38	67.56
Bureau of Land Management	144,378.32	30,656.14	21.23	12.07
US Fish & Wildlife Service	0.00	0.00	0	0.00
National Park Service	96,557.29	21,716.63	22.49	8.07
US Forest Service	567,011.91	225,411.20	39.75	47.41
Other Federal (BOR, tribal, etc.)	0.00	0.00	0	0.00
State	49,339.00	2,138.62	4.33	4.13
Division of Wildlife	13,131.86	549.60	4.19	1.10
State Parks	0.00	0.00	0	0.00
State Land Board	36,207.14	1,589.02	4.39	3.03
Other State	0.00	0.00	0	0.00
Local	94.27	0.00	0.00	0.01
City	94.27	0.00	0.00	0.01
County	0.00	0.00	0	0.00
Joint City/County	0.00	0.00	0	0.00
Metro District	0.00	0.00	0	0.00

School District	0.00	0.00	0	0.00
Special District	0.00	0.00	0	0.00
Private/NGO	338,475.90	61,266.45	18.10	28.30
Land Trust	0.00	0.00	0	0.00
NGO	7,853.41	1,766.68	22.50	0.66
Private	330,622.50	59,499.76	18.00	27.65
Total	1,195,856.69	341,189.04	28.53	

Parcel size in acres (area_ac)	Boulder	Grand
N	3572	7880
Mean	10.0546	29.9144
Median	1.8548	1.2792
Minimum	0.0006	0.0049
Maximum	1513.8135	15152.3579

Table 3: Comparison of Boulder and Grand County parcels.

Resort Area	Beetle Kill Value	Including Recreation Areas: Ski Areas abbreviated (SA) Campgrounds abbreviated (C)
Roaring Fork Valley	1	Aspen/Snowmass (4) SA, Independence Pass
Crested Butte/Snowmass Wilderness	1	Mt. Crested Butte SA, Snowmass Wilderness, Marble C, McClure Pass
Grand Mesa	1	C
San Juan North	1	Telluride SA, Ouray, Red Mtn Pass
Poudre River Valley	1	
Steamboat Springs	2	Rabbit Ears Pass, Steamboat SA.
Rocky Mtn Nat'l Park	2	RMNP C, Grand Lake C, Estes Park
Summit County	2	Breckenridge SA, Keystone SA, Copper SA, A-Basin SA, Lake Dillon, Gore Range Wilderness, Vail Pass Recreation Area
Vail Valley	3	Vail SA, Beaver Creek SA, Vail Pass Recreation Area C
Grand Lake	3	Grand Lake, Lake Granby, RMNP, C
Winter Park	3	Winter Park SA, C

Table 4: Colorado resort study areas and estimated beetle impact.

Small Parcel Vacant Land	
Area	%Chg 94 – 08
Resort Area Average (High Kill)	613%
Winter Park	631%
Grand Lake Area	595%
Non-Resort Average (Low Kill)	403%
Granby Ranch/Grand Elk	452%
Historic Granby	333%
HSS & Hwy 125	341%
Kremmling	488%

Table 5: Average/Median Sale Price, Grand County Small Parcel Vacant Land, 1994 – 2008 % change table

Appendix 1: Field Notes from a MPB Meeting

William Travis

I had to choose today between two pine-bark beetle meetings, the ecosystem science symposium on campus (where Tom was speaking) and the agency/public meeting in Nederland. I went to Nederland specifically to assess the viability of my proposal that we analyze the human dimensions through the public record, including meetings like this, by developing a “propositional inventory” and then rating it on several human dimensions and perception themes that we find in other cases of ecosystem change (and that I want to argue are universal to the human interaction with ecosystems).

The meeting instantly felt familiar, not unlike public meetings I’ve been to on grazing and range reform, elk management in Gunnison, and wolves in Yellowstone. In just 20 minutes of public comments (which followed 1.5 hours of local, state and federal presentations) I caught many of the themes that we found in Yellowstone elk case, what we learned to call “barstool biology”, including the classic theme that poor decisions made by the land management agencies made this happen, and that it could have been prevented.

Here are a few notes organized by the five themes we developed in the SGER proposal.

(1) Explanations (“Why is this happening?” “How unusual is this?”), especially with regard to human vs. natural causes, global warming, past management, etc.

This is a “natural cycle” but the current outbreak is unprecedented “in our recorded history” back to mid 1800s, maybe due to global warming and past management practices.

“This is what it means when you suppress fires for a couple of hundred years”

“probably not outside the range of historic variability” (FS) and we need to adjust our expectations that are based on our short residence in this area.

“This is happening because we did not manage the forest”, the managers let it get away from them, “like the fires in Yellowstone.”

(2) Expressions of value, including aesthetics, loss of resources and property value, and sense of hazard that translate ecosystem change into “crisis.”

“We need to adjust our view of beauty and connection to the forest” to see the positive aspects of the outbreak.

This is going to be devastating to our communities.

We will see impacts on water supply, fire, property values, tourism,

(3) Expectations for the future, and for the potential effectiveness of management.

“we are not going to stop the epidemic” at best you can triage some trees on your properties, and the (agency) can have some effect by “direct treatment” around campgrounds, trailheads, etc., but the large outbreak cannot be stopped.

The Flattops outbreak in the 1940s was fought with lots of spraying, but didn’t stop until a cold snap in February, 1951, killed the beetles,” even though some people, “and the Denver Post” claimed the spraying did it.

Even if you apply ‘direct treatment’ in selected cases, you’ve got to spray those trees for 5-10 years to get them thru the epidemic.

A long discussion on detailed treatment recommendations was revealing: Most prescriptions were clearly untenable. A few residents reported success spraying their own trees, and cutting them down, but the experts told them they had to use a particular blend of carbaryl available only to licensed contractors. And the mechanical treatment prescription was totally infeasible (I think): it requires cutting down before beetle flight, barking or at least splitting the bark along the length, covering with high mil clear plastic, and rotating the trees every week to get them hot and dry, and this could only be done during the warmest summer weeks, so timing was critical. This was clearly untenable and some audience openly scoffed at the feasibility.

The audience was eager to hear that natural remedies and pheromone treatments can work as they seem safer, but the panel was skeptical and one panelists urged them to watch their wallets as the outbreak spreads as several firms are thinking of how to make money off of homeowner concerns.

(4) The proposed responses driven by these assessments, which then become new, anthropogenic “pulses” and “presses.” The response of the forest to these new anthropogenic forces then feeds back into human institutions and generates new land management decisions.

We need more logging, and markets for the bio-mass.

We should expand forest health treatments under fed and state legislation, the Boulder Dist has about \$1.50 to spend per acre, so needs to concentrate in high use high value areas.

The PBB can be treated within the framework and methods of wildfire mitigation, so we need to expand fire mitigation efforts, you should work toward Community Wildfire Protection Plans (CWPP), then we can get “bug money” in there, too. These all have to be in the high risk, interface areas, we simply won’t be treating backcountry and steep slopes.

(5) How response pathways reflect peoples' understanding of forest ecosystem dynamics, land management regime (e.g., wilderness vs. open space), their notions of forest health (or ill-health), their understanding of secular change, and notions of the leverage that management can have on forest structure and dynamics.

There was not much time for public comments, and much of that time was taken up arguing about pesticides, but a few ecosystem management themes did appear:

This is creating a major fire hazard. It will be like the Hayman Fire.

The outbreak could have been prevented, or would have been less extreme, with more management, like logging and prescribed fire. [although an agency person pointed out very clearly that the LPP forest above about 8,000 feet where the worse outbreak will be, don't burn like that, and that prescribed fire rarely is designed to yield crowning-stand replacing fires needed to affect higher elevation LPP forests].

Environmental regulations get in the way of response, e.g., the USFS won't let loggers come in, not even firewood collection. [the FS rep said loggers aren't banging on the door, never were in this low-productivity forest and they have to pay about \$1,000/ac for meaningful mechanical treatments; and they do indeed offer firewood sales and freebies.]

Any surprises? One challenge I see in this work is whether the social analysis can uncover some new insight that you couldn't logic out without bothering to analyze the public record. The goal has to be to look for universal human dimensions, that would operate in other ecosystem change cases, and not to conduct a policy analysis. Again, those themes, it seems to me are;

1. Why is this happening, and what role did humans (e.g., thru land management) play in it.
2. Sense of how ecosystems work: balance, chaos, contingency, etc.
3. Sense of threat, loss, and sense of control
3. Notions of how it will play out and what should be done, especially linked to land use ideologies.

I'm especially interested in ideology-driven explanations and prescriptions that you see in other cases, grazing, predators, fire, etc. Finally, can we tease out how these perceptions bias us toward particular response pathways that then create new presses and pulses into the forest ecosystem. These questions need more thought.

Appendix 2:

Media Cover: Selections from the Print Media

Tancredo takes on massive infestation by millions of ... beetles?

By [David Williams](#) 05/30/2008

Congressman Tom Tancredo, R-Littleton, is once again targeting a massive wave of infiltrators devastating Colorado's landscape, but this time the relentless anti-immigration crusader and former presidential candidate isn't after human interlopers.

"The pine beetle infestation I believe has reached the point that we can call it a natural disaster," Tancredo said on a conference call with reporters Thursday, announcing he has fired off a letter to Gov. Bill Ritter directing him to request a preemptive federal natural disaster designation and funds from the Federal Emergency Management Agency to start building more logging roads and cutting down more dead trees.

Tancredo also announced that sometime next month he will introduce his charter forest bill, which will give more local control over beetle-kill mitigation projects, streamline the National Environmental Policy Act hurdles for Forest Service thinning efforts and set tighter deadlines for resolving lawsuits filed by environmental groups.

"It is for the purpose of giving the Forest Service the ability to deal with the problem without having to through the enormous and cumbersome process that presently plagues them," said Tancredo, who in his [letter](#) to Ritter blames "radical environmentalists and poor forest management policy" for potentially catastrophic fires that could result from the beetle epidemic.

Beetle Blazes New Fire Strategy

By **Mark Jaffe**

The Denver Post

Article Last Updated: 06/12/2008 12:56:26 AM MDT

Rather than sending out lines of firefighters to contain a blaze, agencies will consider "giving up some acreage" in order to keep crews safe, according to U.S. Forest Service officials.

"There may be situations where we have to step back and say, 'We can't do what we did in the past,' " said Jim Krugman, a Forest Service natural resource specialist. Instead, crews may fight fires occurring in some beetle-ravaged areas only at key points, such as where there are homes or roads.

Thick beds of pine needles, fallen timber and weakened trees create great risks, officials say. Fallen timber makes getting in and out of an area difficult. Hotter fires can spread quickly among tree crowns. And falling trees pose a risk.

"We don't know what the fire will be like in that environment," Krugman said. "We don't have experience or good models of these fires."

Decisions on how to fight fires are always made on a case-by-case basis depending on factors such as weather and the fires' proximity to developed areas, fire officials said.

"How a fire is fought in beetle-killed trees will change over time as the condition of the trees change," said Rich Homann, fire division supervisor with the Colorado State Forest Service, a Colorado State University agency.

"The goal, however, is always the same: the safety of the firefighters and the safety of the public," Homann said.

In the past year, the area destroyed by the pine bark beetle in three Colorado national forests has grown by 50 percent to 1.5 million acres.

"It took 10 years to reach a million acres and one year for the beetle to affect another 500,000 acres," said Mary Ann Chambers, a spokeswoman for the Forest Service's pine bark beetle incident management team.

The three national forests affected by the beetle are the White River, the Arapaho-Roosevelt and the Medicine Bow-Routt.

About a third of the acreage is in wilderness areas where Forest Service policy is to let a fire burn, Chambers said.

Another third of the land is in roadless areas, where in most cases the fire would also be left to burn, she said.

The remaining third is in areas where there may be structures, homes and roads.

"We are always going to try to protect the public," Krugman said. "While we aren't going to let a fire rip, we are going to have to give up some acreage and fight it differently."

Air resources — airplanes dumping fire retardant — are most often used to support ground firefighters, said Greg Toll, chief of the Boulder Fire Department's wild lands division.

But if a large fire were to burn through a beetle-kill forest, it "would certainly be tough to control and more dangerous."

In those cases, said Toll, "we have to think about using air resources first."

Schweitzer suggests state of Montana take over management of some federal forests to reduce wildfire danger

Posted on June 8

By the Associated Press

MISSOULA - Gov. Brian Schweitzer says that creating healthier forests, possibly by having the state take over management of some federal timberland, is the best way to combat the infestation of bark beetles in the West.

In a speech, Schweitzer suggested that instead of spending \$50 million to \$200 million annually to fight wildfires, the state should budget \$75 million each year for treating its forests before they're burned or killed by beetles. The governor made the comments at the University of Montana during a conference to discuss the beetle infestation.

“We propose the federal government manage like we do after a fire n complete timber sales in six to eight months after a fire,” he said. “When we have dead or dying trees, we harvest them, but our neighbor doesn’t do a dang thing, in their checkerboard fashion.”

Schweitzer said leaders could propose a plan to manage 10 percent of federal timberland.

Montanans have been trying to discourage mountain pine beetles, Douglas fir beetles, and western spruce budworms from overwhelming trees. Across the western United States, mountain pine beetles destroyed more than 2.9 million acres of forest in 2005. In Montana alone, the most recent numbers from 2006 show that 2.4 million trees across 750,000 acres were killed by the beetles.

Ken Gibson, an entomologist with the Forest Service in Missoula, said thinning forests and replacing them with various tree species, sizes and ages can reduce the chance of a beetle attack.

November 18, 2008

Bark Beetles Kill Millions of Acres of Trees in West

By **JIM ROBBINS**

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HELENA, Mont. — On the side of a mountain on the outskirts of Montana’s capital city, loggers are racing against a beetle grub the size of a grain of rice.

From New Mexico to British Columbia, the region’s signature pine forests are succumbing to a huge infestation of mountain pine beetles that are turning a blanket of green forest into a blanket of rust red. Montana has lost a million acres of trees to the beetles, and in northern Colorado and southern Wyoming the situation is worse.

“We’re seeing exponential growth of the infestation,” said Clint Kyhl, director of a Forest Service incident management team in Laramie, Wyo., that was set up to deal with the threat of fire from dead forests. Increased construction of homes in forest areas over the last 20 years makes the problem worse.

In Wyoming and Colorado in 2006 there were a million acres of dead trees. Last year it was 1.5 million. This year it is expected to total over two million. In the Canadian provinces of British Columbia and Alberta, the problem is most severe. It is the largest known insect infestation in the history of North America, officials said. British Columbia has lost 33 million acres of lodgepole pine forest, and a freak wind event in 2006 blew mountain pine beetles, a species of bark beetle, over the Continental Divide to northern Alberta. Experts fear that the beetles could travel all the way to the Great Lakes.

In the next three to five years, Mr. Kyhl said, virtually all of Colorado’s lodgepole pine trees over five inches in diameter will be lost, about five million acres. “Already in many places, every lodgepole over five inches is dead as far as the eye can see,” he said.

Foresters say the historic outbreak has several causes. Because fires have been suppressed for so long, all forests are roughly the same age, and the trees are big enough to be susceptible to beetles. A decade of drought has weakened the trees. And hard winters have softened, which allows the beetles to flourish and expand their range.

Hoping to keep their forests from completely dying, to earn money by selling dead and infected trees and to mitigate fire risks, landowners are scrambling to cut the pines. If enough are cut — up to 75 percent — it might leave some behind that, with less competition for water, can survive. Still, for many landowners, cutting most of the forest where they have built their homes is painful. “I’ve literally had people in my office crying,” said Gary Ellingson, a forestry consultant for Northwest Management.

The black, hard-shelled beetle, the size of a fingertip, drills through pine bark and digs a gallery in the wood where it lays its eggs. When the larvae hatch under the bark, they eat the sweet, rich cambium layer that provides nutrients to the tree. They also inject a fungus to stop the tree from moving sap, which could drown the larvae. That fungus stains the wood blue.

“The Latin name is *Dendroctonus*, which means tree killer,” said Gregg DeNitto, a Forest Service entomologist in Missoula, Mont. “They are very effective.”

To fend off the bugs, trees emit white resin, which looks like candle wax, into the beetle’s drill hole. Sometimes the tree wins and entombs the beetle. Often, though, the attacker puts out a pheromone-based call for reinforcements and more of the beetles swarm the tree. In a drought the tree has trouble producing enough resin, and is overwhelmed.

There are some defenses. Owners nail to a tree an “aggregator pheromone” in a small packet, which mimics the chemical scent given off by beetles when a tree is full of insects. It can work when beetles are not too numerous, but at some point the beetles are not deterred.

Large, old, high-value trees, ones that shade campgrounds or yards, can be sprayed with an insecticide. But the trees need to be sprayed from the base to the height at which it is less than 4 inches around. Each tree costs about \$10 to \$15 if hundreds are sprayed.

Lodgepole pines are largely confined to high altitudes. But the beetles have moved into ponderosa pine forests on Colorado’s front range, Mr. Kyhl said, which means it could kill forests around homes in the densely populated region.

The beetles will only be truly checked, experts say, if temperatures that used to reach 30 and 40 below for weeks return to the Rockies, temperatures that have not been seen in decades.

The death of the forests worries the tourism industry. Many ski areas have cut down their forests because of the hazard of falling trees and have revegetated the land.

At Vail Ski Resort, for example, which has been particularly hard hit, workers have removed thousands of dead trees and planted new ones.

The dead trees that blanket the mountains are shifting ecosystems as well. In Yellowstone, for example, the beetles are killing the white-barked pine trees, which grow nuts rich in fat that are

critical to grizzly bears in the fall. Biologists in Canada say streams will flash-flood because live trees will no longer catch snow and allow it to slowly melt, and it could injure salmon and destroy habitat. On the other hand, woodpeckers and other insect eaters will thrive.

Wildfire is the biggest threat. Some towns like Steamboat Springs and Vail, Colo., are surrounded by dead forests, and the Forest Service and logging companies are clear-cutting “defensible space” so firefighters have a place to fight fires.

After the trees die, the risk of crown fires that move through the canopy is the threat. After four or five years, as the dead trees fall to the ground, the threat of catastrophic fire is most severe. Fires in the piles of logs severely damage soils, prevent regrowth and cause mudslides.

Rainfall on damaged ground could also lead to widespread mudslides and silt buildup in rivers and reservoirs, which many mountain communities depend on for water. Strontia Springs Reservoir, a main water source for Denver, required a \$20 million cleanup after a large fire resulted in severe erosion.

The other major problem is large numbers of falling trees. In Colorado and Wyoming, officials have closed 38 campgrounds for fear trees could fall on campers. They have reopened all but 14.

But there is a lot more to do. “We know they are going to fall,” Mr. Kyhl said. “And they are going to fall in the next 10 to 15 years. There’s campgrounds, thousands of miles of road, picnic areas, power lines and trails. How do we keep the facilities open for people to use?”

The agency is faced with clearing a strip of 75 to 100 feet of dead trees along highways so they are not closed by blow downs.

Then there is a question of what do with the wood. Sawmills have diminished in the West in recent years, and there are not enough mills to take all of the timber.

In Colorado, entrepreneurs have been scrambling to find ways to use it. Two pellet plants have been built, which turn the trees into sawdust and then pack them into a clean-burning pellet used in wood stoves.

Some trees are being shredded for use in biomass boilers, and carpenters are using the pine stained blue from the fungus for furniture.

In Alberta, a newsprint mill is testing a system to use the millions of dead acres of pines. Because of the fungal stain the trees aren’t bright enough for paper, but a computerized process adjusts the amount of bleach.

Still, the volume of timber used is small compared with the vast acreage of dead trees.

The West that depends on tourism, meanwhile, wonders what their customers will think about the dramatic change in scenery. Four million visitors a year come for sightseeing and recreation to Grand County in Colorado, where much of the forest is now dead. “What happens,” said Ray Jennings, director of emergency management for Grand County, “if this becomes an ugly place to be?”

This article has been revised to reflect the following correction:

Correction: November 21, 2008

An article on Tuesday about the devastation of forests from pine bark beetles in the West misstated the year and precise location of a new infestation in the Canadian province of Alberta. A freak wind event blew beetles into Alberta in 2006, not 2007. And the beetles were blown into northern Alberta, where they had never before been observed. (The beetles were already part of the ecosystem in southwestern Alberta.)

The spreading epidemic of pine bark beetles

Article by Allen Best

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THE BARK BEETLE EPIDEMIC along Interstate 70 and regions northward has received broad attention, and rightly so, with concerns that the outbreak might move south into Central Colorado.

While epidemics have come and gone in decades past, this is unlike anything in recorded history. You get glimpses of it while driving on I-70, but only glimpses. For a truly profound moment, you must leave behind the interstate, drive northward from Silverthorne, then cross Ute Pass into the Williams Fork Valley. As best I can tell, that is ground-zero for the current epidemic.

More than a quarter-century ago I worked in that valley, a winter shoveling snow at the molybdenum mill operated by Amax. I was young then, and could stay up half the night and go climb a mountain the next day. Now, I do neither, and returning there in June, looking at the slopes above the William Fork River, I saw trees that looked like I sometimes feel. Live trees were the exception. Foresters say 90 percent of lodgepole pine will die in this epidemic, and that looks to be the case already in the Williams Fork. The only places of profuse greenness are in those areas of logging operations in recent decades. More commonly the picture is similar to that of a burned forest, but without the charcoal. In short, I saw Colorado not as it used to be, but rather Colorado as it will be.

The landscape is changing profoundly. So are attitudes. Fifteen years ago, the dominant sentiment in ski towns was an almost knee-jerk reaction against all timber sales and, by extension, the U.S. Forest Service. "I've read about those guys in *Sports Illustrated* and what they're doing on the Tongass Forest in Alaska," said one of Vail's more strident speakers at a meeting in 1988.

All timber sales were ugly, and by extension, all trees were beautiful.

I remember another incident, from 1996, when the Forest Service proposed to burn the bushes and some trees along Vail's periphery. This was before the Los Alamos fire in New Mexico in 2000, when a prescribed fire went awry. A distressed homeowner, a transplant from California, said she had moved to Colorado to be next to trees. She wanted no part of this controlled fire. Nor was she alone. The hidden assumption was that today's scenery would remain forever. Nature was a constant, not a process.

But if forests seemed to change little during the 20th century, they are changing rapidly now. Changes similar to those of northern Colorado are possible, maybe even probable, in the lodgepole forests around Leadville, Salida, and other parts of Central Colorado.

The argument here is that if this great die-off is a more-or-less natural process, it nevertheless provokes a reassessment of our relationship to the landscape.

The first wave of Euro-American settlement during the 19th century mining boom was a simple one of exploitation. That led to the withdrawal of the commons into forest preserves beginning in 1881, and then, in 1905, delegation to the U.S. Forest Service to regulate forest use. After World War II came more changes: the arrival of a well-defined recreation industry, particularly the ski resorts, and then additional layers of environmental laws. This resulted in a fundamentally different way of looking at the forests, as backdrops, in which all efforts to manipulate the forests were viewed skeptically, as the anecdotes from Vail tell us.

That we've already reached a new era is told by a postscript from the ski towns. A couple of years ago, a delegation from Vail and other ski towns and resort valleys went to Washington D.C. This time, the locals were pleading with the federal government for money to manage the adjacent forests.

In effect, they were asking for below-cost timber sales. I don't know if they got any money, but the larger story is clear enough. The federal government cannot possibly become what amounts to a gardener, tending to the vast stands of forests that are the backyard and backdrop in our new settlement of Colorado, the settlement based on aesthetics and not commodity extraction. Who should pay for the management of the forest interface has yet to be worked out. But the potential -- only the potential at this time -- exists for a different relationship.

How we got here

Forest ecologists say that bark beetles are a fixture of our forests. Colorado has three primary species: the mountain pine beetle; the spruce beetle; and the ips beetle, which depends upon piñon trees. All are active steadily, killing the occasional weakened tree when populations are endemic. The last significant outbreak in the Vail-Granby area was in the early 1980s, but petered out in 1985. The current epidemic is often attributed to a "perfect storm."

But the contributing factors to this storm vary. One common argument is that the forests of lodgepole pine tend toward an even age, mostly 100 to 125 years, when they're more susceptible to diseases and bugs. The boilerplate explanation is that the miners, railroad builders, and homesteaders cut trees at a tremendous rate. One estimate of the cut of lodgepole pine in the I-70 corridor counties (Eagle, Summit and Grand) shows 180,000 acres cut in the first decade of the 20th century, a figure barely exceeded for the rest of the century. Also, many accounts point to major forest fires in the 19th century. In some stories, it was the Utes, and in others the finger is pointed at prospectors who wanted to see the rocks underneath without the nuisance of vegetation.

I don't buy all of this story. First, although you can credit settlers with the pluck, desperation and enterprise needed to denude hillsides without the assistance of chainsaws, why would they bother to remove spindly trees unsuitable for timbers? Or clear-cut distant, dangerously steep slopes for firewood?

I'm also dubious of laying the blame on stand-replacing fires in the 19th century. Denver's newspapers paid minute attention to the Colorado mountain landscape during the mining era, and I haven't come across many stories about fires with the magnitude of the Hayman Fire.

Also at issue is the extent to which forests have been logged. Some argue that the epidemic can be explained

by the lack of logging. Again, I'm skeptical, for reasons I'll explain later.

But the most important contributing factor to this "perfect storm" is the warmer and drier weather of the last decade. Much of that decade, including the exceptionally dry year of 2002, has had below-average precipitation. Trees have been weakened, making them more susceptible to bark beetles.

What knocks bark beetles back is extreme cold. A single night of -20°F won't do it, and probably not even 30° below. It takes sustained cold -- some say a week of 40° below -- to kill the beetles. A lesser cold spell during November or April will do the same thing. Beetles during mid-winter have an internal anti-freeze that shields them from ordinary cold.

Such cold is rare. We know this anecdotally. Less certain is the empirical evidence. Nolan Doesken, the state climatologist and the chief record-keeper for about 30 years, says long-term and reliable weather records in the Colorado mountains are surprisingly thin. Few recording locations have stayed constant for even 50 years, let alone a century. Often, thermometers have been moved nearer or farther away from buildings. In addition, reservoirs change temperatures, such as those in Gunnison. Still, there's just enough clear record that Doesken is confident in saying that extreme cold has become far more rare. It was, however, also rare during the 1930s.

Of course, from what I remember of a few nights in Kremmling in the 1970s, there shouldn't be any pine beetles there, even now. On Jan. 4, 1979, it got to 62° below at Bob's 66, which matches the state record set some decades before at Taylor Park, north of Gunnison. For a week that winter it rarely got above zero. Weather less gelid than that in Russia turned back both Napoleon and Hitler.

Going to war

The metaphor of war is frequently invoked in discussions of bark beetle epidemics. One such epidemic of spruce beetles traced to a windstorm in 1939 on the Flat Tops, north of Glenwood Springs, prompted a declaration of war by the late 1940s. Some of this came from the U.S. Forest Service, then even more than now a quasi-military outfit. A video produced at the time sounds like a newsreel from the Philippines.

The *Denver Post* became the chief cheerleader of the war effort. Lumbermen were interviewed to bemoan the loss of valuable resources, while marmots and other critters were reported to be fleeing the scene of destruction. The newspaper castigated any that dared to question the need for federal money. The Forest Service recruited Navajos from the rez and drunks from Denver's Larimer Street to spray "goop" -- a chemical poison -- onto the trees. For several years, the war continued, and the *Post* was exhorting the troops for yet another summer when, in a small story, the newspaper reported a surprise. The beetles had disappeared. It seems that cold temperatures of -50° the previous winter in both Eagle and Kremmling had suppressed the beetles. If not land mines, buckets of the chemical "goop" remained in the forest until just a few years ago. Maybe some still remain.

The current epidemic along the I-70 corridor can be traced to 1996. This time, the debate is more sophisticated. Only once has the *Denver Post* resorted to trite talk of wars and such. The Forest Service has likewise had a more measured response. Four years ago when I talked to Frank Cross, then the chief bug specialist in the regional office of the Forest Service, he counseled restraint. Telling efforts could be made in special places, such as at ski areas, or near campgrounds, but any effort to ferret out all beetles in the backcountry, he said, was misguided.

This beetle epidemic has rewritten the rules. In previous epidemics, pesticide liberally splashed on trees protected them. This time there are so many beetles flying every summer that even a small patch of tree missed can be invaded by beetles. Each pair can lay up to 75 eggs between the bark and the tree trunk. Pine beetles are

reputed to hit only the older, larger trees, but in fact, some new growth and smaller trees have also been attacked.

Unshackle the professionals

To foresters, the beetle epidemic represents a kind of ironic, bitter-sweet triumph. They were taught in schools that they could manage forests. During the '90s, they felt spurned, rejected, and disrespected as logging operations fell off sharply. Their message now is that if only the public had allowed them to manage the forest, we would not have the bark beetle epidemic, or at least something well short of its current dimensions. Just let them tend the forest, they seem to say, and it will always be healthy.

Their argument has some merit. The pendulum swung too far during the 1990s. As in the case of the planning commissioner in Vail, every timber sale was the Tongass giveaway. But there's also plenty of nonsense coming from foresters.

One day in September, at a conference near Winter Park devoted to bark beetles, I listened as a young state forester stood, pointing to a nearby mountain -- Big Sheep in those parts, to differentiate it from Little Sheep -- and proclaimed that instead of turning red, it could be green, if only the professionals were allowed to have at it and do their jobs.

I questioned him on the point. Nearby Fraser had been a logging town for a century. There were camps everywhere in the woods. After World War II, operations were centralized at sawmills in the nearby towns, Granby and Kremmling. The one in Kremmling, Edward Hines, was operating at full capacity in the 1970s, and at least once I watched the mill manager do his best to bully Forest Service rangers for not offering enough timber.

In 1984, his sawmill was replaced by Louisiana-Pacific, a big outfit based in Portland with a hard reputation, which it fully lived up to. It cut lots of wood, and then blamed the Forest Service for not offering more. It had a new product called Waferwood that glued chips together. The glue had formaldehyde. It came out that L-P personnel were instructed to dismantle the pollution control equipment after the state health inspectors had left. Even Kremmling, with its blue-collar sensibilities, ultimately was happy to see L-P leave. When it did, L-P delivered its pink slips two days before Christmas. The CEO didn't fly in on his Citation jet to deliver them personally.

I tell this story not to generalize. Not all timber operators were like L-P. But, in fact, the Forest Service "got a lot of the cut out" during the 1970s and even the 1980s. It's probably fair to say that the lumbermen had some legitimate beefs. In the end, though, the lack of a strong wood-products industry in Colorado says more to the so-so nature of our trees and the flattening world.

Nearly all the sawmills are gone now. A few years ago, the sawmill in South Fork closed. Only one major sawmill, located in Montrose, still operates, taking wood from more than 300 miles away -- an astounding investment in diesel fuel for relatively scrawny logs.

Standing there by Big Sheep Mountain that afternoon in September, I asked why it had never been logged. It was public land, outside of wilderness. Three sawmills had been located nearby. Forest Service rangers had even been ordered to "get out the cut." Yet the trees had been allowed to grow, and were now old and big in an epidemic of beetles that were invading young and thin trees.

The answer, it turns out, was because the slopes were too steep for logging roads. That's the story in much of Colorado where the bark beetle is now having its way. It was just too steep for logging.

Using the biomass

But there is, in fact, plenty of dead wood standing, with more sure to arrive soon. Within a few years, all of Summit County is likely to look like the Williams Fork Valley where I once worked. There, as well as in Vail and in Grand County, there is much talk about what to do with the wood. For one thing, if you aim to cut down the trees, it's useful to have a buyer.

The market for old lodgepole pine is relatively thin. Spruce trees on the Flat Tops killed by spruce beetles in 1950 were harvested, for house logs, until just a few years ago. Lodgepole pine, however, have a different fiber. The wood breaks down rapidly, and within five years cannot be used to create two by fours.

Summit County thought about building a biomass burner near county buildings in Frisco, but was told it would cost too much. Such heating systems must be installed initially, not as retrofits. A delegation from Vail visited Austria, the native land of one of its former mayors, and learned about community electricity generation by burning plants. In Walden, a small-scale operation already exists. Mountain Parks Electric is investigating getting part of its electricity from biomass burners, lessening the demand for coal.

One question hanging over all such capital-intensive projects is how long a supply of wood can be guaranteed. Most operators want 20 to 30 years supply of wood. Financiers also will want to know who will buy this product.

In Kremmling, two separate and apparently competitive plans are afoot for pellet mills. But can enough bags be sold at Home Depot to keep both busy? One possibility now being investigated is the idea of creating a large enough burner for a new hotel in Vail to generate a need for pellets by the truckload. Forests along the town's perimeter are already being thinned. This year, 8,000 trees were removed, and most of them hauled to Kremmling. The majority of cost was borne by Eagle County government, with lesser amounts from the Town of Vail, plus state and federal grants. Vail, year by year, is trying to create a moat of defensible space.

Fear of fire

Fear of fire is propelling much of the excitement. Senator Ken Salazar last December got a huge headline in a Denver newspaper when he likened our beetle-infested forests to a major disaster, labeling them the "Katrina of the West." It's a galvanizing phrase, but also misleading. That point was made clear to me last summer when I met with the fire chief in Grand Lake. Located at the west entrance to Rocky Mountain National Park, Grand Lake is still a place of knotty-pine cabins set among the whispering pines -- pines now turning red. Across the lake, all of Shadow Mountain is rusty looking. But what distinguishes Grand Lake is that there's only one way out of the town, out to Highway 34. It's easy to imagine a giant forest fire raging, flames being pushed by stiff winds from the west, until there is no escape.

I wondered if the prospect of a forest fire kept the fire chief awake at night. No, he said, not really. For a time it bothered him, but now he felt he had done pretty much all he could do. And in a way, he said, all these dead trees didn't change the story all that much. That comment surprised me. Cops and journalists are ever beckoned by drama. I expected the same from a firefighter.

But his explanation made sense. When a tree died, he said, the red needles on the branches heighten fire risk temporarily, because they can carry a crown fire. After the needles fell, he explained, the fire danger receded for a number of years. Eventually there was a strong likelihood of a major, major fire. But, he added, there had always been a danger. Fires can occur in forests in the right conditions, and although harder to get going, can burn even hotter. So, he concluded, all these beetle-killed trees were just a not-so-subtle reminder to take defensive measures that needed to be taken anyway.

So, this is probably not the "Katrina of the West" that Salazar described, although it could be, if continued drought exacerbates the situation. Scientists refused to attribute Katrina to global warming, but instead concluded it was part of natural variability. And scientists, including a team of forest ecologists headed by W.H. Romme of Colorado State University have argued that large fires on the Colorado landscape should not be viewed as unusual, even if they do not occur often.

"... we should expect large fires in the lodgepole pine in the future, and these future large fires should not be viewed as abnormal from an ecological standpoint," they say in a paper called "Recent Forest Insect Outbreaks and Fire Risk in Colorado Forests: A Brief Synthesis of Relevant Research." "The key point about lodgepole pine forests is that they were dense and burned infrequently historically, and they are dense and burn infrequently today."

So big beetle outbreaks, if uncommon, are not unnatural. Ditto for big fires in the lodgepole forests of the high country. In fact, the two are not necessarily related, say Romme and his associates. In other words, just because a forest is full of standing dead does not mean there will be a fire roaring through it. Yet it may be a catalyst for action. I have long been struck by the artificiality of the boundary lines in places like Vail and Summit County. On one side is designated wilderness and, on the other, mountain-style suburban and exurban living. The same thing seems to be happening in the upper Arkansas Valley. Ultimately, there needs to be greater responsibility assumed by local governments for their permissive land-use patterns. The Forest Service model needs to be re-examined.

But that is perhaps another essay.

Perceptions

In all this, I am struck by the fact you just can't yank words off the shelf such as "war" and "victim" and "natural." What words are used ultimately say as much about the perception as they do about the subject being observed.

Romme, et al., make much the same point. "From a purely ecological standpoint, dead and drying trees do not necessarily represent poor 'forest health,'" they write. "They may instead reflect a natural process of forest renewal."

During September, while at the bark beetle conference, I drove to a dude ranch and cross-country ski center located in a secluded valley between Granby and Winter Park. From the valley's sagebrush flats a forest sweeps up to tundra and Continental Divide, beyond which is a spire of rocks, the namesake for the Devil's Thumb Ranch.

It's a beautiful setting made more pleasing yet at sunset when the sun ray's bend over the horizon, tinting the snow first orange and then red in a phenomenon called alpenglow. There was no snow when I visited, but the trees, thousands and thousands of them, nearly all rust red with dead needles, lent the feel of alpenglow. These dying trees, I thought to myself, are they not a beautiful sight?

Allen Best covers forests, resort towns, and natural-resource issues from his home in Arvada.

Appendix 3: Ownership Parcels by Lodgepole Cover

Boulder County

Frequency distribution of percent area of lodgepole pine within privately owned parcels where lodgepole occurs, broken down by parcel size classes.

Parcel size classes used (see charts below):

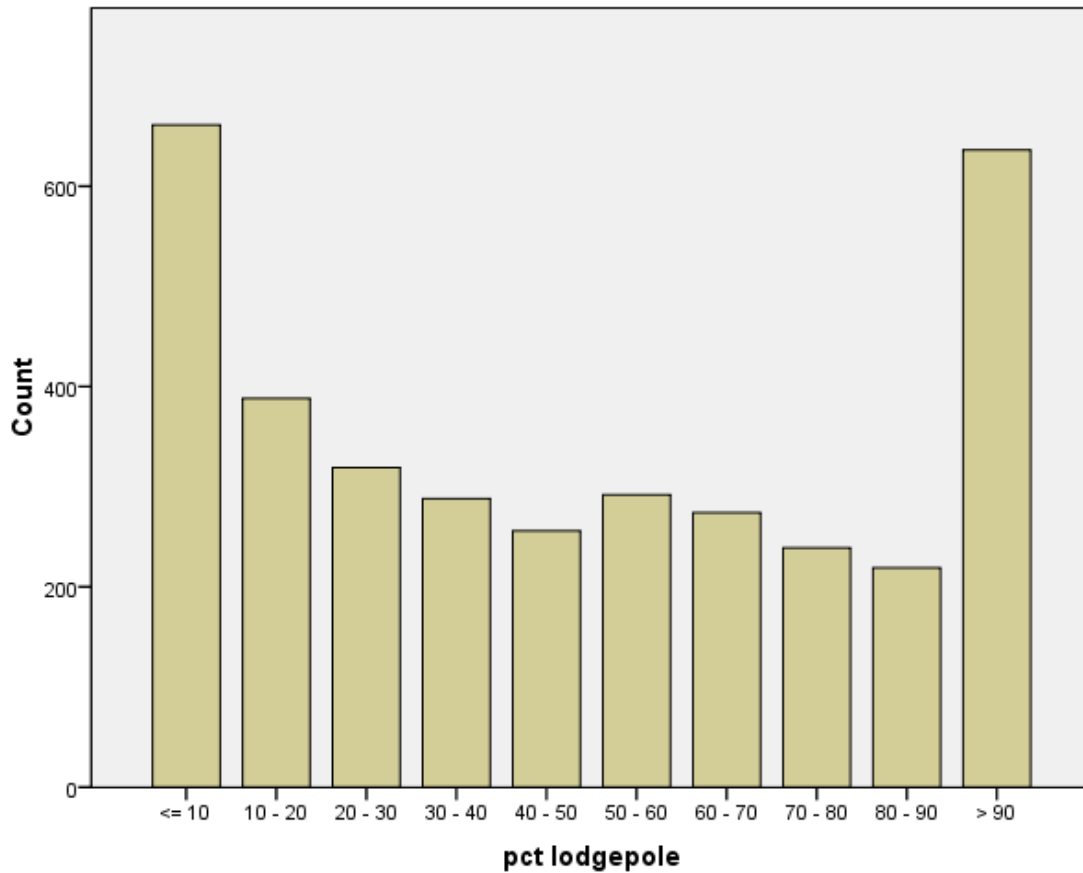
- 5 acres or less
- 5 to 35 acres
- 35 to 100 acres
- 100 to 500 acres
- More than 500 acres

Data:

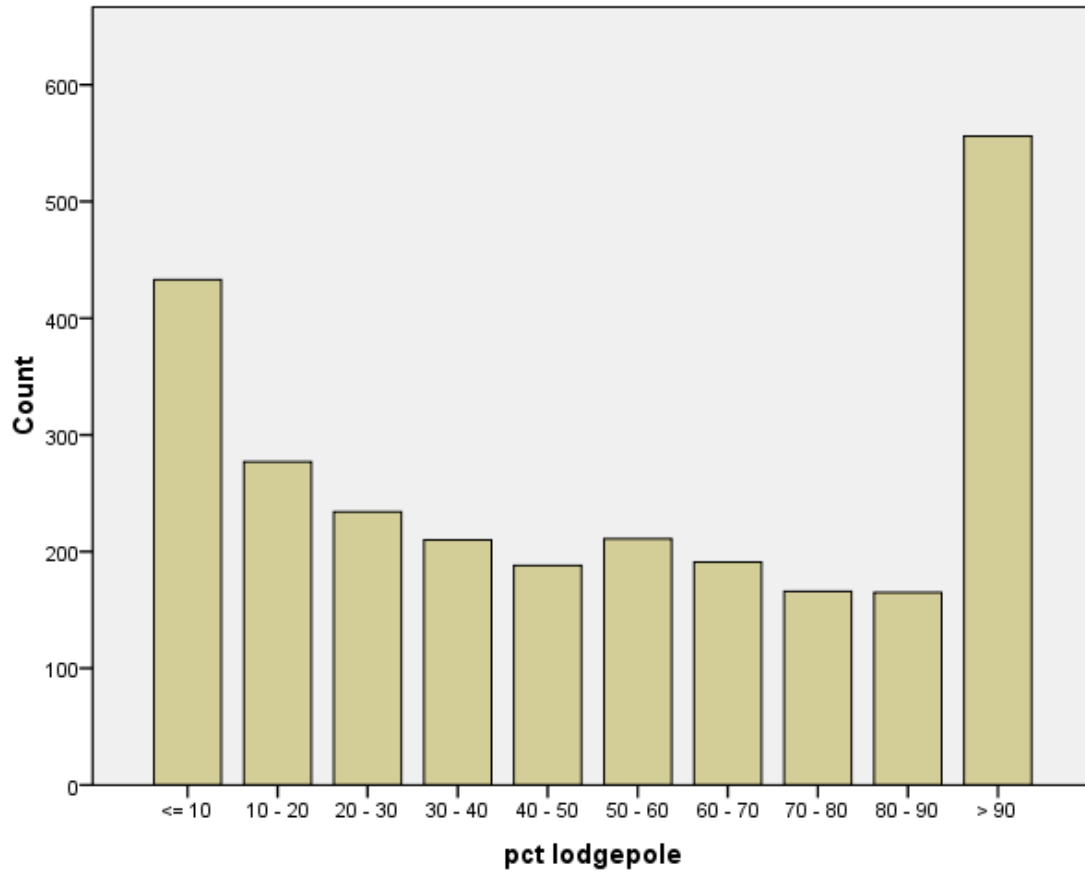
Land Ownership: Boulder County Parcel data (**old, unapproved source ca. 2004**)

Parcels:

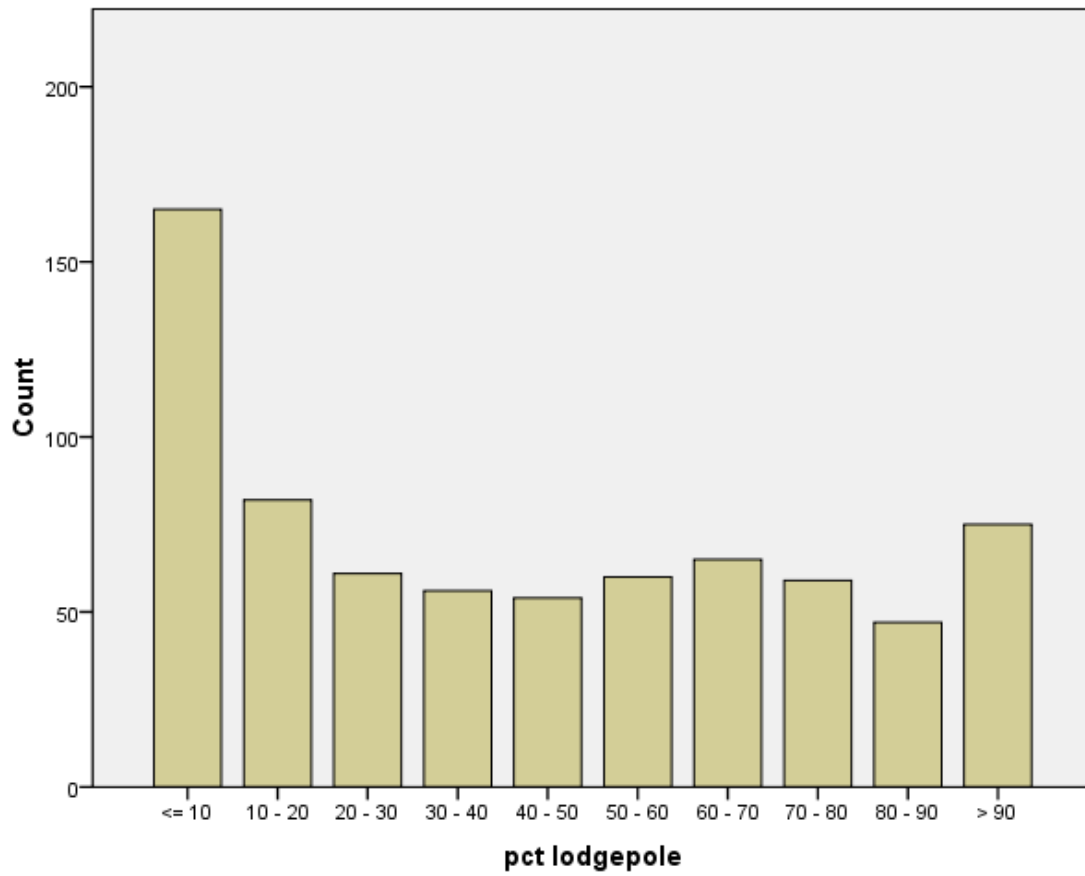
Vegetation: LANDFIRE Existing Vegetation Type, SAF 218: Lodgepole Pine, accessed from <http://www.LANDFIRE.gov>, Jan 19, 2009



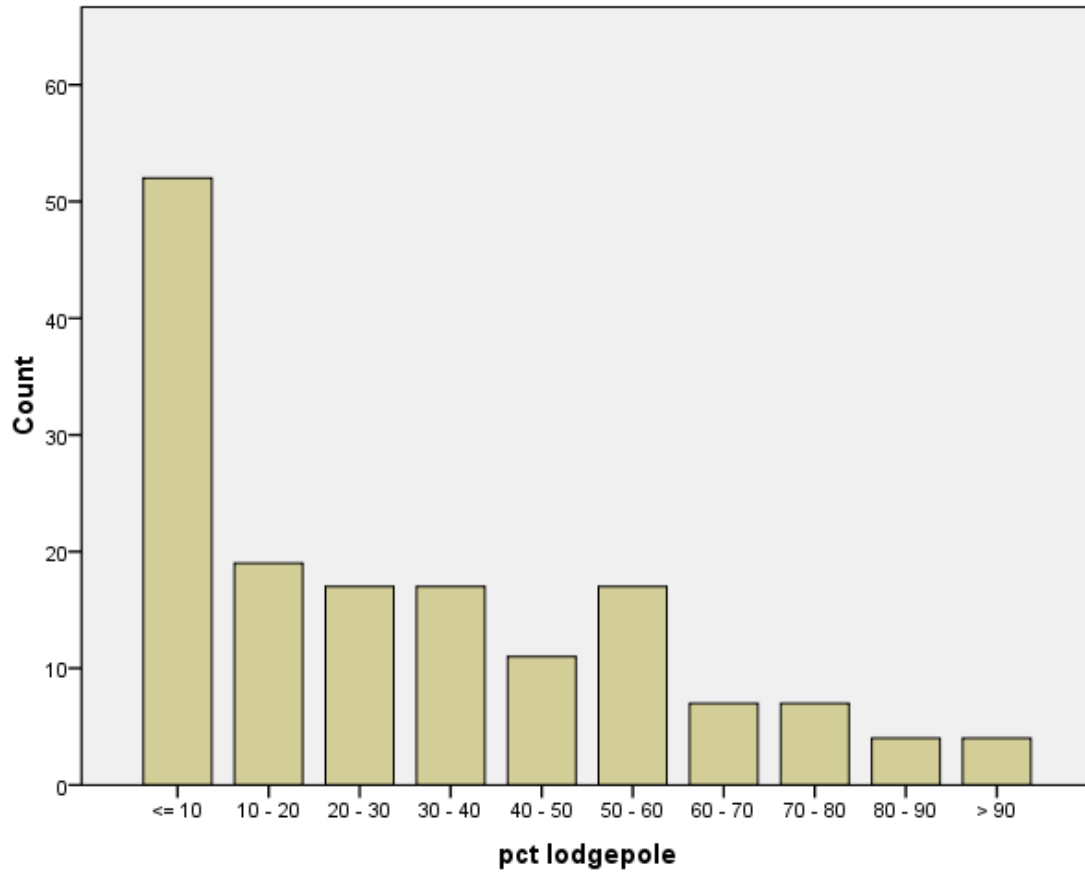
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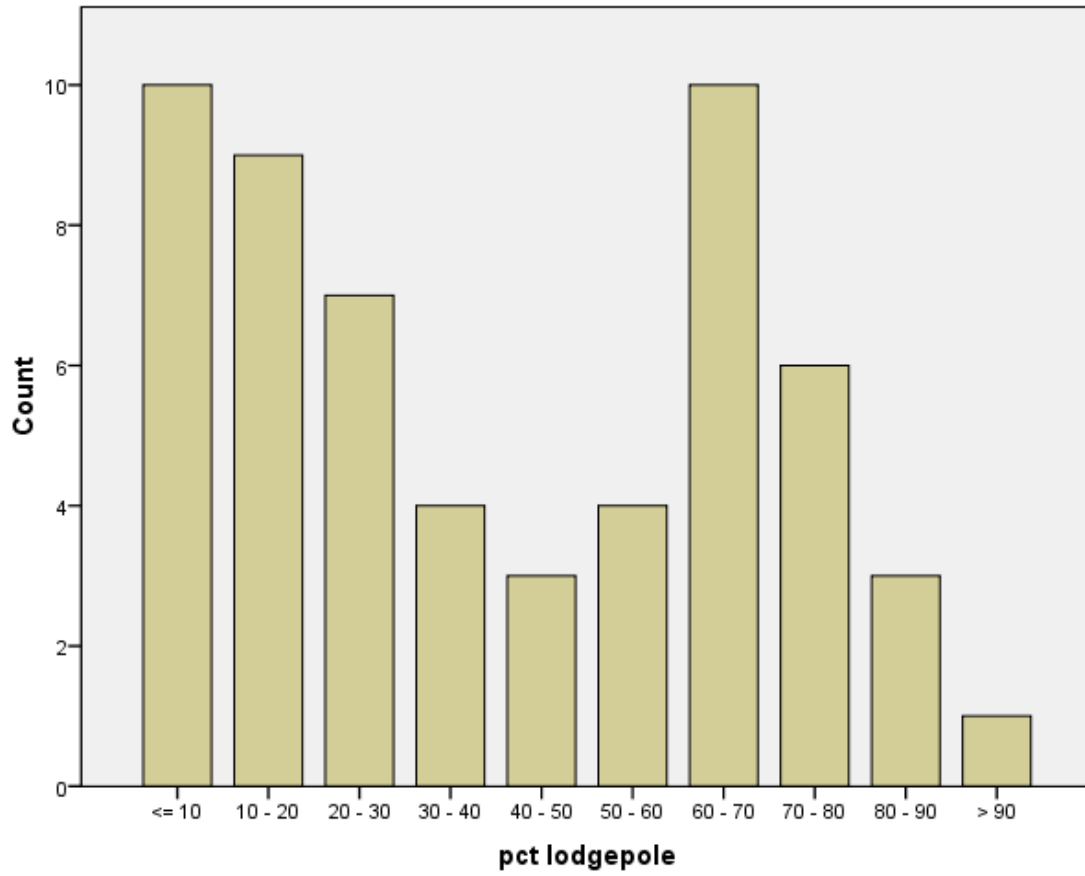
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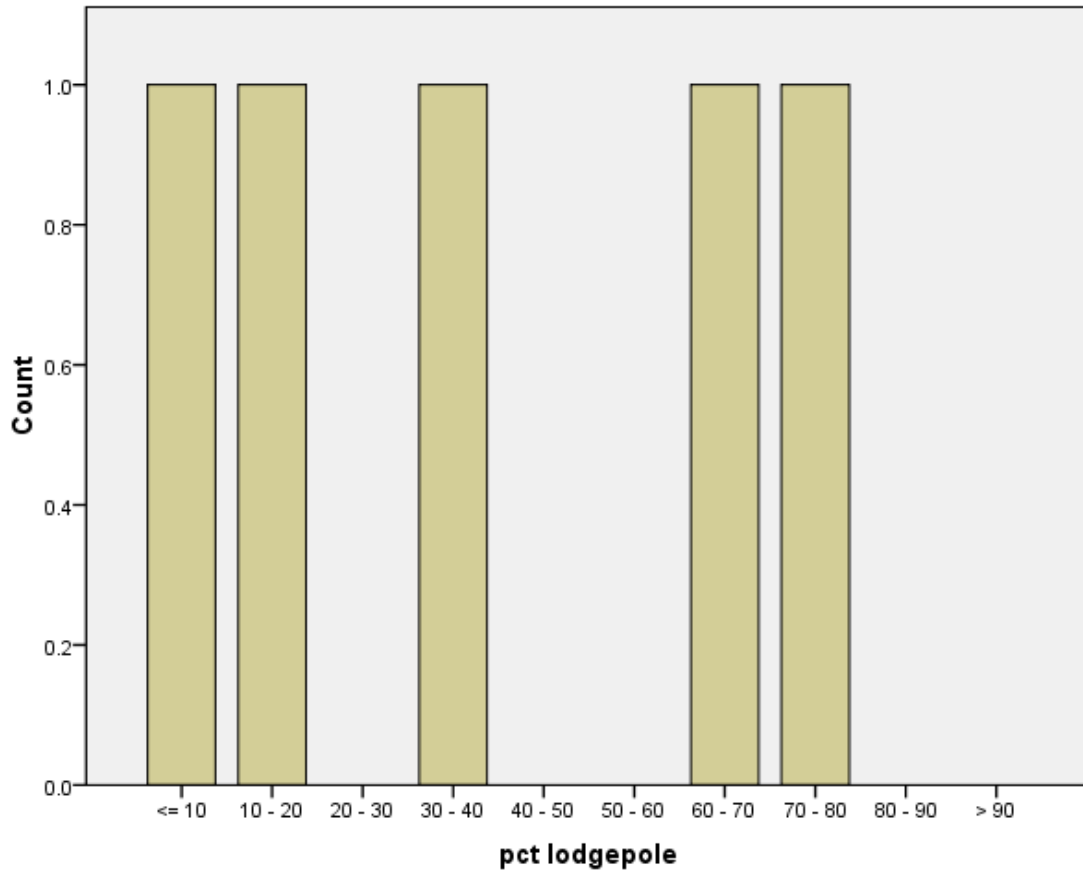
3. Parcels 5 – 35 acres



4. Parcels 35 – 100 acres



5. Parcels 100 – 500 acres



6. Parcels larger than 500 acres

Grand County

Frequency distribution of percent area of lodgepole pine within privately owned parcels where lodgepole occurs, broken down by parcel size classes.

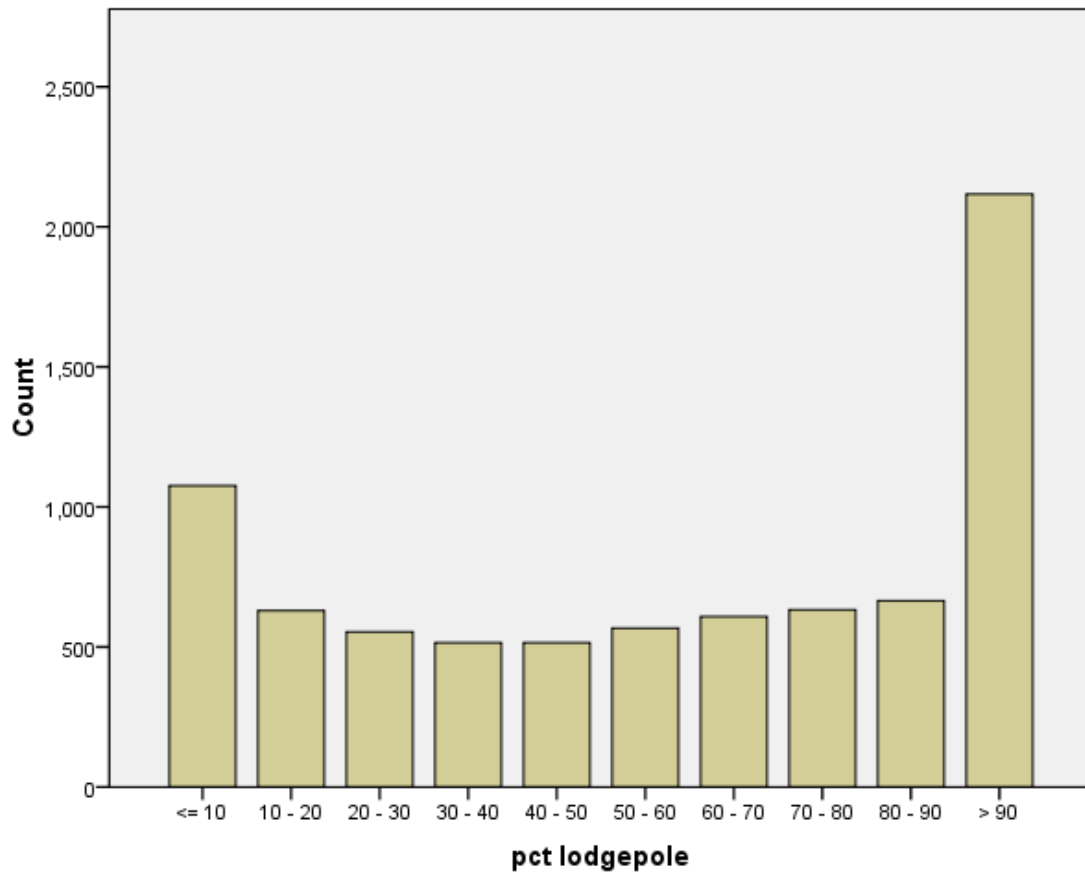
Parcel size classes used (see charts below):

- 5 acres or less
- 5 to 35 acres
- 35 to 100 acres
- 100 to 500 acres
- More than 500 acres

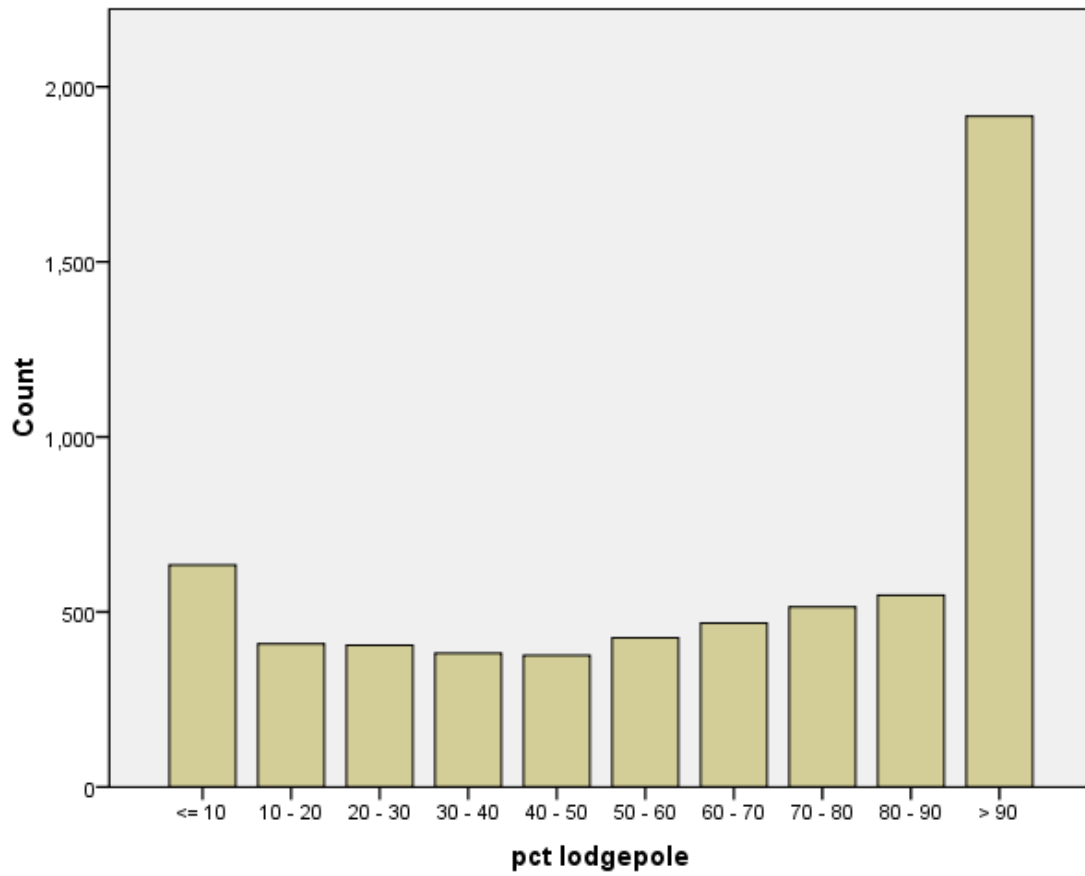
Data:

Land Ownership: Grand County GIS Department (<http://co.grand.co.us/GIS.html>)
 Parcel boundary data accessed Feb 4, 2009; assessor data accessed April 24, 2009

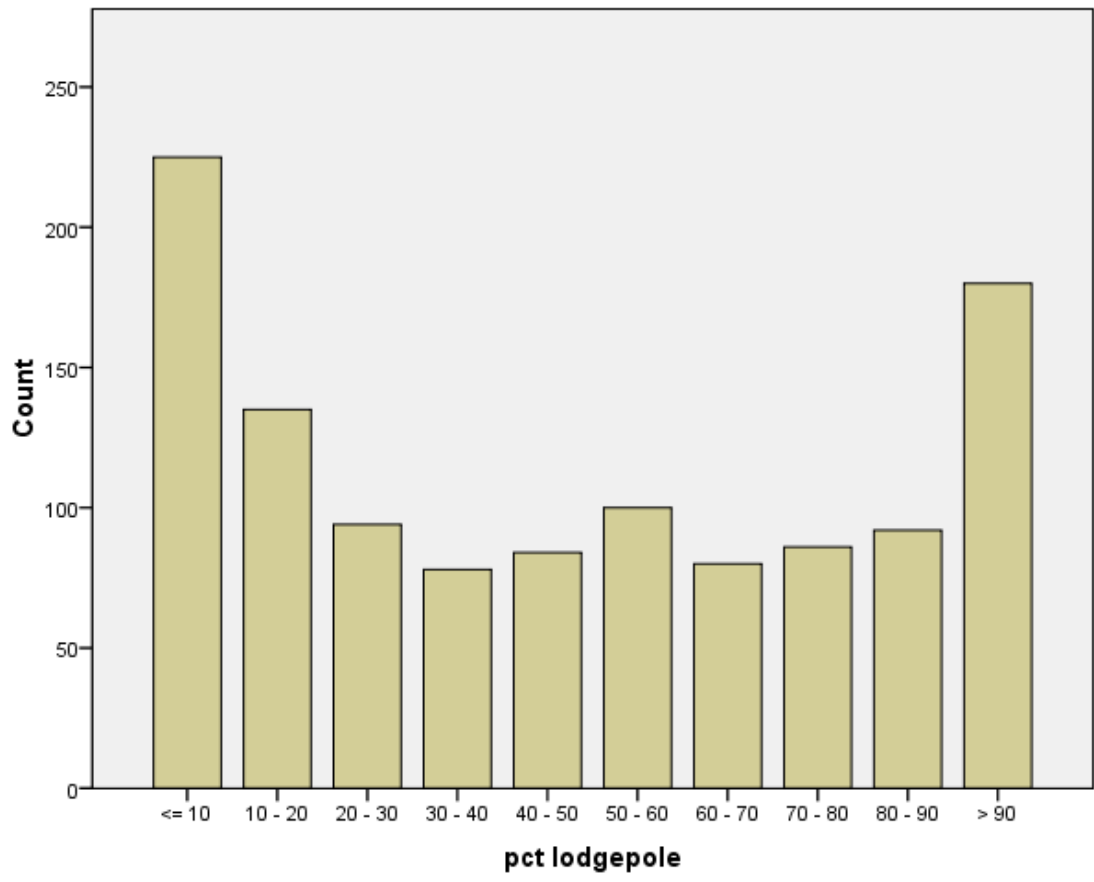
Vegetation: LANDFIRE Existing Vegetation Type, SAF 218: Lodgepole Pine,
 accessed from <http://www.LANDFIRE.gov>, Jan 19, 2009



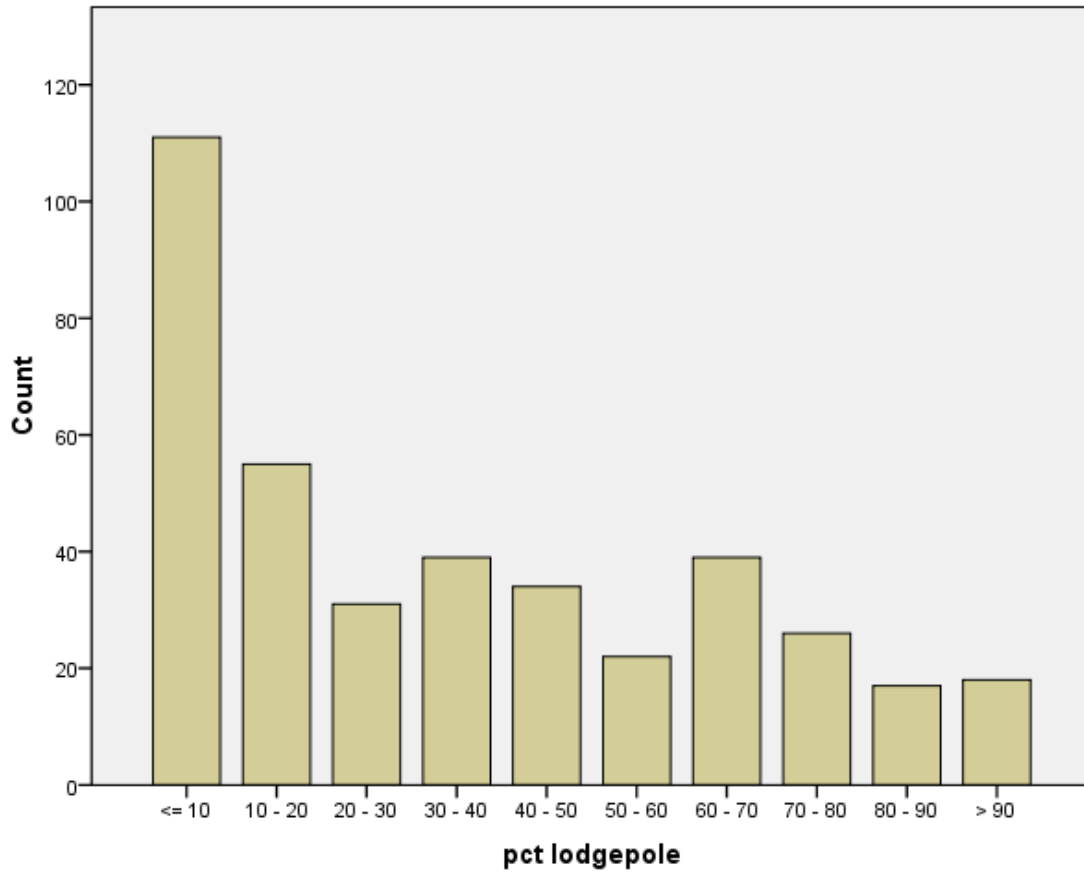
1. All size classes



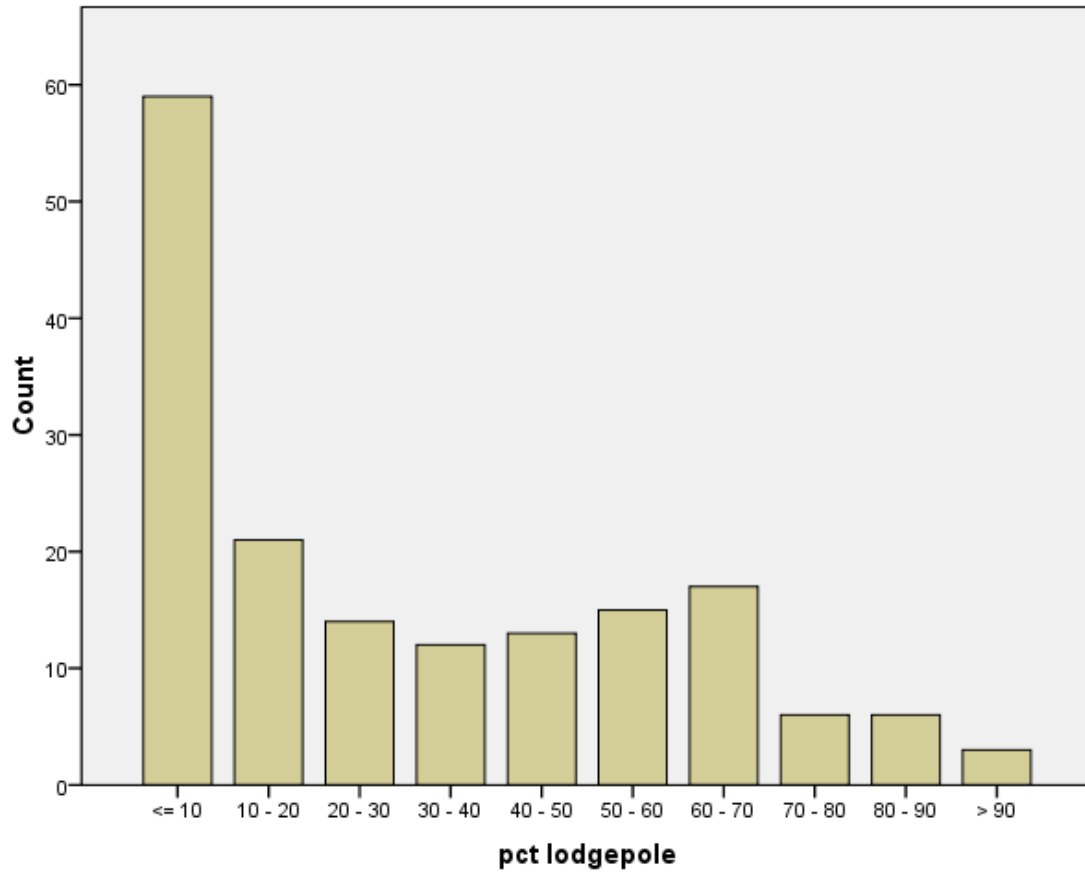
2. Parcels 5 acres or less



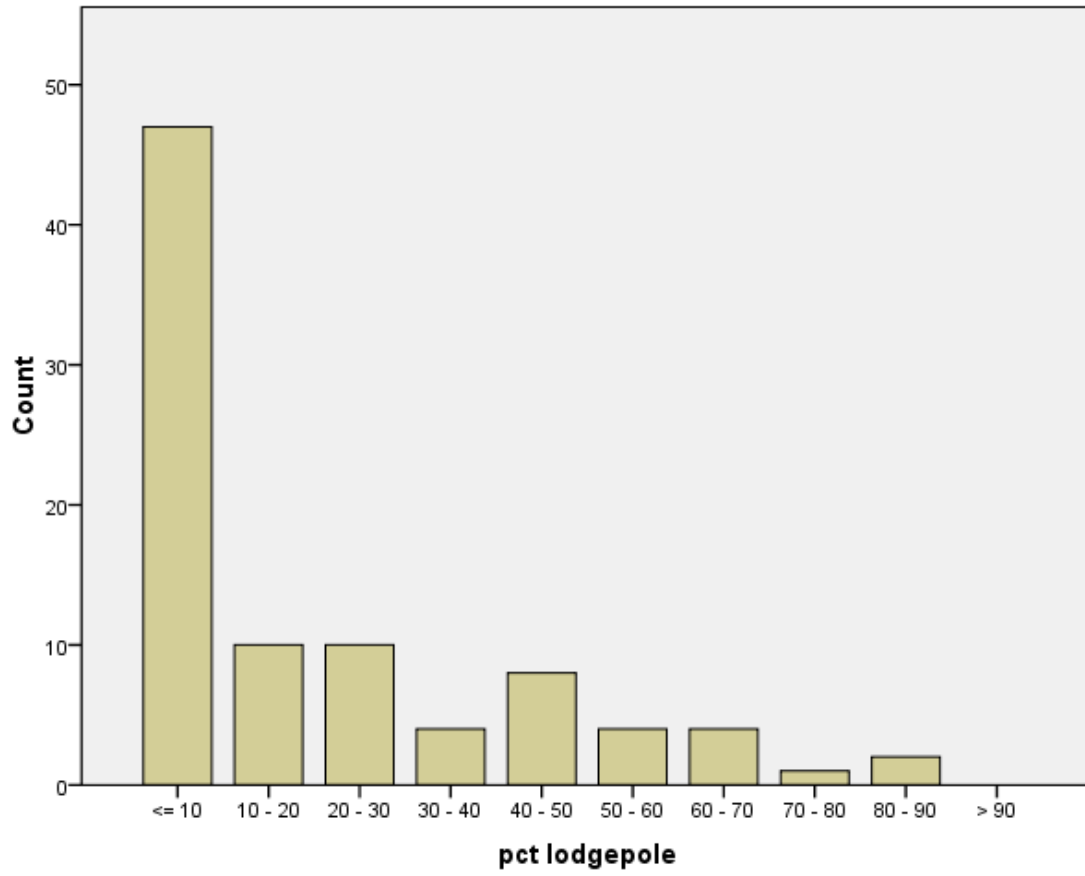
3. Parcels 5 – 35 acres



4. Parcels 35 – 100 acres



5. Parcels 100 – 500 acres



6. Parcels larger than 500 acres