Communicating Forest Management Science and Practices through Visualized and Animated Media Approaches to Community Presentations

An Exploration and Assessment

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Natural-resource managers have used a variety of computer-mediated presentation methods to communicate management practices to diverse publics. We explored the effects of visualizing and animating predictions from mathematical models in computerized presentations explaining forest succession (forest growth and change through time), fire behavior, and management options. In an experimental design using purposive samples, rural-mountain, town, and student groups gained substantial information from both the visualized, animated presentation and the nonvisualized, nonanimated presentation. Mountain residents gained significantly more information from the visualized and animated presentation than from the nonvisualized and nonanimated presentation.

Keywords: *visualization; animation; presentation software; forest-management models; Microsoft PowerPoint; wildland fires*

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Communicating science to the public can take many avenues depending on purposes of the communication and the audience(s) involved. When the goal is greater involvement of the public in science-related policy decisions at the local level, increased importance is being accorded to formal presentations of information and issue positions by expert sources at meetings of the local publics, stakeholders, advisory groups, and the like (O'Keefe, Ward, and Shepard 2002; Wondolleck and Yaffee 2000). Such presentations are becoming more technologically sophisticated, taking advantage in particular of the latest in portable computer software and media for visual depictions. This research examines a pilot effort involving the use of animation in such visual portrayals and its relative effectiveness. The setting is one of the more common in building participative decision making: the communication of natural-resource management practices to the public.

Advances in computer technology now enable natural-resource managers to use a variety of software to enhance their management of natural resources and to communicate management practices to diverse publics. For example, managers use complex models to predict forest change, fire behavior, and the effects of management decisions. Members of the public need to understand the nature of these models and be able to interpret their output. Hobbs (2000) notes that in a democracy, any analytical procedure used to set conservation priorities must be understood by everyone who is affected by it and that all decisions must be able to be explained to be credible. This study investigated the effectiveness of computer-presentation technology and custom visualization software for presenting output from forest-growth and fire-behavior models—that is, software designed to predict how forests grow and fires behave under different conditions—to the public.

Public presentations have long been an important mode of communicating natural-resource management information to diverse publics. Through the years, resource managers have used a variety of communication and presentation methods, including 35-mm slide shows, overhead transparencies,

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hook-and-loop boards, films, videos, posters, and flip charts (Fazio and Gilbert 1981, 1986, 2000; Gilbert 1964, 1971). Managers now use laptop personal computers, portable projection units, and presentation software in their public presentations. Advances in presentation software allow presenters to use illustrative techniques including animations, still line art, sound, video, and World Wide Web sites. Such techniques provide the opportunity to enhance the presentation of complex natural-resource management techniques such as modeling.

Modeling

As ecologists learn more about the complexity of forest ecosystems, the task of responsible management becomes increasingly complicated. Managers must anticipate the responses of forests to change at many temporal and spatial scales, account for social and economic considerations, and recommend actions to meet specific (and often conflicting) objectives (Mowrer 1997).

Managers now rely on mathematical models and computer-based information systems to help with these tasks (Barrett 2001). Models are, in many cases, the only way to predict effects of management choices across large areas and throughout long time periods (McCarter et al. 1998; Mladenoff and Baker 1999). Mathematical modeling is also crucial for effective fire management and suppression efforts (Andrews and Queen 2001). Recent technology integrates fire-spread models with forest-growth and management models, creating more powerful but more complex tools for managers and planners (Keane and Long 1998; Reinhardt, Keane, and Brown 2001).

Communicating Modeling to the Public

Hobbs (2000) and McVicker (2000) made the case for dialogue with the public, public understanding, and public acceptance as necessary for responsible management of public lands, echoing public-policy mandates emanating from the United States Environmental Protection Agency, United States Department of Agriculture (USDA), and other resource-related agencies. Presentations that explain models and summarize model output are a common component of dialogue with the public, and presenters now use computer-generated line drawings (visualizations) to depict specific model predictions and animated sequences of drawings (animations) to portray ecological processes (Bergen, McGaughey, and Fridley 1998; McGaughey 1998). For example, in a recent planning process for the Tenderfoot Creek Experimental Forest in central Montana, the Forest Vegetation Simulator (FVS) was used to predict results from several forest-management strategies. The Stand Visualization System (SVS) was used to prepare visualizations of modeled pretreatment and posttreatment conditions (Andrews and Queen 2001).

McGaughey (1998) pointed out two important uses of visualizations: (1) to project the visual effects of forest-treatment options during the design process and (2) to help managers communicate their intentions to other resource specialists and the public. He stressed that visualizations must be accurate lest the stakeholders' (interested public's) expectations exceed what is physically and biologically possible. Bergen et al. (1998) quoted Sheppard (1986, 1989) as saying the fundamental objectives of visual simulations are understanding, credibility, and lack of bias. McCarter et al. (1998) used SVS to depict model output and claimed that their approach facilitated outreach and education. While these authors assert the effectiveness of presentations, they did not report data documenting the effectiveness of visualizing model results in communicating with key publics.

Andrews and Queen (2001) asserted that modeling aids communication among decisionmakers, land-management agencies, and the public, but such dialogues are complex and sensitive. Information that scientists view as factual and objective may be perceived differently by nonscientists. Weber and Word (2001) commented that the fate of science information is a complex matter. Barrett (2001) argued that if models of vegetative change for forest- management planning are to be used to educate the public about forest-ecosystem dynamics, then developers should focus on effective user interface, documentation, and research on effective communication techniques.

Therefore, a need exists to empirically assess the effectiveness of formal presentations. We asked, does a formal presentation about forest modeling indeed increase knowledge about forest processes in members of the public? To what extent do computer visualizations and animations enhance a formal presentation about model output? In what ways do formal presentations influence public perceptions of forest management and the USDA Forest Service?

Communication and Education Research Findings

Studies of formal presentation techniques, visualization, and animation have been a tradition in both communication and education research. While the work is often sketchy with sometimes conflicting findings, a brief review of that literature is insightful here.

Presentation studies. Surprisingly few researchers have investigated the effectiveness of formal presentations using presentation-software programs. The studies we have found were published in trade magazines or as corporate technical reports.

In *Presentations*, a trade magazine, Simons, Andres, and Petersen (2000) reported on a project commissioned by *Presentations* and 3M to explore the effects of information presented in a text pamphlet, overhead transparencies, and multimedia presentations (professionally designed PowerPoint slides using graphics and animations) in three different studies with college students at a western United States university. While the authors do not report statistical significance, the multimedia presentation tended to score higher for free recall and information comprehension in a training study and an informational meeting study. In one part of the study, nearly two-fifths of the participants preferred the vendor presented in a multimedia presentation to the vendor presented in an overhead-transparency presentation; in a second part, 80 percent of participants preferred the multimedia presentation to the printed pamphlet.

One study found that presentations using overhead transparencies were more persuasive than presentations without overhead transparencies and that the overheads enhanced the understanding of abstract concepts, maintained higher listener interest, and increased audience retention (Minnesota Mining and Manufacturing 2002; Vogel, Dickson, and Lehman 1986).

Visualization studies. Research on computer interfaces provides further insights. Chen and Yu (2000) conducted a meta-analysis of studies of visualization research. They investigated thirty-five studies and found that, given the same cognitive abilities, users tend to perform better with simpler visual interfaces—that is, the layout and design of the multimedia or Web site. The authors called for further investigations to explore visualization effectiveness and potential differences based on the cognitive abilities of individuals.

Animation studies. Animation in computer-based instruction has been defined as a series of rapidly changing images that suggest movement (Rieber and Hannafin 1988). Most research on teaching with animation has focused on computer-based instruction in K-16 classroom settings, while some research has focused on adult learners in formal settings.

In reviewing empirical studies, Rieber (1990) recommended the use of animations when they are congruent with the learning task, when learners are new to a topic, and when learners may not understand or recognize the relevant visual cues—that is, visual symbols, icons, or other visualizations—or when animation's contribution to computer-based instruction may lie in interactive graphic applications—that is, the user controls the interactivity. Rieber, Boyce, and Alkindi (1991) studied the potential benefit of computer-based training using the above principles to introduce the concepts of force, inertia, velocity, and acceleration and their relationships. The researchers found that animations did not provide an advantage over static visuals for undergraduate students and reported that this was consistent with earlier research in training settings (Moore, Nawrocki, and Simutis 1979; Reed 1985; Rieber, Boyce, and Assad 1990).

Based on a detailed literature review of animation in instructional environments, Large (1996) argued that to contribute to learning a specific topic, animation must overlap with the text (i.e., provide redundancy), be consistent, and provide relevant, concrete detail. He speculated that animation might help people learn topics that involve changes through time and cannot be easily visualized. However, he also pointed out that personal factors influence learning; those most relevant to presentations would include prior knowledge, experience, motivation, and attitude. Adults can store, retain, and retrieve information better than children and are better able to form internal images from carefully designed and highly imaginable text, so they may have less need for visual aids and animation than children. Large noted that most multimedia studies with adults have been investigations of participants who are used to retrieving information from text—primarily undergraduate and graduate students.

We found no studies investigating the effect of animations in informal learning and education settings such as public presentations.

Research Questions

This study explored the effect of presentations, with and without visualized and animated computerized graphics, in explaining forest growth and change, fire behavior, and mathematical models to samples from three adult populations: rural-mountain residents, town residents, and college students. The specific research questions follow:

RQ1. Were there significant differences in knowledge scores within groups between participants who viewed a visualized and animated presentation and participants who viewed a nonvisualized and nonanimated presentation?

RQ2. Were there significant differences in knowledge scores between groups after viewing the visualized and animated presentation?

RQ3. Were there significant differences in knowledge scores between groups after viewing the nonvisualized and nonanimated presentation?

RQ4. Were there significant differences in knowledge scores within and between groups in their perception of the Forest Service and were there significant differences within and between groups in their assessment of the mathematical models in adding to the credibility of the Forest Service?

Methods

The study consisted of having purposive sample groups from three adult populations—rural-mountain residents, town residents, and students (see description below)—first complete a pretreatment questionnaire, then view either a visualized or nonvisualized presentation, and then complete the posttreatment questionnaire. The pretreatment and posttreatment sections of the questionnaire covered knowledge and foils—that is, questions on topics not covered in the presentation, media usage, and background. The research protocol was reviewed and approved by the university's institutional review board.

Populations Studied

Forest fires burn thousands of acres of public and private lands along the eastern slope of Colorado's Rocky Mountains every few years. The study area lies along the eastern slope within or adjacent to forests managed by state and federal agencies. Our participants included rural-mountain residents, town residents, and college students. The rural-mountain residents lived in the Rocky Mountains of northern Colorado on property adjacent to and sometimes interspersed with national forests six thousand feet above sea level. The town residents lived in a metropolitan area, population about 120,000, in the adjacent foothills, about five thousand feet above sea level. The college students were recruited from communication classes in a liberal-arts college within a land-grant university in the same metropolitan area. Because of the risks posed by forest fires, we felt these residents would have a compelling interest in how the USDA Forest Service makes forest- and fire-management decisions. It is important to note that all data were collected prior to 15 April 2002. This is important because between 15 April and 10 September 2002, some 300,000 acres of forested lands throughout Colorado burned; the largest fire, southwest of Denver, Colorado, burned some 140,000 acres, including the area described to the public in this study.

Study Design

We recruited 142 participants for the study and divided each population sample group into two subgroups. One subgroup viewed a visualized Microsoft 2000 PowerPoint presentation (containing line drawings and animations produced by computer software directly from data and model results) while the other group viewed a nonvisualized presentation (also in PowerPoint but containing no line drawings or animations; Table 1).

TABLE 1
Numbers of Rural-Mountain Residents, Town Residents, and Students in the Respective Treatment and Comparison Groups

	Visualized/ Animated	*Nonvisualized/ Nonanimated*	*Total*
Rural-mountain residents	27	21	48
Town residents	27	36	63
Students	19	12	31
Total	73	69	142

Local community organizations recruited resident participants for the study. Each community organization received one hundred dollars for recruiting participants, and each participant received a ten-dollar honorarium for helping with the study. Students were recruited from undergraduate journalism and speech classes by announcing the project in classes and asking for volunteers. Each student received a ten-dollar honorarium.

Presentation Design

We developed a basic presentation that first introduced the use of models in forest management and then used the Forest Vegetation Simulator (FVS) with Fuels and Fire Extension (FFE) to show how forests grow and change, how fires affect this change, how forest structure affects fire behavior, and how management decisions influence forests and fires. FVS (Stage 1973; Wykoff, Crookston, and Stage 1982) is a mathematical model that simulates forest growth and productivity and the effects of potential management actions on forest dynamics. It is used widely in the United States and Canada to prepare forest-management plans, assess habitat, and estimate effects from insects and pathogens (Dixon 2002; Mowrer 1997). The recent Fuels and Fire Extension to FVS (FVS-FFE) simulates surface vegetation available for combustion (fuels), tree characteristics, fire behavior, and tree mortality in the event of fire as a forest changes through time (Reinhardt, Keane, and Brown 2001). FVS-FFE uses the SVS (McGaughey 1997, 1998) to produce visualizations and animations directly from data and model output. Simulations were run using data from the Cheesman Reservoir area southwest of Denver, Colorado (Fornwalt et al. 2002; Kaufmann et al. 2001; Kaufmann, Huckaby, and Gleason 2000; Kaufmann, Regan, and Brown 2000).

The basic presentation included black-and-white photographs depicting forest conditions in 1900 and current conditions; color photographs illustrating

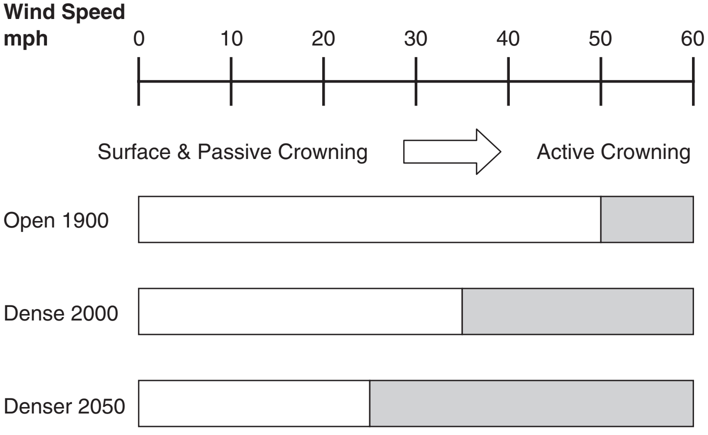

Figure 1: Example of a Horizontal Bar Graph Illustrating the Modeled Wind Speed at which Active Crown Fire (Severe Fire Behavior that Consumes Tree Crowns and Kills Most Above-Ground Plant Parts) Is Likely to Occur in Forests with Different Structures

NOTE: The open 1900 (historic) forest was dominated by large trees with little tree regeneration (170 trees per acre); the dense 2000 (current) forest has more than twice as many large trees with hundreds of small trees (409 trees per acre); the denser 2050 (predicted future) forest modeled by FVS has even more trees of all sizes (547 trees per acre).

tree species, tree-growth patterns, fires, and management practices; conceptual diagrams; text-overview slides using bullet lists to cover key concepts; and bar graphs. The eleven bar graphs used vertical and horizontal formats (example shown in Figure 1). We used the animation tool in PowerPoint to reveal specific information progressively.

From the basic presentation, we constructed a nonvisualized version and a visualized version. The forty-minute, sixty-four–slide nonvisualized presentation included ninety-one (sixty-three color and twenty-eight black-and-white) photographs. The forty-five-minute, seventy-one-slide visualized presentation included sixty-five (fifty color and fifteen black-and-white) photographs—fewer than the nonvisualized presentation because many concepts were depicted by line-art illustrations from the stand-visualization system. Of these, thirty-one were still illustrations and thirteen were animated illustrations. These illustrations were constructed directly from the data and showed the forest in 1900 and current conditions, modeled succession (forest growth and change through time, Figure 2), modeled management treatments, and

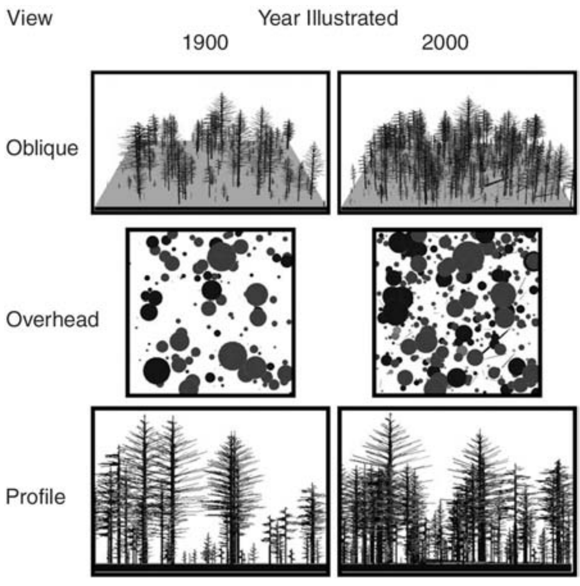

Figure 2: Line Art Example from Visualized Presentation Illustrating Forest Succession (Change through Time)
NOTE: Each illustration represents data describing tree density in a one-acre area. The 1900 forest and 2000 forest are viewed from an oblique aerial angle (top), overhead (middle), and profile (bottom) view. The visualized presentation used the 1900 and 2000 images in each pair as the first and last image in a ten-image animation of succession.

modeled fire behavior (Figure 3). The line art consisted of illustrations viewed from several angles (Figure 2). Because the animated screens of the visualized presentation displayed quickly, we showed each animation twice before moving ahead in the presentation.

Smith gave all presentations for the rural-mountain residents and the town residents and the visualized presentation to students. Zimmerman gave the nonvisualized presentation to students. Both presenters talked from a script to maintain consistency.

Questionnaire Design

To assess the effectiveness of the presentations, we developed a questionnaire in which the first thirty questions were designed to assess a participant's

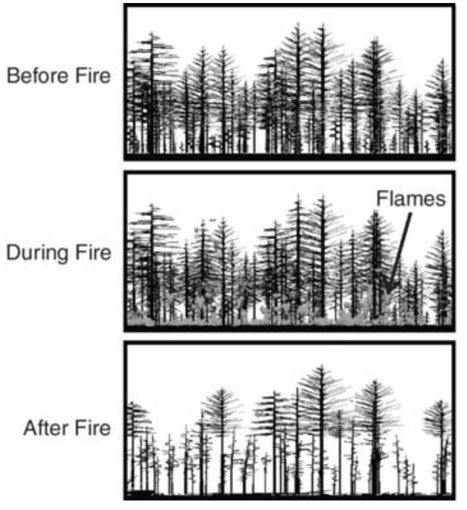

Figure 3: Line Art Examples from Visualized Presentation Illustrating Modeled Fire Behavior

NOTE: The presentation used these three images in a seven-image animation of the fire spread through a forest.

general knowledge of forest biology and management. Of these, twenty-two questions focused on the content of the presentation: forest succession, fire behavior, forest management, and use of models for decision making. Eight questions served as foils—questions on topics not covered in the presentation—to ascertain the influence of asking the same questions before and after the presentation.

The questionnaire introduction acknowledged that some people were knowledgeable about forests, forest fires, and forest management while others were not. We provided the statement based on two rationales. First, we wanted to give participants social license to acknowledge that they did not know about forest management topics by circling a *don't know* response (see below). Second, we provided the introduction to reduce the possibility of generating pseudodata. Chaffee (1971) argued that participants in surveys often provide the socially desirable answer and/or answer questions about topics that they have not thought about. Then the directions asked participants to read each question. If they did not know the answer to the question or they were unsure of their answers, participants were instructed to circle the *don't know* response. If they thought they were familiar with the topic of the statement, they were instructed to rate the question on a one-to-seven scale where one meant *not at all true* and seven meant *usually true*.

We pretested the questionnaire twice with graduate students—many of whom were nontraditional students—and area adults to enhance the wording of individual questions with graduate students and undergraduate students in journalism and communication. The content-related and foil questions constituted the entire prepresentation survey and part of the postpresentation survey. The postpresentation survey included additional questions: fourteen questions asked about the presentation itself, nine asked about the visual aids used in the presentation, and two asked about the presentation in relationship to the credibility of the USDA Forest Service.

We asked a panel of experts ($n = 3$) in forest and fire ecology to answer the knowledge-related questions so we could compare participant responses to those of experts.

Audience members' frame of reference—knowledge, attitudes, prior experiences, and cognitive skills—can influence their receipt and processing of new information and thus confound the potential effect of presentations. Therefore, the postpresentation part of the questionnaire asked participants about their prior experience with forests and fires; ownership of rural-mountain property and the amount of their mountain lands covered with forests; whether their property had been threatened by forest fires or burned by forest fires; how likely they were to pay attention to news-media coverage of forest fires; prior exposure to issues related to the environment and forest fires; and concern about forest fires.

Prior experiences with governmental agencies may influence how participants react to and process the information provided in the presentation. Therefore, the postpresentation part of the questionnaire asked participants about their experience with the USDA Forest Service, the helpfulness of the Forest Service at managing forests on private property, and their perception of the agency's effectiveness in managing fires in national forests. It also asked if they had heard, read, or seen any news coverage about forest fires and the Forest Service in the past month or so.

Demographic questions in the postpresentation part of the questionnaire explored where participants lived, their education level, and completion of high-school and/or college biology, botany, conservation, and agriculture courses. Additional questions assessed participants' concern about the environment, their involvement in their respective communities, and their ability to visualize or see pictures in their minds when thinking about forests. Finally, participants were asked to report their ethnic background, annual household income, gender, and age.

Treatment Setting

Each participant attended a single presentation. Depending on participant availability, sessions were held in the early afternoon or early evening. Whenever possible, sessions were part of the recruiting organization's regular meetings. Students attended lunch-hour presentations. Complimentary refreshments were provided at all sessions for adult residents while students received complimentary pizza and soft drinks. To acquire sufficient participants for the study, we gave two visualized presentations to the rural-mountain and student groups and two nonvisualized presentations to town groups. Statistical analyses of independent variables and potential confounds showed no significant differences between participants in the first and second sessions; therefore, the data were combined.

Each session began with a welcome and an introduction from the principal investigator followed by an overview of the session and an introduction of the research team. The researchers explained we were seeking help with a research project on communicating potential forest-management practices to the general public. Most participants sat at tables facing a 5′ by 5′ projector screen. When tables were not available, participants sat in chairs with clipboards for writing surfaces. Following the introduction, participants were informed that the presentation was part of the research project, were briefed on being involved in research, and then were given the required human-subjects (Institutional Review Board) participation consent forms to read and complete. In addition, they received their honorarium and receipt form for the honorarium.

After participants returned the consent forms and receipts, the researchers instructed participants to complete the first thirty questions of the questionnaire (measuring their level of general knowledge), then stop and not look further at the questionnaire. The questionnaire also instructed participants to stop after completing the initial thirty questions. The researchers monitored participants as they completed the questionnaire. No participants were observed reading beyond the first thirty questions.

After the presentation, researchers instructed participants to answer the remaining questions on the questionnaire, taking as long as they needed. After participants completed their questionnaires, the researchers collected the questionnaires. As the last step in having participants help with the research and following requirements for the Institutional Review Board human-subjects guidelines, we debriefed the participants. The debriefing included the presenter's and researchers' providing a brief explanation of the research project, providing each participant with a written explanation of the research project, and answering any questions participants had. No session took more than ninety minutes.

Data Analysis

Our first analysis provided two scores. First, we compared the percentage of *don't know* responses before and after the presentation. Second, we analyzed the scores based on participants' one-to-seven rating of each question for which they thought they knew the answer. We reversed scoring for negative statements to produce all scores in the same direction. We ran ANOVA and post hoc tests to determine if the responses within groups and between groups were significantly different. The pretest scores were treated as covariates. For nominal data, we ran pairwise chi-square tests comparing the percentage responses within groups. The level of significance was set at $p = .05$.

Demographics

Demographic characteristics of participants differed between groups but varied little within groups (Table 2). No significant differences for age, education, income, gender, and ethnicity were found between participants in the visualized and nonvisualized presentations in the rural-mountain or town-resident groups. Among the student participants, the nonvisualized-presentation group had significantly more female participants than the visualized-presentation group. None of the town residents or college students listed mountain homes as their primary residence, whereas 98 percent of rural-mountain residents did so. Three of the town residents and four students reported having a mountain cabin as their secondary residence. Eight percent of the rural-mountain residents' property had been threatened by forest fires and 11 percent said their property had been burned by forest fires.

Results

All scale postpresentation scores were relatively high, in the $M = 4.74$ to 6.30 range (on the 1 to 7 scale where 1 = *not at all true* and 7 = *usually true*).

Significant reductions in the percentage of *don't know* responses for individual questions were observed for all groups regardless of treatment. For both the visualized and the nonvisualized presentations, the total number of *don't knows* for individual questions dropped by 87 percent on questions regarding succession, 87 percent on questions regarding fire behavior,

TABLE 2
Summary of Demographic Information about Rural-Mountain-Resident, Town-Resident, and College-Student Participants

	Rural-Mountain Residents	*Town Residents*	*College Students*
Average age (years)	61[a]	44[b]	21[c]
Income > $50,000 (%)	46[a]	63[b]	10[c]
Bachelor's degree or higher (%)	42[a]	71[b]	13[c]
Completed high-school biology course (%)	60[a]	78[b]	97[c]
Completed college biology course (%)	23[a]	52[b]	55[c]
White, non-Hispanic (%)	95[a]	83[a]	90[a]
Female (%)	52[a, c]	73[b]	55[a, b]
Male (%)	48[a, c]	27[b]	45[a, b, c]

NOTE: Where the superscripts are the same letter, there are no significant differences between the groups at $p < .05$; where the superscripts are different, there are significant differences between participants at $p < .05$.

78 percent on questions regarding management, and 95 percent on questions regarding modeling after participants viewed the presentations.

The panel of three experts, who reviewed the PowerPoint presentations and then answered the information-related questions, gave no *don't know* responses. They had mean knowledge scores for succession, $M = 7.0$; fire behavior, $M = 6.96$; management, $M = 7.0$; and models, $M = 6.95$.

For all groups, the mean after scores for the succession, fire-behavior, and model scales were significantly higher than the mean before scores (Table 3). On the forest-management scale, we found no significant differences between the before and after scale scores. We found no significant differences in the prescores between groups for any subject-matter scale (succession, fire behavior, management, and model).

Effect of Visualized Presentations on Knowledge

The rural-mountain participants viewing the visualized presentation, when compared to rural-mountain participants viewing the nonvisualized presentation, scored significantly higher on the knowledge questions regarding fire behavior, fire management, and simulation models (Table 4). No significant differences were observed between the visualized and nonvisualized scores for college students and town residents. We found no significant differences within the groups when we assessed the potential confounds—that

TABLE 3
Mean Scores on Four Knowledge Scales before and after Presentations for All Participants

Scale	*Mean Before Score*	*Mean After Score*	*df*	*t Value*	*Significance*
Succession	5.28	5.61	133	3.05	.0028
Fire behavior	4.74	6.10	131	14.08	.0001
Forest management	6.10	6.30	131	1.69	.0943
Model	5.47	6.22	124	9.35	.0001

TABLE 4
Comparison of Mean Knowledge Scores within the Rural-Mountain-Resident, Town-Resident, and Student Groups after the Presentation

	Rural-Mountain Residents		*Town Residents*		*Students*	
Concept	*Nonvisualized*	*Visualized*	*Nonvisualized*	*Visualized*	*Nonvisualized*	*Visualized*
Succession	5.84	5.80	5.73	5.56	4.65	4.93
Fire behavior	5.90*	6.31*	6.14	6.13	5.74	6.10
Management	5.85*	6.55*	6.40	6.51	6.51	6.18
Model	5.94*	6.56*	6.27	6.28	6.18	6.13

*Differences significant at the $p < .05$ level; ANOVA.

is, threats to the validity of our conclusions. Specifically, we found no significant differences in their paying attention to reports of forest fires, owning forested property, seeing images of forests in their minds when thinking about forests, perceptions of the Forest Service's helpfulness in protecting private property, the Forest Service's responsibility for fire management, concerns about environmental issues, or community involvement.

Differences between Groups Viewing the Visualized Presentation

Rural-mountain residents and town residents scored significantly higher than students on the succession-knowledge questions after viewing the visualized presentation (Table 5). No significant differences emerged between groups on the other knowledge scales. While not significantly higher, a general pattern emerges in which the rural-mountain residents tended to score slightly higher than town residents and students on all post-presentation knowledge scores.

TABLE 5
Comparison of Mean Knowledge Scores between Groups after Viewing the Visualized Presentation

Concept	*Rural-Mountain Residents*	*Town Residents*	*College Students*
Succession	5.80[a]	5.56[a]	4.93[b]
Fire behavior	6.31[a]	6.13[a]	6.10[a]
Management	6.55[a]	6.51[a]	6.18[a]
Model	6.56[a]	6.28[a]	6.13[a]

NOTE: Where the superscripts are the same letter, there are no significant differences between the groups at $p < .05$; where the superscripts are different, there are significant differences between participants at $p < .05$.

TABLE 6
Comparison of the Mean Knowledge Scores between Groups after Viewing the Nonvisualized Presentation

Concept	*Rural-Mountain Residents*	*Town Residents*	*College Students*
Succession	5.84[a]	5.73[a]	4.65[b]
Fire behavior	5.90[a]	6.14[a]	5.74[a]
Management	5.85[a]	6.40[a]	6.51[a]
Model	5.94[a]	6.27[a]	6.18[a]

NOTE: Where the superscripts are the same letter, there are no significant differences between the groups at $p < .05$; where the superscripts are different, there are significant differences between participants at $p < .05$.

Differences between Groups Viewing the Nonvisualized Presentation

In the nonvisualized presentation, as in the visualized presentation, rural-mountain and town participants scored significantly higher on knowledge of succession than did students (Table 6). No significant differences emerged between groups on the remaining knowledge questions.

Foil Questions

To assess the potential effect of answering the prepresentation part of the questionnaire, we used eight foil questions. Three of the eight foil questions produced significant increases from the presections to the postsections of the questionnaire, with responses to the remaining five questions not significantly different. The three questions with significant differences were

TABLE 7
Perceptions of the Presentation, Average of All Groups and Treatments

Negative Concept	*Average Score*	*Positive Concept*
a. Very difficult to understand	6.23 ± 1.03	Very easy to understand
b. Not at all informative	5.51 ± 2.06	Very informative
c. Very hard to follow	5.55 ± 1.96	Very easy to follow
d. Not at all well organized	6.19 ± 1.05	Well organized
e. Not at all concise	5.20 ± 1.83	Very concise
f. Not at all useful	5.30 ± 1.65	Very useful
g. Not at all visually pleasing	5.65 ± 1.41	Very visually pleasing
h. Not at all interesting	5.76 ± 1.51	Very interesting
i. Not at all well scripted	5.36 ± 1.86	Well scripted

NOTE: Responses to "I found the overall presentation to be . . . " using a scale from 1 to 7.

(1) "When foresters refer to *slash*, they are referring to the debris left after trees are cut or fell by wind or fire," (2) "Heavy amounts of slash improve resistance to an area to fire," and (3) "Yarding unmerchantable timber destroys habitat for many wildlife species."

Perception of the Presentations and Visuals

Participants rated both the presentations and the visuals in each presentation highly. The groups viewing the visualized presentations rated them as significantly more visually pleasing than the groups viewing the nonvisualized presentations (M =5.96 ± 1.14 vs. M = 5.32 ± 1.59, t = –2.73, df = 137, p = .007). No other significant differences emerged between the groups viewing the visualized versus the nonvisualized presentations (Table 7), although the group viewing the visualized presentation rated the presentation slightly higher, on average, than the group viewing the nonvisualized presentation.

Perceptions of Visuals

Participants rated the visuals used in the presentations highly (Table 8). The groups viewing the visualized presentations rated visuals significantly more attractive (M = 5.73 vs. 4.92, t = –2.83, df = 128.40, p = .005) and easier to follow than did the groups viewing the nonvisualized presentations (M = 6.26 vs. 5.66, t = –2.23, p = .028). While the ratings of the visuals on the seven other variables were not significantly different, the group viewing

TABLE 8
Participants' Overall Assessments of the Visuals in Response to "I Found the Visuals to Be . . . "

Negative Concept	*Average Score*	*Positive Concept*
a. Very difficult to understand	6.34 ± .92	Very easy to understand
b. Not at all informative	5.32 ± 2.01	Very informative
c. Very hard to follow	5.97 ± 1.61	Very easy to follow
d. Not at all well organized	6.19 ± 1.05	Well organized
e. Did not enhance the information at all	5.82 ± 1.80	Enhanced the information
f. Not at all useful for understanding	5.99 ± 1.48	Very useful for understanding
g. Not at all interesting	5.76 ± 1.51	Very interesting
h. Not at all visually pleasing	5.84 ± 1.14	Very visually pleasing
i. Not at all attractive	5.35 ± 1.68	Very attractive

NOTE: Responses on a scale of 1 from 7.

the visualized presentations tended to rate the visuals slightly higher than the group viewing the nonvisualized presentations.

When comparing rural-mountain residents', town residents', and students' perceptions of the visuals, only two variables differed significantly between the visualized and nonvisualized presentations. The town residents viewing the visualized presentation rated the visuals as significantly better organized than did the town residents viewing the nonvisualized groups ($F = 2.50$, $df = 5, 133$, $p = .033$; $M = 6.55$ vs. 5.72, Duncan $p = .05$). The town residents viewing the visualized presentation rated the visuals significantly higher in improving their understanding than did the town residents viewing the nonvisualized groups ($F = 2.40$, $df = 5, 134$, $p = .040$; $M = 6.48$ vs. 5.39, Duncan $p = .05$).

Presentation and Perceptions of USDA Forest Service

Based on the presentation, participants rated the Forest Service and the agency's use of models highly. We found no significant differences within or between groups in participants' perception of the USDA Forest Service ($M = 5.93 \pm 1.57$, range 5.40 to 6.83 using a 1 to 7 scale where 1 = *strongly disagree* and 7 = *strongly agree*) and no significant differences in agreement that models, such as those described in the presentation, added to the credibility of the Forest Service ($M = 6.06 \pm 1.19$, range = 5.60 to 6.31).

When comparing responses within and between groups, the rural-mountain visualized participants ($M = 3.96$) and rural-mountain nonvisualized participants ($M = 4.37$) rated the Forest Service as significantly less helpful in protecting private property than did the town visualized participants (M = 5.58; F = 2.986, p = .014, df = 5, 128, Duncan p = .05), using the 1 to 7 scale where 1 = *not at all helpful* and 7 = *very helpful*). Further, the rural-mountain visualized participants (M = 3.96) rated the Forest Service as significantly less responsible in regard to fire management than did all other groups (M = 4.84 to 5.79, using a 1 to 7 scale where 1 = *not at all responsible* and 7 = *very responsible;* F = 4.80, df = 5, 131; p = .000).

Discussion

For natural-resource managers to engage in meaningful dialogue with the public about the conditions of forest lands and plans for future management, all parties must understand basic principles of forest succession, fire behavior, and forest-management techniques—including the use of computerized models. Our study, while limited in scope, demonstrates that carefully planned and developed presentations, whether visualized or nonvisualized, can help the USDA Forest Service communicate complex ecological and management information to diverse publics to improve their understanding of forest-management practices.

Developing and delivering an effective presentation is not a trivial matter. We spent more than 120 hours during some twelve weeks drafting, polishing, and refining the visualized and nonvisualized presentations to increase their effectiveness. A substantial amount of this time was invested in model runs useful for planning the communications. We designed visuals that helped illustrate, reinforce, and complement the concepts presented in the narrative. We worked at length with the stand-visualization system (software visualization program) parameters to obtain clear illustrations. We sought photographs that represented the terrain and vegetation common to mountains in or near where the participants lived. The data used for modeling were obtained from similar forests within one hundred miles of where the participants lived. Although we scripted the narrative, the presenters used the script as notes to guide their presentations rather than read the script verbatim. We believe this special attention and effort in developing and giving the presentations played a key role in making them effective.

Both the visualized and the nonvisualized presentations increased participants' knowledge and perception of their knowledge (as shown by increased knowledge scores and reduction in *don't know* responses) for three public audiences—rural-mountain residents, town residents, and students.

Participants reported that both presentations and the described model added to the credibility of the Forest Service. Even the rural-mountain residents, who tended to rate the Forest Service as less helpful than did the town residents and students, followed this pattern.

This study demonstrates that use of visualization and animation techniques can increase the appeal of a technical, information-packed presentation to the public. Participants ranked the visualized presentation more visually appealing overall than the nonvisualized presentation and ranked visual aids more attractive and easier to follow in the visualized presentation. These differences did not translate into consistently greater knowledge, however, as marketing research suggests might occur (Simons, Andres, and Petersen 2000), nor did the greater appeal of the visualized presentation lead to higher ranking of the agency's credibility by its viewers. McQuillan (1998) warns that the wow effect of technology may mislead the public into inappropriate confidence and certainty about model predictions, so managers may find it reassuring that visualization and animation did not appreciably alter viewers' confidence in model results.

The visualized presentation was associated with significant knowledge gain over the nonvisualized presentation only for the rural-mountain participants. Perhaps these participants were less able to interpret information in the nonvisualized presentation because they tended to be older and have less educational background in biology than town residents and students. This is congruent with Rieber's (1990) claim that animation may be particularly useful when learners may not know the relevant cues for assimilating information. The findings also indicate that research focusing on students and young, well-educated adults may not represent responses of the public in general. Large (1996) pointed out that most research on animation with adults has been conducted with undergraduate and graduate students (a convenient audience to sample), who may be better skilled at retrieving information from textual communications and forming internal images from text than other groups of adults. Rural-mountain residents viewing the visualized presentation showed greater knowledge gain than those viewing the nonvisualized presentation in regard to fire behavior but not in regard to succession—both topics that involve change through time. Thus, our research does not unequivocally confirm Large's assertion that animation may be especially effective for presenting topics that involve change through time.

Communication researchers have long recommended audience differentiation based on a range of characteristics (Friedson 1972) and have suggested segmenting audiences and presenting different mixes of information for different audiences based on their awareness of a topic and its relevance to them (Grunig 1989). The Research Roadmap Panel for Public Communication of Science and Technology in the 21st Century (Borchelt 2001) argued that diverse audiences have many different uses for science and technology information, and such audiences have many different levels of understanding of science and technology. Natural-resource managers must recognize that specific publics and stakeholder groups will interpret and use agency information on an issue in light of their preexisting information, knowledge, opinions, and attitudes on the topic and their perceptions of the risks associated with management decisions to themselves, their communities, and the environment. The media mix that benefits different publics may vary from one topic to another (O'Keefe, Boyd, and Brown 1998; O'Keefe, Ward, and Shepard 2002).

Communication research during the past thirty or more years suggests that even a well-prepared, skillfully delivered presentation can only be part of effective communications with the public. Increasing public knowledge of natural-resource management practices does not ensure agreement with those practices, so dialogue is essential. Stamm (1972) cautioned that information is only part of a complex array of factors influencing attitudes and public perceptions of natural-resource issues. After studying hundreds of studies of diffusion of information and hardware, Rogers (2003) cautioned against top-down technology transfer and called for community-change agents—community advocates with similar backgrounds as the public's—to help facilitate changes. Juanillo and Scherer (1995) called for a dialectal communication—that is, a democratic exchange of information, opinions, and issues among the different stakeholders—when communicating risk about scientific and environmental issues. They pointed out that many issues involve risks to the local residents or communities. In such cases, they argued for empowering stakeholders with the skills and background that will enable them to appreciate different perspectives, scrutinize opinions and perceptions about risks, and sharpen their skills for making judgments about environmental issues.

Recent advances in computer programming provide increasingly sophisticated visualization and animation techniques. For example, the Microsoft PowerPoint Office Suite 2002 lists more than thirty different animation techniques for presentations. However, research on the effectiveness of these techniques in enhancing communication has been sparse. Our study, while limited in scope, demonstrates a generally positive response by adults to the use of visualization and animation. It also illustrates the potentially complex outcomes of using these techniques to communicate specific knowledge and the potential differential effects of using these techniques with different audiences.

Some readers may question the time required to produce the PowerPoint presentation developed for this research. In this case, our data suggests that the time spent carefully identifying the primary, secondary, and other audiences, slanting the narrative (text) to such audiences, translating and explaining scientific terms, selecting or shooting appropriate photographs, and developing line art, tables, and figures produced effective presentations.

Conclusions and Recommendations

A carefully designed presentation can enhance public understanding and perceptions of understanding of complex ecological information, mathematical models, and natural-resource management practices. Use of visualization and animation in technical presentations can increase the appeal of the presentations, though it may not necessarily increase participant knowledge or alter participants' attitudes. Future research needs to investigate the effectiveness of different presentation techniques in public presentations with different adult audiences. Special attention should focus on investigating the salience of the topic to adult audiences; using alternative research designs, such as the Solomon four-group design or posttest-only control-group design (Campbell and Stanley 1963); and using larger, random samples.

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