Visualization models as predictive, data-based tools for assessing future ecological landscapes and supporting management decisions

Research thesis

In Partial Fulfillment of the Requirements for the Degree of

Doctor of Philosophy

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Submitted to the Senate of the Technion - Israel Institute of Technology

Sivan 5781, Haifa, May 2021

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The generous financial help of Ramat Hanadiv is gratefully acknowledged.

List of publications of this thesis:

(1) Hadar, L., Orenstein, D.E, Carmel, Y., Mulder, J., Kirchhoff, A. Perevolotsky, A. and Osem, Y., 2021. **Envisioning future landscapes: A data-based visualization model for ecosystems under alternative management scenarios** (*Landscape and Urban Planning).*

(2) Hadar, L., Orenstein, D.E, Carmel, Y. and Osem, Y., 2019. **Visual models as predictive, science-based tools for assessing future ecological landscapes and supporting management decisions.** *10th IALE World Congress, July 2019, Milano, Italy (Poster).*

(3) Hadar, L., Mulder, J., Perevolotsky, A. and Osem, Y., 2015. **3D visualization as a science-based tool for assessing future ecological landscapes and supporting management decisions: Demonstration from a Mediterranean Nature Park in Israel.** *9th IALE World Congress, July 2015, Portland, Oregon USA (Lecture).*

Abstract

Human-driven landscape changes strongly influence landscape functionality and aesthetics. While landscape planners have access to biophysical data for decision-making, they often do not have the necessary information about social variables, such as aesthetic tastes, feelings, or functions of a place. Visualizing future landscapes under alternative management scenarios could be a valuable tool for aiding land management decisions. Towards these ends, empirical, quantitative ecological data on vegetation composition, pattern, and processes in a Long-Term Ecological Research (LTER) site in Israel were integrated into computerized, 3-D representations of current and future landscapes.

Our objectives were (1) to visualize landscape-shaping processes, such as wildfire, grazing, and species colonization, to assist managers, planners, and the public to envision the long-term visual significance of management alternatives; (2) to validate the similarity between the 3-D model and reality, and; (3) to study the unique contribution of the visualization tool to decision-making processes regarding natural resource management, and how such models can mediate between objective features of landscapes and the way they are perceived by different audiences.

The visual model we developed is based on 30 years of scientific knowledge and ecological data describing vegetation processes in Ramat Hanadiv, a case study of ecological conditions and processes relevant to the Mediterranean and other complex ecosystems worldwide.

Validation was performed by comparing ‘current state’ model representation with real-world photos from the perspective of the observer. The model was found to be a valid representation of reality.

The contribution of the visualization to decision making, its impact on the nature of decisions, and the confidence level of respondents from different backgrounds and organizations were examined experimentally (N-176), compared to responses when participants were provided with scientific data through conventional tools (executive summaries, graphs, and GIS maps).

The visualization significantly increased the confidence level of respondents compared to those who received only conventional tools, as it allowed respondents to see the long-term management results of their decisions and reduce the uncertainty. In contrast, our

hypothesis that the visualization would influence management decisions towards greater intervention in nature was not supported. The visualization, when significant, was a moderating factor that reduced the tendency of respondents to choose an intervention management strategy.

However, the visualization did not operate as a universal language and management decisions were largely reflective of the professional background and organizational affiliation of the respondents. The visualization mainly influenced the confidence of respondents with a planning background, compared to those with a scientific background who presented high confidence level even without the visualization and were not affected.

Contrary to our expectations, the visualization did not affect the responses of the public group, who preferred executive summaries and sought further processing and mediation of the scientific information.

Looking to the future, I suggest that the ability to create future landscapes using scientific data can assist to improve decision-making processes, balancing ecological and social needs.

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1.0 Introduction

"For here the natural landscape is eloquent of the interplay of the forces that have created it. It is spread before us like the pages of an open book…"

Rachel Carson, 1962

Landscapes are socio-ecological entities that reflect a region's economic, cultural, and social history, past decisions and values, ecological conditions, and the interactions between these factors (Haberl et al., 2006). These qualities, and the fact that landscapes are dynamic by nature (Forman, 1995), make the landscape scale the most appropriate level of organization for discussing regional planning (Ahern, 1999; Wu and Li, 2006; Sutton, 2013), natural resource management and conservation (Turner et al., 2001; Sayer et al., 2013). In the decades to come, dramatic changes are expected in the natural environment due to human activities, such as changes in land-use practices, human population growth and climate change. The character of future landscapes depends on these changes and, to a great extent, on our decisions regarding the management and planning of natural resources and landscapes.

This research focuses on an effort to develop a visualization model of future landscapes under different potential management regimes, and to validate and test this model in stakeholder-driven management decision-making processes. As such, the research combines three unique, though sometimes overlapping, bodies of knowledge. These include (1) theories of land management, (2) landscape and landscape aesthetics research, and (3) landscape visualization and its use for integrating stakeholders into land-use management. In this section, I review each of these, as well as their spaces of overlap.

1.1 Active and adaptive management of Mediterranean landscapes

Mediterranean landscapes have been described as multi-scale mosaics of different vegetation types and structures, associated with high resilience and rich ecological diversity, co-evolving with social systems due to an ongoing history of human intervention (Naveh and Whittaker, 1979; Naveh and Carmel, 2004). They are often referred to as "human modified ecosystems" and "cultural landscapes" (Naveh, 1998; Blondel, 2006). Present and past management and land use, together with environmental and habitat variables, create structural and functional complexity associated with high diversity in terms of vegetation formations, dominant life-forms, dominant species, growth rates, etc. (Cowling et al., 1996; Farina, 2000; Perevolotsky and Sheffer, 2011).

In the face of increasing human pressures on natural ecosystems and their uniquely high biodiversity, Mediterranean ecosystems are important from a conservation perspective (Myers et al., 2000; Cox and Underwood, 2011). Hence, strategies concerning their management at the landscape scale needs to be established (Scarascia-Mugnozza et al., 2000).

Active management is one of the most contemporary approaches to managing open spaces (Perevolotsky, 2005; Perevolotsky and Shkedy, 2013). In contrast to a more traditional "hands-off" approach, active management advocates intervention in ecological processes to facilitate the provision of multiple benefits from the ecosystem. Such an approach is crucial for addressing a major challenge of managing landscapes that have evolved under frequent anthropogenic disturbances – controlling shrub encroachment and regulating woody vegetation cover and biomass (FAO and Plan Bleu report, 2018).

The **Long-Term Ecological Research network (LTER)** is part of the world-wide efforts to better understand ecosystems and processes through research and monitoring. LTER contributes to the creation of a knowledge base supporting policy and to the development of management options in response to global environmental challenges like climate change[1]. The research here took place in an Israeli LTER site which is part of this network.

Another concept, the **adaptive management strategy** (Holling, 1978; Haney and Power, 1996), is one of the pillars of the Long-Term Ecological Research Network (LTER, Baker et al., 2000; Haase et al., 2016; Mirtl et al., 2018), and is predicated on the idea that good scientific information will reduce uncertainty and inform future practices through a process that links management experimentation, hypothesis testing and observation of ecosystem responses (Nichols and Williams, 2006; Bakker et al., 2017). However, this approach has been criticized for its limited actual application and adaptation to different conditions and scales (e.g., Williams, 2011; Tony, 2020)

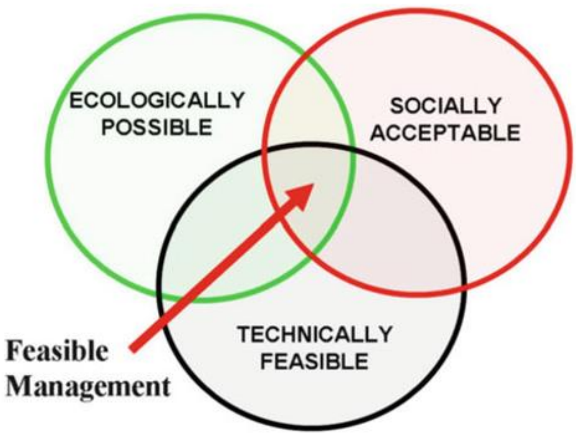
[1] https://www.lter-europe.net/

1.1.1 Incorporating social considerations into landscape management

Despite the availability of good scientific data and high public trust in science in general (Wellcome report, 2018), most decisions regarding the management of natural landscapes are challenged by additional considerations. These include tradeoffs, aesthetic values, and costs versus benefits, alongside individual and group interpretation, often influenced by underlying values and perceptions, e.g., what is the desired landscape and who should decide what is desired? How is the landscape perceived by people from diverse backgrounds and what are its important visual qualities, aesthetics, and functionalities vis-à-vis diverse human uses?

By combining empirical scientific data and subjective considerations regarding diverse priorities, desires, and perceptions, landscape management has the task of merging what ecosystem services an area can provide, what people want, and how the area can be designed and managed to achieve what people want (Oliver et al., 2013; Fig. 1). To meet the goal of integrating these components, both scholars and practitioners of land management must develop, test, and apply decision-support tools that can merge the public's needs with the area features towards management strategies that are both ecologically sound and socially acceptable (Robinson et al., 2019).

Fig. 1. Components of successful resource management (from: Oliver et al., 2013)



1.2 Landscape research

Landscape Research is wide-ranging definition that includes disciplines such as environmental conservation, human geography, landscape architecture, urban studies, archaeology, heritage and cultural studies, as well as landscape ecology.

Within this framework, the science of landscape ecology aims to provide a theoretical foundation and act as a guiding discipline supporting a management approach that integrates ecological knowledge and social considerations (Liu and Taylor, 2002). As an "interdisciplinary field that investigates problems and perspectives related to different perceptions of landscapes and the different interests of a wide range of actors" (Tress et al., 2005, pg. 2), landscape research provides an opportunity to connect a broad range of different expertise, develop integrative approaches that bring together ecological, cultural, and economic understanding and propose solutions to environmental problems (Naveh and Lieberman, 1994; Tress et al., 2005). Several scholars (e.g., Farina, 2000; Emborg et al., 2012) consider the field of landscape ecology to be the guiding discipline supporting such integrated approaches and the discipline best equipped to guide landscape restoration strategies. Without a theoretical foundation (such as that provided by landscape research), the questions of which landscapes are undesirable or preferable become a "value-driven popularity contest" (Emborg et al., 2012, pg. 140).

Nevertheless, in recent decades, landscape ecology has often been criticized for not being able to convey its theory into problem-solving nor the knowledge of species and landscapes to users without detailed understanding of ecological processes, such as managers, designers, and planners (e.g., Moss, 2000; Opdam et al., 2002; Nassauer and Opdam, 2008). A similar argument has been claimed regarding ecology in general (Carmel et al., 2013).

Although not all streams within the discipline of landscape ecology focus on practical management and decision-making, a process towards more applied research in landscape ecology is taking place, as reflected in the professional literature (Wu, 2017). Current concern for environmental issues resulted in the emergence of several new interdisciplinary research fields (e.g., ecological economics, sustainability science, ES science, ecological aesthetics), that aim at a more in-depth assessment of human-nature relations (Singh et al., 2013). Correspondingly, it is expected that landscape ecology will also evolve from being a science dealing with spatial patterns, scales, and heterogeneity (Pickett and Cadenasso, 1995) into a "transdisciplinary field, in which the degree of integration among disciplines, prominence of humanistic and holistic perspectives and direct relevance of societal issues all increase" (Wu, 2006, 2013).

1.3 The role of aesthetics in landscape management

With the increasing realization that land use management requires the integration of social perceptions, forest planners, designers, and managers are increasingly active in trying to define public perceptions of natural landscapes. People tend to judge things visually and such judgments can have major implications on public acceptability of different management plans (Bell, 2001). Human responses to the visual landscape derive from an interaction between the landscape's biophysical attributes and perceptual processes of the human viewer. A complex mental process of information reception and processing mediates between the physical and the mental landscape and is influenced by various biological, cultural, and individual factors (Jacobs, 2011).

In accordance with this perspective, the proposed research follows Hull and Revell's (1989) definition of landscape and scenes as: "The outdoor environment, natural or built, which can be directly perceived by a person visiting and using that environment. A scene is the subset of a landscape which is viewed from one location looking in one direction (pg. 324)". The perceived landscape, or ‘visual resource’, is therefore defined as the scenery encountered by the observer, i.e., **a function of the interaction of humans and the landscape** (also supported by Zube 1982; Arriaza et al., 2004 and many others). The human component is a subjective impression, reflecting past experience, knowledge, expectations, and the socio-cultural context of individuals and groups (Lewis and Sheppard, 2006; Jacobs 2011). The landscape component includes the attributes of the environment, both individual elements and landscapes, as entities. Researchers emphasize the importance of the landscape's complexity (Misgav 1994; Fry et al., 2009; Ode et al., 2010) and of external factors such as the viewer location, perspective, size of viewshed, distance from the object etc. (Stamps, 1997) in making aesthetic judgments.

There is some debate as to whether there are universal preferences or whether preferences are exclusively linked to individual, social and demographic contexts.

Aesthetic judgments are subjective by nature and often seem disconnected from the environment being judged. On the other hand, in accordance with Immanuel Kant's philosophy (1971), although the judgment of taste is based on a subjective principle, it has some universal validity which is derived from the assumption that everyone has the same cognitive capacities (*"sensus communis*").

Either way, defining preferences demands social research. A new branch of perceptions research introduces the concept of **cultural ecosystem services** as “the nonmaterial benefits people obtain from ecosystems through spiritual enrichment, cognitive development, reflection, recreation, and aesthetic experiences” (The Millennium Ecosystem Assessment, Sarukhán and Whyte, 2005). There is increasing acknowledgement that human well-being is tightly linked to natural ecosystems (Sarukhán and Whyte, 2005, Bieling et al., 2014), and landscape quality is regarded as providing a cultural ecosystem service (e.g., Daniel et al., 2012), a resource that arouses sensual, cultural, and spiritual responses essential to our quality of life (Zube 1982; Wu 2013). In urban society there is growing awareness of the importance of the visual component and of its roles in the mitigation of urban stress and as a stimulus for a range of pleasurable emotions (Ulrich, 1979, 1986; Zube 1982; Dwyer, 1992; Tyrväinen et al., 2014). The amenity values of forests, for example, both scenic beauty and recreational value, have become increasingly significant, especially near urban areas (Tahvanainen et al., 2001).

1.3.1 Approaches to landscape assessment

The field of landscape assessment tries to identify the ‘visual quality’ of landscapes and how it should be considered during the decision-making process. Objective categorization of landscape aesthetics can be based on expert judgement (the expert paradigm) or on judgements by lay people ("non-experts"), that value the landscape directly and respond to the stimulus it evokes, without cognitive processing (Zube, 1982).

Landscape assessment includes, in most cases, a description and classification of the landscape inventory, alongside ranking of the landscape's visual quality. The products of such an analysis are mostly presented as maps, tables, text, and graphic images. This approach is traditionally applied in many governmental organizations such as the U.S.

Forest Service, U.S. Bureau of Land Management, U.K. Countryside Agency, Natural England (Swanwick, 2002; Vlami et al., 2017).

Two main approaches are defined in the literature (e.g., Briggs, and France, 1980; Arriaza et al., 2004), with regard to the evaluation of landscape quality:

(1) **Direct approach** (public preferences) - includes methods that compare and integrate the subjective assessments of landscape quality by individuals or groups, in order to encompass the diverse and changing perceptions of individuals and to reach a consensus (Arthur et al., 1977). The essence of the preference approach is the judgment of the landscape as a whole, as opposed to other techniques, which rely on the definition of different components to explain variation in landscape quality. Several assessment tools are based on a 'more or less preferred' rating system for landscape preference, that can either refer to benefits associated with use (e.g., Amir and Gidalizon 1990; Misgav 1994, 2000), or with non-use, such as the willingness-to-pay (WTP, Kotchen and Reiling 2000; Shechter et al. 1998) or other methods (Fleisher and Tsur 2000).

(2) **Indirect approach** (descriptive inventories) - quantitative and qualitative methods for evaluating landscapes based on the presence and/or intensity of their features (Fines, 1968). These techniques are used mainly by planning and management professionals in the search for relationships between landscape features and landscape preferences. The basic assumptions underlying this approach are that the value of a landscape can be explained in terms of the values of its components, and that scenic beauty is embedded in the landscape components and is therefore a physical attribute of the landscape. This approach has been criticized for the subjectivity implied in the valuation of the components of the landscape and for the fact that it does not capture any interactive effects of the individual components (Dunn, 1976) nor does it portray the landscape as a complete entity (Misgav 1994; Minter 1999).

Whatever the approach, aesthetic discussions are challenging and may often not lead to consensual judgments due to a lack of an agreed-upon criterion for making such judgments (Zafon, 2016). The lack of standards for measuring the intensity of environmental visual impact is defined as one of the most important problem in environmental aesthetics (Cats-Baril and Gibson, 1986; Ode et al., 2008; Tveit et al.,

2013) that can, according to some critics, result in capricious and irrational decisions (Stamps, 1997).

1.3.2 Managing for both ecological and aesthetic value

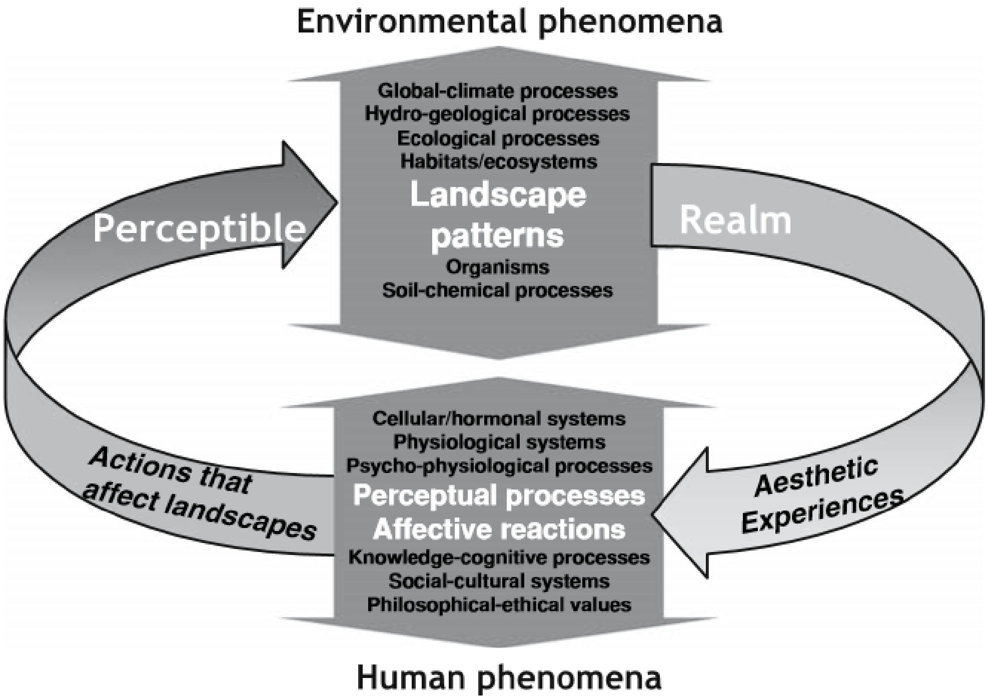
Many studies examined the impact of landscape management on ecosystem functionality and diversity (Turner 1989; Kolasa and Rollo 1991; Naveh and Lieberman 1994; Lavorel et al., 1997; Henkin et al., 2007; Bar-Massada et al., 2008; Gil-Tena et al., 2010; Gabay et al., 2011; Glasser et al., 2012). Such an impact is mainly the result of a change in landscape patterns through the intervention in vegetation cover and structure for practical and design purposes.

However, forest and landscape management activities such as clear cutting, thinning or removal of undergrowth have also impacts on the aesthetics and on the amenity value of the landscape. People have certain attitudes towards such management, particularly near urban areas, and land managers need to deal not only with changes in the landscape, but with changes in the public's perceptions of the landscape (Tahvanainen et al., 2001; Ryan, 2005; Depietri and Orenstein, 2020).

Bell (2001) reviewed the changes in forest landscape management between the years 1980-2000, particularly regarding the extent to which the visual component is incorporated into the landscape's management plan. He showed a move away from managing scenery by "screening and hiding", to planning and designing of the desired forest (the "positive design" approach, the British Forestry Commission, 1989) and, in the 90's, to functional forest planning based on natural patterns and processes ("ecological forestry", Gobster 1995; Seymour et al., 1999). The last idea is also embedded in other approaches such as "ecosystem management" (Grumbine, 1994) or "close-to-nature-management" (Larsen, 2012), in which the perceived forest aesthetics is based on appreciation of natural processes.

Some authors (Nassauer, 1995; Gobster et al., 2007) discuss the ways in which aesthetics and ecology may have either complementary or contradictory implications for a landscape, depending on the scale, interaction with the landscape ‘‘perceptible realm’’ (Fig. 2) and the personal, social, and environmental context. They argue that landscape planning, design, and management that communicate in a "recognizable landscape language" (Nassauer, 1995) and address the aesthetics of future landscape patterns, can be powerful ways to also protect and enhance ecological goals.

Fig. 2. Model of human-environmental interactions in the landscape (from: Gobster et al., 2007)



However, there are abundant examples showing that aesthetic quality does not always coincide with ecological goals, recreational goals, or other benefits like fire-protection (e.g., Depietri and Orenstein, 2020). A good example for that is the public debate vis-à-vis the creation of fuel-break zones in Mediterranean regions, a significant management activity in forest fire prevention. Fuel-breaks are areas in which the amount of fuel is reduced and are designed to locally modify fire behavior and therefore to limit damages and impacts to people and property and to the forest (Etienne, 1989; Agee et al., 2000).

Fuel-breaks are considered as an important component of the landscape mosaic supporting high biodiversity (Moreira et al., 2001; Ben Mayor and Simon, 2013; Hadar et al., 2013; Ashkenazi, 2016) and enriching the landscape as a whole by creating new landscape patch types and habitats (Gabay et al., 2008). They can serve as communal forests (Jeanrenaud, 2001) and supply opportunities for recreational activities (Koniak et al., 2011 and personal experience). Unfortunately, fuel-breaks are not always perceived as aesthetically attractive or even as good management by the general public (Ryan, 2005 and personal experience), that sees them as "sacrifice areas" and in many cases objects to their creation. Inherent conflicts between the management of natural areas for aesthetic and ecological objectives also exist with relation to the use of prescribed burning, and the decision to leave dead and downed trees in the forest. Both activities contribute to the health of the forest, provide new habitats, and are based on natural processes but decrease the perceived visual quality of the landscape and are hence not liked by the public (Ribe, 1989; Gobster 1999; Zimroni et al., 2016; Gundersen et al., 2017).

1.3.3 The role of information in landscape perception

The findings presented in section 1.3.2 emphasize the need to incorporate the visual factor into any management plan, but also raise the question of information and its role in changing the public's attitude and perceptions. Research has shown that the public’s visual preferences are affected primarily by the existing information and personal values and are often somewhat resistant to change (Daniel 2001). Other studies examined the way in which providing information about ecosystem management affects landscape preference and aesthetic appreciation. Kearney (2001) found an increase in acceptance and visual quality ratings for forest clear-cuts when the public was shown pictures of the resulting ecosystem that benefited birch and jack pine regeneration. Another study in the Pacific Northwest (Ribe, 1999, described in Ryan, 2005) found that providing information (through photo-simulation) about the ecological benefits of thinning increased the public’s acceptance for this practice, but not scenic beauty ratings. He concluded that acceptance for ecosystem management may be influenced by ecological information, while the visual preference is more resistant to change. Ryan (2005) reviews the literature and shows how the effect of information on scenic beauty ratings varies between subgroups such as office workers vs. students and how, when it comes to practices that have severe visual impact like fire, providing information could not overcome the effect and change perceptions. He highlights the importance of developing appreciation to landscape change and to natural processes as essential to ecosystem health.

These examples emphasize the importance, as part of any sustainable management approach, of incorporating the visual component and public perceptions into landscape management plans.

1.4 Integrating science and discourse-based management

In the last two decades, there is a growing recognition that anthropogenic impact on natural systems must be viewed and studied not only as external drivers (Grimm et al., 2000) or "one of the factors creating and responding to environmental heterogeneity" (Turner et al., 2001), but as an integral component of coupled social-ecological systems (Haberl et al., 2006). **Long Term Socio-Ecological Research (LTSER)** proposes new thinking that links humans with their environment (Redman et al., 2004; Collins et al., 2011; Mirtl et al., 2013), by combining long term monitoring, historical research, forecasting, and scenario building, all focusing on human and ecological systems and their interactions, towards more sustainable decision making (Singh et al., 2013).

These changes have catalyzed a shift from the traditional approach of "objective" expert-based decision-making regarding the management of natural resources, and particularly, of landscapes, to a broad “discourse-based” decision-making framework. Such a framework is one in which various stakeholders (e.g., citizens, NGOs) are involved in dialogue in order to address situations characterized by environmental or land use conflicts and it is becoming increasingly popular in both the literature (Cheng and Sturtevant, 2011; Emborg et al. 2012; Sayer et al., 2013) and in practice (Sheppard, 2005; Boedhihartono and Sayer, 2012; Orenstein and Groner, 2015; Mitchell et al., 2016). The key principles of this framework - community participation, knowledge-based decision-making and transparency of information are fundamental components of sustainable forest management (UNCED, 1992, Agenda 21).

Nevertheless, this approach is fraught with challenges, as it has to bridge gaps of combining empirical approaches and "soft knowledge" from the humanities, solve scaling issues, balance between “expert” knowledge and “local” knowledge and include human communication and learning as part of ecosystem management. Addressing these challenges is essential, as it is increasingly accepted in natural resource planning and management that while decisions regarding, for instance, forest landscape restoration may be perceived as simply an applied ecology and vegetation management issue, it is actually a deeply social and political process (Emborg et al., 2012). According to Emborg et al. (2012, pp. 135), we must move beyond a "one right view of good landscape (or forest) restoration" perspective to one recognizing the existence of many different ways to value landscapes. Orenstein and Groner (2015) also discuss the ambiguity of being ecologists who hold the conservation of rare species and biodiversity indisputable and at the same time socio-ecologists who see the importance of community participation in environmental decision-making. Accepting that view means that the ecologists themselves become stakeholders, and not "the agents of truth and last word in decision making" (pg. 292).

1.5 Ecological and social complexity of forest landscapes

Our knowledge of forest ecosystems and management impacts have expanded significantly in recent years (Schweier, 2018; Leal, 2019). This information is anticipated to support decision-making according to the sustainable forest management approach (Osem et al., 2008; Machar, 2020). However, forestry is a highly complex field that needs to integrate information from different disciplines and make it comprehensible to people of different backgrounds - forest managers, decision makers, and the general public (Meitner et al., 2005; Kaspar et al., 2018). One underlying problem is that alongside the spatio-temporal and biophysical complexity of the forest ecosystem lays social complexity with diverse goals, values, and visions of future forests. Social complexity also has a dynamic nature, and continuing changes in cultural norms and values are no less difficult to manage than the variability and uncertainty in the biophysical realm (Meitner et al., 2005).

Many studies have examined the impact of landscape management on ecosystem functionality and diversity (e.g., Turner, 1989; Glasser and Hadar, 2014), but far fewer studies address the actual impact of such management on aesthetic preferences (although see Gundersen et al., 2017; and a review by Gobster, 1999). Forest and landscape management operations such as clear cutting, thinning or removal of undergrowth have impacts on the aesthetics and the amenity value of the landscape. People have diverse and often strong opinions regarding such management, particularly near urban areas (Depietri and Orenstein, 2020), and land managers need to deal not only with changes in the landscape, but with changes in the public's perceptions of the landscape (Tahvanainen et al., 2001; Ryan, 2005; Depietri and Orenstein, 2020) and their implications on the acceptability of different management plans.

These challenges require the development of new decision-support tools that can make empirical data and scientific knowledge more accessible and relevant to stakeholder-driven planning and management processes and can help balance the tradeoffs between ecological and social management goals (Kaspar et al., 2018). This can be done, for example, by the illustrative demonstration of the consequences of different decisions in an interactive process between researchers and stakeholders (Haberl et al. 2006; Bennett et al., 2017).

1.6 Visualization and landscape communication

The need for effective communication in the management and planning of natural landscapes resulted in a considerable increase in the use of two and three-dimensional visualizations (Barrett et al., 2007; Lewis et al., 2012; Edler et al., 2020). However, the use of such information requires assessment of how people perceive and use it, and whether its use leads to more effective decision making.

Many authors have described and reviewed human reliance on visual information to process information and distinguish between different situations (e.g., Bruce, Green and Georgeson, 1996; Sheppard 2001, 2012). Visualizations are therefore considered a universal language that uses our innate abilities to understand visual information.

At the landscape scale, visualization models are particularly advantageous due to their ability to overcome the disadvantages of using purely ecological knowledge and data to convey information to the broader public. Measurements are in most cases limited to specific parameters and to small spatial and temporal scales and do not allow us to achieve an integrated picture of ecological processes (Haberl et al., 2006).

Three-dimensional, computer-based visualizations can assist in mitigating the difficulties of communication and understanding of complex ecosystems such as forests (Meitner et al., 2005). Most forest models treat forests as nested hierarchies of complex systems that change over time. Such complicated scientific information often cannot clearly be explained or absorbed by laypeople (Sheppard, 2012). According to Rensink (2000) we, as humans, are constrained in our ability to assimilate such quantitative information accurately and completely. We can detect subtle changes in a visual array when one situation is evaluated immediately after another, but in general we are unable to detect this change when a time lapse is applied between the two situations. In order to explicitly perceive change, we need focused attention, a phenomenon often referred to as "change blindness" (Rensink, 2000). Visualizations can overcome this constraint by, for example, a compression of the temporal scale like in a time-lapse movie thereby representing changes in data that are not commonly apparent to us (Meitner et al., 2005).

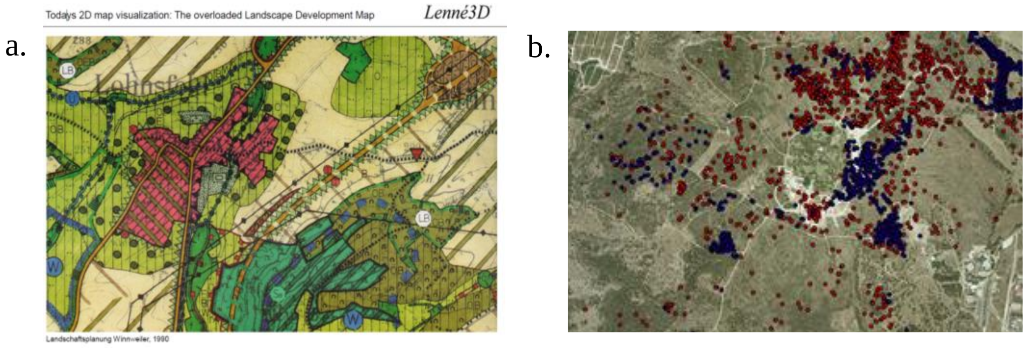
1.6.1 Advantages of 3D computerized visualizations

The use of visualization is not new, but in the last few decades there has been a substantial increase in the types, usage, and sophistication of such computer-based techniques towards highly realistic products from multiple viewpoints, through photo manipulation, retouch, image processing, 3D, etc. In the past, these techniques remained accessible to only a few experts. Today, technological developments have generated an increase in interest in the tool in many fields, including the film industry, virtual reality, and visual information in business. Computer games and the evolution of GIS into a more user-friendly tool created "hunger" and demand for realistic and interactive visualization capabilities. Consequently, the number of visualization preparers and users and their volume in planning decisions is also growing exponentially (Sheppard, 2012).

There are many ways to evaluate landscapes visually: actual visits to the field or forest, photographs, computer-aided graphics, and image-capture technology. Two-dimensional visualizations, although commonly used in fields like forestry (as maps, GIS inventory layers or spatial modeling outputs, see Fig. 3), are often too abstract and do not necessarily overcome the scale, the complexity, and the change blindness problems described above. Furthermore, these tools do not give a clue about aesthetics, sense of place, or functioning and hence lack the capability of visualizing the landscape in a way that can intuitively be assessed by stakeholders.

Therefore, visualizations were found in some cases to have limited utility in public participation contexts on forestry issues (Lewis and Sheppard, 2006). In contrast, 3D models can extrapolate present day monitoring from small scale plots with an unlimited amount of information layers, to be used as an empirical basis for future scenario building at large scales and can eventually represent "a whole spectrum of the environment" (Okunlola and Ewulo, 2013, pp. 135). Such models can be used to create different realistic representations of the data, which can be more easily assessed by stakeholders.

Fig. 3: Examples of common 2D tools to communicate planning and scientific data to non-experts: (a) Landscape development map and (b) GIS map showing trees distribution (Ramat Hanadiv)



Computerized, evidence-based visualization models can integrate social, economic, and ecological parameters and enable interdisciplinary analyses. 2D visualizations, although commonly used in fields like forestry (as maps, GIS layers or spatial modeling outputs), are often too abstract and cannot fully represent landscape complexity, particularly their aesthetic qualities. Photographs may provide valid representation of current landscape conditions, but their inability to represent future or hypothetical conditions limit their utility in public participation contexts on forestry issues (Lange 2001; Meitner et al., 2005). To compensate for the shortcomings of other visual data, 3D models can extrapolate upon data from plot-level monitoring with a vast number of information layers, including historical data and environmental changes, and so can be used as an empirical basis for constructing visual representations of future scenarios at large scales.

1.6.2 Representation of future landscapes using evidence-based visualization

When present state is the question under discussion, visualizations can naturally be compared to actual visits on-site. In a study conducted in Vienna, visualization was found to better direct attention to certain landscape elements and communicate the spatial structure, but on the other hand was poor in conveying aspects of materials and texture, movement, interaction, and light (Wergles and Muhar, 2009).

When comparing the use of visualizations with verbal information, it has been found that people's perceptions towards planned or managed landscapes do not always coincide. In a study in Finland (Tahvanainen et al., 2001), for example, people's perceptions towards different silvicultural treatments were compared from pictures produced by image-capture technology and from providing verbal information. The results show that preconceptions concerning the forestry treatments did not consistently correspond to the visual perceptions. The authors suggest that people may have certain mental images about the landscape under different management actions, even without any illustration.

Due to the many different meanings of the term "visualization", I would like to clarify that by "landscape visualization" (also called in the literature "visual simulations" or "landscape modelling"), I refer in this thesis to realistic, computerized, evidence-based 3D perspective views of actual places. The main advantages of such visualization models are that they allow us to "see" the three-dimensional structure of massive data sets, integrate social, economic, and ecological parameters and enable interdisciplinary analyses. Such models can simplify complex scientific information for consumption by non-experts (Lewis and Sheppard, 2006; Meitner et al., 2005) and enable people to experience the landscape more fully and from whatever viewpoint they choose (versus seeing the landscape solely from the planner’s viewpoint; Bell, 2001; Sheppard, 2012), using a medium that relates to people’s daily life in terms of what they are used to seeing.

Dynamic 3D models have the power and flexibility to present alternative future landscapes side-by-side, within the same setting, and over time, and therefore they offer a powerful comparative tool to engage people in environmental issues and problem-solving (Sheppard, 2005; Wergles and Muhar, 2009; Okunlola and Ewulo, 2013). Such models have been used, for example, to present visually the possible consequences of climate change, thereby educating stakeholders, raising community awareness, setting a common ground (i.e., boundary object) between diverse demographic groups, thereby catalyzing stakeholder-informed policy formulation (Sheppard et al., 2012; Schroth et al., 2015).

1.6.3 The use of dynamic media

While photographs can provide valid representation of current landscape conditions, an important limitation is that future or hypothetical conditions cannot be represented. To overcome this limitation, it is possible to create controlled visual simulations based on biophysical data associated with alternative future environmental conditions (as presented in this research). Advances in computer processing power and graphic software have substantially improved the precision and accuracy of environmental visualizations (Downes and Lange, 2015; Edler et al., 2020). Further, electronic communications and computer networks enable efficient and economical distribution of visualizations to expanding audiences. Consequently, the use of visualization in landscape assessment research and practice is gradually increasing as well (Lovett et al., 2015; Edler et al., 2020). As to presentation mode, concern has been raised about the relative ease that established media can be used to bias our perception. Some authors argue, for example, against reliance on static images for the communication of landscape experience, especially for landscapes that have significant dynamic or nonvisual (sound) elements (reviewed in: Daniel and Meitner, 2001). Danahy (2001) argues that the mode of visualization should match the human "dynamic and peripheral vision" and that communication of landscape experience should be complemented with dynamic viewing through immersive technologies and panoramic imaging. Orenstein et al. (2015), also highlight the contribution of using an immersive presentation (the Technion's Vizlab) for accentuating focus group discussions in a study of the social and cultural values of individuals and groups regarding a forest ecosystem.

1.6.4 Realism, abstraction and validity - challenges of visualization

Alongside their benefits, visualizations also pose challenges for both the preparers and the users (Sheppard, 2001; Nassauer, 2015).

One basic assumption behind the use of visualizations is that they reflect valid representations based on accurate perceptions and sound judgments made in response to direct experience with the landscape (Daniel and Meitner, 2001; Wergles and Muhar, 2009; Downes and Lange, 2015). This “response equivalence”, has been previously described as a fundamental requirement for many landscape assessments (Palmer and Hoffman, 2001; Lovett et al., 2015) and has been experimentally tested as a measure of validity (e.g., Bishop and Rohrmann, 2003; Wergles and Muhar, 2009).

However, the need for abstraction and simplification leads to a necessary compromise in realism. There is an open and ongoing discussion about what should be considered a valid representation of the landscape and what level of realism is sufficient for engaging the public (Lange, 2001; Appleton and Lovett, 2003; Billger et al., 2016). Several researchers argue in favor of maximizing realism. Highly realistic visualizations of forest landscapes were found to be more valid (Daniel and Meitner, 2001; Lange, 2001; Ribe et al., 2018) and improve communication.

Daniel and Meitner (2001) compared scenic beauty ratings for an identical set of forest landscape scenes, based on four visualization modes differing in their realism-abstractness dimension. Their conclusion was that data visualizations intended to provide indications of perceived scenic beauty would be valid only if high levels of photo-realism were achieved in the graphic displays. This conclusion was also supported by Barrett et al. (2007) who found that simplified representations of forest structure were hard to communicate even to experts without the addition of verbal information, all the more to the general public. Although, in general, highly detailed visualizations improve communication, the type of landscape elements was also found to be important since not all elements of a visualized scene are of equal importance in helping the viewers to imagine the landscape. According to Appleton and Lovett (2003), effort may be best directed towards improving the realism of the ground, including vegetation, especially in the foreground.

The Mediterranean landscape provides an excellent opportunity to explore this approach due to its high structural complexity (Morán-Ordóñez et al., 2019), rich biodiversity, and the lack of a "natural landscape" archetype. Given the high complexity of these landscapes, our main challenge was to find the optimal balance between abstraction and realism and identify the minimal set of landscape variables that will provide a valid representation of an extremely diverse plant community in the eyes of the beholder. However, I believe the research will also be relevant to a wide range of dynamic and highly complex ecosystems, such as tropical forests, managed commercial forests, forest-savanna transition zones, and more.

A significant portion of the literature reviewing visualization deals with improving communication of environmental data by combining different data sources or translating numbers into symbolic or figurative representation or images (Metze, 2020; Edler et al., 2021). Visualizations are often used to illustrate the visual impact of adding elements such as wind turbines or solar panels to the landscape (Maehr et al., 2015; Ribe et al., 2018), or to envision possible large-scale impacts of climate change (Sheppard, 2012; Schroth et al., 2015). Yet, very few express the science of dynamic ecosystem processes, such as grazing or fire that have complex effects on ecosystems.

The combination of emerging technological developments, access to information, responsiveness (interactivity) and visual immersion through panoramic displays ("virtual reality"), have led to concerns regarding potential misuses of the technology (Sheppard 2001; 2012) and a tendency to be enchanted by the technology and thus steer towards particular decisions (Appleton and Lovett, 2003; Lovett et al., 2015). One of the main challenges has been the high dependence of the final products on the process (in terms of assumptions, content and context choices, viewpoints, scale, resolution, etc.), and on the mode of presentation (screen size, immersive display/static presentation, color).

Moreover, the data do not always correspond to the highly realistic visualization systems and any small inaccuracy can mislead the viewer. These limitations are inherent in the visualization medium and cannot be completely compensated. However, keeping the transparency of the medium so that the viewer will be able to identify mistakes, retrace the steps of the preparation and develop "healthy skepticism" may, to some extent, moderate these limitations (Sheppard, 2001).

A "good enough visualization" was defined by Perkins (1992, in Sheppard, 2001) as one with *"A high degree of perceived realism, conveys maximum quality, contains enough data, yet is efficient in terms of equipment costs, storage and management…"* Other authors have highlighted key principals such as providing high-quality bio-physical data, linking the visualization to scientific models in order to have a defensible product (Bell, 2001) and, obviously, defining the goals and audience. In addition, it is important to accept the fact that visualizations are not universal but target, context, place, and audience specific.

As a final consideration: as described earlier, visual products are highly dependent upon the process, and consequently may significantly affect observers' perceptions, understandings, and evaluations. In a highly cited paper from 2001, S.J. Sheppard from UBC, called for establishing a framework for guidance and supporting resources for landscape visualization, and above all a code of ethics, to develop what he calls “defensible landscape visualizations”. This article raised awareness and many other researchers and visualization preparers today (e.g., Schroth, 2010; Lindquist 2015) refer to or follow Sheppard's proposed principles: accuracy, representativeness, visual clarity, reliability, fidelity, truthfulness, ecological validity, image veracity *(Proposed interim code of ethics for landscape visualization, S.J. Sheppard 2001).*

Facing these challenges, my goal was to develop a valid tool based on ecological data and in-depth scientific research, which can be used for the communication of complex landscapes to various audiences. The visual products (images, panoramic tools, and short films) that were developed and validated in the first stage of my research, were tested in the second stage to assess their efficacy in communicating to decision makers and the public future landscapes possibilities and the science and management strategies that may shape those futures (Fig. 4).

1.7 Summary

What might the future landscape look like? Which factors will shape it and what influence will managers and planners have on these processes? Will the landscape be "right" or desirable, and if so – for whom?

Schroth (2015) defined visualization to be a "time travel", showing historical or future conditions and bringing the future to life. Despite the limitations described above, visualizations have two important advantages from a "sustainability" perspective. First, given the fact that our management decisions made today will impact future generations, the visualization technology allows us more easily to put ourselves "in the shoes of our grandchildren", when we make decisions about ecology, functionality, aesthetics, and uncertainty. Furthermore, as mentioned above, visualization as a knowledge communication tool has a key role in the translation of information and conversion of data from one form to another which is more appropriate for users. Visualizations can simplify complex scientific information by collecting it and presenting it in familiar patterns. However, in the dialog with stakeholders and the public, we should remember that "information transfer is not a one-way street" and that these technologies are also capable of representing the ideas and "mental models" of the community, allowing information to flow in the other direction" (Meitner et al., 2005).

The use of visualization offers great potential as a component of stakeholder-integrated land use and nature resource management and planning. Nevertheless, there is an immediate need in additional research aimed at refining the models and their use, and providing scientists, practitioners and planners with tools that will help them communicate in a common language in order to balance competing objectives and improve the way the management meets the goals of maintaining and enhancing the visual quality of landscapes, while simultaneously considering ecological characteristics.

2.0 GOALS AND REASEARCH QUESTIONS

In this study, I present a state-of-the-art 3D computerized landscape model and assess the quality of visualizations produced by the model, and their potential relevance for management decision-making. The model is based on long-term, quantitative ecological data, which is used to visualize the predicted appearance of future landscapes under alternative management scenarios.

Our overall objective was to develop and validate our models, both regarding their degree of perceived visual accuracy (section 3.1), and their utility in stakeholder-driven management processes (sections 3.2 and 3.3).

The goals of this research were:

I. DATA-BASED VISUALIZATION MODEL: DEVELOPMENT AND VALIDATION

To visualize major landscape shaping processes, such as wildfire, cattle grazing, or species invasion, to managers, planners and the public and envision the visual significance over decadal time scales of management alternatives.

To develop a data-based visualization model of future landscapes under different management regimes, and to validate it.

Question 1.1:

How can quantitative scientific data describing vegetation composition, structure, and spatial pattern, be translated into a three-dimensional computerized visualization model of current and future landscapes?

Question 1.2:

Is the model a valid representation of reality? i.e., does the visualization reflect the same perceptions and judgments that would have been made in response to direct experience with the landscape?

II. APPLICATION: EFFECTS ON DECISIONS AND LEVEL OF CONFIDENCE

To study the unique contribution of data-based visualization models to decision-making processes regarding natural resource management, and how such models can mediate between objective features of landscapes and the way they are perceived by different audiences.

Question 2.1:

Does the visualization model and its capability to illustrate future landscapes change management decisions compared to the use of data presented by conventional means such as maps, graphs, and verbal information ("conventional tools"), and how?

Question 2.2:

Does the visualization model affect the level of confidence that people have in their decisions compared to conventional tools, and to what extent?

Question 2.3:

Will the effect of the visualization on both aspects (decisions themselves and confidence) be different for people from different organizations or with different professional background (scientific, planning, or without relevant background)?

III. APPLICATION: EFFECTS ON PERCEPTIONS OF DIFFERENT GROUPS

To explore and characterize how data-based visualization models can integrate different perceptions and values on intervention in nature, complexity of ecosystems and the role of science in decision making to promote discourse-based sustainable management.

Question 3.1:

How do people with different professional backgrounds perceive the tools that were used to communicate scientific knowledge (text, maps, and visualization), in terms of the extent to which they assisted them in making decisions about landscape management?

Question 3.2:

What are their opinions regarding the level of realism of the visualization model, complexity versus simplicity and contribution to decision-making?

2.1 HYPOTHESES

1. The data-based visualization model is a reliable representation of the best of our knowledge and experience about the management of Mediterranean vegetation.
2. Exposure to the visualization model will significantly influence respondent decisions, more favorably predisposed to active intervention in the natural ecosystem and more confident in their decisions, because it allows to see what the results would look like and reduce the uncertainty.
3. Different professional groups perceive active management differently, therefore I expect an interaction effect between the model and the professional background, such that people with different professional backgrounds or from different organizations will respond differently to the visualization model.

2.2 STUDY SITE –RAMAT HANADIV NATURE PARK AS A CASE STUDY

My research was conducted in Ramat Hanadiv, a privately-owned Nature Park and memorial to the Baron Edmond (Benjamin) de Rothschild, operated for the benefit of the public by the Rothschild Foundation. The site covers approximately 450 hectares of land perched on a plateau at the southern tip of the Carmel Mountain range, overlooking the coastal plain and the Mediterranean Sea to the west, and the Samarian Hills to the east. At the heart of the park are the carefully manicured Memorial Gardens and the crypt of the Baron and Baroness Edmond de Rothschild. Surrounding the Gardens is a Mediterranean Nature Park consisting of open landscape abundant with indigenous fauna and flora. The Nature Park also features historical and archaeological sites, accessible through a network of hiking trails. The integration of educational, scientific and leisure functions makes Ramat Hanadiv a unique site in Israel. The Park represents a set of conditions and processes relevant to many landscapes in the Mediterranean region and is one of the most researched and closely managed open spaces in Israel. All data and past research are publicly accessible at: http://ramathanadiv.maps.arcgis.com/home/index.html

The varied vegetation formations dominating the nature park reflect the climatic gradient, the topographic and edaphic variability, and the impact of human activity over long historic periods, including grazing and tree cutting. The typical vegetation formation in Ramat Hanadiv is Mediterranean garrigue dominated by low or mid-size shrubs such as *Phillyrea latifolia*, *Pistacia lentiscus* and *Calicotome villosa*, and by the dwarf shrub *Sarcopoterium spinosum*. Between the shrub clumps are exposed rock or shallow soil patches covered by herbaceous vegetation. As part of its historical conservation policy, Ramat Hanadiv was fenced in 1950, and grazing was excluded from its area for a period of 40 years, until the early 1990s. Although this policy facilitated the regeneration of woody vegetation, it also led to the encroachment of herbaceous patches, altered the composition of vegetation and animal communities, and increased the frequency and intensity of wildfires (Seligman and Perevolotsky 1994; Perevolotsky and Shkedy, 2013). Like other places around the Mediterranean basin, the main management challenges include controlling woody vegetation cover, minimizing fire intensity and damage, determining, and managing optimum cattle and goat grazing regimes, adaptive management for climate change impacts, and dealing with pine colonization and invasive species.

Ramat Hanadiv has invested efforts in ecological research since 1985 and from 2003 the Nature Park operates as an LTER site. Within this framework, and in addition to studies dealing with specific research questions, a long-term monitoring program of several predetermined variables and organisms is being conducted. The vision of this program is that the combination of monitoring and management will allow, over the long term, to conserve and enrich the diversity of species, communities, landscapes, and processes that characterize the Mediterranean landscape in the park.

2.3 RESEARCH APPROACH: DATA-BASED MODEL

The complex interactions between scientific data, their interpretation and their integration in management strategies necessitate the development of scientific concepts and tools for better understanding of how different perceptions and values affect interpretation of scientific knowledge and its application in management decisions.

To address the research questions, I developed (in cooperation with programmers from *Lenne'3D*, Germany) and tested three-dimensional computerized landscape models which are based on quantitative ecological data and can therefore visualize the scientifically predicted appearance of future landscapes under alternative management scenarios.

Based on GIS layers, satellite imagery, and quantitative datasets derived from field observations representing over 25 years of research in the park, we developed a model that visualizes decadal time scales of management alternatives related to different situations of mixed garrigue-pine ecosystems. Such alternatives are, for example, selective or complete pine removal, cessation of grazing, post-fire treatment and doing nothing ("letting nature take its course"). A special emphasis is placed on the role of Aleppo Pines in the Mediterranean landscape and the process of pine colonization, a management challenge relevant to many Mediterranean ecosystems.

In the process of developing the 3D model, detailed scientific knowledge and ecological parameters were used to describe vegetation structure and processes (species composition, cover, height, density, spatial pattern, gaps). Detailed description of the model, the data used, basic assumptions and technical information is elaborated in the methodology section.

3.0 METHODOLOGY

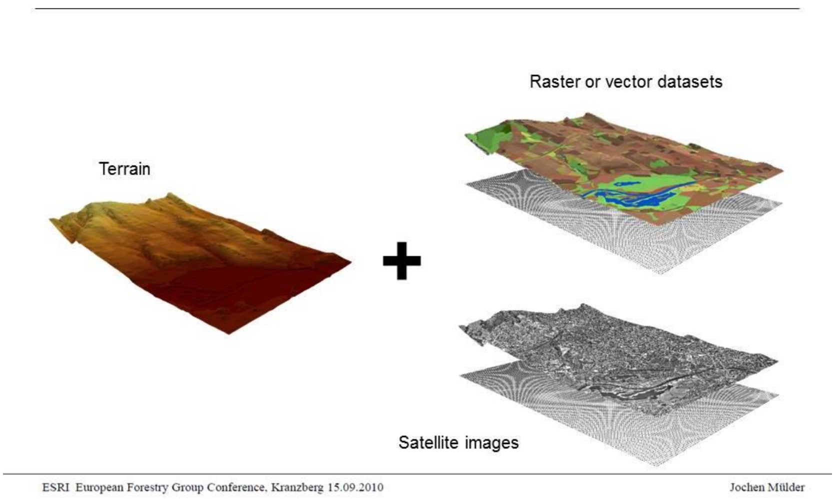
3.1 DEVELOPMENT AND VALIDATION OF A DATA-BASED MODEL:

This chapter describes the process of developing a visualization model of Ramat Hanadiv's current landscapes (3.1.1); testing the model's validity vs. reality (3.1.2); and developing a data-based visualization model of Ramat Hanadiv's future landscapes, under different management scenarios (3.1.3).

The approach: Geo-visualization

Geo-visualization or "Geographic Visualization" can be described as a set of tools and techniques to support the visual representations and analytics of geospatial data. Geo-visualization emphasizes information transmission by the communication of geospatial information in ways that, combined with human understanding, allow data exploration and decision-making processes (Laurini, 2017).

Fig. 5: Main elements of Geo-visualization (J. Mulder, 2010)

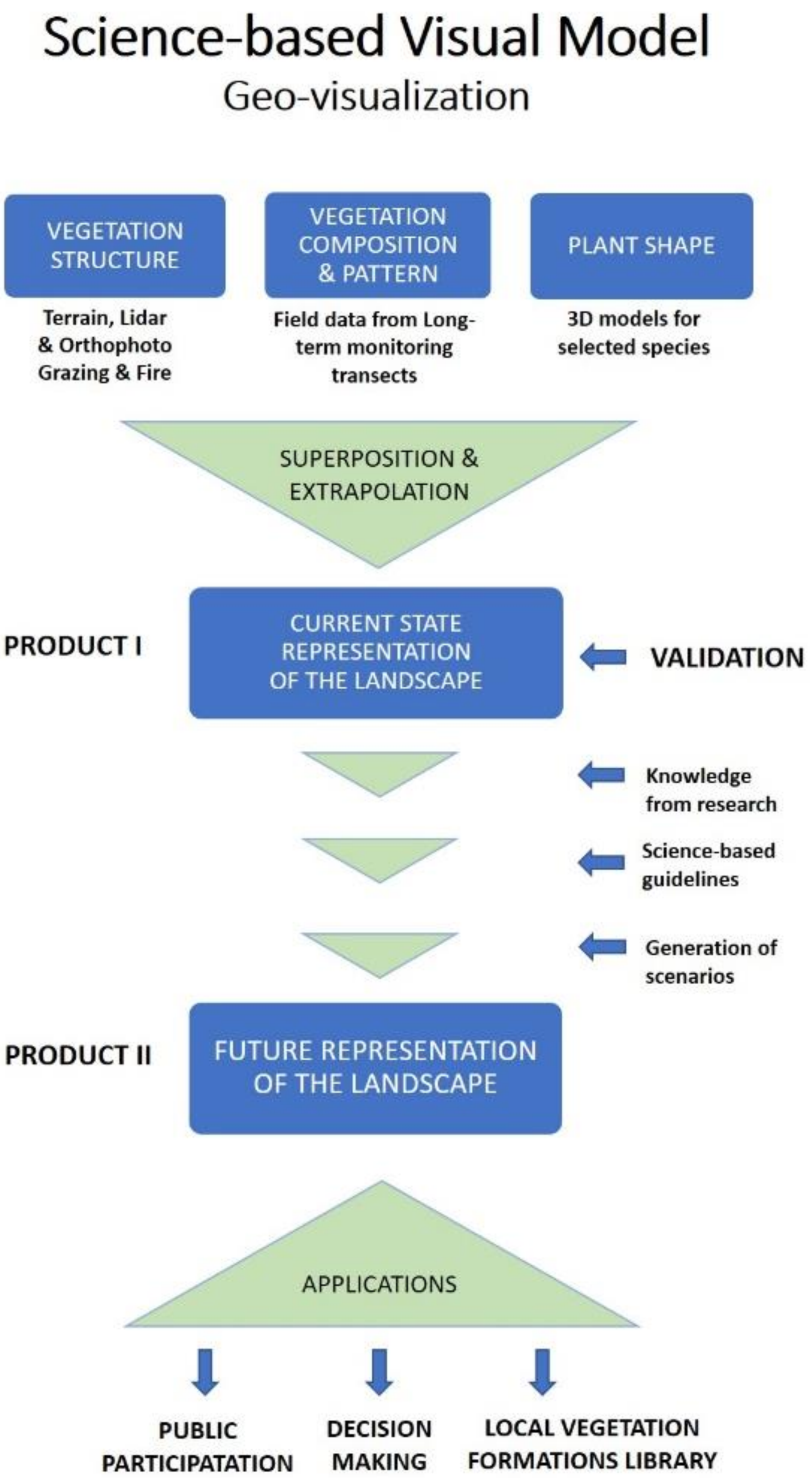


The models were developed in cooperation with ***Lenne'3D GmbH,*** a German company that offers modelling and 3D visualization services and develops software products for interactive rendering of landscapes and gardens, using the geo-visualization approach (http://lenne3d.com). The software used was a visualization system developed in-house by *Lenne'3D* programmers and called Biosphere3D**.**

The model provides real-time 3D landscape visualization of large landscapes (approx. 500 ha) based on quantitative data describing species composition, plant sizes and distributions, patch types and spatial patterns. A set of realistic and botanically coherent plant models was created for each of the 27-plant species chosen for the model (Table 1a-b). The model is characterized by (1) its interactivity (provides real-time-landscape visualization); (2) the highly detailed plant models, botanically accurate as possible; (3) the level of detail (visualizing large landscapes with millions of plants); (4) photorealistic and sketchy representation; (5) its ability to model 3D landscapes, including realistic plant distributions, plant community composition and spatial patterns; (6) its ability to support different standards (XML, Shapefiles).

The first and most important stage of the process was to develop a reliable representation of the current landscape state, to serve as a basis to any future scenario. Developing the current state representation was a bi-directional dynamic process that involved calibration and refining of the products by five different landscape management experts, all with close familiarity with the field itself. The experts mainly addressed the level of realism of the elements in the image (soil color, trunk texture, appearance of a certain species, flowering intensity of herbaceous patches or shrubs, etc.). This stage of "**expert validation**", alongside a “validation perception experiment” (detailed in section 3.1.2), was important to reach the best representation possible of current reality. Only after completing this stage, the model was used to develop future scenarios, according to parameters, assumptions and guidelines determined by the researcher team.

Fig. 4: Flowchart describing stages in developing the visualization model



3.1.1: DEVELOPMENT OF THE CURRENT STATE MODEL

I. Data sources:

Several data sources were used in creating the current state model, which, at the second phase, served as the basis for all future scenarios.

(a) **Terrain:** Within Ramat Hanadiv Nature Park, the data source was a Lidar image from 2012 (res. 1x1m). Outside the park, the free SRTM global terrain was used (res. 90x90m).

(b) **Imagery** (mostly not visible in the 3D model): within Ramat Hanadiv an orthophoto from 2011 was used (res. 0.25x0.25m). Outside the park, BING Map was used (via ESRI, res. 1x1m).

(c) **Texturing:** Draped textures within the park were based on Ramat Hanadiv's soils layer (Kaplan, M., 1989), with some spatial details added to it. A layer of roads and trails was drawn based on the imagery.

(d) **Management:** I used GIS layers representing the prominent grazing management categories in the park (cattle and/or goat grazing vs. ungrazed areas), and a layer separating areas that were previously burnt (in 1980) and those not.

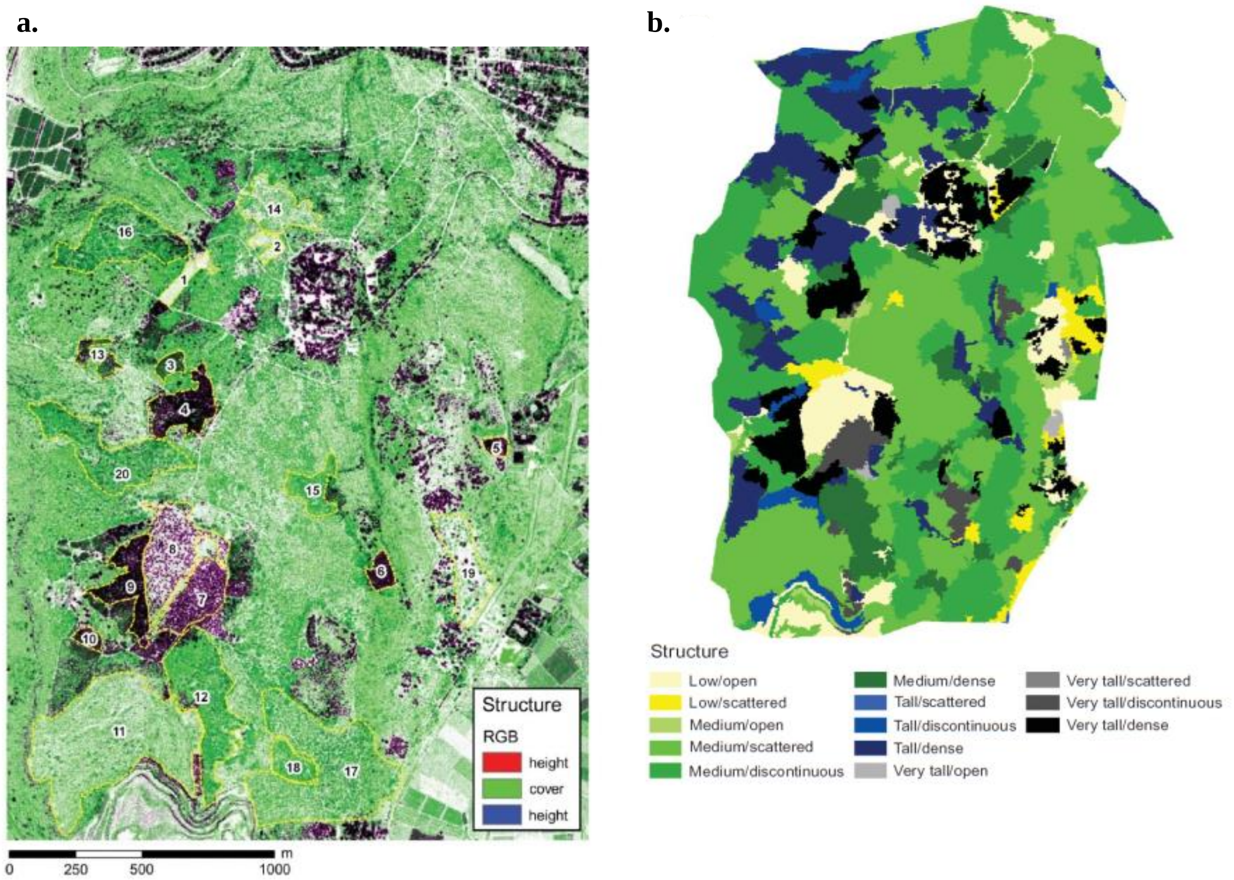
(e) **Vegetation type:** The visualization was based primarily on a vegetation structural types map of Ramat Hanadiv, produced from aerial photography and Lidar datasets (Bar Massada et al., 2012, Fig. 6a-b), in which different categories (e.g., tall dense maquis, medium sparse garrigue, sparse cypress grove, etc.) represent vegetation height, density and dominant woody composition**.**

Detailed description of categories:

- The categories "low open shrubland"; medium sparse garrigue" and "medium dense garrigue" were directly taken from the Lidar categories.
- The types "tree dense-cypress" and "tree sparse-cypress" were taken from the Lidar and manually assigned to the areas where cypress trees actually exist.
- The type "tree dense-*Pinus brutia*" and "tree sparse-*Pinus brutia*" were taken from the Lidar and assigned to all other "tree dense" and "tree sparse" areas of the Lidar data.

- The distribution pattern for the "tall dense maquis" category was created by analyzing the stand data for the overstorey and LTER plots data (vegetation transects) for the understory.
- In any case of missing data, a protocol for the collection of complementary field data was developed and applied.

Fig. 6a-b: Vegetation structural units, created by automated segmentation of Lidar and Orthophoto layers (Bar-Massada et al., 2012). (a) Raster map; (b) Vector map after auto-segmentation.



(f) **Aleppo pines *(Pinus halepensis)*:** The most widespread pine species and the most extensively used for afforestation in Israel. In the last decades, its expansion into natural habitats is becoming a frequent occurrence and an important environmental issue (Lavi et al. 2005).

All pines were divided into three size categories: large, planted trees; seedlings above 3m and seedlings below 3m.

Distribution of planted pines was taken from historical information layers followed by a detailed field survey (Osem et al., 2011). Tree height attributes were taken from Lidar (DSM-DTM).

Seedlings above 3m (recognizable and based on an aerial photo analysis (Osem et al., 2011). Tree height attributes were taken from the Lidar. If the Lidar height was below 3m, then random values were assigned from the rest of the trees that have height attributes.

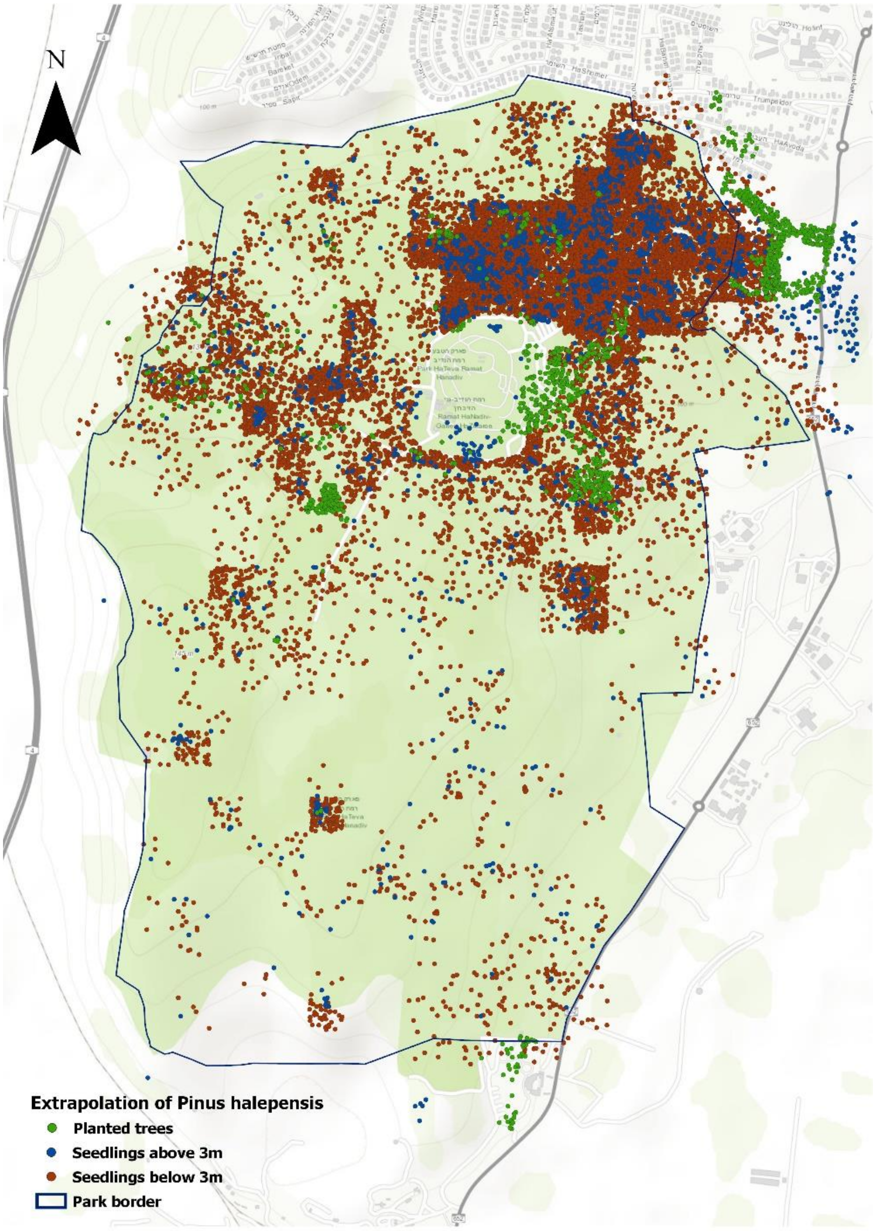
Seedlings below 3m: data were based on a fine resolution ground survey conducted by Osem et al. (2011, sample only) and extrapolated to the scale of the park (using a 100x100m grid, Fig. 7).

Mode of extrapolation:

- 100x100m grid for the area of the invasion front (highest density, North of the park, Fig. 7).
- Count of seedlings above 3m for each cell.
- Count X 12 seedlings below 3m for each cell, based on the ratio from the ground survey.
- Random distribution in each cell.
- Random tree heights between 0.6-2.5m.

Since I had a limited number of model types, each tree had to be assigned to a particular model, according to rules based on its height, location (in forest or stand alone, and its dehydration state (dry or green). Following these rules, trees of 4-6m are represented by 4m height models, trees of 6-10m are represented by 9m height models and trees of 10-16m are represented by 12m height models.

Fig. 7: Aleppo pine extrapolation map (based on the findings of Osem et al., 2011). Map is based on a 100x100m grid, drawn for the area of the highest density, North of the park and used to extrapolate the number of seedlings to the park's scale. In each cell, seedlings above 3m were counted, multiplied by 12 to get the number of "below 3m seedlings" and randomly distributed, with random tree heights between 0.6-2.5m.



II. Creating 3D models for selected species

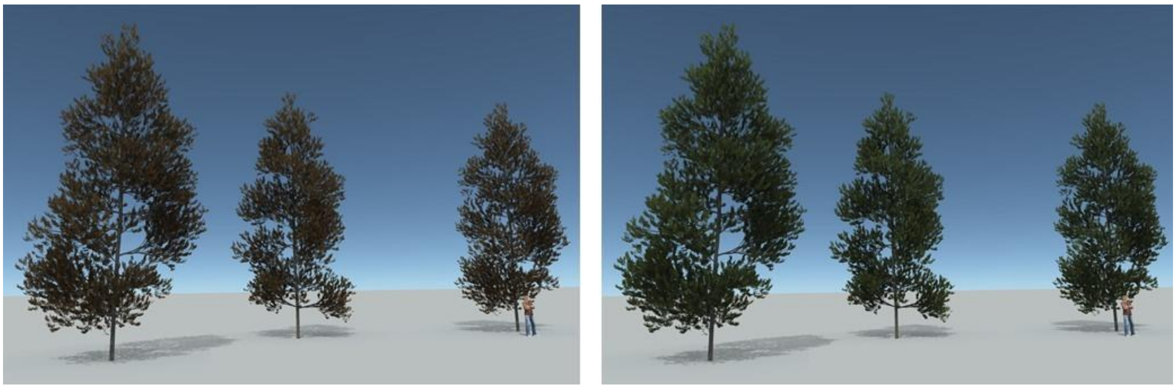
In this stage, 15 woody plant species and 12 herbaceous species that are considered prominent in the ecological and aesthetic landscape (“key players”) were identified and represented in their current condition and under every future scenario. These species include all local tree and shrub species that grow in the nature park, that have been described before as "landscape modulators" (i.e., species that create distinct landscape patches, that differ from their surroundings, Shachak et al. 2008), along with 5 dominant species of climbers, and common herbaceous species that represent typical patches and different life forms (geophytes, hemicryptophytes & annuals). All models were assigned for specific vegetation strata and distributed according to spatial pattern data for each structural type, e.g., patch size, distance between patches, distribution mode (random, aggregated, structured). The data required for each model was derived from prior ecological knowledge and high-resolution photos (Fig. 8a-c). It included the plant’s species, developmental stage, age, height, growth habit (in forest or stand-alone), condition (green/dry/green crown ratio), season, number of trunks, canopy and trunk diameter, colors, and textures (Table 1a).

Fig. 8a: Evolution of a plant model (*Anemone coronaria*, Source: ***Lenne'3D*****)**

Fig. 8b: Quality and level of detail: High Dynamic Range images (HDR)

Fig. 8c: Intra-species variation in size and dryness level

(*Cupressus semperivirens*, Source: ***Lenne'3D*****)**



III. Vegetation modeling of structural types

The cover and distribution of different structural types were derived from the vegetation structural types layer described above (Bar Massada et al., 2012, Fig. 6b).

8 different categories were defined: *(1) Low open shrubland; (2) Medium dense garrigue; (3) Medium sparse garrigue; (4) Tall dense maquis; (5) Dense Pine grove; (6) Sparse Pine grove; (7) Dense Cypress grove; (8) Sparse Cypress grove.*

Vegetation modelling was conducted as follows: Average vegetation gaps, as well as the relative cover and height distribution for each species, were derived from transect measurements. Since the number of species in the vegetative community exceeds the number of species reproduced for the 3D models, coverage was extrapolated to only the species represented by 3D models. Distribution patterns for each species were estimated from species sequence and grouping within the transects. Health conditions (% dead and dehydrated trees in each structural type) were also incorporated into the model. The typical composition of common herbaceous patch types is also represented in the model, as detailed in section III below.

Table 1a: plant models used in the visualization – woody layer

Species	Height	Variation	Species	Height	Variation
Calicotome villosa	2.84m	Green	***Pistacia lentiscus***	1.2	Green +/- fruits
	1m	Green		0.6	Green +/- fruits
	2.84m	Dead (dry)	***Quercus calliprinos***	3.9m	Green, 1 trunk
	1m	Dry		3.5m	Green, 3 trunks
Olea europaea	5m	Green, Solitaire		3.9m	30% dry, 1 trunk
Pinus brutia	10m	Dry, Forest		3.5m	30% dry, 3 trunks
Pinus halepensis	1.2m	Green, Seedling		3.9m	60% dry, 1 trunk
	1.2m	Dry, Seedling		3.5m	60% dry, 3 trunks
	2m	Green, Young		3.9m	Dead, 1 trunk
	2m	Dry, Young		3.5m	Dead, 3 trunks
	4m	Green, Solitaire	***Cupressus semperivirens***	10m	Green
	4m	Dry, Solitaire		10m	Dry
	9m	Green, Solitaire		2m	Green
	9m	Dry, Solitaire		2m	Dry
	12m	Dry, Solitaire	***Sarcopoterium spinosum***	0.58	Green (semi-dry)
	9m	Green, Forest	***Ceratonia siliqua***	6m	Green
	9m	Dry, Forest	***Asparagus aphyllus***	1.9m	Climber on Phyllirea
	12m	Green, Forest		2.7m	Climber on Pistacia
	12m	Dry, Forest	***Clematis cirrhosa***	2.4m	Climber
	12m	Green, Solitaire	***Ephedra foeminea***	1.7m	Climber
Phillyrea latifolia	1.5m	Green	***Smilax aspera***	2.4m	Climber
	1.5m	Dry	***Rubia tenuifolia***	1m	Climber
	3m	Green			
	3m	Dry			

IV. Vegetation modeling of herbaceous patches

The herbaceous plant community of the nature park is composed of more than 500 species that could not all be represented by models of individual species. Therefore, the vegetation in the different herbaceous patches was represented by 5-6 dominant species characterizing each patch (through size, life-form, appearance). Herbaceous patch types were based on quantitative field data from vegetation sampling of transects (Table 1b). Distribution patterns were derived from relative frequency data of the represented species. All these models were assigned for the herbaceous layer. Since only few representative species were modeled, and to avoid a potential visual bias caused by extrapolating the cover of attractive flowers, only the real relative frequency for each species was represented in its full form (including the flower) and the rest in its green form (without the flower).

Four typical patch types were represented (Fig. 9a-d): (a) Un-grazed patch (full potential green); (b) Grazed patch; (c) Anemone patch (which develops under heavy cattle grazing conditions); (d) Cyclamen patch (common in dense pine understory).

Fig. 9a-d: Representation of herbaceous patch types

(a) Typical ungrazed patch (4% anemone); (b) Typical grazed patch (1.3% anemone); (c) Anemone patch (grazed, 18% anemone); (d) Cyclamen patch (ungrazed, pine understory, no vines).

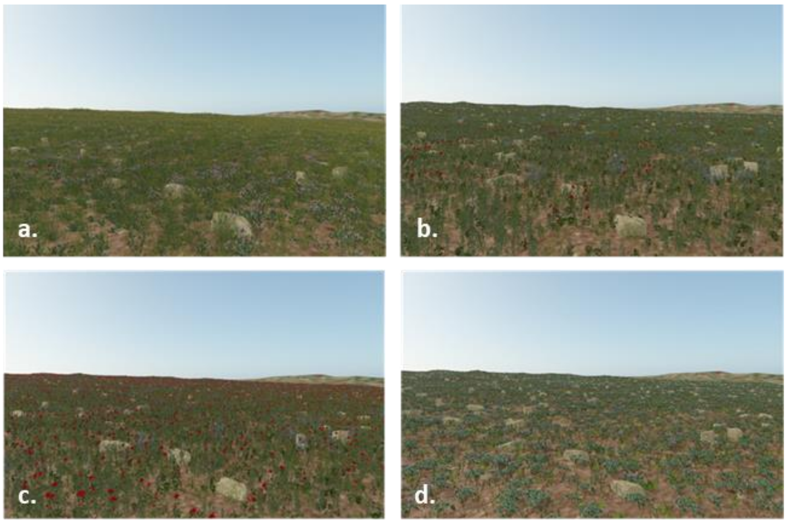


Table 1b: plant models used in the visualization – different herbaceous patches

Species name	%	Life form	Height
Un-grazed patch			
Brachypodium distachyon	0.029	annual grass	0.20m
Cyclamen persicum	0.038	geophyte	0.15m
Andropogon distachyos	0.011	perennial grass	0.7m
Piptatherum blancheanum	0.011	perennial grass	0.7m
Urospermum picroides	0.022	composite	0.35m
Grazed patch			
Brachypodium distachyon	0.022	annual grass	0.2m
Eryngium creticum	0.021	spiny composite	0.40m (Rosette 0.03)
Plantago afra	0.016	small prostrate	0.2m
Trifolium clypeatum	0.014	legume	0.2m
Allium trifoliatum	0.017	geophyte	0.4m
Cyclamen patch			
Allium trifoliatum	0.037	geophyte	0.4m
Aristolochia parvifolia	0.047	geophyte	0.18m (width 0.5m)
Cyclamen persicum	0.331	Geophyte (climber)	0.15m
Geranium Robertianum	0.066	annual forb	0.17m/0.2m
Asparagus aphyllus	0.261	climber	
Clematis cirrhosa	0.129	climber	
Anemone patch			
Anemone coronaria Full form (flowering)/ Green form (nonflowering)	0.180	geophyte	0.25m

% = Relative frequency

V. Data structure

OIX files are special file format by *Lenné3D GmbH* describing schematic plant distributions based on the previously described relevant data. They include a controlled vocabulary (ontology) of defined vegetation types and parameters such as coverage (quantified), distribution pattern (sociability) and height tolerance (plant type ratio) for each 3D model (XML files). All models are assigned for specific vegetation strata.

More details regarding the development technical aspects can be found in: Hadar, L., Orenstein, D.E, Carmel, Y., Mulder, J., Kirchhoff, A. Perevolotsky, A. & Osem, Y. Envisioning future landscapes: A data-based visualization model for ecosystems under alternative management scenarios. Accepted for publication in *Journal of Landscape & Urban Planning,* August 2021.

3.1.2 VALIDATION OF THE MODEL

In developing the model, I attempted to achieve the necessary abstraction without compromising on visual realism. The expectation for a high degree of persuasive power, high complexity, and high dependence on the process and technology of 3D visualizations (Sheppard, 2001; Nassauer, 2015), demands the demonstration of enough similarity between the model and reality before it can be implemented in decision-making processes.

As my research deals with people's visual perceptions of landscapes, and I assume that the scenarios are based on the best available ecological knowledge (Table 2), the most important indicator that the models are valid is that of whether the models are considered to be reliable representations of landscapes from the perspective of the observers. Therefore, in addition to the expert-based calibration process, I conducted a validation procedure based on the way people perceive the landscape.

Validation was conducted by comparing the current state model representation with the real world (photo "frames" taken in the field at the very same locations as were reproduced from the model, Fig. 10a-b, Fig. 11). My assumption was that perceived similarity between the model and the field photographs would be sufficient to assume that people would trust the model and refer to it as a valid representation of reality.

The "current state" model representation of 12 selected locations in the park (Fig. 10b) were compared, separately for each case, to a set of 8 "real world" photos taken in the field. In each set, only one photo represents the same location and angle as the model (this will be referred to as the "model photo", Fig. 10a) and the rest from a "photo pool" taken at all other locations (approx. 80 photos).

All the field photos in the photo pool were taken by a professional photographer, from the same coordinates, height, aperture, zoom, light conditions and season (late winter) as represented in the model, but from different angles (taken at exact angles with a compass, to avoid bias, Fig. 10a). Images with distractions such as sea view, cars, or goats, that could have caused bias in judgment have been removed from the image database. This stage was completed in Mid-February 2016.

The next stage was querying a sample of 40 professional respondents (ecologists, landscape architects, foresters, and local land managers) regarding the similarities between the model and the field photos. To examine whether the visualization reflects the same perceptions and judgments that would have been made in response to direct experience with the landscape, the respondents were shown a set of 8 photos and an image from the model in 12 iterations and asked to select and rank the 3 photos that in their opinion were most similar to the model image (see example, Fig. 11). The set of 8 photos, to which the model image was compared, were composed of the model photo, taken from the same location and angle, and 7 other photos taken at other locations (to avoid auto-correlation) that were randomly picked from the photo pool. It was emphasized to the respondents that the model represents average vegetation structure and composition, hence one should not look for similarity in the location of every object in the image but refer to the appearance of the landscape as a whole.

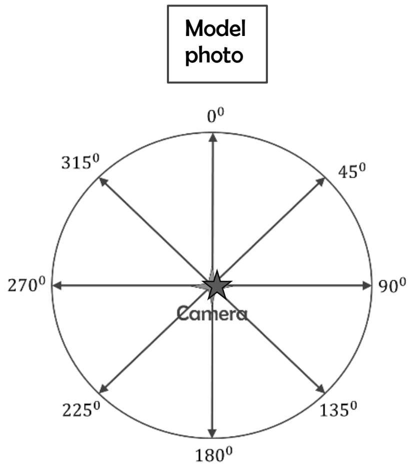
Statistical analysis

All the respondents' choices were encoded into a general binary matrix and analyzed using *Repeated G-tests of Goodness-of-fit* (McDonald, 2014), to check whether there was an overall deviation from the expected distribution and whether there was a significant variation among the different locations. This method suits nominal variables with p values adjusted for multiple comparisons.

VALIDATION EXPERIMENTAL DESIGN

Fig. 10: (a) Sampling circle demonstrating a single camera location and the angles towards which the photos in the field were taken (b) a map of the camera locations within the park area. The colors represent different vegetation structures.

a.



b.

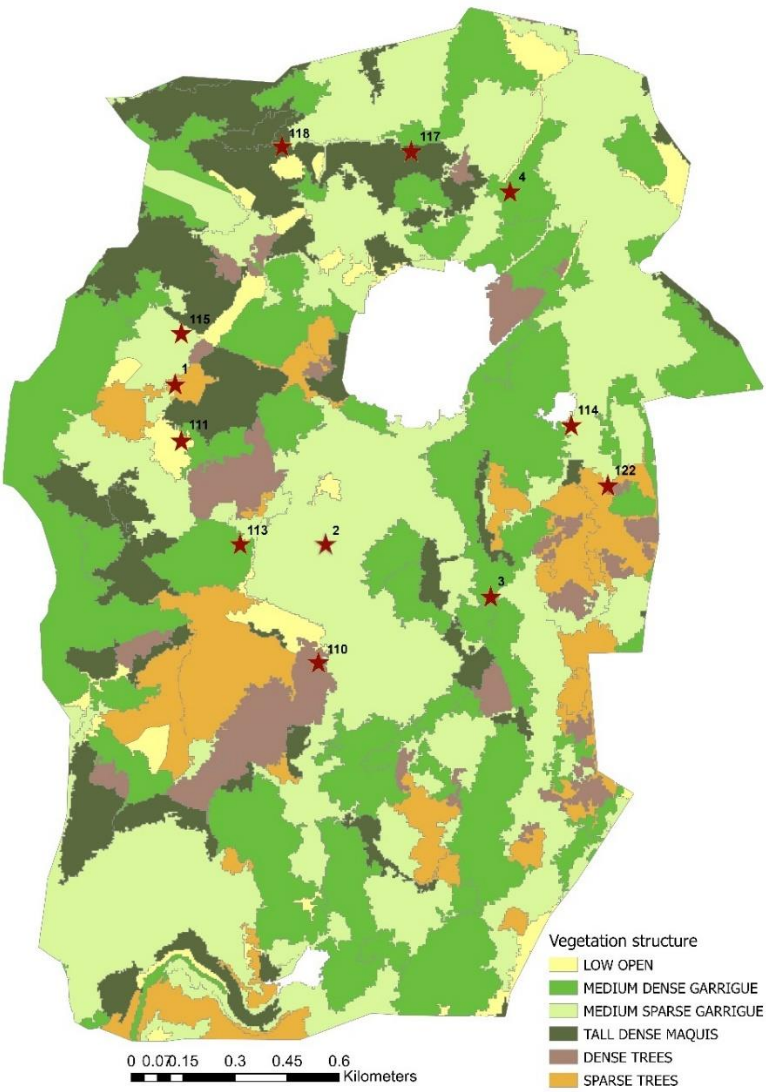


Fig. 11: Example of an experimental panel to test the perceived fit between the model (right) and field photos. Location 117b, matching photo is number 3

Results of the validation exercise are reported in the Results section 4.1.2. below.

3.1.3: DEVELOPMENT OF FUTURE SCENARIOS

Only after the completion of the current stage model and its validation, was the model used to develop future scenarios, according to the parameters, assumptions and guidelines determined by experts (the research team).

Seven management scenarios were developed, all based on a 1-hectare cell size, representing an average management unit. The scenarios visualize and predict the appearance of future landscapes under alternative management decisions. They differ only in vegetation structure and composition without the introduction of new species or patch types. In choosing the scenarios, I focused on land management challenges common to many areas in the Mediterranean region (over decadal time scales), e.g., what would be the visual significance of post-fire treatments, selective or complete removal of pines from the ecosystem, cessation of grazing or "letting nature take its course”, i.e., allowing for vegetative succession with no active or direct human intervention (Table 2).

The output of this stage is a computerized dynamic model of the whole park, from which different images and short films that represent the current state, and the future landscapes of Ramat Hanadiv were created. Fig. 14, for example, represents one specific location (garrigue with sparse pines), in the current state (14a) and in seven different future scenarios. Another perspective, with a road, is represented in Fig. 15a-h.

Table 2. Ecologically based guidelines for the creation of future scenarios

SCENARIO	1	2	3	4	4a	5	6
DEFINITION	**BUSINESS AS USUAL (BAU; no change in management)**	**COMPLETE PINE REMOVAL**	**MODERATE INTERVENTION**	**POST FIRE; 10-year projection.**	**POST FIRE; 30-year projection.**	**POST-FIRE PATCH MANAGEMENT**	**CESSATION OF GRAZING**
PROJECTION HORIZON	30 years	30 years	30 years	10 years after fire	30 years after fire	30 years after fire	30 years
DETAILS	Cattle & goat grazing continues; Aleppo pines left as they are (no treatment)	Removal of all Aleppo pines of all sizes	Complete removal of Aleppo pines below 3m every 5 years	Wildfire burns the entire area. Scenario will present a ground cover of seedlings of the same age (cohort), 4m tall	Wildfire burns the entire area. Scenario will present a mature, tall, and dense pine forest with an upper layer of same age and a suppressed understorey with pine seedlings	Pine management - applying different treatments to different patches to create a heterogeneous landscape pattern	Cease all cattle and goat grazing in the entire park area
GUIDELINES	Planted pines stay as they are	Understorey changes will not be modelled	Planted pines stay as they are	Seedlings will be distributed as follows: 4-6 seedlings in a radius of 10m around every pine that was present before the fire	Seedlings will be distributed as follows: 4-6 seedlings in a radius of 10m around every mature pine that was present before the fire. Above density of 150 trees/hectare, pine digital model changes from solitary to grove growth form.	The north part of the park ("invasion front"), where patch management will be applied, and the south part of the park, where all pines will be removed, ("Pine Free Zone", PFZ), will be separated	After 30 years, our assumption is that each formation experiences succession as follows:
	Seedlings > 3m will grow to 9m or 12m (randomly) + 10% random death		Seedlings > 3m will grow to 9m or 12m (randomly) + 10% random death (to mature trees)	30% removal of the woody garrigue cover	All seedlings will be 12m tall (a cohort)	In the northern part, management will be as follows:	Tall dense maquis patches stay as they are (dominated by oaks)
	Smaller pines will be added according to the key 1:12 (300m from a dispersing tree); or 1:4 (greater distance). They will be randomly distributed between height categories 2,4 and 9 m. +10% random death (all sizes)		All Aleppo pines < 3m will be removed	Tall Phillyrea shrubs will be removed, only ≤ 1.5m shrubs will be left	20% random mortality (25% mortality in patches with tree density above 150 trees/hectare)	Management units will consist of one-hectare patches	Medium dense garrigue patches consisting of tall, dense maquis, stay as they are (dominated by mature Phillyrea and Pistacia)
	Understorey changes will not be modelled			Tall Pistacia shrubs will be removed – only shrubs ≤ 0.6m will be left	Tall Phillyrea shrubs will be removed, only 1.5m shrubs will remain	Patches (one-hectare grid cells) will be randomly distributed in the area, and each will be subjected to one of three treatments:	Medium sparse garrigue transforms to medium dense garrigue
					Removal of the woody garrigue cover 30% more that in scenario 4 (due to pine shade)	**(1) Complete removal of all pines (60% of the northern area)**	Low open areas transform to medium sparse garrigue
					Within a 10m perimeter around every mature tree, 4-6 seedlings (2m tall) will be distributed	**(2) Mixed forest 50-100 trees/hectare (30% of the northern area)**	Coniferous grove understory experiences a 30% increase in height and cover
					Tall Phillyrea and Pistacia shrubs will be removed from the model	**(3) Coniferous forest 200-300 trees/hectare (10% of the northern area)**	Aleppo pines experience a 40% decrease in density
					Relative cover of Pistacia will increase by 20% (as it is more shade tolerant than other shrub species)		

3.2 APPLICATION OF THE MODEL: EFFECTS ON DECISIONS AND LEVEL OF CONFIDENCE

The visualization model, that was developed and validated in the first stage, was tested regarding its effect on people’s decisions about landscapes and landscape management strategies.

I suggest that the model's advantages include objectivity, high level of visual realism and simplification of the complex picture of the Mediterranean landscape.

These qualities allow the user to present to a sample of stakeholders, different scenarios in the same areal setting and ask them to make management decisions based on the information provided. Their decisions in the various situations and their level of confidence will be examined and compared - with and without the model.

More specifically, I examined:

1) The potentially unique contribution of a data-based visualization model to decision-making, as compared to the use of data presented by means of conventional tools such as maps, graphs and verbal information (question 2.1);
2) Whether or not the use of the visualization model helps respondents to be more confident regarding their decisions (question 2.2), and;
3) Whether responses to the use of the visualization models were different depending on the professional background of the respondent (question 2.3).

3.2.1 Experimental design

To answer these questions, I invited both professionals and the community to participate in a decision-making experiment, consisting of answering a set of management questions. The experiment took place during 2018-2019 (in 6 different sessions).

Research venue

As my research is based on the case study of Ramat Hanadiv, that can be characterized according to its public and professional community, I decided to conduct this stage of the research at Ramat Hanadiv's visitors pavilion, in a large semicircular meeting hall, without 3D screening.

This enabled me to keep uniformity in the perspective from which the landscape is presented to the respondents (bird's eye view, from within the landscape, etc.) as well as to other variables related to the mode of display that have the potential to significantly affect the results (screen size, screen resolution, light conditions, same room, chairs, seating arrangement with respect to screen position etc.).

Recruitment of participants

I desired to sample diverse audiences and succeeded in bringing 176 participants (aged 26-81; Ave = 49.42, SD 12.48), of which 2/3 were professionals - planners, ecologists, and land managers - and 1/3 were from the general public, to participate in the experiment (see Table 3).

The "professional" respondents' group was composed of professional teams in organizations that manage open landscapes, such as The Forestry Service (JNF), the Nature Park's Authority or the Department of Natural Resource Management in the Ministry of Agriculture, as well as of landscape architects that live and work in the area. I approached all these organizations and offices through a direct call to participate in a decision-making experiment regarding landscape management.

The "public" group was based on people of miscellaneous backgrounds from the nearby community, who responded to the call to participate in the experiment.

Experimental settings

In each of the 6 sessions, the participants were randomly assigned to two equal sized groups **'treatment' (**visualization model**)** and **'control'** (conventional tools) and separated into two different identical rooms. The term "conventional tools" refers to common tools that have been accepted in the history of planning for making information accessible to decision makers: GIS maps, executive summaries, and graphs.

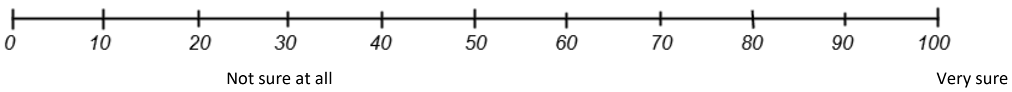
Each executive summary included an accessible one-page summary and one simple graph (Appendix 3). The GIS maps were created for maximal accessibility and visibility in terms of information layers, background, and symbology (Appendix 4).

Throughout every step of the experiment the groups were guided by two experienced mediators that followed the same (written) guidelines, to prevent bias that may have resulted from providing missing or excess information to one of the groups.

Prior to the start of the experiment, and in order to bring all participants to a common ground (baseline), a short ppt. presentation with visual background about the park's goals, landscape, topography, trails, and vegetation accompanied by short explanations was presented by the mediators to both groups.

The groups were provided with the same scientific information presented either through visualization models and/or by conventional tools (GIS maps, executive summaries, and graphs). The respondents were asked (independently) to "wear the hat" of Ramat Hanadiv's Nature Park manager and provide their choices of alternative management regimes that impact the landscape visually in 5 different cases, representing relevant management dilemmas based on the information that was provided to them and according to their own perspective.

In every situation, the respondents were given two options to choose from and asked to make a decision (e.g., to clear/not to clear the pines in the area). Each respondent was asked to specify the degree of certainty s/he has in their decision in a scale of 0-100% (e.g., 75% certain that I want to clear the pine trees), see full Questionnaire in Appendix 2.



The questionnaire was composed of 3 sections, each of which deals with a different management dilemma, including post-fire treatments (1 case), pine colonization and forestry treatments (3 cases), and grazing regime (1 case). Each case included an **"intervention scenario",** as compared to a **"non-intervention scenario**".

These two definitions may be directly linked to "active management" vs. "conservation", but since in Mediterranean ecosystems conservation sometimes involves intervention, the meaning of the "non- intervention" scenario is mostly keeping the management as before (Business as usual, BAU).

The dilemmas were as follows (see detailed description of scenarios in Table 2):

Case 1: "Clearing scenario" - Clearing of all pine trees vs. BAU (no intervention)

Case 2: "Thinning scenario" - Clearing of all pine trees vs. Thinning

Case 3: "The moderate scenario" - Thinning vs. BAU (no intervention)

Case 4: "Grazing scenario" - Cessation of grazing vs. BAU (no intervention)

Case 5: "Fire scenario" - Post fire patch management vs. BAU (no intervention)

All the information provided to support decision making (except printed executive summaries) was screened to the group in a loop, on wide screen, without any time limit.

In order not to base their answers on a single case, and to widen their perspective, the visual significance of different management choices for the long term (30 years) was presented, for each case, from 3 different locations and perspectives.

Since the mode of presentation and the perspective of the visual information have the potential to affect responses, the perspective of the visual scenes was maintained as uniform as possible, and all information regarding the preparation of the visuals were transparent and accessible to respondents.

It was emphasized to the participants at the beginning of every session that there is no right or wrong answer, that each section stands on its own, and that they may change their minds and answers.

In addition to the three sections described above, the questionnaire also had a fourth section in which participants were asked to prioritize the tools presented to them and indicate the extent to which they helped their decision-making. Open questions about the experiment were also part of this section.

Table 3. Experimental design (number of respondents per group, N=176)

N/A – background unknown.

Group / **Background**	**Treatment** Conventional tools + Visualization Models	**Control** Conventional tools
Scientists	29	35
Planners	28	25
Public	23	25
N/A	9	2
Total	89	87

Group / **Organization**	**Treatment** Conventional tools + Visualization Models	**Control** Conventional tools
NPA (Nature and Parks Authority)	12	15
JNF (Forestry Service)	23	22
Public	24	21
Landscape Architecture firms	23	18
Academic institutions	7	11
Total	89	87

3.2.2. Statistical analysis

Every decision was defined and categorized as a choice of an "intervention solution" versus a "conservative solution" (non-intervention). The average level of confidence as well as the number of cases in which the respondent chose an "intervention solution (percentage out of 5 cases) were calculated for all the respondents.

Data analysis examined the effect of the treatment (the visualization model) and affiliation group on the nature of the decisions (choice of intervention/non-intervention) and on the level of confidence, using 2 approaches:

1) **Logistic regression** (nominal logistic fit) **for each of the 5 cases (dilemmas) separately,** to examine the effect of the treatment as the independent variable and the affiliation group as another explanatory variable on the decisions (dependent variable). The affiliation group was defined either by the variable "Professional background" (levels: Scientific; Planning; Other) or by the "Organizational affiliation" (levels: NPA; JNF, Landscape Architecture firms (independent); Academic institutes; Public).

Age Category and place of residence in childhood (Urban; Rural) were also examined as covariates but were found to be non-significant and were therefore removed from the analyses.

2) **Analysis of variance** based on two dependent quantitative variables:
   (a) Average confidence level (%)
   (b) Choice in intervention (number of cases out of 5)

The analyses were done for the differences in the average level of confidence and the percentage choice for an "intervention solution" between treatments and affiliation groups (2-way ANOVA; Student’s t-test). Since these variables are proportional (percentage data), arcsine square root transformations were done to normalize the data.

A Shapiro-Wilk test was conducted for normality of errors and Bartlett's test was conducted for homogeneity of variances. In cases where ANOVA assumptions were not met and appropriate mathematical transformations could not be found, non-parametric, signed-rank analyses of the data were performed, as suggested by Conover and Iman (1981).

The parameters "age category" and "place of residence in childhood" were also examined and found to have no effect on the choices and confidence level (and were therefore removed from the analysis).

All the analyses were done using JMP 15, SAS Institute Inc.

3.3 APPLICATION OF THE MODEL: EFFECTS ON THE PERCEPTIONS OF DIFFERENT GROUPS

At this stage, a qualitative analysis was performed to study the perceptions of the participants in the experiment (previous stage) vis-à-vis the visualization model, its role and limitations in decision-making following their experience, as well as about issues like intervention in nature through vegetation management, complexity of natural ecosystems and more. Also, I wanted to explore qualitatively whether the tools to which the respondents were exposed (visualization model or conventional tools) affected their perceptions towards these issues.

Three sources of information were used at this stage:

I) **Multiple choice questions:** at the end of the questionnaire (see Table 11 in appendix), the respondents were asked to provide their opinion on the experiment itself and the extent to which the various sources of information presented to them contributed to their decision.

The results of the multiple-choice questions were analyzed using Excel and JMP. A Chi Square test was performed to check null hypothesis of independence between the respondents' professional background and organizational affiliation and their preference for the best decision-support tool. In response to the question "which tool of the tools provided to you contributed the most to your decision", despite the request to choose the one tool that helped them the most, 30 of the respondents chose more than one tool and four chose a tool that did not exist in this experiment and were omitted from the analysis.

II) **Open questions -** In addition to two multiple-choice questions, the respondents were asked to indicate difficulties and note what sources of information they were missing in order to make a more confident decision, alongside a request to write any comment they had regarding the experiment. A thematic analysis was conducted by grouping, sorting and sifting the answers to the open questions, separating them into paragraphs and coding them according to a list of recurrent themes that were identified in the text and defined by the researchers. Neutral expressions without meaning relevant to the experiment were omitted from the analysis. 196 meaningful statements were included in the analysis.

The justification for performing manual data coding and analysis lies in the fact that these are qualitative, non-numerical and non-structured data, and within this framework the researcher has the right to communicate and connect to the data, understand ideas arising from them, to facilitate the developing of data-based theories (Basit 2003; Chowdhury, 2015).

The data were manually analyzed, a decision based on resource and expertise considerations, database nature and size and its place in the broader context of the study, as claimed by Basit (2003).

The thematic data was analyzed using Excel.

III) **Open discussions -** Another source of information is transcripts and summaries of the discussions that took place in the classroom at the end of each round of the experiment (6 groups). After participating in the experiment, the research and its objectives, as well as short films showing different scenarios, were presented to the participants by the researchers (in 30 minutes) and they were given the opportunity to respond freely. These texts were used as supplementary information only, mainly regarding their attitude towards the visualization model and to support and explain the experiment results.

4.0 RESULTS

4.1 DEVELOPMENT AND VALIDATION OF A DATA-BASED VISUALIZATION MODEL

The objective of the first phase of the research was to develop a visualization model based on detailed quantitative ecological data, as a decision-support tool for management of Mediterranean landscapes, as well as for communicating scientific information to the public.

In the following sections I describe and provide visual examples of the model as representations of current and future landscape states (section 4.1.1 and 4.1.3, respectively) in different locations and situations. Since my broader objective was to test the utility of future landscape models in decision-making processes, and their potential to help build trust and confidence among the viewers, I had to first validate the current state landscape models by assessing the degree to which the viewers found the computer-generated visualizations accurate representations of real (photographed) landscapes. The results of the validation process are presented in section 4.1.2.

4.1.1 Development of the current state model

The output of the current state landscape model is a computerized, highly realistic, dynamic set of representations of the current state vegetation across the entire park. From this model, different images and short films that represent the landscape at different locations, vegetation structural types and management regimes were created and validated using the knowledge and visual perceptions of a sample of experts. Fig. 12, for example, represents four different "vegetation structural types" characteristic of Ramat Hanadiv's landscapes.

Fig. 12a-d: Examples of current state representation of vegetation structural types demonstrating interaction between vegetation and management regimes.

a. Sparse pines (cattle grazing, anemone patch); b. Dense cypress (cattle grazing); c. Dense pine grove with cyclamen patch; d. Tall dense maquis (ungrazed).

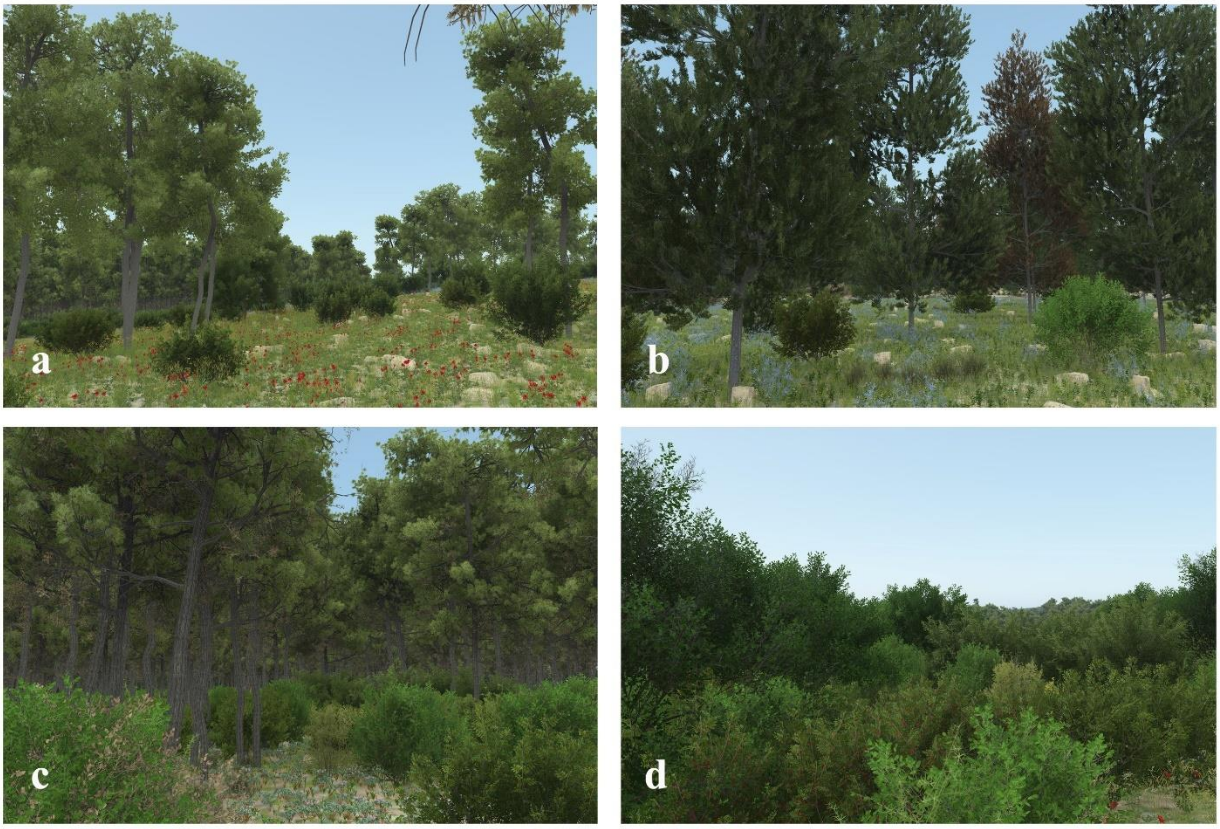


Fig. 13a-d: Examples of current state representation from different perspectives

Short films

Links to short videos demonstrating short walking trails in the Nature Park landscapes changing from the current state vegetation into future scenarios:

1) Timsach dry riverbed – 30-year projection, business as usual (BAU)
2) Timsach dry riverbed – 30-year projection, cessation of grazing

The films were used as complementary material in the experimental stage (described in section 4.2).

4.1.2 Validation of the model

Participants most often selected the "correct" photo (the photo that was represented by the landscape model) as their first guess -- significantly more than expected by chance, for 10 of the 12 sites. Moreover, the correct photo was one of the three selected photos in 393 of 474 cases. This yields an average success rate of 82.9%, much higher than the 37.5% expected by chance, and highly significant in 11 of 12 sites (Table 4). The current state model was therefore determined to produce valid representations of reality (G-test; P<0.0000). No relationship was found between the vegetation formation and success in identifying the corresponding photo. In two specific cases, the respondents were unable to identify the correct picture in the first attempt due to the (random) presence of a very similar picture in the experimental set (case 118, corrected in the second choice). Since the model is an average representation of vegetation structure, the decision may be influenced by the location of dominant elements in the image (e.g., a tall tree on the right, a group of shrubs to the left and open area in the middle), even if the frequencies were completely different (an “element bias”, case 1E; Table 4).

These results indicate that the model is perceived by observers as an accurate visual representation of the landscape it is based upon. Given that the model is derived from specific quantitative parameters, and that similar parameters could be constructed for future scenarios, I assume that the model can be used to coherently visualize future scenarios.

Table 4. Validation experiment data and results

FORMATION	LOCATION	N	Match 1st. picture						Match 1 of 3 pictures					
			No. Match	% Match	% Expected	Df	G-VALUE	*P-VALUE*	No. Match	% Match	% Expected	Df	G-VALUE	P-VALUE
NATURAL GARRIGUE	115	40	14	0.350	0.125	1	13.372	0.0002554	38	0.950	0.375	1	60.542	< 0.00001
PLANTED GROVES	122	40	20	0.500	0.125	1	33.067	< 0.00001	30	0.750	0.375	1	23.263	< 0.00001
NATURAL GARRIGUE	114B	37	20	0.541	0.125	1	36.668	< 0.00001	28	0.757	0.375	1	22.332	< 0.00001
DENSE MAQUIS	117B	40	17	0.425	0.125	1	22.295	< 0.00001	32	0.800	0.375	1	30.261	< 0.00001
NATURAL GARRIGUE	2N	39	15	0.385	0.125	1	16.823	0.0000410	33	0.846	0.375	1	36.888	< 0.00001
NATURAL GARRIGUE	113	39	31	0.795	0.125	1	91.482	< 0.00001	35	0.897	0.375	1	46.625	< 0.00001
PLANTED GROVES	110	40	36	0.900	0.125	1	124.781	< 0.00001	38	0.950	0.375	1	60.542	< 0.00001
DENSE MAQUIS	118	40	4	0.100	0.125	1	0.243	0.6219368	31	0.775	0.375	1	26.618	< 0.00001
NATURAL GARRIGUE	4W	40	19	0.475	0.125	1	29.275	< 0.00001	34	0.850	0.375	1	38.520	< 0.00001
LOW OPEN	111	40	17	0.425	0.125	1	22.295	< 0.00001	37	0.925	0.375	1	54.091	< 0.00001
NATURAL GARRIGUE	3N	40	30	0.750	0.125	1	82.450	< 0.00001	39	0.975	0.375	1	68.092	< 0.00001
NATURAL GARRIGUE	1E	39	4	0.103	0.125	1	0.190	0.6632159	18	0.462	0.375	1	1.216	0.2702411
Average match (%)							47.89660						82.80737	
Expected							12.50000						37.50000	
Total G-VALUE							472.94318						468.98860	
Degrees of freedom							12						12	
P-VALUE for total G							< 0.00001						< 0.00001	

4.1.3 Development of future scenarios

The product of this stage is a set of images and short films that represent the predicted future landscapes of Ramat Hanadiv according to the model's data-based extrapolations, at different locations in the park under seven different management scenarios. I suggest, based on previous research conducted in the park, literature review, and our prior experience, that these scenarios allow observers to "take a glimpse" into future landscapes, support decision-making, and promote public participation and dialogue.

To develop vegetation formations in the park under a diversity of management regimes, I developed the following seven scenarios. The relevant data was fed into the models to produce representations of each (full details in Table 2):

Scenario I - Business as usual (continuation of current policies including grazing, no other intervention in the vegetation), 30-year projection horizon.

Scenario II - Complete pine removal (of all Aleppo pines, at all sizes), 30-year projection horizon.

Scenario III - Moderate intervention (complete removal of all Aleppo pines below 3m, every 5 years), 30-year projection horizon.

Scenario IV - Post-fire, no intervention, 10-year projection horizon.

Scenario IVa - Post-fire, no intervention, 30-year projection horizon.

Scenario V - Post-fire, patch management (pine management applying different treatments to different patches to create a heterogenous landscape mosaic), 30-year projection horizon.

Scenario VI - Cessation of grazing (cattle and goats, from the entire park area); 30-year projection horizon.

Figures 14 and 15 display results of specific locations and vegetation structural types, under the seven management scenarios developed by the future conditions visualization model. The future scenarios were developed based on a 1-hectare cell size, according to parameters, assumptions, and guidelines determined by management experts (detailed in table 2). They were used to predict the appearance of Ramat Hanadiv's future landscapes as part of the material provided to the participants in the decision-making experiment (section 3.2), in which they were asked to make a management decision regarding each of five management dilemmas.

Fig. 14a-h: Representation of current and future scenarios of a garrigue landscape with sparse pines

a. Current state, sparse pines; b. Scenario I - 30 years; BAU; c. Scenario II - 30 years; complete pine removal; d. Scenario III - 30 years; moderate intervention; e. Scenario IV - 10 years; post-fire; no intervention; f. Scenario IVa - 30 years; post-fire; no intervention; g. Scenario V - 30 years; post-fire; patch management; h. Scenario VI - 30 years; cessation of cattle grazing.

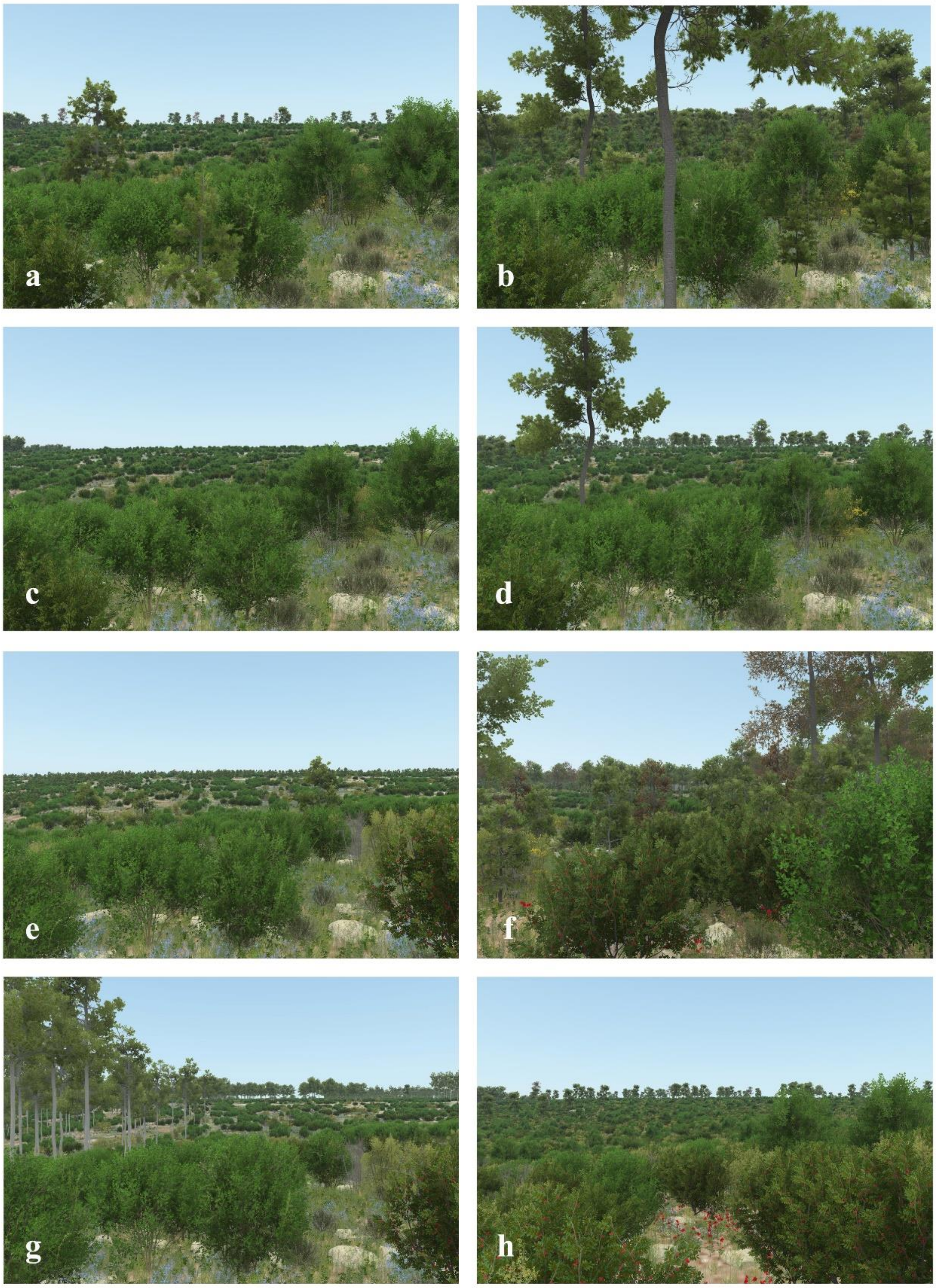


Fig. 15a-h: Representation of current and future scenarios of a different perspective with a road.

a. Current state, sparse pines; b. Scenario I - 30 years; BAU; c. Scenario II - 30 years; complete pine removal; d. Scenario III - 30 years; moderate intervention; e. Scenario IV - 10 years; post-fire; no intervention; f. Scenario IVa - 30 years; post-fire; no intervention; g. Scenario V - 30 years; post-fire; patch management; h. Scenario VI - 30 years; cessation of cattle grazing.

4.2 APPLICATION OF THE MODEL: EFFECTS ON DECISIONS AND LEVEL OF CONFIDENCE

In the previous section I demonstrated and validated how quantitative scientific data regarding vegetation structure, spatial pattern, and composition can be translated into an accurate visual representation of present and future landscapes. In the next stage, I examined whether the visualization tool, developed to support decision-making, had an influence on the management decisions of stakeholder respondents and if so, whether their decisions were directed more towards intervention in natural processes or towards more conservative solutions. As a reminder, I consider natural processes to be natural succession, pine colonization, tree death etc. The more conservative solutions support the approach of “letting nature take its course”. In addition, I examined the effect of the visualization model on the level of confidence the respondents felt in their decisions.

To test the hypothesis that exposure to the visualization model will significantly influence respondent decisions, more favorably predispose the respondent to active intervention in the natural ecosystem, and increase their confidence in their decisions, I applied two separate statistical models: Analysis of variance and logistic regression.

4.2.1 Analysis of variance

To reveal a potential impact of the use of the visualization model on management decisions and confidence in those decisions, I constructed a two-way ANOVA.
I examined the effect of the tools (conventional tools with or without the visualization model) and group affiliation (professional background and organization) on the decisions (intervention-oriented vs. non-intervention-oriented) and on the average level of confidence respondence reported regarding their choices (scale of 0-100%), and the interactions between these factors. The results are displayed in tables 5-7 and Fig. 16-18.

Average confidence

Table 5 shows the average percentage of confidence for the different treatments (tools) and professional backgrounds, and the effect of these variables and the interaction between them on the respondents’ level of confidence (JMP; 2-way ANOVA and

Students t-test). The averages and analysis results for the effects of the treatment and organization, including the interactions between these variables, are displayed in Table 6.

Overall, the respondents were very confident in their decisions, regardless of which tools were used to support their decision-making process, although use of the visualization tool increased confidence even more. For 69.3% of all respondents the average confidence levels were above 80%; only 5.7% were below 50%. The confidence level of respondents with a scientific background was significantly higher compared to those with background as planners or to respondents in the miscellaneous (public) group (without a professional background in these fields).

The use of the visualization model significantly increased the average level of confidence compared to conventional tools (P=0.0242, see Table 5, Fig. 16a). However, there was a significant interaction between the treatment and professional background. While the model significantly increased the confidence level of respondents with a planning background (P = 0.0297), this effect was not found in relation to those with a scientific background or to respondents representing the public.

A significant interaction was also found regarding the treatment and the organizational affiliation (P=0.0087, Table 6, Fig. 16b). The model significantly increased the confidence of landscape architects (and had a non-significant effect on the other groups) and significantly decreased the confidence of employees of the Nature and Parks Authority (NPA).

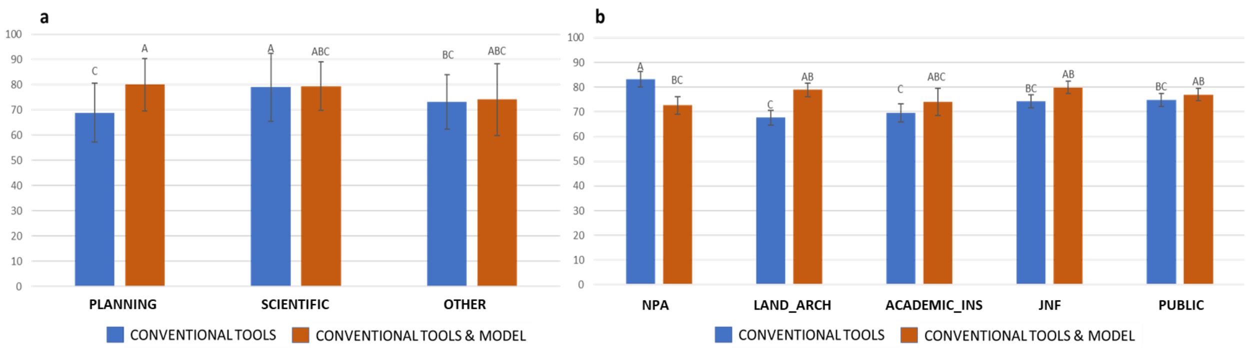
Table 5: Average confidence level of respondents towards their management decisions analyzed by treatment and professional background (JMP, 2-way ANOVA, Students t-test). Significant results (alpha<0.05) are highlighted in red.

Response Average confidence	**ANALYSIS OF VARIANCE**			
RSquare	0.111328			
Source	**DF**	**Sum of Squares**	**F Ratio**	**Prob > F**
C. Total	161	24433.710	3.9086	**0.0023**
TREATMENT	1	682.161	4.872	**0.0242**
PROFESSIONAL BACKGROUND	2	999.060	3.568	**0.0245**
TREATMENT * PROFESSIONAL BACKGROUND	2	964.715	3.445	**0.0297**
Least Squares Mean TABLE				
Level	**Least Sq. Mean**	**Std Error**	**Mean**	**Student's t**
TREATMENT				
MODEL	77.843	1.356	78.112	**A**
CONVENTIONAL TOOLS	73.697	1.300	74.318	**B**
PROFESSIONAL BACKGROUND				
SCIENTIFIC	79.186	1.515	79.158	**A**
PLANNING	74.456	1.628	74.770	**B**
OTHER	73.668	1.730	73.638	**B**
TREATMENT x PROFESSIONAL BACKGROUND				
MODEL, SCIENTIFIC	79.400	2.277	79.400	AB
CONVENTIONAL TOOLS, SCIENTIFIC	78.971	2.000	78.971	A
MODEL, PLANNING	79.993	2.236	79.993	**A**
CONVENTIONAL TOOLS, PLANNING	68.920	2.367	68.920	**C**
MODEL, OTHER	74.136	2.523	74.136	ABC
CONVENTIONAL TOOLS, OTHER	73.200	2.367	73.200	BC

Table 6: Average confidence level of respondents towards their management decisions analyzed by treatment and organizational affiliation (JMP, 2-way ANOVA; Students t-test). Significant results (alpha<0.05) are highlighted in red.

Response Average confidence	**ANALYSIS OF VARIANCE**			
RSquare	0.13697			
Source	**DF**	**Sum of Squares**	**F Ratio**	**Prob > F**
C. Total	172	28039.170	2.8745	**0.0036**
TREATMENT	1	233.161	1.5304	0.1838
ORGANIZATION	4	640.996	1.0519	0.1659
TREATMENT **x** ORGANIZATION	4	1955.940	3.2096	**0.0087**
Least Squares Mean TABLE				
Level	**LS Mean**	**Std Error**	**Mean**	**Student's t**
TREATMENT				
MODEL	76.503	1.589	77.472	A
CONVENTIONAL TOOLS	73.908	1.368	74.069	A
ORGANIZATION				
NPA	77.933	2.390	78.519	**A**
LANDSCAPE ARCHITECTURE FIRMS	73.324	2.013	73.916	**B**
ACADEMIC INSTITUTIONS	71.773	3.329	70.938	**B**
JNF	77.047	1.840	77.111	AB
PUBLIC	75.951	1.804	76.017	AB
TREATMENT x ORGANIZATION				
MODEL, NPA	72.667	3.563	72.667	**BC**
CONVENTIONAL TOOLS, NPA	83.200	3.187	83.200	**A**
MODEL, LAND_ARCH. FIRMS	78.943	2.693	78.943	**AB**
CONVENTIONAL TOOLS, LAND_ARCH. FIRMS	67.706	2.994	67.706	**C**
MODEL, ACADEMIC_INS	74.000	5.520	74.000	ABC
CONVENTIONAL TOOLS, ACADEMIC_INS	69.545	3.722	69.545	C
MODEL, JNF	79.913	2.574	79.913	AB
CONVENTIONAL TOOLS, JNF	74.182	2.632	74.182	BC
MODEL, PUBLIC	76.992	2.469	76.992	AB
CONVENTIONAL TOOLS, PUBLIC	74.909	2.632	74.909	BC

Fig. 16a-b. Two-way ANOVA results. Average confidence level (a) by professional background; (b) by organizational affiliation. Comparison of conventional tools vs. conventional tools and model group



Choice regarding intervention

The results of the analysis of effects of the treatment, professional background, and the interaction between them on the preference for intervention (a parameter named "% choice in intervention"), are summarized in Table 7. Table 7 shows, for the different treatments and professional backgrounds, the mean number of times the respondent chose the more intensive intervention alternative, as a percentage of the five cases presented to them in the experiment. Table 8 presents a similar analysis for the effect of the treatment, with the variable "organization" and the interaction between treatment and organization.

The inclusion of the visualization model had no significant effect on preference for degree of intervention compared to conventional tools. The effect of the professional background was close to significant, as respondents with a scientific background tended to choose the more intense interventionist alternatives compared to respondents with a planning background ($P = 0.0582$, Table 7).

A significant effect of the organizational affiliation was found on the preferred degree of intervention ($P = 0.0003$, Table 8, Fig. 18d). Respondents employed by the Nature and Parks Authority preferred more intervention compared to all other organizations.

Table 7: Average choice in intervention by treatment and professional background (JMP, 2-way ANOVA, Students t-test). Significant/near significant results are highlighted in red.

Response % Intervention	**ANALYSIS OF VARIANCE**			
RSquare	0.048706			
Source	**DF**	**Sum of Squares**	**F Ratio**	**Prob > F**
C. Total	**164**	6.100	1.6281	0.1555
TREATMENT	1	0.091	2.531	0.3284
PROFESSIONAL BACKGROUND	2	**0.226**	**3.141**	**0.0582**
TREATMENT * PROFFESSIONAL BACKGROUND	2	0.040	0.548	0.5648
Least Squares Mean TABLE				
Level	**Least Sq. Mean**	**Std Error**	**Mean**	**Student's t**
TREATMENT				
MODEL	0.543	0.021	0.545	A
CONVENTIONAL TOOLS	0.591	0.021	0.595	A
PROFESSIONAL BACKGROUND				
SCIENTIFIC	0.618	0.024	0.619	**A**
PLANNING	0.545	0.027	0.546	**B**
OTHER	0.538	0.026	0.536	AB
TREATMENT x PROFESSIONAL BACKGROUND				
MODEL, SCIENTIFIC	0.607	0.035	0.607	A
CONVENTIONAL TOOLS, SCIENTIFIC	0.629	0.032	0.629	A
MODEL, PLANNING	0.493	0.036	0.493	B
CONVENTIONAL TOOLS, PLANNING	0.584	0.038	0.584	AB
MODEL, OTHER	0.530	0.040	0.530	AB
CONVENTIONAL TOOLS, OTHER	0.560	0.038	0.560	AB

Table 8: Average choice in intervention by treatment and organizational affiliation

(JMP, 2-way ANOVA, Standard least squares, effect leverage; Students t-test).

Response % Intervention	ANALYSIS OF VARIANCE			
RSquare	0.147827			
Source	DF	Sum of Squares	F Ratio	Prob > F
C. Total	175	6.434	3.199	0.0013
TREATMENT	1	0.043	1.347	0.4999
ORGANIZATION	4	0.726	5.574	0.0003
TREATMENT x ORGANIZATION	4	0.166	1.277	0.4531
Least Squares Mean TABLE				
Level	LS Mean	Std Error	Mean	Student's t
TREATMENT				
MODEL	0.564	0.022	0.548	A
CONVENTIONAL TOOLS	0.598	0.020	0.591	A
ORGANIZATION				
NPA	0.718	0.035	0.726	A
ACADEMIC INSTITUTIONS	0.573	0.044	0.567	B
JNF	0.529	0.027	0.529	B
LANDSCAPE ARCHITECTURE FIRMS	0.536	0.029	0.532	B
PUBLIC	0.549	0.026	0.550	B
TREATMENT x ORGANIZATION				
MODEL, NPA	0.650	0.052	0.650	AB
CONVENTIONAL TOOLS, NPA	0.787	0.047	0.787	A
MODEL, JNF	0.513	0.038	0.513	C
CONVENTIONAL TOOLS, JNF	0.545	0.038	0.545	C
MODEL, LAND_ARCH	0.495	0.039	0.495	C
CONVENTIONAL TOOLS, LAND_ARCH	0.576	0.044	0.576	BC
MODEL, ACADEMIC_INS	0.600	0.068	0.600	BC
CONVENTIONAL TOOLS, ACADEMIC_INS	0.545	0.054	0.545	BC
MODEL, PUBLIC	0.562	0.035	0.562	BC
CONVENTIONAL TOOLS, PUBLIC	0.536	0.038	0.536	C

Fig. 17a-b. Two-way ANOVA results. % Choice in intervention (a) by professional background; (b) by organizational affiliation. Comparison of conventional tools vs. conventional tools and model group

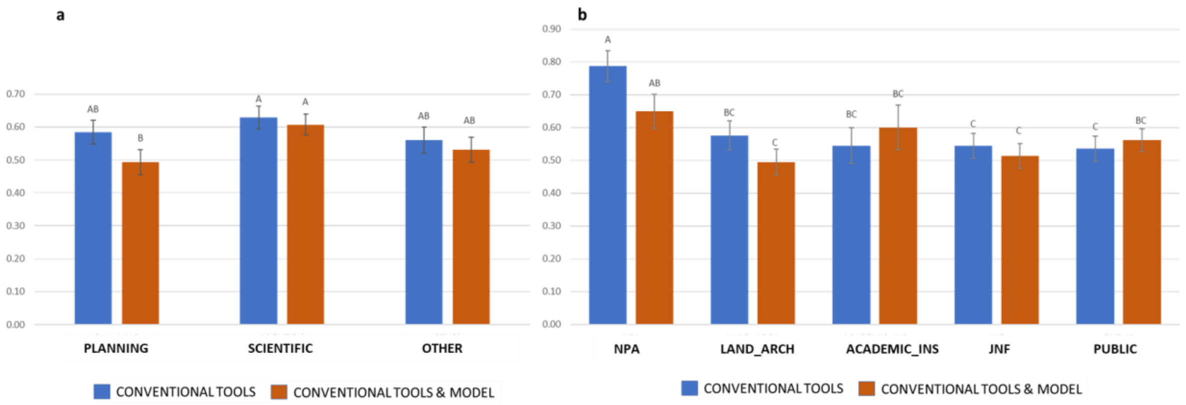
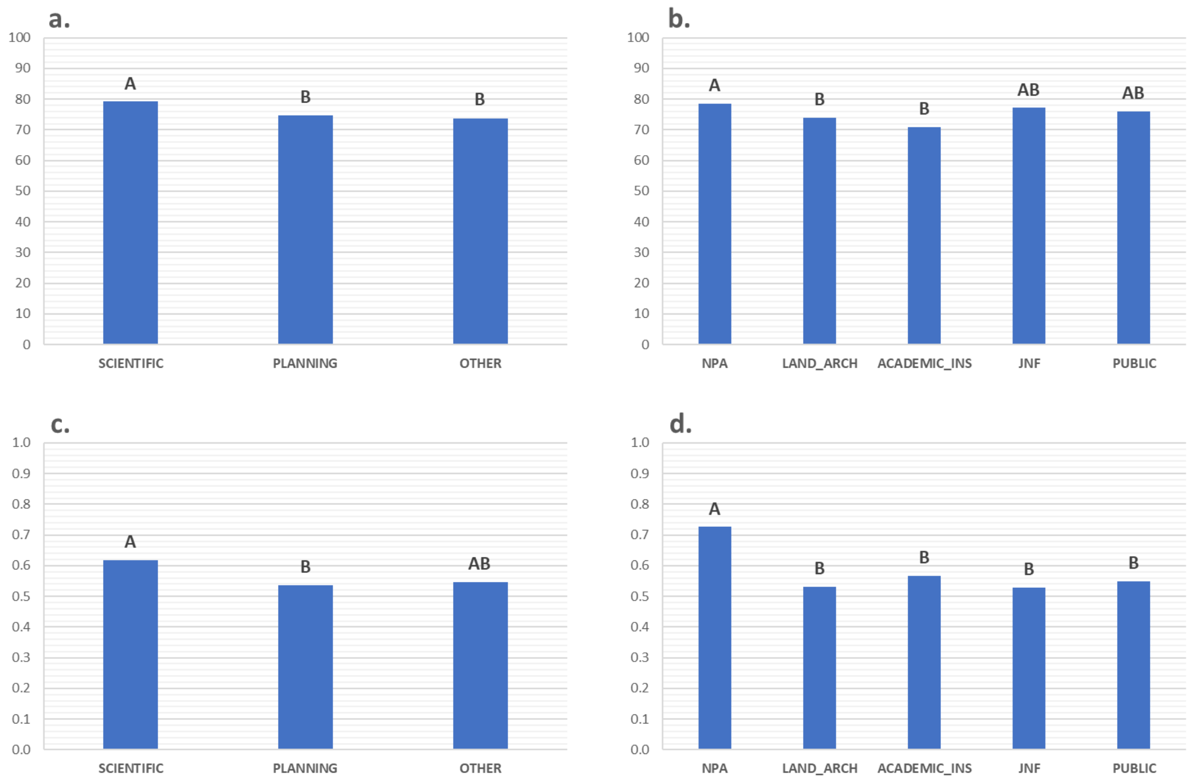


Fig. 18a-d. Two-way ANOVA: post-hoc results (Student's-t test).

Different letters indicate significant difference at alpha<0.05)

a. Average confidence level by professional background; b. Average confidence level by organizational affiliation; c. % choice in intervention by professional background; d. % choice in intervention by organizational affiliation.



4.2.2 Logistic regression

To examine the effect of the treatment (conventional GIS/text tools with or without the addition of the visualization model; independent variable) and various demographic characteristics (explanatory variables) - on the decisions (dependent variable), I also conducted a logistical regression for each case (management dilemma) separately. The effect of the range of explanatory variables, including (1) the respondents' organizational affiliation (independent landscape architecture firms, Nature Parks Authority, Israel Forestry Service, academic institutions or public), (2) professional background (scientific, planning, or other), (3) place of residence in childhood (urban vs. rural) and (4) age category on the decisions themselves and the level of confidence in them was also examined.

The regression analysis found statistically significant effect of the treatment only with respect to two dilemmas: no. 3 (thinning of the pines vs. BAU) and no. 5 (post-fire patch treatment vs. BAU, Table 10). In both cases, the respondents were asked to choose between moderate intervention in pines (non-related to fire in case 3 and as a post-fire treatment in case 5) versus "business as usual" (non-intervention). In these two cases the use of the model led to significantly reduced preference for intervention (e.g., thinning or pine removal in some patches).

The professional background of the respondent was found to significantly affect decisions only in case no. 2, in which respondents with a "scientific" background significantly preferred heavy intervention (complete clearcutting of all pine trees) over a more moderate intervention of thinning the pines. In contrast, planners, and the public (people of miscellaneous professional backgrounds) preferred the more moderate solution of thinning. A significant effect of professional organization (P=0.0000) was found in relation to members of the Nature and Parks Authority (NPA), who consistently preferred solutions that would lead to a landscape with less pines (Case1; clearcutting over thinning and thinning over BAU). However, it is important to note that a high percentage of respondents from the Nature and Parks Authority (77.8%) are of a "scientific" background.

No effect of age category or of the childhood place of residence was found on the choices of intervention vs. non-intervention solutions (these parameters were therefore omitted from subsequent analysis).

4.2.3 Descriptive results

Whenever a moderate intervention option was available for addressing the management dilemmas, (e.g., only thinning versus non-intervention or thinning versus complete pine removal), that option was selected in high percentages regardless of respondent group (on average, ~80.75% of all choices were of the moderate alternative, see table 9 in appendix). When no moderate alternative was available (case 1, complete removal of all pines vs. BAU), the preferences of the respondents approx. evenly divided between heavy intervention (55%) and no intervention (45%).

Despite the above, respondents with a scientific background, as well as members of NPA (as noted, some overlap exists between these variables), significantly preferred more intensive intervention, rather than more moderate intervention (Fig. 18a and 18d).

For management Case 5, 81% of all respondents (including both treatment groups) preferred patch management as a post-fire treatment over non-intervention. This finding may not be surprising since a fire, in its essence, is perceived by many people as a threat that necessitates human intervention (Daniel et al., 2003; Paraskevopoulou et al., 2019). Contrary to what I expected, however, the visualization model which showed the visual significance of non-intervention as a dense, multi-aged, mixed forest, some of which desiccated, increased support for such a non-intervention solution (Fig. 19 case 5).

Fig. 19: Logistic regression results (JMP, nominal logistic fit):

Preferences for intervention-oriented vs. non-intervention-oriented solutions, by treatment (visualization models and/or conventional tools), **professional background** (scientific, planning, or other) **and organizational affiliation (**JNF, NPA, Academic Institution, Landscape architecture firm, Other).

Green represents the more moderate of the two alternatives offered ("moderate" or BAU, depending on the scenario); Blue represents the more intense of the two alternatives offered (heavy or moderate, depending on the scenario).Cases without asterisks are non-significant.

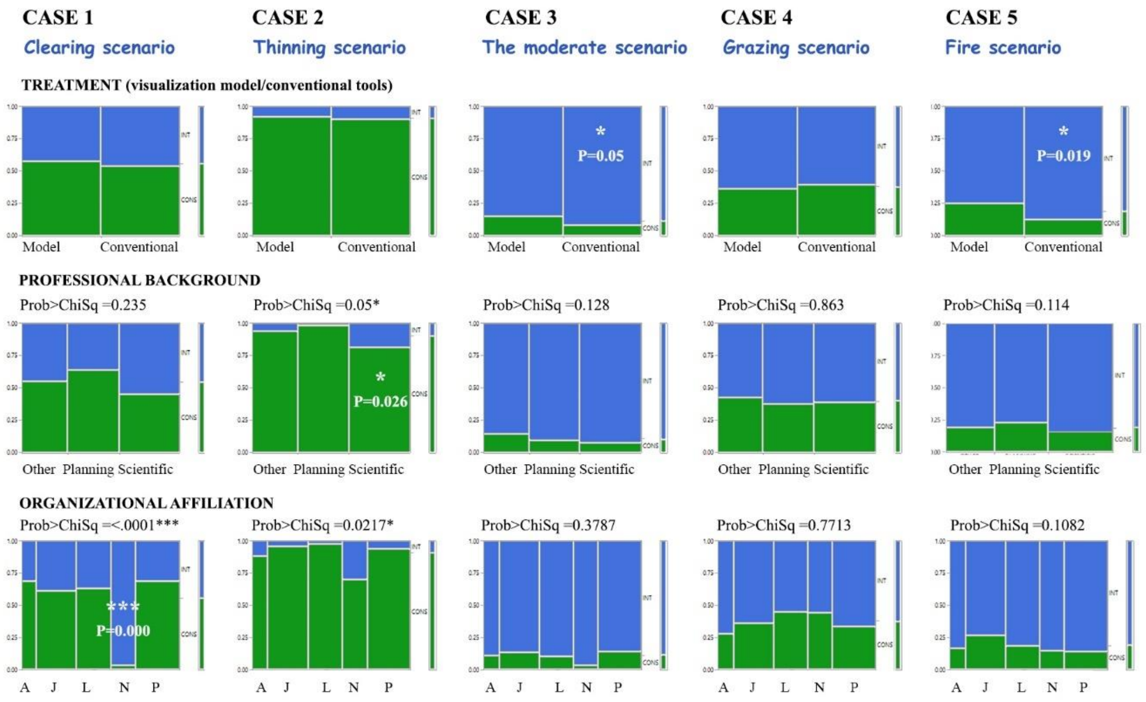
Case 1: "Clearing scenario" - Clearing of all pine trees vs. BAU (no intervention)

Case 2: "Thinning scenario" - Clearing of all pine trees vs. Thinning

Case 3: "The moderate scenario" - Thinning vs. BAU (no intervention)

Case 4: "Grazing scenario" - Cessation of grazing vs. BAU (no intervention)

Case 5: "Fire scenario" - Post fire patch management vs. BAU (no intervention)



A - Academic institutions; **J** - JNF; **L** - Landscape architecture firms (independent); **N** - NPA; **P** - Public

4.3 APPLICATION OF THE MODEL: EFFECTS ON THE PERCEPTIONS OF DIFFERENT GROUPS

In the last part of the questionnaire, the respondents were asked to answer two multiple-choice questions and provide their opinion on the extent to which the various sources of information presented to them contributed to their decision and specifically which tool was most helpful to them in forming their opinions. Of the 176 participants in the experiment, 153 answered the multiple-choice questions.

In the first question, the respondents were asked to write whether the tools that were provided to them helped them very much, moderately, or to a low degree.

A chi-square test of independence was performed to examine the relation between the experimental group (visualization model or conventional tools) and the extent to which the participants felt that the tools helped them make a decision. The relation between these variables was not significant, $X2$ (2, N =151) = 3.044 p = 0.218, i.e., respondents from the visualization model group did not feel that the tools helped them make a decision any more than respondents who were provided with conventional tools. Along with the statistical result, it is worth noting that twice the number of people from the control group (that without the visualization tool) reported that the tools provided to them helped them only “to a low degree”, Fig. 21).

Regarding the second question “which of the tools provided to you contributed the most to your decision”, the analysis included 119 valid responses (of people who chose one tool, as requested).

In the experiment group, when the visualization model was one of the choices, the relation between the organizational affiliation and the choice of the preferred tool was significant ($X2$ (8, N = 119) = 16.096, p =0.041). The null hypothesis of independence is rejected. Landscape architects significantly preferred the visualization model over other tools; participants from the Israeli Forestry Service (JNF) preferred the GIS maps (but also to a high degree, the visualization model) and academics, the public and participants from the Nature Park’s Authority (NPA) preferred the text over any other form of information (Fig. 20c).

Dependence between the organization and the preferred tool was also found in the control group ($X2$ (4, N = 119) = 9.798, p = 0.0439). When the choice was only between executive summaries (text) and maps, landscape architects, Forestry Service respondents, and academics preferred maps, while the public and NPA expressed text as their preferred tool (Fig.20d). No significant association between the professional background (scientific, planning, or other) and the preferred tools was found in either group (Fig. 20a-b).

Fig. 20 a-d: Contribution of different data sources to the decisions, according to the respondents' statements (N=117).

a. visualization group, by professional background; b. conventional tools group, by professional background; c. visualization group, by organization; d. conventional tools group, by organization.

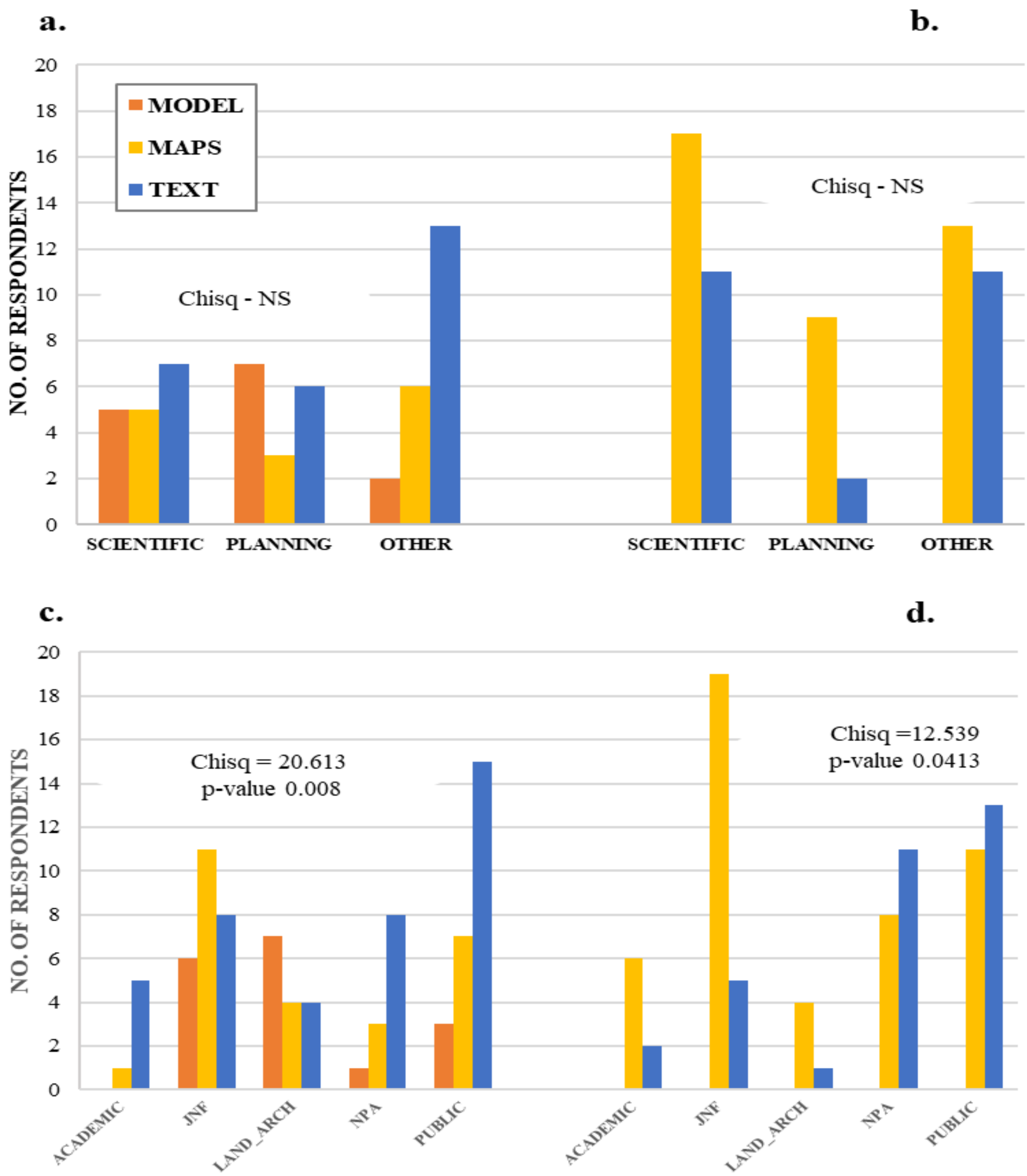
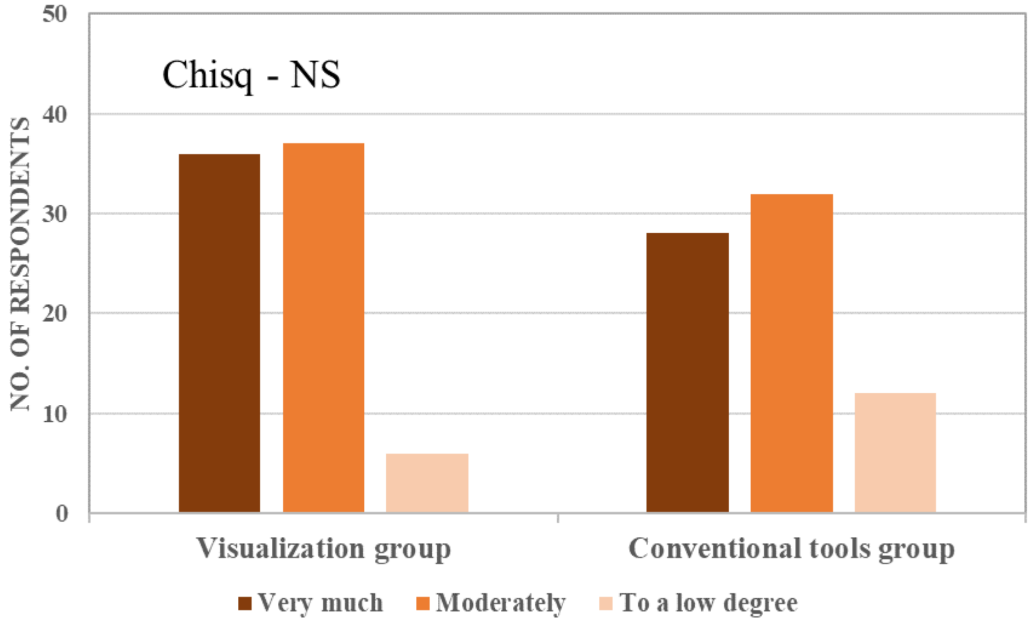


Fig. 21. The extent to which the provided tools helped the respondents in both groups make a decision, according to the respondents' statements (N=151).



4.3.1 Thematic analysis

To study the respondents' perceptions towards the tool, e.g., the level of realism, whether they found the tool too complex or too simplistic, to what extent do they have trust in the model? Which improvements would they make in the tool? etc., the participants were asked to answer two multiple choice questions (results described in the previous section) and freely write their opinion about the tool, what was missing if at all and anything else they want to say about the experiment in which they participated. The analysis included 196 meaningful statements, among which 119 were written by participants from the model group (~ 60%) and 77 (~ 40%) from the conventional tools group.

When I separated the participants' answers into discrete expressions and classified them, I identified and defined four topics divided into sub-topics:

(1) Representation of the natural system and the level of realism.

- Unrealistic representation of post fire patch management (n = 8)
- Other critical comments about realism (n = 6)

(2) The complexity of the natural ecosystem and the need for integrative and non-simplistic solutions.

- Lack of intermediate alternatives that include combinations of several management regimes (n = 37)
- Reference to the inherent complexity of the natural system (n = 3)
- Need to include additional considerations other than the visual (n = 11)

(3) Comments on the methodology / trust in the tools provided.

- Specific references to the survey method (n = 13)
- Suggestions for making improvement (n = 14)
- Claims of bias or deception (n = 10)

(4) Contribution to decision making.

- Prior knowledge and its role in the decision (n = 22)
- Positive contribution of the tools to decision-making (n = 14)
- Negative contribution of the tools to decision-making (n = 5)
- Missing information for decision making (guided question, see questionnaire; n = 52). The expressions classified under this category were subdivided into the following five groups:
    a. Need for additional ecological knowledge.
    b. Requests for more or different tools.
    c. Requests for mediation and analysis of the information presented in the experiment.
    d. Lack of reference to the human dimension (hiking trails, images do not include people, etc.)
    e. Respondents who said nothing was missing (i.e., they were provided sufficient information).

Main findings

1. Representation of the natural system and the level of realism.

14 out of the 119 participants from the model group addressed this issue. Most comments in this theme focused on the insufficiently realistic representation of the post fire patch management scenario or on specific details that bothered the respondent. Among them were 9 landscape architects and 5 from the Forestry Service. The fact that only 11.8% of the statements referred to insufficient realism, and most of them only to one dilemma (post fire) is consistent with the results of the validation experiment in which I showed that the landscape in the model was perceived by the viewers as a valid representation of reality.

2. Ecosystem complexity and the need for integrative and non-simplistic solutions

52 responses addressed this topic (44%), 50% of them by people with a scientific background, 30% with a planning background and 20% by people with miscellaneous background (“public”). These responses were distributed 60%/40% among the model group and the control group, respectively.

73% of these statements claimed that the management alternatives presented to them in the experiment related only to one factor (e.g., choice between thinning or clearing of the pines) and that they should have been able to consider more complex, integrated alternatives such as a combination of grazing and clearing, thinning of trees of certain sizes etc. Some statements raised the inherent complexity in nature, which the respondents thought should have been included in the information provided and that the experiment, overall, was too simplistic.

Some examples (translated from Hebrew):

- *"As a field manager, I would never have acted according to A or B alone. Is there no room for a certain combination of the necessary actions?"*
- *"As a manager, I would like to consider additional courses of action as alternatives."*
- *"There was a lack of more creative options of combinations, the separation between the alternatives is not feasible because fire managers also manage*

grazing and vice versa. In the real world it is impossible to decide only on fire management or grazing and there are intermediate alternatives."

– *"I was missing intermediate alternatives, sometimes the proposed alternatives do not provide a real-life solution, which would require continued treatment over time."*
– *"Lack of integrated scenarios such as clearing along with cessation of cattle grazing."*
– *"Providing the possibility of a mixed solution that includes both thinning of the seedlings and controlled grazing."*

The remaining statements concerning this subject were more general arguments about real world being complex and that there were other considerations and aspects that were not considered in the scenarios, such as fire prevention, soil erosion and more.
25% of the respondents specifically addressed the complexity of the ecosystem and the need to include a variety of factors and considerations in the decision-making process, e.g., they were bothered by "*Isolating the data to only one factor that needs to be considered, while an ecosystem is a fabric of components and hence of considerations"* or declared that *"Abstraction is interesting for research on decision making, but in real life there is a need to include many considerations. This survey leaves no room for this side. Away the abstraction, complexity should be extolled!"****(Scientific, visualization group)***
50% of the respondents that raised the complexity claim were people with a scientific background, that perceived the visualization as over-abstraction of a complex system, for the benefit of making data accessible to the non-experts. This finding concurs with those of the experiment according to which the model did not affect the decisions of respondents with a scientific background (Fig. 16a).

29% of the complexity comments came from respondents with a planning background, for whom I found that the model did have an influence (Table 5; Fig. 16a). Most of these respondents emphasized the fact that there are factors and aspects that were considered in the scenarios.

Regarding the public, of the 42 respondents of “miscellaneous” backgrounds who participated in the experiment, 11 commented on the lack of combined alternatives or over-abstraction (a statement I expected to hear mostly from professionals). The remaining respondents did not comment on these issues. Some of the participants in the conventional tools group noted the lack of visualization that could help them make the decision, for example:

- *"Also, the decisions were based on landscapes only and especially on landscapes with trees, without considerations of other landscapes. It would help to illustrate somehow the impact of the decisions directly on the Mediterranean vegetation, on open areas, etc."*
- *"3D visualization would make it easier from visual perspective. Understanding a map can be easy for one person and too abstract for another. Such visualization could help in terms of being able to imagine a landscape."*

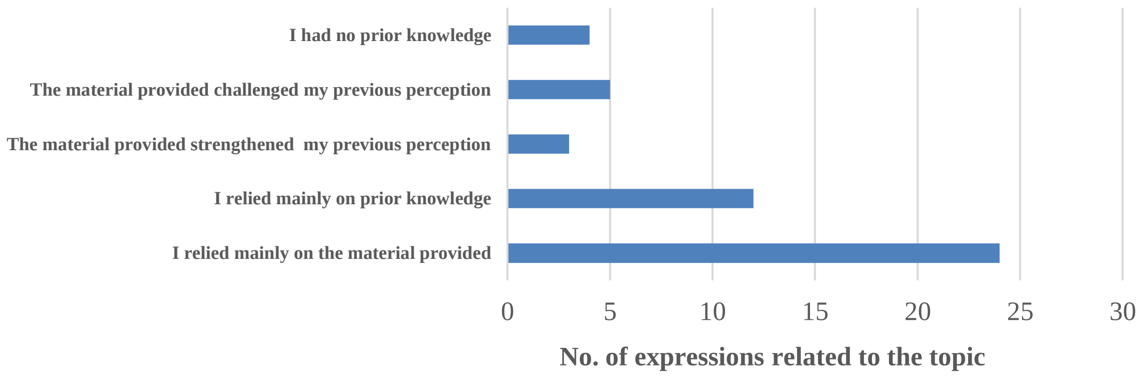
However, the experiment revealed that the visualization, even in its allegedly "too simplified" form, did not affect the "public" group. Moreover, most of the participants in the "public" group chose "text" as their preferred tool, i.e., the way reality was simplified in the model was not perceived as enough for non-experts that (as will be elaborated in the next section), raised a demand mainly for more knowledge, mediation of the knowledge, and tools.

3. Contribution of the tools to decision making: what was still missing for the participants?

After answering 2 multiple-choice questions about the extent to which the tools provided to the participants contributed to their decisions, and which source of information contributed the most, the respondents were asked to write what they were missing for decision-making and indicate difficulties, if any (open question).
I analyzed the text and referred (a) to the role of prior knowledge in the decision-making process, in relation to the tools provided (Fig. 22) and (b) classified the respondents' responses into five categories according to what the participants lacked (Fig. 23).

(a) Prior knowledge and its contribution to decision making

Fig. 22. Contribution of the tools provided to decision-making (n=41)



Some examples

Classified as "I relied mainly on my prior knowledge":

- *"Despite the diverse sources of information, one still needs professional knowledge in forest management to process the knowledge in the maps and the model and therefore decision-making for someone unprofessional is somehow intuitive" (NPA, scientific background)***.**

Classified as "I relied mainly on the material provided":

- *"For the purpose of the study, I tried to rely only on the material provided. However, it should not be overlooked that all information is processed through my worldview and experience. I feel I relied mainly on the material submitted which was of high quality - executive summaries, clear presentation, graphic illustrations and photographs." (Landscape architect, planning background)***.**
- *"The material was very helpful. This information is familiar but not necessarily available for decision making. I had difficulty with the so-called one-dimensional options when reality is much more complex. But this is probably the way to research results. Executive summary and slides helped. Explanations also helped greatly" (Landscape architect, planning background).*

Classified as "the material provided collided with my previous perception":

– *"It was difficult to neutralize the personal experience that was sometimes contrary to the literal description" (JNF, planning background).*

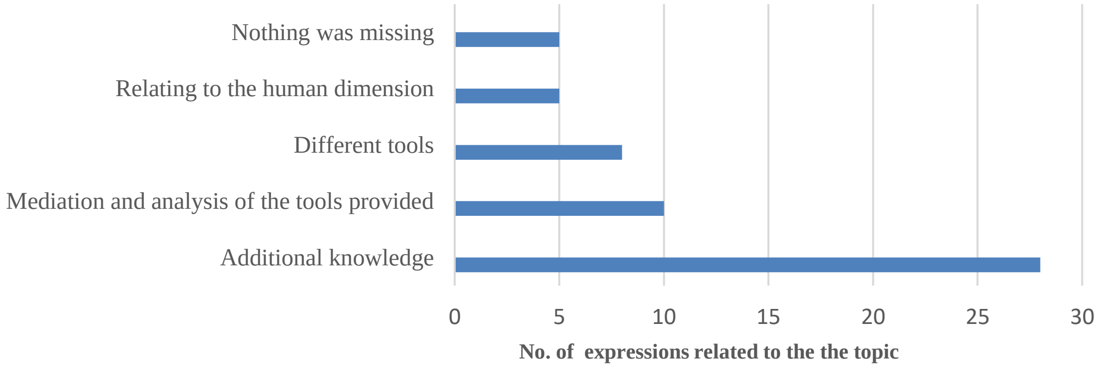
Classified as "the material provided strengthened my previous perception" and also as "I relied mainly on the material provided":

– *"The information provided was focused, helped a lot in making decisions and strengthened my overall perception"* **(***Landscape architect, planning background).*

(b) With respect to the question "what were you missing for a decision"?

Fig. 23. What were you missing to make a decision?

The participants' answers were classified according to the type of information they said they were missing - relation to the human dimension, different tools, mediation, and analysis of the tools provided, or simply additional knowledge, mostly but not entirely ecological, which they lacked to making the decision. Few (five of 41) of the participants declared that nothing was missing.



Examples:

Need in additional knowledge:

- *"I was missing knowing what happens to other trees when the pines take over. Is it at the expense of trees or at the expense of weeds that for me "worth less" (public)*
- *"I lacked knowledge about the impact of the pine trees on the environment and the rest of the vegetation, and in-depth understanding of the importance of the long-term existence of diverse vegetation" (public)*
- *"There is a lack of more information about the vegetation that will take the place of the pines and more information about what kind of vegetation encourages grazing and what are the accompanying problems." (public)*
- *"History of treatment of similar groves, particularly the effect of patch treatment and cessation of grazing on the spread of pines." (public)*
- *"Additional information regarding other management regimes in the park, combination of goats, sheep, location of the thinning areas, for example according to proximity to built-up areas, etc." (Planning)*

Mediation and information analysis

- *"There was a lack of previous analyzes and early moves that were made in the past" (Landscape architect, planning)*
- *"Missing additional information such as field tour, risk management table, what activities and scenery do I want?" (public)*
- *"Lack of more in-depth information on the meanings of each choice and the impact of the alternatives on each of the different dimensions" (public)*
- *Lack of data regarding the reliability of the model and experience" (public)*
- *"I am missing pros and cons for the 2 goals that were set" (NPA, scientific)*

4. Reference to the experiment methodology

Ten out of 196 (5%) of the participants felt that the experiment was somehow misleading or goal oriented. Only two of them were from the conventional tools group. These respondents offered their suggestions for improving the experiment, including offering a wider perspective, to have group decisions while discussing and not individually, visual illustrations (requested by participants in the control group), and in general people asked for more mediation - explanations, preview lecture, video of the area from the air, more perspectives, and seasons.

4.3.2 Results summary

In accordance with my hypothesis, that the data-based visualization model is a reliable representation of the best of our knowledge and experience about the management of Mediterranean vegetation (Hypothesis #1), the visualization model developed in this study was shown to be a valid and reliable representation of the Nature Park's vegetation landscapes. As such, it allowed me to move on to the next stage of examining its practical application as decision-support tool for the management of Mediterranean landscapes. The results from the application stage show that the model significantly increased the level of confidence the respondents had in their management decisions, as I hypothesized, because it allowed participants to see what the results of their management decisions would look like and, therefore, reduced their uncertainty. From this aspect, and with certain stakeholder groups, it can be said that the model is a productive support tool for decision making.

However, my assumption that the model would influence the decisions themselves, moving respondents towards active intervention (for the same reason - the ability to see before making a decision what the results would look like; Hypothesis #2), was not supported by the results. On the contrary, the results of the regression analysis (Figure 19) show that although in general the respondents preferred moderate intervention over non-intervention, in three out of five cases the model was a moderating factor that reduced the percentage of respondents who chose intervention.

As expected, (Hypothesis #3), decisions were affected to a large extent by group affiliation of the respondent (professional background and organizational affiliation), e.g., the model mainly influenced planners rather than the public and respondents with a scientific background tended to prefer intervention.

In support of validation results, only 11% of the respondents referred to insufficient realism in the visual representation of the post-fire scenario. 44% of all respondents addressed the issue of ecosystem complexity and the need in integrative alternatives that include more complex management combination (e.g., grazing and clearing of trees at certain size). Of these, half were respondents with a scientific background, who perceived the visualization was prepared purposely abstract for the benefit of non-experts. This finding concurs with the experiment results according to which the visualization did not affect the scientific background group.

Contrary to my expectation, respondents from the public group did not appreciate the visualization, realistic as it may be, as a decision-support tool in its current form, and most of them (~62%) chose “text” as their preferred support tool. They raised the need for more professional knowledge, and mediation of that knowledge to make more educated decisions.

5.0 DISCUSSION

"Each evening we see the sun set. We know that the earth is turning away from it. Yet the knowledge, the explanation, never quite fits the sight… ***John Berger, 1972***

5.1 PREFACE: CHALLENGES OF SCIENCE COMMUNICATION

“Why is the world green and the vegetation not consumed by growing populations of herbivores" is a question that has preoccupied ecologists for decades (e.g., Hairston et al., 1960; Polis, 1999). One possible answer to this question is that the vegetation is green but often not available as food to herbivores due to the presence of various plant defenses (Fraenkel, 1959).

A similar rationale can also be applied to science communication - data (i.e., “food”) may be available to non-experts, such as decision-makers, educators, and the public, but in the absence of effective communication tools, are not actually accessible therefore cannot be “consumed” by these audiences.

We live in a world where large databases (big data) are increasingly being compiled, stored, analyzed, and shared and are, seemingly, beginning to play a significant role as presumably accessible information for use by decision-makers. In ecology, for example, the Long-Term Ecological Research (LTER) network established in 1980, similarly to the National Ecological Observatory Network (NEON) in the United States, are major platforms encouraging and enabling the creation of quantitative datasets that describe global environmental change and its effects on ecosystems throughout the world (Mirtl et al., 2018). These databases usually include detailed metadata to encourage their uptake for use in future syntheses and comparisons. Nevertheless, some authors argue that collecting vast amounts of environmental data when not led by questions and hypotheses, threatens the principles of evidence-based science that supports management and policy (Lindenmayer and Likens, 2018; Collins and Knapp, 2019). Moreover, common databases such as GIS layers or raster data are in most cases inaccessible to non-experts like decision-makers and the public, who need a more recognizable language for describing landscape attributes (Nassauer, 1995).

From Covid19, through climate change, to forest management - communicating scientific data to non-experts has become increasingly important and a major challenge in an age of information overload, lack of transparency, and lack of tools to support decision-making and public participation processes.

5.2 DATA-BASED VISUALIZATION: AN INTEGRATIVE APPROACH FOR LANDSCAPE ASSESSMENT

Many studies have shown that visual illustration, as well as "before and after" information, are required for people to understand and assess processes and outcomes of planning and management alternatives (e.g., Daniel, 2001b; Sheppard 2001, 2012; de Oliveira and Partidário, 2020). This is because humans are limited in their ability to process large amounts of data and complex information (Rensink, 2000). Thus, there is a need for the development of new tools that integrate complex information into an understandable picture, bridge between social and natural sciences, allow observation from different perspectives, and support sustainable discourse-based management.

To meet this need, I chose to develop and test 3-D computerized visualizations, based on quantitative ecological data that can envision the appearance of current and future landscapes under alternative management scenarios.

The visualizations developed in my study offer an integrative approach to envision vegetation structure by merging data at various ecological scales and integrating knowledge about species, associations, and formations into a product that can assist decision making. One specifically unique feature of this approach lies in its scientific foundation. Firstly, it allows the transformation of ecological data coming from a long-term monitoring program into a visualization tool that accurately reproduces current landscape states. Secondly, it is capable of generating visualizations of future landscapes based on scientific knowledge regarding the interaction between long-term, dynamic ecological processes and hypothetical management scenarios.

Another important contribution of our visualization model lies in the fact that it has been tailored specifically to landscapes characterized by small-scale heterogeneity, multi-layered vegetation, and high structural complexity, as is the case in Mediterranean ecosystems (Perevolotsky and Sheffer, 2011; Filotas et al., 2014). However, being based on a variety of metrics that reflect the complex structure of the landscape, the visualization demonstrates high flexibility and allows the user to envision the outcome of a variety of complex scenarios, like post-fire management interventions and pine expansion from plantations into natural sites.

5.3 MODEL VALIDATION: A BASIS FOR TRUST- BUILDING WITH STAKEHOLDERS

The results of my validation process provided an indication of the similarity between modeled landscapes and the real world, hence of the high realism of the visualization, as perceived by a sample of practitioners and decision-makers with a close familiarity of the studied landscapes.

The visualization developed in my study was based on relatively simple information about vegetation structure in complex forest landscapes, characterized by fine-scale heterogeneity and low visual distinction (ability to distinguish between different landscape representations presented to the observer), as are many landscapes on the planet (Turner et al., 2013). Extrapolation based on detailed data from long-term monitoring plots (representing different vegetation structural types) was used to apply the information to the scale of the entire area. This method makes the approach I suggest feasible for application to other complex, multi-species, multi-layered ecosystems, or ecosystems with human interventions that drive complex vegetation processes, other than the Mediterranean. This can be done given that the site has data on the composition and structure of the vegetation community, information that exists in hundreds of monitoring sites around the world, and access to basic information layers, most of which can be found online.

In developing the model, I had to decide how many, and which species should be represented. Of 660 species growing in the park, I chose to include in the visualization model only 27 of the most predominant species in the landscape (4% of the flora), and 4 herbaceous patch types. I conclude that to produce a realistic picture of the landscape, not all species, nor even most species, need to be included. A knowledge-based selection of the species that dictate landscape appearance should be conducted and these will likely represent a very small percentage of the flora species.

Also, the visualization expresses a representative vegetation structure for each patch type, so that the different elements in the visualization are not necessarily located in the same place as in the field image. These conditions alongside the high complexity and the low visual distinction between different landscapes made the choice of selecting the correct photo a challenging task even for professionals who are experienced in subtle distinction between vegetation formations. Nevertheless, despite these limitations, I succeeded in creating a visual representation of the landscape that was perceived by respondents as highly realistic.

The explanation for this lies in the relationships between structure and species dominance. In the woody layer (trees and shrubs), a small number of dominant species are responsible for most of the total vegetation cover. *Pinus halepensis, Pistacia lentiscus, Phillyrea latifolia* and *Calicotome villosa* alone account for around 90% of the total cover (data from LTER plots).

Thus, in order to best reflect the landscape's appearance, it is important to take into account the visual diversity that exists within a particular dominant species. This can be done by creating a set of models describing its appearance in different sizes and situations. For example, in this work, 4 different models were built for *Pinus halepensis* alone (Table 1a-b). Focusing on dominant species is more important than representing the diversity of species in the area.

The herbaceous layer, in contrast, is perceived at the patch level, as a brown or green background best characterized by its density and texture. I conclude that a visualization focusing on different variations of dominant woody species allows representation of the real structural complexity of the landscape, while the addition of less dominant species does not fundamentally change the way these landscapes are perceived and assessed. These insights coincide with those of Appleton and Lovett (2003) that emphasized the importance of detailed foreground vegetation on the viewers' perceptions and ratings.

An additional advantage of our visualization model is its capacity to portray dynamic processes. Much of the professional literature on visualization relates to the constructed environment (e.g., Wergles and Muhar, 2009) or the addition of static elements to an existing landscape (e.g., Lange and Hehl-Lange, 2005; Maehr et al., 2015), studying their visual effects. Natural landscapes are dynamic by nature and land managers need to manage processes rather than "states" (Westoby et al., 1989; Naveh, 1994 and many more). The model developed in my study is a tool that reflects landscape dynamics, making it suitable for visually examining the long-term impacts of management operations on natural ecosystems.

Two aspects of this study that make use of the visualization model were found to be effective in building trust among stakeholders. First, the model was validated, i.e., perceived by users as an accurate representation of reality. Second, the model had a solid foundation in scientific data, which are highly trusted by the public (Wellcome Report, 2018), and transparency was maintained regarding the methodology and limitations of the model. As such, we could advance to the experimental stage, in which the values and ideas behind management decisions were communicated to various audiences through several alternative and/or complementary tools, with full transparency and opportunity for discussion.

5.4 VISUALIZATION AS A DECISION SUPPORT TOOL: INSIGHTS FROM THE APPLICATION PHASE

Landscape visualization is sometimes described as a” modern crystal ball” that has the ability to simplify complex scientific predictions and present future landscape alternatives for diverse audiences while looking collaboratively for a preferred solution. As human beings that share similar innate abilities to perceive and understand visual information, visualizations are considered a universal language and a powerful tool for involving people in environmental issues (Sheppard, 2001; Lovett et al., 2015; Billger et al., 2017; de Oliveira and Partidário, 2020).

I assumed that the visualization model would illustrate to people the visual implications of their decisions, hence I hypothesized that exposure to the model would strengthen respondents’ confidence in their decisions, as they would be able to see the visual significance of their decisions in the future, thereby reducing uncertainty. Accordingly, the model is expected to increase the level of confidence of respondents in the decision.

My findings revealed a significant increase in the level of confidence the respondents felt in their decisions for those who were given the visualization model. From this perspective, the visualization can be seen as a useful decision-support tool.

In addition, I hypothesized that the model would influence the nature of the decisions, for example, by increasing people's confidence in making a decision more towards intervening in the natural ecosystem rather than selecting a more conservation-oriented (i.e., hands-off) one.

However, the assumption that the model would impact decisions by pushing them more towards active intervention in the landscape (e.g., clearcutting of all the pines, post-fire forestry treatment) was not supported by the results. In cases where the visualization did influence the decisions (two cases, as reflected in the regression analysis, Fig. 19) - this effect was to shift towards less intervention in natural processes, i.e., the visualization acted as a moderating factor that reduced the proportion of respondents who chose intervention.

Furthermore, since landscape perception is an interaction between landscape patterns, the observer's characteristics, and perceptual processes (see Fig. 2 in the introduction, taken from Gobster et al., 2007), I hypothesized that the model would affect people with different backgrounds and/or from different organizations differently, due to factors related to past experience, prior knowledge, expectations, and the socio-cultural context of the individual and group (Zube et al., 1982; Gobster et al., 2007).

More specifically, I hypothesized that there would be a difference between how the visualization affected people with a scientific background in the fields of ecology and environment, people with planning background, and the general public. For instance, while the public may look at the landscape and experience it on a more emotional basis of what they feel and not necessarily on any conscious reasoning, scientists may view the landscape in a more analytical way and try to deduce relevant meanings from it, such as the number of pines in the area, biodiversity, forage quality, etc. Further, ecologists may have preconceived notions of what constitutes an ecologically healthy landscape that may impact their assessments and decisions explicitly or subconsciously. Alternatively, while it may be relatively difficult for the public to imagine the appearance of the landscape without visualization, planners are more practiced in understanding the landscape using conventional tools such as GIS and maps and the visualization model may affect them to a lesser degree.

Based on the “universal language” idea described above (Nassauer 1995), I hypothesized that without prior professional background or active knowledge mediation on the part of the research team, the general public would benefit the most from the visualization as means of data translation from scientific language into the "recognizable landscape language" that Nassauer writes of. Accordingly, I expected that the visual model would mainly impact decision-making by the public respondents, and less so for the land management and planning professionals, who are more accustomed to reading scientific texts and looking at maps and graphs.

I also expected the organizational affiliation of the respondent to influence their decisions, since different organizations have different agendas, and a set of values and perceptions that stem from the nature of the organization, its goals, and, accordingly, the kind of collective connection to the landscape that has developed within the organization. Having familiarity with both the organizations and the individuals who represent them, different responses to land management scenarios were somewhat predictable, but the crucial research question was whether the visualization would affect decision making differently between people from different organizations. For example, if people from a particular organization are very sensitive to a specific ecological phenomenon and the model graphically illustrates its severity (such as the issue of pine colonization), they would be likely to respond differently to the model compared to people who do not attach much importance to this phenomenon.

Nevertheless, I found that the visualization mainly increased the confidence level of planners, in contrast to its lack of impact on confidence among scientists or the public. My a priori expectation that the visual model would affect primarily the public, and less the professionals, was not supported by the results.

5.5 THROUGH THE MIND OR THROUGH THE HEART?

Visualizations tell a story, a particular narrative. As such they "speak to us in different ways than numbers and language: less cognitive, more directly to the eye and heart” (Berger, 1972; Metze, 2020). But any representation of the landscape also frames a particular argument, feeling, or piece of information that has persuasive power, and affects the subjective interpretation of those who are exposed to it.

Here, the story behind the different images presented in the experiment relates to Mediterranean landscapes and the need for active management for multiple purposes, such as nature preservation, protection from wildfires, and provision of cultural values and recreational opportunities. Alongside ecological considerations, there are always visual (aesthetic) implications for choosing different management alternatives. I developed a tool through which I hoped to connect different people and groups to this story and to engage them in management issues through their participation in a decision-making exercise.

But how do people connect to this story? Do they connect to it cognitively or emotionally? This question has challenged my methodology, since, in the experimental exercise I conducted, the participants were asked to assume the role of nature park managers and, based on the information that was given to them, decide if and how to intervene in the existing landscape. Furthermore, they were requested to “focus on the landscape appearance and the extent to which this is the desired landscape according to your perception” (and regardless of any operational or budget considerations).

For the treatment group that was provided with the visualization tool, I expected respondents, and especially those who were not professionals, to connect to the story "less through the mind, and more through the heart" and be able to look at different landscapes and feel whether the aesthetics of the landscape created by a certain management alternative (e.g., with or without pines, more dense vegetation, etc.) were preferable.

Contrary to my expectations, the results suggest that in most cases the path to the heart passed first through the mind. In other words, most respondents, regardless of presence or absence of professional background, wanted to integrate scientific considerations, and not only their impressions of the visual landscape. Choosing the preferable landscape was not as easy or intuitive as I assumed it would be and it seems that both the decisions and the discussion were not led by aesthetic considerations, i.e., despite the request to choose the preferred landscape on a personal level, the exercise was, in fact, a cognitive one. The participants were provided with scientific information in various forms, and though it was emphasized that there was no right or wrong answer, but a personal preference only, the respondents were in a “thinking mode” and felt they had to make an educated decision, though they did not always have the tools to do so. The public, who I expected to be most influenced by the visualization, were put in a place of an expert and perhaps this explains their choice of the text as their preferred tool, which may be perceived as a more professional source of information than an image.

The results support this claim - 50% of the respondents indicated in the questionnaire that they relied mainly on the knowledge provided to them (75% of them from the treatment group with the visualization tool). In the qualitative part of the experiment, the respondents raised many questions about the knowledge they lacked in order to make the decision and insisted on understanding the processes behind the landscape views. Half of the people stated that they lacked ecological knowledge to make a decision, and another 18% requested more processing and analysis of the scientific knowledge (60% of them from the control group).

Case 5, the "fire scenario", compared post-fire management to business as usual (no intervention). In the 'patch management' alternative, the landscape was managed as a combination of cleared, thinned, and untreated patches (Fig. 24, picture a). This alternative was preferred by large majority of respondents compared to the more “natural-looking" landscape (picture b), which prescribed no treatment for 30 years and resulted in dense garrigue with a large number of pines, many of them dry or dead. However, the group that was exposed to the visualization chose the treated landscape to a significantly lesser extent, i.e., the visualization led them to be less in favor of intervention.

The choice of the untreated post-fire landscape may have two possible explanations: (1) the visualization may have raised the appreciation of the untreated landscape since it was perceived more as reflecting natural processes, a notion that is consistent with ideas such as the “close-to-nature” forest management approach (Larsen, 2012; O’Hara, 2016). (2) Since the post-fire non-intervention scenario is the most extreme in terms of pine expansion in the park, Fig. 24b. shows that the non-intervention results are not as dramatic as might have assumed by learning only from the GIS maps and text.

Fig. 24. Example for landscape appearance under intervention management (picture a) versus non-intervention (picture b), case no. 5.

Picture a: Post-fire patch management (30 yrs.)

Picture b: BAU (no intervention, 30 yrs.)

5.6 CONTEXT-BOUNDED VISUAL PREFERENCES

As I have shown above, many factors are involved and influence people’s perceptions of the aesthetics of landscapes (e.g., Scott 2003; Filova et al., 2015). This idea can be referred to as "context-bounded visual preferences" (Metze, 2020) for the visual landscape and it can also be applied to explain the effect of the visualization on the decisions, confidence in decision making, and perceptions of different groups. With this approach, aesthetic preferences are formulated based on factors that I classify into effects operating in three axes: factors related (1) to the landscape (2) to the observer, and (3) to the visualization tool itself.

(1) Factors related to the landscape:

This axis includes a variety of landscape attributes present in the visualization that may affect the viewer's preference, such as geology, botany, light, composition, dimensions, form, and complexity.

Our visualization model was developed, validated, and tested in a Mediterranean Nature Park, consisting of a combination of natural maquis, remnants of traditional agriculture, and planted coniferous groves. These landscapes are characterized by high complexity in terms of spatial heterogeneity, the number of vegetation layers, and species richness and diversity.

The visual distinction (ability to distinguish between different landscape representations presented to the observer) in these landscapes was relatively low. This is likely due to the conditions prepared for this experiment, in which distinct elements that could distract the eye (like cityscape, roads, goats, or sea views) were completely removed from the visual images. To most people, especially those without any professional background in ecology, landscape architecture, or environmental studies, these landscapes may seem to consist only of different shades of green, which are otherwise very similar.

(2) Factors related to the observer:

This axis considers factors related to the observer, which brings their personality, experience, knowledge, and expectations to the experiment. This axis is of central importance in my research and has an important role in explaining my results.

Landscapes are visually framed according to the feelings that the landscape evokes in the observer (the "connotation system"), and the symbolic values and ideologies that the landscape represents for the observer (Rodriguez & Dimitrova, 2011). Different audiences have different cultural backgrounds and are part of different connotation systems. The cultural, professional, and organizational (i.e., workplace) background of the individual, for instance, shapes perceptions about nature, nature conservation, and dispositions regarding intervention in nature through active management, and directly influences the individual's assessment of the legitimacy of different management approaches. I did not study "organizational culture" directly as a factor affecting landscape preferences, partly since not all affiliation groups to which I referred can be defined as "organizations" (landscape architects, for example, are not an "organization" but have shared characteristics that may influence their responses). However, my results suggest that different audiences have different and shared perceptions about intervention in nature that are part of different connotations (feelings that the landscape evokes) and denotation systems (symbolic meaning) systems.

Each organization has its own "professional DNA" (the system of goals, means, and management atmosphere in the organization), which influences the individual's mindset and is a significant factor influencing the nature of decisions, preference for certain landscapes, and the tendency to choose an intervention or non-intervention in nature solution. This topic demands further research.

The Israel Nature and Parks Authority, for example, has traditionally supported non-intervention for many years and applied a conservation policy while removing humans and domestic animals from the ecosystem. In contrast, the Jewish National Fund (JNF, Israeli forest service) has historically implemented a policy of heavy intervention to “beautify” and improve the landscape through afforestation. With time, these two organizations have broadened their perspective and changed their policy. The Israeli Nature and Parks Authority realizes that to preserve Nature in Mediterranean ecosystems, one must intervene in it through active management. On the other hand, the forestry service recognizes the importance of natural processes and local species for maintaining healthy and functioning ecosystems and moved towards a more sustainable forest management policy (Perevolotsky and Sheffer, 2009; Osem et al., 2014).

According to this approach, people from different affiliation groups come with different world views, knowledge, and experience in “reading” and interpreting landscapes, close familiarity with different vegetation formations, experience in looking at plans and maps, etc. These factors act as “collective relational values”, that pertain to the relationships between people and nature and include “preferences, principles, and virtues associated with the relationships, both interpersonal and as articulated by policies and social norms” (Chan et al., 2016).

Since the future scenarios selected for the decision-making experiment dealt with pines and their role in the ecosystem, it can be assumed that the choice of intervention solutions in some cases connects to the positive or negative attitude towards those pines (Aleppo pines), and their perception as a natural component of the ecosystem or as an invasive species that should be removed. These perceptions stem from the framing of pine colonization at the organizational level in terms of good and bad, that alongside being a source of public debate (Osem, 2011; Orenstein, 2020), also affected the choices made at the individual levels. Nevertheless, although the differences between different organizations in terms of preference or aversion to pines are not related to the visualization model, the way the model influences people's choices is the result of the interaction between people's perceptions and the story the model tells compared to other tools. For example, GIS maps display masses of dots representing pine tree proliferation under some management alternatives (see Fig. 3b or appendix 4). If the model reflects the phenomenon of pine expansion in a less threatening way compared to what is depicted using other tools, exposure to the model may moderate the resistance of the “pine opponents” to a scenario involving a high density of pines and increase their support in that scenario.

Two other factors that seem to influence the effect of the visualization on different people include: (1) the level of familiarity that the viewer has with the landscape represented in the visualization (supported by the validation experiment results, and; (2) The professional engagement of people or groups with the landscape, as reviewed by Metze (2020) and demonstrated in some experimental studies (e.g., Natori and Chenoweth 2008; Włodarczyk-Marciniak et al., 2020).

Most non-experts see the landscape as a whole; rarely do they dissect the landscape in the manner of professionals and policy makers, that manage for the provision of different ecosystem services. The visualization model, displayed in the experiment as large realistic images projected on a screen, reflects the environment in a holistic way, that suits the relationships that exist between the public and the landscape - pleasure, leisure, identity, and a sense of belonging.

Some researchers ask whether landscape preferences are culturally dependent or innate (e.g., Adevi and Grahn, 2012). In contrast to studies that found a significant effect of childhood landscapes on landscape preferences, I examined but did not find any significant effect of growing up in a rural versus urban environment and the attitude towards intervention in nature.

(3) Factors related to the visualization and methodological approach:

Different people or groups were affected differently by the visualization also as a result of factors related to the visualization itself, the mode of construction and presentation, and all the choices made along the way.

I have already addressed the subject of abstraction versus realism, and aspects related to the mode of presentation (for which strict uniformity has been maintained, as explained in the methodology section). In addition, the level of mediation and interpretation given to the participants is an important factor that can largely explain the findings. In other words - the effect of the visualization depends on the extent to which the experiment participants were able to "read" the landscape and distinguish between different management alternatives based on the benefits, or "ecosystem services" these landscapes can provide.

This aspect will be elaborated on in the next section.

5.7 DIFFERENT GROUPS-DIFFERENT TOOLBOX: THE IMPORTANCE OF VISUAL VS. FUNCTIONAL LANDSCAPE DISTINCTION

My results indicate that the professional background and organizational affiliation were notable factors influencing attitudes towards different management alternatives and their legitimacy. Hence, they affected the decisions as reflected in the experimental exercise, regardless of the tools through which the information was presented.

These variables are largely linked with the professional engagement with the landscape, and to the cultural-organizational perception concerning issues of nature intervention, regarding pines in particular (along with the set of personal values, which were not examined here).

For landscape architects and planners, the group affinity is lower due to their very occupation in various independent offices, and the level of confidence in their decisions was low compared to those with a scientific background, academic researchers, or organizations like Nature and Parks Authority. For planners, a visualization is a tool that communicates science in a familiar language that raised the level of confidence, as I expected.

The high complexity of the visualized landscapes and the low visual distinction, along with the lack of specific guidelines regarding the desired functions of the landscape under examination – all made it difficult for the participants to develop a value-based perception about the landscapes (desirable/undesirable). This was especially obvious among participants from the general public. In my experiment, the mediation was minimal.

Participants were asked to choose between two alternative landscapes but were not given instructions on how this should be done. Thus, participants may have asked themselves, “Which landscape functions are we trying to improve, reduced fire hazard, high biodiversity, a place for a picnic, carbon fixation, wood production, or others?”

The functional distinction is the extent to which the viewer is able to differentiate between landscapes based on the benefits (“ecosystem services”) they provide. The low functional distinction in this study, together with the low visual differentiation explained earlier, that characterize complex Mediterranean landscapes, made it a difficult task for participants without any professional environmental background (i.e., the public). Consequently, they were pushed to prefer the text, which may have provided them with some translation of the landscape they could hold on to, which was perceived as a more professional source of information than an image.

If, for example, I would have asked the participants to choose the landscape that looks most natural, the visualization, compared to symbols on a GIS map, would most likely be more beneficial for supporting decisions.

Other targets are those inferred from looking at the landscape but that require a deeper understanding of the viewer regarding the ecosystem. For example, if the goal is high biodiversity, the observer can tap from the landscape heterogeneity and complexity that emerge from the visualization and make an assumption about the biodiversity. If the goal is recreation or hiking, the non-expert observer can more easily tap from the image regarding accessibility, shade, aesthetics, and so on.

When no goal was set, the participants did not feel confident enough to trust their emotions and intuition. This made their decisions more difficult, e.g., (Feel) "*insecure in understanding the consequences of each alternative*, (need in) *creating an alternative of other trees that will take the place of the pines. Public participation in decision-making is very important* (public).

To conceptualize the findings regarding the effect of visualization, I propose that the viewer's ability to make a decision regarding the preferable landscape and choose between alternatives is primarily a function of two variables (Fig. 26):

1) **The visual contrast** that is, how distinct are the two alternatives from each other in their appearance and how easy is it for the viewer to differentiate between them (Fig. 25).
2) **The functional contrast,** which is the extent to which the alternative landscapes are different in terms of the benefits (or the "ecosystem services") they provide and the viewer's ability to differentiate between the two landscapes based on these benefits.

I argue that the effect of visualization depends on the extent to which the contrast between the landscapes under examination is greater, both on the aesthetic level (the "visual contrast") and on the functional level (the "functional contrast"). The stronger these contrasts are - the greater the visualization effect will be. I propose a schematic graphical model, in which each person or group that participated in the experiment could be placed along these two axes - the visual and the functional contrasts (Fig. 26). Indeed, some level of interaction should exist between the two axes. I speculate that each professional group would populate a distinct region in such a 2-D space (Fig. 26).

As noted earlier, I assume that the different groups that participated in the experiment have different worldviews, set of values, and engagement with the landscape (their "toolbox"), which affects their ability to differentiate between landscapes based on use aesthetics and or functionality.

In a sense, the complex landscape and minimum level of information mediation by the researchers in my experiment generated a challenging task for non-experts. It does not mean that visualization is not a suitable tool for these audiences. Rather, it suggests that the information provided regarding the management goals and expected benefits, as well as interpretation before and during the experiment, did not satisfy the need and wish of the participants to supply knowledge-based answers. In response, they relied on the more familiar tool of the executive summaries. The importance of facilitation and interpretation for making effective use of the visual information concurs with the literature (e.g., Lewis and Sheppard, 2006; Reed, 2008; Lovett et al., 2015).

I hypothesized that the relationships of the different groups with the landscape can largely explain the different effects of the visualization (Fig. 26). It is likely to assume that people lacking professional background or expertise in landscape planning, ecology or environment perceive the landscape in a more holistic way. For them, the landscape is a source of enjoyment and part of their local identity and sense of belonging to the place. Most "non-experts" do not analyze the landscape based on its potential functionalities or break it down in their minds into its components, although they do examine its suitability for functions directly related to their lives (like a place for a picnic or a trip, as detailed earlier). At the aesthetic level, their personal abilities to distinguish between the "shades of green" are variable.

I speculate that in general, the engagement of scientists with the landscape takes place largely by analyzing it according to its components. A landscape may be disturbed, diverse, structurally complex, include invasive species, support wildlife, and so on. This mode of observation makes it easier to assess whether the landscape is "desirable" without much mediation. In general, scientists came to the experiment with an extremely high confidence level (~80% with or without the visualization) and were very certain as to what needs to be done, sometimes even before being exposed to all the components of the material provided in the experiment.

Examining alternatives in search of the desired option, while taking into account a variety of considerations, is part of the routine work of most planners. Planners most often seek the assistance of ecological consultants on matters of the environment and often step back when it comes to a discourse on scientific findings and their implications. Visualizing the management alternatives improved their confidence in their decisions and therefore served as a decision support tool, as I hypothesized. In addition, practitioners, or “land managers” (such as nature reserve and regional managers in the NPA) make decisions at the local level daily, have practical experience in managing landscapes for a variety of ecosystem services, and are experienced in using tools for evaluating the landscape’s functionality. For them as well, the model could be defined as a decision-support tool.

Fig. 25.: Example of three levels of visual distinction between two images: a. high; b. medium; c. low. For the viewer to formulate a value-based perception, a definition of specific goals is needed, e.g., a. suitability for a picnic; b. wood production; and c. biodiversity.

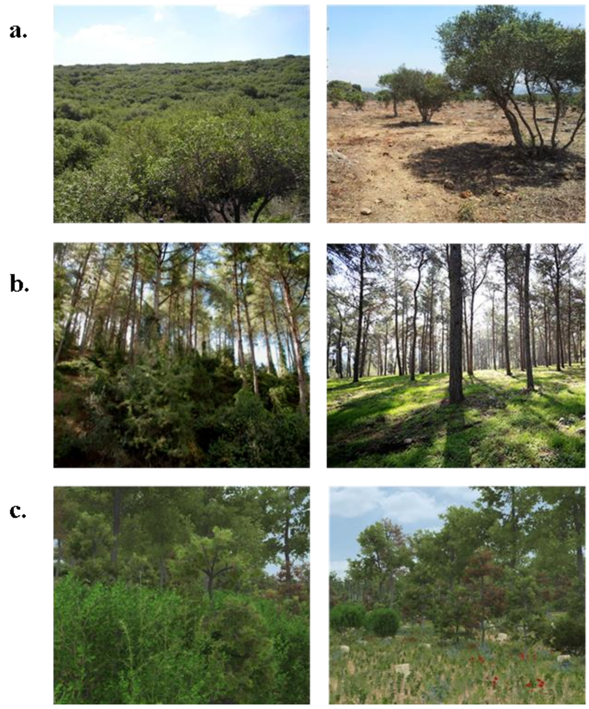
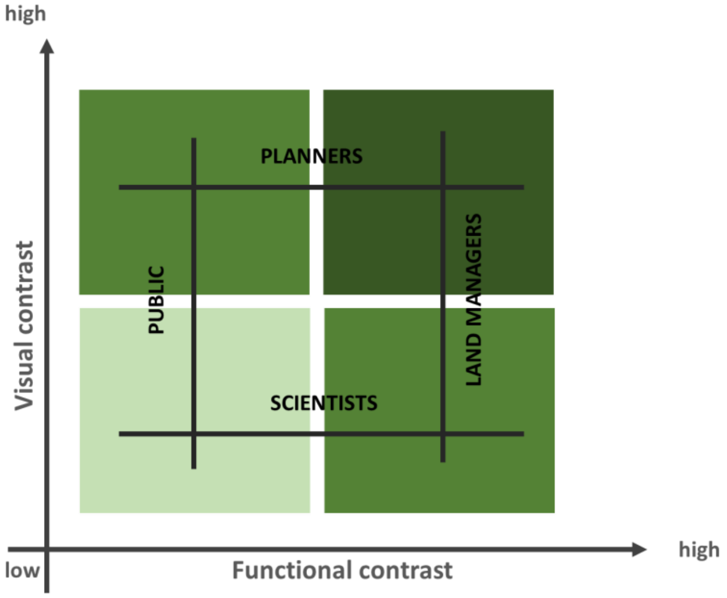


Fig. 26. Visualization effect as a function of the viewer's "toolbox":

The functional contrast is the extent to which the landscapes presented differ from each other in their ability to provide definite benefits; **The visual contrast** is the extent to which the landscapes are distinct from each other in their appearance.



6.0 CONCLUSIONS AND FUTURE RESEARCH

My research deals with the gap between ecological data and their application in policy decisions and the management of ecosystems. I present a decision support tool for complex ecosystems, based on the visualization of scientific data into realistic pictures of future landscapes. With appropriate mediation, our tool can serve as a basis for a more egalitarian public discourse and engage various stakeholders and the public in issues of landscape planning and natural resource management.

Surprisingly, the narrative of active management was well assimilated among the experiment participants. No questions regarding the very need to intervene in nature or responses regarding nature's right to non-intervention arose during the sessions. Instead, interest in details and a high level of ecological literacy were discovered, even among non-professionals (Table 11).

In this study, scientific data describing ecological processes were successfully translated into a vision of future landscapes. However, the effect of the visualization on the decision-making process was complex.

Is visualization a universal language as claimed in the literature?

"The visualizations travel fast across the internet and in social media: they cross linguistical barriers; and in forms of data-visualization – convey information in more convincing ways than words" (Metze, 2020). My conclusion following the experiment is that presenting scientific information as an image or video does not suffice for defining the visualization tool as a universal language for science communication. Multiple factors play a role and influence the observer's response to visualization and the extent of its impact on perceptions and decisions. Different groups seem to favor different tools. The ability of the visualization to create a shared vocabulary and conceptual platform for communication among different stakeholders depends on the participants' world views and values, the landscape features, and the level and content of complementary information (mediation) provided. I assumed that viewers with relevant backgrounds (ecological and botanical) will be affected differently than those lacking any professional because they are most likely to know how to observe the landscape and what to look for. This is an inherent gap between professionals and non-professionals. Bridging it depends largely on the facilitator and the extent to which he manages to produce a common ground for discourse.

Presenting scientific data visually is not sufficient for conveying the ideas and values behind management alternatives, especially when the goal is to provide a decision-support tool, a goal that activates a cognitive mechanism and not necessarily an emotional-based preference (likes / dislikes the landscape). While being able to identify differences among landscapes, viewers will often require further processing of the information and a clear definition of management objectives and targeted benefits to choosing the desired landscape. This idea is well reflected in the respondents" statements, for instance: *"The material provided did not give me enough information to determine the maintenance policy. Is the goal to keep the individual pine trees restricted to allow for a wide variety of species?*" (forest manager); "*I do not know if people roam freely in the whole area. The material does not explain the difference between natural pines and human plantations. Specific goals of the management, assessment of the ecological impact of pines on richness and diversity, rare species and planning visitors' preferences* (is missing)" (public); *"Despite the diverse sources of information, professional knowledge is still required in the forest management to process the knowledge in maps and the model, so decision-making for someone who is not professional is intuitive*"(scientist).

This result concurs with Reed (2008) who emphasized the importance of having clear objectives, as well as highly skilled facilitators in successful participation processes, regardless of the tools that are used. The pre-conditions of my experiment - a complex landscape with low visual contrast and the lack of a clear definition of management goals, made the task of decision making particularly complicated for non-experts. Viewers recognized the visual differences among alternative scenarios but lacked the required tools to formulate a value-based perception about them, e.g., *"The material helped me but also aroused ambivalence about the value of the pines. What do they contribute to the landscape? Some of them interfere with other species and the ecosystem*..." (public)

Does the visualization contribute to a productive, societal discourse about natural resource management?

This question has not been specifically tested in my study. Nevertheless, my results suggest that the visualization model can be considered as a “boundary object,” that integrates information and thus helps to bridge and connect different types of expertise, norms, and values (Carlile 2002). Although the respondents tended to choose moderate solutions when they were available (see Table 9 in appendices), the visualization lowered the confidence of the very confident (Scientists, NPA), and reduced a tendency to intervene in cases where the general tendency (without the use of the model) was to intervene. Thus, it somewhat calmed the adamant stance of the very confident and operated as a moderating factor in the discourse.

Also, the discussion groups that were held after each round of the experiment allowed various expressions regarding the visualization, some of which were clearly emotional, like: "visualization is for the general public, we are professionals"; "visualization equals popular science"; "we are professionals, we know how to read maps, let us work" etc. (Table 11).

Although the visual tool did not influence the decision-making of the general public, the very exposure to it allowed the non-professionals to express themselves as well. One of the insights I had following the study is the great importance and need to produce a tool that will enable not only the communication of scientific knowledge but also interactivity, sharing perceptions and bi-directional knowledge transfer, and changing the role of scientists from a linear to a discourse model (Turnhout et al., 2013).

In this work, I managed to develop and validate a visualization tool for challenging landscapes with a limited set of species and variables. This approach can quite easily be implemented to variable ecosystem types around the globe, given that vegetation data and knowledge about processes that mold the landscape exist. The capability to apply it on larger scales depends on the level of landscape heterogeneity hence the ability to extrapolate from small-scale plots. Based on the visualization tool presented here, I plan to establish a “vegetation formation library” to be used by planners and in landscape restoration projects. Furthermore, I wish to develop a “real-time” tool for envisioning outcomes of management scenarios.

Several questions remain open for future research:

Concerning the construction and validation of the visualization model:

The data and metrics feeding the model are directly adapted for visualization. As such, the model has the potential for continuous improvement through the development of more quantitative visual indices (e.g., tree crown density, leaf area indices, or the proportion of dry vs. green foliage). The collection of such data and their integration into the model will undoubtedly improve the level of realism but would require much more investment. Yet, will greater realism increase the level of trust of stakeholders in the visualization or influence their decisions? What is the level of realism required to achieve the goals of decision-making and public participation support? How many elements and variables can be reduced without compromising perceived realism and what is the added value of including more elements? How do I know if I have achieved this goal? How would the perception be affected if I had used an immersive 3-D display**?**

Concerning the methodological approach:

(1) In the visualization that reflects different management scenarios it is possible and perhaps even necessary to provide complementary information to encourage optimal dialogue between different stakeholders. What additional information is required to improve the effectiveness of the tool?
How will different levels of mediation or interpretation of the represented landscapes affect the response to the model and its impact on different groups? Is more interpretation necessarily better? How can this be checked?

(2) In this study I have focused only on the visual representation of the landscape, as a tool to illustrate future landscapes under different management scenarios. But our perception and experience of the environment do not rely solely on the visual stimulus. Landscapes are also characterized by their collection of sounds, as argued, and demonstrated by many authors (e.g., Pijanowski et al., 2011; Lindquist et al., 2015). In future development of the visualization scenarios in Ramat Hanadiv I would like to include soundscape in the visualization, examine the extent to which sound can be a distinguishing factor between the different landscape scenarios, and test its effect on humans.

6.1 A SUSTAINABLE APPROACH TO DECISION-MAKING IN LANDSCAPE MANAGEMENT

If I go back to the definition by Perkins (1992) mentioned in the introduction, I argue that the visualization developed and tested in my study meets the objectives of a "good enough visualization". The integration of high-quality data layers, long term monitoring data, and expert knowledge (including close familiarity and a good understanding of inter-species relationships in the community) into one comprehensible product, culminated in a tool that conveys high quality, contains enough data, is cost-effective, and has high a degree of perceived realism.

The visualization tool presented here can serve as a “boundary object”, bringing together scientists, with their in-depth understanding of natural systems, and a diverse array of stakeholders with opinions, desires, and knowledge about natural landscapes for collaborative discussions regarding their shared future. This tool represents the integration and translation of different knowledge sources in a way that can bridge the gap between landscape ecology research and its applied value for planning and management.

Finally, visualization is sometimes described as "time travel", showing historical or future conditions and bringing the future to life (e.g., Schroth et al. 2015).

At a time when talking about sustainability and the world we leave for future generations is so ubiquitous, landscape visualizations allow us to "take a glimpse" into this world. Given that full transparency is maintained regarding preparation and assumptions underlying the construction of the tool, landscape visualizations can add aesthetic/visual considerations into the societal discourse about human-nature relationships from a sustainability viewpoint.

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8.0 APPENDICES

Appendix 1: Additional tables

Table 9: Distribution of choices among no/light intervention and heavy intervention alternatives (full dataset)

Case no.	Name	Choice of heavy intervention	Choice of moderate intervention	Choice of no intervention/ BAU
1	Clearing scenario	77 (45%)	N/A	96 (55%)
2	Thinning scenario	16 (9%)	156 (91%)	N/A
3	The moderate scenario	N/A	156 (89%)	20 (11%)
4	Grazing scenario	N/A	109 (62%)	66 (38%)
5	Fire scenario	N/A	143 (81%)	33 (19%)

Table 10. Results of the logistic regression analysis: Preferences for intervention-oriented vs. non-intervention-oriented solutions, by treatment (conventional tools with or without visualization models), professional background (scientific, planning, or other) and organizational affiliation (JNF, NPA, academic Institution, landscape architecture firm, other)

Nominal logistic fit	**P-VALUE**				
	Case1	**Case2**	**Case3**	**Case4**	**Case5**
	Clearing scenario	Thinning scenario	The “moderate” scenario	Grazing scenario	Fire scenario
PROFFESSIONAL BACKGROUND	0.390	**0.026***	0.165	0.993	0.935
TREATMENT (Model/conventional tools)	0.929	0.549	**0.050***	0.985	**0.019***
TREATMENT * PROFFESSIONAL BACKGROUND	0.243	0.637	0.075	0.864	0.296
Chi-Square	12.804	18.329	8.551	5.396	8.878
Prob>ChiSq	0.235	**0.050***	0.128	0.863	0.114
ORGANIZATION	**0.000*****	0.443	0.237	0.915	0.253
TREATMENT	0.584	0.455	0.0371*	0.660	**0.024***
TREATMENT * ORGANIZATION	0.378	0.230	0.266	0.610	0.112
Chi-Square	58.621	32.046	9.660	13.335	14.417
Prob>ChiSq	**0001**.>***	0.0217	0.3787	0.7713	0.1082

טבלה 11: ניתוח תמטי (thematic analysis) של הערות המשתתפים בניסוי קבלת ההחלטות, היגדים לפי נושאים מרכזיים ונושאי משנה (ביקורת-כלים קונבנציונאליים).

Table 11: Thematic analysis of the comments of the participants in the decision-making experiment, statements by major topics and sub-topics ("control" means conventional tools).

היגדים Comments	ארגון ORG	רקע Background	טיפול Treatment	פירוט Details	סיווג נושאי Topic
					ייצוג המערכת הטבעית ורמת הריאליזם
ההדמיה על הכתמיות הציגה נוף שאינו טבעי	אדריכלי נוף	תכנוני	ויזואליזציה		ייצוג לא ריאליסטי של הטיפול הכתמי אחרי שריפה
המבטים היו מצוינים ומרשימים ברמה הגרפית. הטיפול הכתמי באורנים מוצג באופן סכמטי מדי (האורנים המטופלים מוצגים כפיקסלים ולא באופן טבעי)	אדריכלי נוף	תכנוני	ויזואליזציה		
חסר מידע על סוגי קבוצות הצומח שגדלים יחד עם האורנים או קבוצות שצומחות בלעדיהם. כלומר מה שההמחשה הציגה אבל בפירוט מילולי. פירוט על סוגי הטיפול, למשל הטיפול הכתמי, למה הא בריבועים חדים שכאלה, מה היתרונות של טיפול כזה וכו'	אדריכלי נוף	תכנוני	ויזואליזציה		
טיפול כתמי שונה ממה שהוצג שיצר מראה מסודר מלאכותי מעט מבחינה נופית, שהוא פחות רצוי לדעתי.	קק"ל	מדעי	ויזואליזציה		
חלק שלישי את הטיפול הכתמי יש לעשות בצורה רנדומלית על כל השטח ולא במשבצות שגורמות ליער להיראות כמו יער משקי ומוריד את הערך הנופי של כתמיות אחרי דילול	קק"ל	מדעי	ויזואליזציה		
המידע החזותי של ה GIS ושל ההדמיות גרם לתחושת זרות מהמקום.	אדריכלי נוף	תכנוני	ויזואליזציה		
לא היה תמיד קשר ברור בין הממ"ג למראה הוויזואלי, הכתמיות הוגדרה כריבועים	רט"ג	מדעי	ויזואליזציה		
מעט חוסר אמון במודל הוויזואלי.	אדריכלי נוף	תכנוני	ויזואליזציה		
בחלק מההדמיות צפיפות האורנים לא באה לידי ביטוי	אדריכלי נוף	תכנוני	ויזואליזציה		הערות אחרות
ברוב המקרים לא היה הבדל משמעותי בהצגה של 2 מצבים קיצונים לדוגמה: ממשק רעייה או ממשק שריפה - בעיקר בהדמיה	אדריכלי נוף	תכנוני	ויזואליזציה		

		ויזואליזציה	מדעי	קק״ל	היו כמה עצים שריחפו באוויר ללא גזעים.
		ויזואליזציה	מדעי	קק״ל	במודל קשה להבחין בזריעי האורנים אלא אם הם מעל קו הנוף. המפות ממחישות את צפיפותם יותר טוב
		ויזואליזציה	תכנוני	אדריכלי נוף	המחשות המודל נראו לא מציאותיות
		ויזואליזציה	מדעי	קק״ל	בהמחשות המודל היה קשה להבחין בין זריעי אורנים לשיחים/עצים נמוכים של רחבי עלים. המחשות מודל פנורמיות 360 מעלות היו יכולות לסייע מאוד
מורכבות המערכת הטבעית וצורך בפתרונות אינטגרטיביים ולא פשטניים					
חוסר בחלופות ביניים/ שילוב ממשקים		ויזואליזציה	אחר	ציבור	שילוב של פתרונות ממשק שונים יחד
		ויזואליזציה	אחר	ציבור	חסר שילוב בין רעייה כריתה ודילול.
		ויזואליזציה	אחר	ציבור	חוסר אופציות נוספות ויכולת לשנות את התמהיל בפועל.
		ויזואליזציה	אחר	ציבור	מתן אפשרות פתרון מעורב שכולל גם דילול זריעים וגם רעייה מבוקרת. אפשר לנהל את הכתמים בצורה אסתטית יותר. ממשקים קטנים ומגוונים
		ויזואליזציה	מדעי	אקדמיה	היה חסר שילוב של אפשרויות
		ויזואליזציה	מדעי	קק״ל	. לא הוצגו חלופות מורכבות התואמות יותר את האפשרויות.
		ויזואליזציה	מדעי	קק״ל	חלופות נוספות של ממשקים אפשריים
		ויזואליזציה	מדעי	קק״ל	חסר ממשק משולב של רעיה + דילול/כריתה מלאה,
		ויזואליזציה	מדעי	רט״ג	חסרות אופציות יותר יצירתיות של שילובים, ההפרדה בין החלקים אינה ריאלית כי מנהלי שריפות מנהלים גם רעייה ולהיפך. בעולם האמיתי אי אפשר להחליט רק על ניהול שריפות או רעייה. חסרת חלופות ביניים,
		ויזואליזציה	מדעי	רט״ג	חסרת חלופות ביניים
		ויזואליזציה	תכנוני	אדריכלי נוף	חסר שילוב של מדיניות ממשק בין I החלקים השונים, למשל דילול זריעים והמשך רעייה. החלופה של דילול זריעים לא מוחלט אלא עם שיקול דעת-להשאיר חלק מהם.
		ויזואליזציה	תכנוני	אדריכלי נוף	היה חוסר בבדיקת חלופות נוספות לאופן הדילול.
		ויזואליזציה	תכנוני	אדריכלי נוף	היו חסרות אפשרויות נוספות לבחירה (שמירה על הקיים = עצים בוגרים ובמקבי דילול כל הזריעים מתחת ל 3 מ׳ ודילול כמעט מוחלט של הזריעים מעל 3מ׳)
		ויזואליזציה	תכנוני	אדריכלי נוף	כמנהל הייתי רוצה לשקול דרכי פעולה נוספות כאלטרנטיבות.

		ויזואליזציה	תכנוני	ציבור	אפשרויות של שילובי טיפולים רעייה ודילול שילוב היתרון של הרעייה בלי החסרונות שלה.
		ויזואליזציה	תכנוני	קק״ל	לדעתי יש לתת יותר חלופות להחלטה האם עסקים כרגיל או כריתה מלאה של האורנים
		ויזואליזציה	תכנוני	קק״ל	אין מספיק נתונים לגבי מראה נוף הפארק ולדעתי יש לתת יותר חלופות להחלטה האם עסקים כרגיל או כריתה מלאה של האורנים.
		ביקורת	אחר	ציבור	היעדר תרחישים משולבים דוגמת כריתת עצים יחד עם הפסקת רעיית בקר.
		ביקורת	אחר	ציבור	בחלק הראשון הייתה חסרה לי אפשרות ביניים של ניהול הפארק : דילול זריעים ובשאלה 2 הייתה חסרה אפשרות העסקים כרגיל
		ביקורת	מדעי	אקדמיה	בתור מנהל שטח אף פעם לא הייתי פועל לפי א או ב בלבד. האם אין מקום להכניס שילוב מסוים של הפעולות הנחוצות?
		ביקורת	מדעי	אקדמיה	חסרות אפשרויות ביניים בנוסף לשתי האפשרויות.
		ביקורת	מדעי	אקדמיה	מכיוון שהיו מעט חלופות לבחירה והיו חלופות קיצון חסר היה לי גיוון באופן הטיפולים במקרים מסוימים. נדמה היה כי נדרשת גמישות נוספת באשר לטיפולים המוצעים.
		ביקורת	מדעי	רט״ג	חסרות אפשרויות ביניים וכן שילוב בין שיטות ממשק
		ביקורת	מדעי	רט״ג	חסרות חלופות ביניים, לעיתים החלופות שהוצעו לא מספקות פתרון אמיתי כמו בחיים, דורשות המשך של טיפולים חוזרים לאורך זמן
		ביקורת	מדעי	רט״ג	כדאי להראות גם מודל משולב רעייה+כריתה/דילול
		ביקורת	מדעי	רט״ג	חסרות אפשרויות ביניים.
		ביקורת	מדעי	רט״ג	להציג עוד אלטרנטיבות. מגוון ברעייה. הוצג מצב עתידי, היה צריך גם להציג סה״כ עם רעייה בעיבוד ממוחשב
		ביקורת	מדעי	רט״ג	חסרו יותר תרחישים ויותר מגוון פעולות ממשק אפשריות
		ביקורת	מדעי	רט״ג	תוצאות של ממשק משולב רעייה+כריתה,
		ביקורת	מדעי	רט״ג	חסר תרחיש כולל של כל האפשרויות השונות. הכנסת אפשרויות נוספות לממשק.
		ביקורת	תכנוני	אדריכלי נוף	היו חסרות לי אופציות נוספות למשל לא רק כריתה מלאה או דילול של זריעים אלא

					כריתה חלקית כאופציה נוספת שהייתה מקלה על החלטתי
		ביקורת	תכנוני	אדריכלי נוף	חוויתי קושי בהפרדה בין כל התרחישים שתוארו בחלקים השונים של הסקר כיוון שבמציאות כדאי להתחשב בכל הגורמים ולא רק באחד. מה קורה אילו אני מדללת את האורנים וגם משאירה את מצב הרעייה כפי שהוא?
		ביקורת	תכנוני	אדריכלי נוף	חסרה: התייחסות משולבת ממשקים, התייחסות לאפשרות רעיית עיזים
		וויזואליזציה	אחר	ציבור	אני רואה אפשרויות נוספות שעדיפות בעיני על החלופות שהוצאו.
		וויזואליזציה	מדעי	רט״ג	חסרות אלטרנטיבות, למשל היעדר רעיית בקר לא בהכרח אומר שלא ניתן עי רועים אחרים כמו עזים או רועים טבעיים.
		וויזואליזציה	מדעי	רט״ג	חסר לי מה המשמעות של ממשק משולב רעייה+שריפות, גורמים אחרים שמשפיעים על השטח/ או ממשקיים, מידת היחוד של הצמחייה ביד הנדיב והחשיבות לשמר אותה במתכונת הנוכחית, חלופות ממשקיות שלא הוצגו
		וויזואליזציה	מדעי	רט״ג	הבעיה העיקרית היא ההפרדה בין שיטות הממשק כאשר יש קשר הדוק בין כריתה, רעייה ושריפה. האפשרויות לא תאמו את הפתרון המשלב באופן מדויק.
		וויזואליזציה	מדעי	קק״ל	אלטרנטיבות מועטות + בחירה בין תרחישים שלא בהכרח לא מתקיימים יחד.
התייחסות למורכבות		ביקורת	אחר	ציבור	בידוד הנתונים לגורם אחד בלבד שבו צריך להתחשב בעוד שמערכת אקולוגית היא מארג של מרכיבים ומכאן של שיקולים.
		וויזואליזציה	מדעי	אקדמיה	חסרה יציאה לשטח להתרשמות בלתי אמצעית. ההפשטות מסייעות למקד אך גם מפספסות פרטים. ההפשטה מעניינת לצורך מחקר על קבלת החלטות אבל בחיים האמיתיים יש מקום לתכלול שיקולים רבים. הסקר הזה לא נותן מקום לצד הזה. הלאה ההפשטה, המורכבות-על נס!
צורך בתכלול שיקולים נוספים		וויזואליזציה	מדעי	רט״ג	היו חסרים שיקולים נוספים שלא הובאו בחשבון. חסרים ככל הגורמים המשפיעים: שריפות התבססות אורנים ומגוון ביולוגי
		וויזואליזציה	אחר	קק״ל	יש עוד שיקולים מלבד תפיסה חזותית כגון סחיפת קרקע שיפועים וכד׳ שצריכים להילקח בקבלת החלטות.

פרט לחזותי		ויזואליזציה	מדעי	רט״ג	הנושאים אינם מנותקים אחד מהשני . בעולם האמיתי יש צורך להשתמש במגוון כלים משלימים לקבלת התוצאה הרצויה וזה חסר בשאלון.
		ויזואליזציה	מדעי	רט״ג	חסרים כלל הגורמים המשפיעים : שריפות התבססות אורנים ומגוון ביולוגי
		ויזואליזציה	תכנוני	אדריכלי נוף	ההחלטות מבקשות מענה לשאלה מאוד ספציפית הקשורה למראה הנוף. בפועל יש המון שיקולים אחרים, לדוגמה במקרה של שריפות ההמחשות של המודל הוויזואלי היו מרשימות ללא התערבות, יחד עם זאת המעשה הנכון והאחראי יותר הוא דווקא כן דילול השטח.
		ויזואליזציה	תכנוני	קק״ל	יש פה שיקולים שונים אליהם לא התייחסנו וזה מפשט תהליכים מורכבים, אולי קצת יותר מדי (בעיה מובנית וידועה של מחקרים
		ויזואליזציה	תכנוני	קק״ל	היו חסרים שיקולים נוספים שלא הובאו בחשבון
		ביקורת	אחר	ציבור	כמו כן ההחלטות היו מבוססות נוף בלבד ועוד נוף עצים ללא שיקולים של נופים אחרים. היה עוזר משהו להמחיש את השפעת ההחלטות על הצמחייה הים תיכונית באופן ישיר, על שטחים פתוחים וכדי.
		ביקורת	תכנוני	אדריכלי נוף	המידע היה מאוד מצומצם ולא התייחס להיבטים רבים.
		ויזואליזציה	מדעי	רט״ג	השאלות חותכות וקשות כי במציאות הממשק משולב גם רעייה לזמן קצר, גם כריתה, דילול, גיזום, שריפה מבוקרת אם צריך וכו׳. קביעה של ממשק מסוים לזמן של 30 שנה אינו מייצג וקשה לקביעה חותכת.
		ביקורת	תכנוני	קק״ל	הבקשה היא בעצם להתייחסות צרה בכל פעם להתייחס לפרמטר אחד והמצב בד״כ מורכב יותר ויש יותר גורמים משפיעים.
		ויזואליזציה	אחר	ציבור	ההחלטות היו עם גורמים מבודדים, אלו לא החלטות ריאליות. החלטות צריכות להביא את כל הגורמים יחד.
הערות על המתודולוגיה / אמון בכלים שסופקו					
התייחסות לשיטת הסקר		ביקורת	מדעי	אקדמיה	הייתה חסרה הבנה של ההשלכות של התרחישים השונים על מראה הפארק +על היבטים חשובים אחרים בממשק הפארק, כגון סכנת שריפות
		ויזואליזציה	מדעי	קק״ל	המודל הוויזואלי הוא נחמד אבל מראה רק מבט מאוד ספציפי שלא ניתן על פיו להחליט.

		ויזואליזציה	תכנוני	אדריכלי נוף	לא פשוט לחזות את העתיד ומודלים והדמיות לא לוקחים בחשבון תהליכים ופתרונות שיתקיימו, יתפתחו עליהם-אין אנו יודעים
		ויזואליזציה	מדעי	רט״ג	השאלות שהוצגו ברוב המקרים לא הציגו דילמות אמיתיות. הייתה רק אפשרות אחת התואמת את הנתונים שהוצגו. כל ההנחות התבססו על התפתחות ליניארית של תהליך ללא שום אפשרות של שינוי מתהליך אקולוגי.
		ביקורת	מדעי	רט״ג	הביצוע הפרונטאלי די מייגע, שאלון אינטרנטי פשוט היה יכול לתת מענה לבעיה
		ביקורת	מדעי	רט״ג	הנתונים הגולמיים היו חסרים להבנה עמוקה יותר של התהליכים. החומר היה קצת ״לעוס״ לי מדי
		ביקורת	מדעי	רט״ג	ההתנהלות של הסקר איטית מדי ובזבזנית בזמן ומייצרת תחושה לא נעימה למשתתפים
		ביקורת	תכנוני	קק״ל	קצב הניסוי איטי. 5 שאלות בשעה !!!
		ויזואליזציה	מדעי	קק״ל	המחשות המודל הוויזואלי לא היו ברורים לגמרי במיוחד לגבי זריעי האורנים שלא באו לידי ביטוי בהמחשות
		ויזואליזציה	אחר	רט״ג	אהבתי את השילוב בין בחירת תשובה לרמת הביטחון
		ויזואליזציה	תכנוני	אדריכלי נוף	אהבתי את הצורך להחליט בין בחירות קיצוניות כן-לא. זה עזר להרגיש יותר בטוח עם החלטות בהמשך.
		ויזואליזציה	מדעי	קק״ל	היו רק שתי תשובות קיצון אבל האפשרות של האחוזים עשתה את זה יותר נוח
		ויזואליזציה	מדעי	אקדמיה	הממד הצר של הצגת השאלה והעובדות בהקשר הצר של האורנים - ברור. מנגד הקשה על קבלת ההחלטה מכיוון שזה לא מייצג את כל התמונה ואורנים כאן מקבלים ביטוי של חיובי/שלילי טוב/רע ולא מוצגים כתורמים למערכת.
הצעות לשיפור		ביקורת	אחר	ציבור	הדמיה תלת ממדית הייתה מקלה מבחינה ויזואלית, הבנת מפה יכולה להיות קלה לאדם אחד ויותר מדי מופשטת לאחר. הדמיה כזו הייתה יכולה לעזור מבחינת היכולת לדמיין נוף.
		ביקורת	אחר	ציבור	המצגת והגרפים אינם ברורים מספיק. ממליץ על הרצאה קצרה על הנושא לפני הסקר

		ביקורת	תכנוני	אדריכלי נוף	חסר מידע לגבי טיפולים אפשריים לאורך הזמן המגיבים לתרחישים שונים. צילומים/המחשות לגבי המראה המתקבל כעבור שנים - המחשות תלת ממדיות.
		ביקורת	תכנוני	אדריכלי נוף	היתה חסרה המחשה ויזואלית (הדמיות) של המצבים השונים על בסיס תמונות בשטח
		ביקורת	תכנוני	קק״ל	התקצירים היו קצרים מדי. בנוסף, סרטון קצר מהאוויר על מבנה הנוף ברמת הנדיב,
		ביקורת	אחר	ציבור	הייתי שם תמונה של התערבות ותמונה של עסקים כרגיל באותה שקופית כך נוח יותר לראות את ההבדלים.
		ביקורת	מדעי	רט״ג	כמו כן נראה לי שעדיף להציג בשקופית אחת בכל פעם את שלושת האפשרויות זו לצד זו - זה מקל על ההשוואה.
		וויזואליזציה	מדעי	קק״ל	המחשות המודל הוויזואלי נתנו נקודת מבט סובייקטיבית ואולי היה נכון לתת עוד נקודות מבט.
		וויזואליזציה	מדעי	קק״ל	ההמחשות הוויזואליות לא היו מספיק חד משמעיות בשל היותן מודל ממוחשב. צריך היה לנסות לצרף תמונות אמיתיות המתארות את האפשרויות השונות.
		וויזואליזציה	תכנוני	אדריכלי נוף	מכיוון שמדובר ב 30 שנה, הדבר השפיע על ההחלטות שלי. במידה ולא הייתה הגדרת זמן הייתי מרגישה בטוחה יותר לבחור באפשרות של הטבע יעשה את שלו מכיוון שבתפיסה שלי זמן רב יותר מ 30 שנה לוקח כדי להגיע לאיזון ולראות תהליכים שקשורים גם בגורמי אקלים.
		וויזואליזציה	תכנוני	אדריכלי נוף	היה עוזר אם התקריבים היו מיוחסים למבט הכללי ואז הייתי יודעת בכל פעם על איזה חלק מהפארק מדובר.
		וויזואליזציה	תכנוני	אדריכלי נוף	חסרה נקודת מבט יותר רחבה במבטים הממוחשבים.
		וויזואליזציה	מדעי	רט״ג	החלטות נעשות בד״כ בצוות והניסוי הצריך שלא יהיו חילופי דעות.
		וויזואליזציה	מדעי	אקדמיה	אופן הצגת המודל הוויזואלי - היה כדאי לרכז את כל המבטים לכל ממשק. הצגה ויזואלית בעונות שונות של השנה. חסרה המחשה עד כמה כל אחד מהמבטים השונים נפוץ בפארק ומייצג את צורות הנוף הקיימות בו. כדאי לתת לכל משתתף להביט בתמונות בעצמו ללא מגבלת זמן ולא בקונטקסט
		ביקורת	אחר	קק״ל	יש תחושה שהסקר מאוד מגמתי

טענות להטעיה		ביקורת	אחר	קק״ל	השאלון היה מאוד מוכוון מטרה. שחור/לבן ללא תחומים אפורים
		ויזואליזציה	מדעי	קק״ל	אני חושבת שיש השפעה רבה לאופן שבו הוצגו זריעי האורנים במודלים הממ״גים. זה שרואים כתמים אדומים בולטים על נוף ירוק משפיע מלכתחילה על הגישה (הזריעים הם מעין ״כתם״ בנוף ירוק וזה א בהכרח כך מבחינה ויזואלית.
		ויזואליזציה	מדעי	רט״ג	. חלק הרעייה מכשיל. אי אפשר לקבל החלטה לאחר שהדילול מוצג כאופציה בחלק 1.
		ויזואליזציה	תכנוני	אדריכלי נוף	המבטים גם כן למרות שחלק מהם קצת הטעו.
		ויזואליזציה	תכנוני	אדריכלי נוף	. מפות הממ״ג סכמטיות מדי, הארגון בריבועים מטעה
		ויזואליזציה	מדעי	אקדמיה	ההמחשות מטעות ואף מנסות לתת כיוון/לדחוף לגבי כיוון מסוים.
		ויזואליזציה	תכנוני	אדריכלי נוף	התקריבים קרובים מדי ומעט מגמתיים.
		ויזואליזציה	אחר	ציבור	המפות והמודלים היו לי מעט מגמתיים.
		ויזואליזציה	אחר	ציבור	ההדמיות/תמונות יכולות להיות מטעות בשל זוויות שונות שנעשו
תרומה לקבלת החלטות					
התייחסות לידע קודם כבעל חשיבות בהחלטה		ויזואליזציה	תכנוני	אדריכלי נוף	המידע שסופק היה ממוקד, סייע רבות בקבלת החלטות וחיזק את התפיסה הכללית שלי
		ויזואליזציה	מדעי	רט״ג	למרות מקורות המידע המגוונים עדיין נדרש ידע מקצועי בממשק יער כדי לעבד את הידע במפות ובמודל ולכן קבלת ההחלטות למישהו שאינו מקצועי יש בה מן האינטואיציה
		ויזואליזציה	תכנוני	אדריכלי נוף	לצורך המחקר השתדלתי להתבסס רק על החומר שניתן. עם זאת אין להתעלם מכך שכל מידע עובר ומעובד דרך תפיסת עולמי וניסיוני. אני מרגישה שהסתמכתי בעיקר על החומר שהוגש שהיה באיכות גבוהה - תקצירי המנהלים, המצגת הברורה ההדמיות הגרפיות והצילומים.
		ויזואליזציה	תכנוני	אדריכלי נוף	בחלק מההדמיות צפיפות האורנים לא באה לידי ביטוי. על כן ההחלטה שלי התקבלה על סמך מידע קודם והערכה לגבי שינויים עקב צפיפות עתידית של האורנים אם או ללא התערבות.

		ויזואליזציה	תכנוני	אדריכלי נוף	החומר שסופק חיזק את התפיסה הכללית שלי.
		ויזואליזציה	תכנוני	אדריכלי נוף	קשה לי להפריד בין הידע הקודם שלי והשפעתו על קבלת ההחלטות שלי.
		ויזואליזציה	תכנוני	אדריכלי נוף	החומר שסופק תאם וסיכם יפה את הידע הכללי שכבר היה ידוע לי. ולכן סייע במידה מסוימת לקבלת החלטות. המיפויים תרמו במיוחד להבין את תמונת המצב הנוכחית.
		ויזואליזציה	תכנוני	אדריכלי נוף	ניתן לקבל החלטות גם ללא המידע המקדים שאולי מתערב ומשנה את ההחלטות והציונים שניתנו. בכל חלק בניסוי ראינו מספר מבטים אבל ענינו פעם אחת בלבד בשאלון. למרות שההעדפה הייתה לפעמים שונה בין המבטים.
		ויזואליזציה	מדעי	קק״ל	היה קושי לנטרל את הניסיון האישי שלעיתים היה בניגוד לתיאור המילולי
		ויזואליזציה	אחר	ציבור	לא היה חסר לי מידע ממשי וגם ההחלטות שלי התבססו גם על מידע אקולוגי קודם.
		ויזואליזציה	אחר	ציבור	האמת שפשוט חסר לי ידע אישי כך שהרגשתי שקבלת ההחלטות אינה מבוססת דיה ושנית ברור מן הסתם שבסופו של דבר קבלת החלטות שכאלה מבוססת על שלל המרכיבים כדוגמת דילול רעייה ויש עוד מרכיבים שאינני מכיר. תודה!
		ויזואליזציה	אחר	ציבור	חומר הרקע עוסק בנושאי ספציפיים - אין לי ידע בנושא מעבר לסקר. הסתמכות התשובות הייתה על בסיס החומר שהוגש.
		ויזואליזציה	אחר	ציבור	אני מושפע מתרומת האורנים לשריפות ולכן ניתן לראות בתשובותיי המעטה אורנים. אי לכך אני מציע להרבות בנטיעת אלונים ואלות
		ויזואליזציה	תכנוני	אדריכלי נוף	לדעתי ייצוגים רדוקטיביים כאלה עשויים לשמש לקבלת החלטות רק עבור מי שיש לו כבר ידע מוקדם ועמוק עם השטח עצמו.
		ביקורת	אחר	ציבור	חשתי קושי כשתפיסתי הקודמת עמדה בסתירה או בהפרעה למה שהוצג בנתונים.
		ביקורת	אחר	ציבור	הקושי הוא ידע מוקדם שהיה לי על אורנים ושריפות ובעקבות השריפה בכרמל ושלא הייתי אמורה להשתמש בו.
		ביקורת	תכנוני	אדריכלי נוף	אני פחות מכירה את הנושא כך שאין מקום להשוואה עם ידע קיים
		ביקורת	תכנוני	אדריכלי נוף	קבלת ההחלטות נלקחה הן על בסיס ידע קודם וניסיון והן על בסיס תקצירי המנהלים.

					שמשקלם של תקצירי המנהלים בשיקול דעתי היה 80% לפחות
		ביקורת	תכנוני	אדריכלי נוף	המידע סייע חלקית מאוד לעומת ידע ותפיסות קודמות.
		ביקורת	אחר	ציבור	באופן אישי קשה לי יותר לנתח מפות. היה לי קצת קשה להבין מהמפות את ההשפעות השונות על השטח. קשה להתרכז בטקסט. נראה שלבחור כל פעם שניים מתוך 3 רק מבלבל בסוף בחרתי לפי חיבתי לעצים והניסיון שלי.
		ביקורת	תכנוני	אדריכלי נוף	החומר שסופק עוזר בקבלת החלטות אך התשובות מתבססות גם על ידע קודם. עזר גם ניסיון עם שריפות שארעו לאורך השנים בחיפה ובזכרון יעקב.
		ביקורת	מדעי	ציבור	חסר לי ידע מקצועי בתחום הבוטניקה
המידה בה הכלים שסופקו תרמו - חיובי		ויזואליזציה	תכנוני	אדריכלי נוף	התשובות שלי התבססו על החומר שסופק כמעט באופן מלא.
		ויזואליזציה	תכנוני	אדריכלי נוף	החומר סייע בקבלת ההחלטות; החומר עזר במידה רבה.
		ויזואליזציה	תכנוני	אדריכלי נוף	החומר סייע במידה רבה. הדמיות הממוחשבות תרמו מאוד
		ויזואליזציה	תכנוני	אדריכלי נוף	ההדמיות מאוד עזרו לקבל החלטות בעיקר כי זה נתן את הנפח ותרם לנצפות בשטח ולא כמות. המפה נתנה כמות.
		ויזואליזציה	תכנוני	אדריכלי נוף	המפות היו לא מועילות על רקע נתוני המבטים.
		ויזואליזציה	מדעי	אקדמיה	המפות עזרו במיוחד תקצירי המנהלים תרמו מידע עיוני וחשוב ההדמיות מאוד עזרו לקבל החלטות בעיקר כי זה נתן את הנפח ותרם לנצפות בשטח ולא כמות
		ויזואליזציה	תכנוני	אדריכלי נוף	לגבי השריפות המודל הוויזואלי כן מוביל בהחלטה שלי.
		ויזואליזציה	תכנוני	אדריכלי נוף	החומר עזר במידה רבה. תמונות ההדמיה עזרו במיוחד.
		ויזואליזציה	תכנוני	אדריכלי נוף	החומר עזר מאוד. המידע הזה מוכר אך לא בהכרח זמין לקבלת החלטות. היה לי קושי באפשרויות החד ממדיות כביכול כשהמציאות הרבה יותר מורכבת. אבל זו כנראה הדרך לתוצאות מחקר. תקציר המנהלים והשקפים עזרו. גם ההסברים עזרו מאוד.
		ויזואליזציה	תכנוני	אדריכלי נוף	המודל הממוחשב תרם רבות לקבלת ההחלטות. אני מאמין שלולא מודל זה קבלת

					ההחלטות הייתה שונה. כמו כן תקצירי המנהלים. מה שהיה חסר אלו הגורמים המשפיעים על המודל. אולי לא נלקחו בחשבון כל הגורמים והתוכנית העתידית של הפארק.
		ביקורת	תכנוני	אדריכלי נוף	החומר סייע לי אבל גם עורר אמביוולנטיות לגבי ערכיות האורנים. במה הם תורמים נופית? בכמה הם מפריעים למינים אחרים ולמערכת האקולוגית. הידע הוא גרפי ולא כמותי מספרי. חסרות דוגמאות ממקרים אמיתיים
		ביקורת	תכנוני	אדריכלי נוף	החומר סייע לי להסתכל על התמונה בכללותה, על יתרונות וחסרונות רעייה אל מול הביקורת המצב הקיים או התערבות דילול, אל מול סכנת שריפות והצורך להתמודד עם סכנה זו בניהול שטחים פתוחים. המידע שתרם לי הכי הרבה זה הנתון על הפצת זרעים ברעיית בקר
		ויזואליזציה	תכנוני	אדריכלי נוף	החומר היה מספק. הטקסט שמסביר את ההיסטוריה של אורן ירושלים היה מאוד משמעותי עבורי. המבטים העתידיים עזרו לי להבין ולקבל החלטה
		ויזואליזציה	תכנוני	אדריכלי נוף	התמונות לשם המחשה תרמו במיוחד וכמו כן חלוקת התרשים לפי צבעי הנביטה.
המידה בה הכלים שסופקו תרמו - שלילי		ויזואליזציה	תכנוני	אדריכלי נוף	המידע שסופק היה ממוקד וניתב את סוג התשובות. החומר על תוצאות הרעייה וכמות זרעי אורנים היה מפתיע והפך את הקערה על פיה. החומר שסופק סייע רבות בקבלת החלטות. המקור שתרם לי הכי הרבה הוא המידע על הרעייה ותוצאותיה.
		ויזואליזציה	תכנוני	קק״ל	החומר שסופק לא נתן לי מספיק מידע לקביעת מדיניות התחזוקה. האם המטרה היא לשמור על הגבלת הפרטים של עצי האורן כדי לאפשר מגוון מינים רחב? האם לאחר שנפעיל מדיניות מסוימת נפעל בתחומים נוספים כמו דילול יזום על ידי עקירה של הנבטים? מה שהכי עזר לי לקבל החלטה זה השקפים שהראו את המצב אחרי 30 שנה בטיפולים השונים. לא ברור האם ניתן לנקוט פעולות נוספות ואם אין מגבלת תקציב...
		ויזואליזציה	תכנוני	קק״ל	תחושתי היא שהתרשימים ביחד עם תקצירי המנהלים עזרו לי לקבלת החלטה יותר מההדמיות.

		ויזואליזציה	תכנוני	קק"ל	המודל הוויזואלי אינו מספק! כאשר המודל מראה את תמונת המצב כעבור 30 שנה לא נראים הזריעים של היום בגובה כ 3מ'. כיצד ייראו בעוד 30 שנה-כלומר בגובה של 15-20 מ' לפחות
		ביקורת	תכנוני	אדריכלי נוף	המידע היה מאוד מצומצם ולא התייחס להיבטים רבים. הכי תרם תקציר המנהלים בחלקו ובחלקן המפות. היו חסרים ניתוחים קודמים ומהלכים מוקדמים אשר נעשו בעבר במהלך שנות הפעילות
מידע חסר לקבלת החלטה	ידע נוסף	ויזואליזציה	מדעי	אקדמיה	חסרה העלות הכספית של התרחישים והשפעות נלוות לאמצעים המוצעים (חלב, פריחה אביבית וכו). כמובן שקשה לאמוד אבל שילובי שיטות מאוד מתבקש
	ידע נוסף	ויזואליזציה	אחר	ציבור	היסטוריה של טיפול בחורשים דומים במיוחד השפעת טיפול כתמי והפסקת רעייה על התפשטות אורנים.
	ידע נוסף	ויזואליזציה	מדעי	קק"ל	חסרים נתונים על תהליכים אקולוגיים צפויים. לא הייתה התייחסות לתהליכים שיעברו על הצומח שאינו אורנים.
	ידע נוסף	ויזואליזציה	תכנוני	ציבור	מידע נוסף לגבי ממשקים אחרים בפארק, שילוב עיזים, כבשים, מיקום אזורי הדילול למשל ע"פ קרבה לשטח מיושב וכו'
	ידע נוסף	ויזואליזציה	תכנוני	קק"ל	היה חסר מיפוי של התפתחות מינים אחרים במקביל ואת ההשלכות של ההתערבות/אי התערבות היערנית על כל המינים בשטח. תודה ובהצלחה!
	ידע נוסף, כלים	ויזואליזציה	אחר	קק"ל	חסר מידע ורקע נוסף כמו מפת שיפועים קרקעות וכו', המחשה בקנ"מ שונה יכלה לסייע (מספר קנ"מים). הממשק והסקר מתייחסים לאורן ולא למינים נוספים.
	ידע נוסף, תיווך וניתוח מידע	ויזואליזציה	אחר	ציבור	חסר ביטחון בהבנת התוצאות של כל חלופה, יצירת חלופה של עצים אחרים שיתפסו מקומם של האורנים. חשובה מאוד שותפות הציבור בקבלת החלטות.
	ידע נוסף, תיווך וניתוח מידע	ויזואליזציה	תכנוני	קק"ל	חסרים נתונים מעמיקים יותר לקבלת החלטות - סקרים, מקרי בוחן במקומות אחרים. קבלת החלטות שכזו צריכה להיעשות לאחר בחינה ולימוד בנושא בצורה מעמיקה + סקרים אקולוגיים נלווים.
	כלים	ויזואליזציה	אחר	ציבור	חסרה תמונת מצב של רמת הנדיב טרום 1990, לפני שהחלה הרעייה. תודה!

	כלים	וויזואליזציה	תכנוני	אדריכלי נוף	הייתי מוסיפה לכל תרחיש עוד תמונות הדמיה.
	ידע נוסף	וויזואליזציה	אחר	ציבור	חסרה לי האפשרות לנטוע או להשאיר אורנים במקומות מתוכננים במידה נכונה.
	ידע נוסף	וויזואליזציה	אחר	ציבור	חסרות אופציות לטיפול נוסף לאחר קבלת ההחלטות, אופציות לנטיעות, להחזרת הבקר ולניסוי חלקי על חלק מהשטח
	התייחסות לממד האנושי	וויזואליזציה	תכנוני	אדריכלי נוף	חסר לי לדעת האם אנשים מסתובבים חופשי בכל השטח. החומר לא מסביר את ההבדל בין אורנים טבעים לנטע אדם. מטרות ספציפיות של הממשק, הערכה של ההשפעה האקולוגית של אורנים על עושר ומגוון, מינים נדירים והעדפות המטיילים.
	התייחסות לממד האנושי	וויזואליזציה	תכנוני	אדריכלי נוף	חסר לי להבין את הקונטקסט של המבטים, היכן נמצאים, האם מייצגים את האזורים השונים בפארק? להתייחס לשכבות של שימוש האנשים - היכן נוהגים לשהות? איזה אזורים מצולמים בפארק? להעמיק המבטים בשינויים בחורש - לראות פירוט יתר של השינויים שיש, גדלים שונים של צמחייה, פריחות ועוד.
	תיווך וניתוח מידע	וויזואליזציה	אחר	ציבור	נתונים לגבי אמינות המודל וניסיון עבר
	ידע נוסף	ביקורת	אחר	ציבור	חסרים שיקולי תקציב ופירוט סוגי הצמחים והעצים באזור.
	ידע נוסף	ביקורת	אחר	ציבור	חסרה תמונה של יער צפוף, חסר קצת פירוט על היתרונות של מרעה בקר.
	ידע נוסף	ביקורת	אחר	ציבור	היה לי חסר לדעת מה קורה לעצים אחרים כאשר האורנים משתלטים. האם שה על חשבון עצים או על חשבון עשבייה שמבחינתי "שווה פחות"
	ידע נוסף	ביקורת	אחר	ציבור	חסר יותר מידע על הצמיחה שייקח את מקום האורנים ויותר מידע על איזה צמחיה מעודד הרעייה ומה הם הבעיות הנלוות.
	ידע נוסף	ביקורת	אחר	ציבור	חסר ידע על השפעת עצי האורן על הסביבה ויתר הצמיחה. חוסר הבנה מעמיקה של חשיבות המשך קיום צמחייה מגוונת
	ידע נוסף	ביקורת	אחר	רט"ג	חסר יותר מידע על אופי הרעייה, גודל עדר, סוג הסתובבות ועוד ואופי הטיפול באורנים ועוד
	ידע נוסף	ביקורת	מדעי	אקדמיה	חסר יותר ידע על ממשקים קודמים וניסיונות לממשק כפתרון.

	ידע נוסף	ביקורת	מדעי	קק״ל	היה חסר מידע מממשק העבר
	ידע נוסף	ביקורת	מדעי	קק״ל	הייתה חסרה התייחסות לכל הצמחייה ולא רק אורנים. ברור שמדובר על אורנים בלבד ואין התייחסות לנוף בכללותו
	ידע נוסף	ביקורת	מדעי	קק״ל	חסר ידע על דינמיקת צומח ים תיכוני מלבד אורן ירושלים, ממשק קיים והחלטות היסטוריות בניהול ממשק הצומח בפארק, מטרו או תכנית אב לפארק ממנה נגזרים ייעודי השטח בפארק ולפיהם תכנית הממשק בפועל, סטטיסטיקה של התוכנית המודלים המוצגים
	ידע נוסף	ביקורת	מדעי	קק״ל	חסרות פעולות ממשק נוספות. הרצון להשאיר אורנים כבתי גידול לעופות וצומח. חסרים יעדים בתחום החי.
	ידע נוסף	ביקורת	מדעי	רט״ג	חסרה הבנה מעמיקה יותר על הצמחייה המקומית - איזה מינים מצויים. הקושי העיקרי הוא הבנה איך ייראה הנוף העתידי. המחשה ויזואלית אולי. מה עלויות הטיפול של הדילול והאם הריסה ודילול של הקיים תעזור בעתיד. החלופה של שילוב בין הימצאות אורנים באחוז מסוים ונוף מקומי הינה הדבר האידיאלי לפי דעתי.
	ידע נוסף	ביקורת	מדעי	רט״ג	חסרה מפת תפוצת אורנים מחוץ לרמת הנדיב שיש לה השפעה על רמת הנדיב, טיפולים של כריתה והסרת זריעים ברמת הנדיב. הקשיים הם כתמים רציפים המפרים את היעילות של טיפול כזה. חסרה השפעת אורנים ותפוצתם על הצמחייה המקומית
	ידע נוסף	ביקורת	מדעי	רט״ג	אילוצי ממשק מצד הישוב - אזורי חיץ. אילוצים או התניות על הפחתת השפעות אקולוגיות שניתן להשיג בעזרת עצים גדולים, שירותי מערכת הפחתת מזהמים, סינון רעש והפחתה ועוד.
	ידע נוסף	ביקורת	תכנוני	אדריכלי נוף	מידע מפורט לגבי ההשפעה של עצי האורן על הצומח שסביבם - מדכא צמחייה? מידע רב יותר לגבי התועלת של הרעייה.
	ידע נוסף	ביקורת	תכנוני	קק״ל	חסר רקע על קיומו של אורן ירושלים באזור הזה בעבר. השפעה של תצורות הצומח על אוכלוסיות בעלי חיים, מה קיים במרחב הסובב.
	כלים	ביקורת	אחר	ציבור	חסרים תצלומי אוויר מהעבר עד היום וצילומים מהשטח כיום במקביל למפות הממ״ג והמודל הוויזואלי

	כלים	ביקורת	אחר	קק"ל	תחום עיסוקי ניהול שטחים פתוחים ומרעה. לדעתי לא הייתי צריך להשתתף בניסוי. קבלת ההחלטות בהתאם לנתונים הייתה טובה אך הייתי מצפה לראות על המפות צירים וטופוגרפיה בצורה הרבה יותר ברורה. חשוב לזמן משתתפים שזה לא תחום עיסוקם מכיוון שאיני יכול לתת חוות דעת נקיה.
	כלים	ביקורת	מדעי	אקדמיה	אני מניח שהיה לי קל יותר לקבל החלטות העזרת הדמיות של צילומי אוויר.
	כלים	ביקורת	מדעי	קק"ל	חסר סיור שטח
	ידע נוסף	ביקורת	מדעי	רט"ג	חסרה חלוקת שטח הפארק לייעודי שטח לדוגמה אזור שרוצים לשמור על מגוון המינים, אזור לפיקניקים וכו'. חסר מידע על הרעייה-גודל העדר, בקר/עיזים, עצמת רעייה. כדאי להוסיף שאלות גם על עצמת רעייה.
	ממד אנושי	ביקורת	אחר	ציבור	בתחילה היו חסרות ההשלכות שיש לאורנים על הסביבה בהיבט של התכסית/שריפות/הנאה לבני אדם. בהמשך המידע ניתן וקל יותר היה לקבל החלטה.
	התייחסות לממד האנושי	ביקורת	תכנוני	קק"ל	חסרות תמונות וגם תמונות עם נופשים
	התייחסות לממד האנושי, כלים	ביקורת	אחר	ציבור	חסר מידע נוסף כגון סיור בשטח, טבלת ניהול סיכונים, איזה פעילויות ונוף אני רוצה?
	תיווך וניתוח מידע	ביקורת	אחר	ציבור	מידע יותר מעמיק על משמעויות של כל בחירה והשפעת חלופה זו על כל אחד מהממדים
	תיווך וניתוח מידע	ביקורת	מדעי	רט"ג	חסר לי סיכום מילולי של כל המגמות בכל אחת מהחלופות
	תיווך וניתוח מידע	ביקורת	מדעי	רט"ג	חסר לי טקסט נוסף שמסביר על היבטים נוספים או מעמיק יותר ממה שכעת. תמונות של הנוף אולם מוערות (כלומר עם הדגשות על התמונה של פרטים רלוונטיים)
	תיווך וניתוח מידע	ביקורת	מדעי	רט"ג	חסרים לי יתרונות וחסרונות עבור 2 המטרות שהוגדרו.

	תיווך וניתוח מידע	ביקורת	תכנוני	אדריכלי נוף	היו חסרים ניתוחים קודמים ומהלכים מוקדמים אשר נעשו בעבר במהלך שנות הפעילות
	תיווך וניתוח מידע	ביקורת	תכנוני	אדריכלי נוף	חסרה התיחסות לממשק עם הסביבה ואופן הטיפול באזורים אלה.
	ידע נוסף	ויזואליזציה	מדעי	רט"ג	תוצאות של רעייה בעוצמות שונות, האם שילוב של אזורי חיץ סביב ריכוזי האורנים יכול למנוע התפשטות, האם קיימות שיטות להקטנת הרבייה של העצים הבוגרים או מניעת הפצה, אפילו ריסוס לנפילת האצטרובלים לפני ההבשלה). לא בהכרח הוצגו כל האפשרויות, למשל בנושא השפעת הרעייה יש עוד אפשרויות מלבד אלה שצוינו.
	תיווך וניתוח מידע	ויזואליזציה	מדעי	קק"ל	חסרה השוואה בין רעיית בקר לעיזים מבחינת השלכות סביבתיות נופיות.
לא היה חסר לי כלום	כלום	ויזואליזציה	אחר	רט"ג	לא היה חסר כלום לקבלת החלטות
	כלום	ויזואליזציה	אחר	קק"ל	לא היה חסר כלום. כלל אצבע: נדרש ממשק! כיתום = מגוון ביולוגי גדול יותר. תודה!
	כלום	ויזואליזציה	אחר	קק"ל	לא היו קשיים בקבלת ההחלטות
	כלום	ביקורת	אחר	ציבור	לי אישית לא היה חסר דבר.
	כלום	ביקורת	אחר	ציבור	לא חסר כלום.

Appendix 2: Decision-making experiment: Questionnaire (Hebrew and English)

נוף הצומח הים-תיכוני: קבלת החלטות ממשק

תודה על השתתפותך בסקר זה על דרכים שונות לניהול הצומח הים-תיכוני והשפעתן על מראה הנוף בעתיד. כל תשובותיך תישארנה בעילום שם, ותוצאות הסקר לא תשמשנה לשום מטרה פרט למחקר זה. בכל פרסום תופרדנה התוצאות מהפרטים האישיים כך שלא ניתן יהיה לזהות את הנשאל. משך הסקר הינו כ-45 דקות.

השאלון כתוב בלשון זכר, מטעמי נוחות בלבד, אך מיועד לשני המינים.

בתודה מראש על שיתוף הפעולה,

צוות המחקר של רמת הנדיב והטכניון.

פרטים אישיים

ארגון: _______________________ תפקיד: ________________

תאריך: _______________________ שנת לידה: ________________

מקום מגוריי העיקרי היום: ___________________

מקום מגוריי העיקרי בילדות (אנא סמן):

ישראל / חו"ל

ישוב כפרי / ישוב עירוני

בהמשך יוצגו בפניכם שלוש סוגיות הקשורות לניהול פארק הטבע ברמת הנדיב.

הנך משמש בתפקיד מנהל פארק הטבע.

אנא קרא את המידע המוצג בפניך וענה על השאלות מתוך נקודת מוצא זו ועל בסיס השקפתך האישית בלבד (אין תשובה שהיא נכונה/לא נכונה).

חלק ראשון: נופי האורנים של רמת הנדיב

נוף הצומח האופייני לרמת הנדיב הינו שיחייה הנשלטת ע"י עצים ושיחים מקומיים כמו בר זית בינוני, אלת המסטיק, אשחר ארצישראלי וקידה שעירה.

היעד המרכזי של הפארק הוא לספק לציבור הרחב מקום לפנאי, נופש וטיול בחיק הטבע. מטרה נוספת היא שמירה על ערכי הטבע והנוף בפארק. בשטח ישנה רעייה עונתית של בקר.

אתה מנהל השטח ולאחרונה זיהית כי בשטח שבאחריותך התבססו, באופן ספונטאני, עצי אורן רבים. הנך מעריך כי הדבר ישפיע על מראה הנוף ועל הפעילויות שתוכל לפתח בשטחך, אך אינך יודע כיצד ולאיזה כיוון.

לפניך מוצג מידע מדעי על פיזור האורנים בשטחי החורש והשיחייה ברמת הנדיב.
על בסיס מידע זה והרקע שקיבלת, עליך להחליט כמנהל האם ואיך להתערב בנוף הקיים.

- קרא את תקציר המנהלים.
- היעזר בחומר הגרפי המוקרן בפניך בנוגע למראה הנוף העתידי.

לפניך מספר אפשרויות. על בסיס הידע שהוצג בפניך - איזו החלטה תקבל?

בקבלת ההחלטה אנא התמקד בהיבט של מראה הנוף והמידה בה נוף זה הינו הרצוי למקום על-פי השקפתך (ללא התחשבות בשיקולי תפעול ותקציב).

1. **עליך לבחור בין** (סמן בעיגול את תשובתך):

א. **"עסקים כרגיל"** - ללא שינוי בממשק הקיים, למשך 30 שנה (אי התערבות באורנים, הרעייה ממשיכה)

ב. **כריתה מלאה** של כל האורנים ללא מתן אפשרות להתבססות לאורך זמן ("עתיד ללא אורנים")

כמה בטוח הנך מרגיש בהחלטתך (ב-%)?

0 10 20 30 40 50 60 70 80 90 100

לא בטוח כלל **מאוד בטוח**

2. עליך לבחור בין (סמן בעיגול את תשובתך):

א. **כריתה מלאה** של כל האורנים ללא מתן אפשרות להתבססות לאורך זמן ("עתיד ללא אורנים")

ב. **דילול זריעים** - הסרת כל האורנים הצעירים אחת ל-5 שנים, להאטת התהליך

כמה בטוח הנך מרגיש בהחלטתך (ב-%)?

0 10 20 30 40 50 60 70 80 90 100

לא בטוח כלל **מאוד בטוח**

3. עליך לבחור בין (סמן בעיגול את תשובתך):

א. **דילול זריעים** - הסרת כל האורנים הצעירים אחת ל-5 שנים, להאטת התהליך

ב. **"עסקים כרגיל"** - ללא שינוי בממשק הקיים, למשך 30 שנה (אי התערבות באורנים, הרעייה ממשיכה)

כמה בטוח הנך מרגיש בהחלטתך (ב-%)?

0 10 20 30 40 50 60 70 80 90 100

לא בטוח כלל **מאוד בטוח**

חלק שני: השפעת רעייה

לפניך מוצג מידע מדעי על רעיית בקר והשפעתה על נוף הצומח ועל פיזור האורנים בשטחי החורש והשיחייה ברמת הנדיב.

היעד המרכזי של הפארק הוא לספק לציבור הרחב מקום לפנאי, נופש וטיול בחיק הטבע. מטרה נוספת היא שמירה על ערכי הטבע והנוף בפארק.

אתה מנהל השטח ומתלבט האם, עקב ריבוי האורנים בשטחך, נכון יהיה להמשיך את ממשק הרעייה הקיים בו מזה 25 שנה או להפסיקו.

על בסיס המידע שלפניך עליך להחליט כמנהל האם להפסיק את הרעייה (להוציא את הפרות מהשטח).

- קרא את תקציר המנהלים.
- היעזר בחומר הגרפי המוקרן בפניך בנוגע למראה הנוף העתידי.

לפניך מספר אפשרויות. על בסיס הידע שהוצג בפניך - איזו החלטה תקבל?

בקבלת ההחלטה אנא התמקד בהיבט של מראה הנוף והמידה בה נוף זה הינו הרצוי למקום על-פי השקפתך (ללא התחשבות בשיקולי תפעול ותקציב).

4. **עליך לבחור בין** (סמן בעיגול את תשובתך):

א. **"עסקים כרגיל"** - ללא שינוי בממשק הקיים, כולל המשך הרעייה, למשך 30 שנה.

ב. **הפסקת הרעייה** בשטח ("הטבע יעשה את שלו").

כמה בטוח הנך מרגיש בהחלטתך (ב-%)?

0 10 20 30 40 50 60 70 80 90 100

לא בטוח כלל **מאוד בטוח**

חלק שלישי: שריפות במערכת הים-תיכונית

תאר לך שביום בהיר אחד פרצה שריפה מהישוב השכן וכילתה את שטח הפארק כולו.

אתה מנהל הפארק, ומתלבט מה עליך לעשות עכשיו. היעד המרכזי של הפארק הוא לספק לציבור הרחב מקום לפנאי, נופש וטיול בחיק הטבע. מטרה נוספת היא שמירה על ערכי הטבע והנוף בפארק.

לפניך מוצג מידע מדעי על שריפות והשפעתן הצפויה על נוף הצומח הים-תיכוני לצד מידע גרפי על מבנה הצומח ופיזור האורנים בשטחי החורש והשיחייה ברמת הנדיב.

על בסיס מידע זה עליך להחליט כמנהל איזו החלטה לקבל.

לפניך שתי אפשרויות, על בסיס הידע שהוצג בפניך - איזו החלטה תקבל?

בקבלת ההחלטה אנא התמקד בהיבט של מראה הנוף והמידה בה נוף זה הינו הרצוי למקום על-פי השקפתך (ללא התחשבות בשיקולי תפעול ותקציב).

5. היות ולא ניתן לדלל את כל שטח הפארק (5,000 דונם) ולמדת שחשוב לשמור על המגוון הנופי בשטח, הוצע לך לחלק את הפארק ליחידות, לכרות את כל האורנים בחלק מהאזורים (60% מהשטח), לדלל את העצים לתצורת יער דליל באחרים (5-10 עצים לדונם; 30% מהשטח) ולטפח יער אורנים צפוף (20-30 עצים לדונם; 10% מהשטח). דרום הפארק כולו יישאר ללא אורנים.

על בסיס מראה הנוף בלבד (ללא שיקולי תפעול ותקציב) עליך לבחור בין **(סמן בעיגול את תשובתך):**

א. **אי התערבות** - "הטבע יעשה את שלו"

ב. **טיפול כתמי** - התערבות בשטח דרך דילול כמות האורנים כמתואר לעיל

כמה בטוח הנך מרגיש בהחלטתך (ב-%)?

0 — 10 — 20 — 30 — 40 — 50 — 60 — 70 — 80 — 90 — 100

לא בטוח כלל ... **מאוד בטוח**

<u>חלק רביעי: שאלות פתוחות לגבי ההתנסות</u>

1. באיזו מידה החומר שסופק לך כאן סייע לך בקבלת ההחלטות (לעומת ידע ותפיסות קודמות)?

   במידה רבה / במידה בינונית / במידה מועטה

2. איזה מקור מידע תרם לך במיוחד לקבלת ההחלטות?

   א. הטקסט ותקצירי המנהלים

   ב. מפות הממ"ג (GIS)

   ג. המחשות המודל הוויזואלי (במידה ורלוונטי)

3. מה היה חסר לך על מנת לקבל החלטות? ציין קשיים, אם היו.

____

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____

____

4. נשמח לשמוע כל הערה נוספת שיש לך בנוגע לנושאי הסקר

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כעת השלמת את הסקר – תודה על השתתפותך!

The Mediterranean Landscape: Decision Making for Management

Thank you for participating in this questionnaire on the different approaches to managing Mediterranean landscapes and their impacts on the appearance of the future landscape. All your answers will remain anonymous, and the results of the questionnaire will not be used for any purpose other than this study. In each publication the results will be separated from the personal details so that it will not be possible to identify the respondent. The questionnaire lasts 45 minutes.

The questionnaire is written in masculine form, for convenience only, but is intended for both sexes.

Thank you in advance for your cooperation,

The research team at Ramat Hanadiv and the Technion

Personal details

Organisation: __________________________ Role: __________________________

Date: __________________________ Year of birth: ____________________

My current primary place of residence: ________________________________

My primary place of residence during childhood (please indicate):

Israel / Abroad

Rural settlement / Urban settlement

We will now present you with three dilemmas related to the management of the Nature Park at Ramat Hanadiv

Please read the information presented and answer the questions based only on this starting point and your opinion (there is no correct/incorrect answer)

Part One: The Pine Landscapes of Ramat Hanadiv

The vegetation characteristic of Ramat Hanadiv is a garrigue dominated by local trees and shrubs, such as mock privet (*Phillyrea latifolia*), mastic tree (*Pistacia lentiscus*), Mediterranean buckthorn (*Rhamnus lycioides*) and spiny broom (*Calicotome villosa*).

The primary objective of the park is to provide the public with a place for recreation, leisure, and hiking in nature. Another objective is conservation of the natural and landscape assets of the park. Seasonal cattle grazing takes place in the park.

You are the field manager and you recently noticed that in the area under your responsibility many pine trees have established spontaneously. You estimate that this will affect the appearance of the landscape and the activities you'll be able to develop in your area, but you don't know how or in what direction.

We now present scientific information on the distribution of pines in the woodland and garrigue areas of Ramat Hanadiv. Based on this information and the background you have received, you must decide, as manager, whether and how to intervene in the existing landscape.

- Read the executive summary
- Use the graphical information presented regarding the appearance of the future landscape

You have a number of options. Based on the information presented – which decision will you make?

When making your decision please focus on the appearance of the landscape and the extent to which it is desirable landscape for the park in your opinion (disregarding operational or budgetary constraints).

1. **You must decide between (circle your answer):**
    a. **"Business as usual"** – no change in current management for 30 years (non-intervention with pines, grazing continues)
    b. **Complete removal** of all pines with no long-term establishment ("A future without pines")

How certain do you feel about your decision (in %)?

0 10 20 30 40 50 60 70 80 90 100

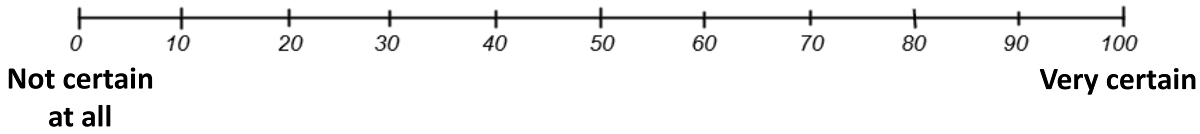
Not certain at all **Very certain**

2. You must choose between (circle your answer):

a. **Complete removal** of all pines with no long-term establishment ("A future without pines")

b. **Thinning of seedlings** – removal of all young pines once in 5 years to slow down the process

How certain do you feel about your decision (in %)?

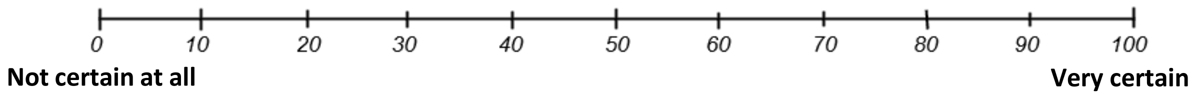


3. You must choose between (circle your answer):

a. **Thinning of seedlings** – removal of all young pines once in 5 years to slow down the process**.**

b. **"Business as usual"** – no change in current management for 30 years (non-intervention with pines, grazing continues)

How certain do you feel about your decision (in %)?



Part Two: The Impact of Cattle Grazing

We now present you with scientific information about cattle grazing and its impact on the landscape and on the distribution of pines in the woodland and garrigue areas of Ramat Hanadiv. The primary objective of the park is to provide the public with a place for recreation, leisure, and hiking in nature. Another objective is conservation of the natural and landscape assets of the park. You are the field manager and are debating whether, due to the increase in pines in your area, it would be appropriate to continue the grazing regime that has been in place for 25 years or to discontinue it.

Based on the information presented, you must decide, as manager, whether to discontinue grazing (remove the cows from the area).

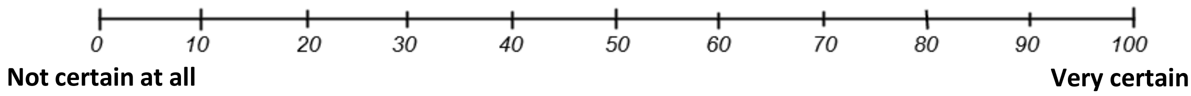
- Read the executive summary
- Use the graphical material presented regarding the appearance of the future landscape

You have a number of options. Based on the information presented – which decision will you make?
When making your decision please focus on the appearance of the landscape and the extent to which it is desirable for the location in your opinion (disregarding operational or budgetary constraints).

4. You must choose between (circle your answer):

a. **"Business as usual"** – no change in current management for 30 years
b. **Cessation of grazing** in the field ("Let nature take its course")

How certain do you feel about your decision (in %)?



Part Three: The Impact of Fire

Imagine that one fine day a fire broke out in the nearby town and destroyed the entire area of the park.
You are the park manager, and are debating what to do now. The primary objective of the park is to provide the public with a place for recreation, leisure, and hiking in nature. Another objective is conservation of the natural and landscape assets of the park.
We now present you with scientific information about fires and their expected impact on the Mediterranean landscape, together with graphical information about the vegetation structure and the distribution of pines in the woodland and garrigue areas of Ramat Hanadiv.
Based on this information you must decide, as manager, which decision to make.

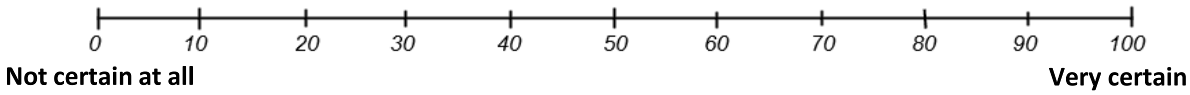
You have two options; based on the information presented – which decision will you make?
When making your decision please focus on the appearance of the landscape and the extent to which it is the desirable landscape for the park in your opinion (disregarding operational or budgetary constraints).

5. Since it is not possible to thin the entire park area (500 hectares), and you have learned that it is important to maintain landscape diversity in the park, it was suggested to divide the park into units, remove all of the pines in some areas (60% of the park's area), thin the trees to a sparse forest formation in others (5-10 trees per dunam; 30% of the park's area) and nurture a dense pine forest (20-30 trees per dunam; 10% of the park's area). The southern part of the park will remain free of pines.

Based only on the appearance of the landscape (disregarding operational or budgetary constraints) you must choose between **(circle your answer):**

a. **Non-intervention** – (“Let nature take its course”)
b. **Patch-scale treatment** – intervention by reducing the number of pines as described above

How certain do you feel about your decision (in %)?



Part Four: Open Questions about the Experiment

1. To what extent did the material provided assist you in making decisions (in contrast to your previous knowledge and perceptions)

   To a great extent / to an intermediate extent / to a small extent

2. Which source of information contributed significantly to your decision making?
   - **a. The text and executive summaries**
   - **b. GIS maps**
   - **c. Illustration by a visual model (where relevant)**

3. What information was lacking for making decisions? Indicate any difficulties that arose.

   ____
   ____
   ____
   ____
   ____
   ____

4. We would be happy to receive any additional comments you have with respect to the questionnaire topic.

   ____
   ____
   ____
   ____
   ____

You have now completed the questionnaire – thank you for participating!

Appendix 3. Decision-making experiment: Three executive summaries.

(1) The establishment of Aleppo pines in the natural garrigue of Ramat Hanadiv;

(2) impacts of cattle grazing; (3) impacts of fire.

רמת הנדיב
Ramat Hanadiv رمات هنديف

התבססות אורן ירושלים בחורש הטבעי ברמת הנדיב

תקציר מנהלים

התפשטות צמחים מתחום תפוצתם המוכר לעבר שטחים חדשים היא חלק בלתי נפרד מהדינאמיקה של מערכות אקולוגיות. התופעה של התפשטות עצי אורן ירושלים מחלקות נטועות והתבססותם בשטחי צומח ים תיכוני טבעי סמוכים נצפית לאחרונה באזורים רבים ומגוונים בישראל.

אורן ירושלים הוא מין מקומי בישראל מזה אלפי שנים ומהווה גם בימינו מרכיב בצומח הטבעי של ארצנו (בעיקר בכרמל ובהרי יהודה). מחקרים מדעיים מצביעים על כך שבמהלך ההיסטוריה חלו תנודות בתפוצה של אורן ירושלים במזרח התיכון בכלל ובישראל בפרט. כיום, קיומן של אוכלוסיות טבעיות (שלא ניטעו ע"י קק"ל) של אורן ירושלים בישראל מוגבל לאזורים מצומצמים יחסית עם תנאי בית גידול מיוחדים. אלה הן אוכלוסיות ששרדו מאוכלוסייה רחבה יותר שהתקיימה כאן בעבר.

ההערכה המקובלת היא כי הייעור האינטנסיבי שנעשה בישראל במחצית השנייה של המאה העשרים גרם לשינוי דרמטי הן מבחינת מספר עצי האורן המייצרים ומפיצים זרעים והן מבחינתם תפוצתם, היות והאורנים ניטעו באזורים רבים בהם לא התקיימו באותה עת אוכלוסיות טבעיות של אורן ירושלים.

שני מרכיבים אלו הגבירו במידה משמעותית את הסיכוי להתבססות אורנים בשטחים נוספים בחבל הים-תיכוני של ישראל.

רוב חורשות האורנים ברמת הנדיב ניטעו ע"י קק"ל בין השנים 1976-1978. לאור המלצות מומחים ורגישותו של אורן ירושלים למזיקים, רק חלק קטן מהחורשות שניטעו התבססו על מין זה (לדוגמה – לאורך כביש הכניסה לרמת הנדיב).

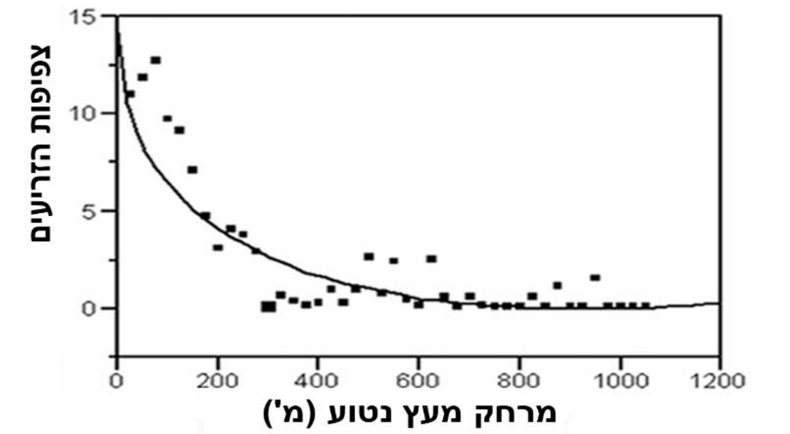
כיום, 30 שנה אחרי, ניתן לראות בתוך שטחי החורש הטבעי ברמת הנדיב כמות רבה של עצי אורן ירושלים, אשר רובן לא ניטעו ברמת הנדיב אלא הופצו אל השטח והתבססו בו .

מחקר שיזמה הנהלת רמת הנדיב, בחן את הדינמיקה של תהליך התבססות אורן ירושלים בפארק הטבע של רמת הנדיב. במסגרת המחקר מופו ואופיינו בשטח ומהאוויר שלושה דורות של עצי אורן ירושלים הפזורים בפארק. במחקר נמצא כי תהליך ההתבססות הינו דינאמי ותלוי באדם. נמצא כי פיזור האורנים בשטח הפארק תלוי באופן חזק במרחק מעצים נטועים בוגרים (ראו גרף מס' 1)

ובמבנה הצומח (מבחינת כיסוי וגובה הצומח). קצב ההתבססות היה גבוה באופן מובהק בתצורות צומח פתוחות (שיחייה נמוכה או חורש דליל) כאשר בתנאים של חורש מפותח וסבוך יותר (מבחינת כיסוי וגובה הצומח) פוחתת צפיפות האורנים המתבססים בשטח.

גרף מס' 1: **צפיפות זריעי האורנים ביחס לקרבה לעצים נטועים**

("זריעים" = עצים צעירים אשר התבססו בשטח)



באשר לחיזוי הדינאמיקה העתידית של התבססות האורנים בפארק וההשלכות הנופיות של התופעה, ניתן לציין מספר נקודות:

1) קצב התבססות האורנים צפוי להתגבר בטווח הקרוב עקב הגעת עצים צעירים שהתבססו בשטח לשלב של ייצור זרעים, תהליך שיביא לעלייה במספר האורנים מפיצי הזרעים ברחבי הפארק. בעקבות תהליך זה, שטחים שהיום עדיין מרוחקים מעצים מפיצים, ייחשפו ללחץ התבססות אורנים ההולך וגובר.

2) מאידך, בטווח הארוך יותר יש סיכוי להאטת קצב ההתבססות עקב הזדקנות אורנים נטועים וירידה בייצור הזרעים.

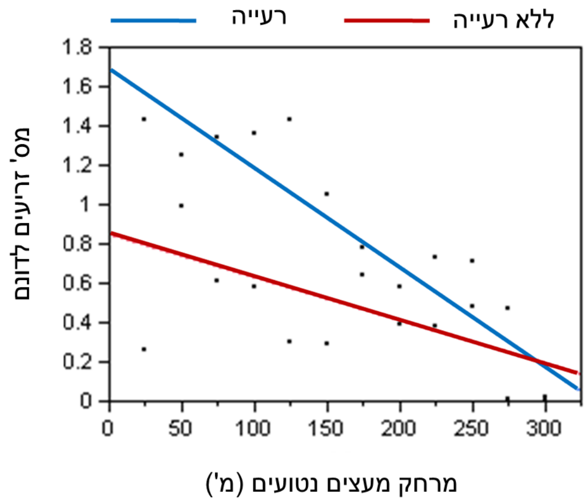
3) ההתנגדות לתהליך ההתבססות תלויה, ככל הנראה, בדינאמיקה של הצומח הטבעי. בשטחים בהם נמצא הצומח הטבעי במגמה של התפתחות (עלייה בכיסוי ובגובה הצומח) תתגבר, ככל הנראה, ההתנגדות להתבססות האורנים, כלומר – קצב ההתבססות יואט.

התבססות אורן ירושלים בחורש הטבעי – השפעת רעיית בקר

תקציר מנהלים

הצומח הטבעי בישראל עוצב תחת פעילות אדם במשך אלפי שנים. מבין השפעות האדם ניתן לציין את הרעיה והשריפה כהפרעות בעלות חשיבות רבה בעיצוב הצומח.
שני גורמים אלו מאטים את תהליך התפתחות הצומח (הסוקצסיה) המוביל לכיסוי השטח על ידי צומח מעוצה צפוף ופותחים מרחב להתבססות מיני חלוץ מסוגים שונים, דוגמת צמחייה עשבונית חד שנתית ומינים מעוצים כמו אורן ירושלים.
הרעיה וגם השריפה נחשבים היום ככלי ממשק לניהול ועיצוב מערכות צומח ע"י האדם.
רעיית בקר בחורש הטבעי תורמת לגיוון הנוף ולמניעת שריפות, אך גם לשינויים במבנה ובהרכב הצומח הטבעי.
ברמת הנדיב מונהגת רעיית בקר מאז 1990. ניטור ארוך טווח המתבצע ברמת הנדיב מזה כ-15 שנה מצא כי לרעייה השפעה חיובית על עושר ומגוון הצומח, לצד הפחתת סיכון השריפות דרך צמצום כמות העשבייה היבשה בעונת הקיץ. הרעייה תורמת גם למינים ספציפיים, לדוגמה, במחקר שהתבצע ברמת הנדיב לאורך מספר שנים נמצא כי נדרשת רעיית בקר על מנת להבטיח קיומם של מרבדי כלניות בשטח הפארק.
ביחס לתהליך התבססות האורנים בפארק הטבע, נמצא כי רעיית הבקר גרמה לעלייה מובהקת בצפיפות זריעי האורנים בשטח הפארק (ראו גרף 2). כמות האורנים המתנחלים בשטחים הנתונים לרעיית בקר הייתה גדולה פי שניים, לערך, בהשוואה לשטחי הביקורת המוגנים מרעייה.
המסקנה הייתה כי הסרת הצומח העשבוני מהשטח ע"י הבקר מעודדת את תהליך התבססות האורנים בשטח הפארק (אוסם וחוב' 2010).

גרף מס' 2 : השפעת רעיית בקר על צפיפות האורנים המתנחלים ברמת הנדיב



אורן ירושלים בנוף הים-תיכוני - השפעת שריפה

תקציר מנהלים

שריפה היא תהליך אקולוגי חשוב המניע מערכות אקולוגיות רבות בעולם, דרך הסרת חלק ניכר מכמות הצומח. למערכות האקולוגיות הים תיכוניות הטיפוסיות מספר מאפיינים בעלי משמעות מההיבט של השריפות - הקיץ חם ויבש והצמחייה ניתנת לשריפה בקלות, אולם מותאמת ובעלת כושר השתקמות מהיר לאחר שריפה.

כתוצאה מפיתוח מואץ וקיטוע של אזורים טבעיים רבים, הפכו השריפות לגורם סכנה משמעותי עבור האדם, וסביבתו. האתגר והחובה הניצבים בפני מנהלי שטחים פתוחים הם הפחתת האיום והנזק שעלולות לגרום שריפות, בד בבד עם הבטחת המשך תפקודה של האש כחלק בלתי נפרד מהמערכת האקולוגית.

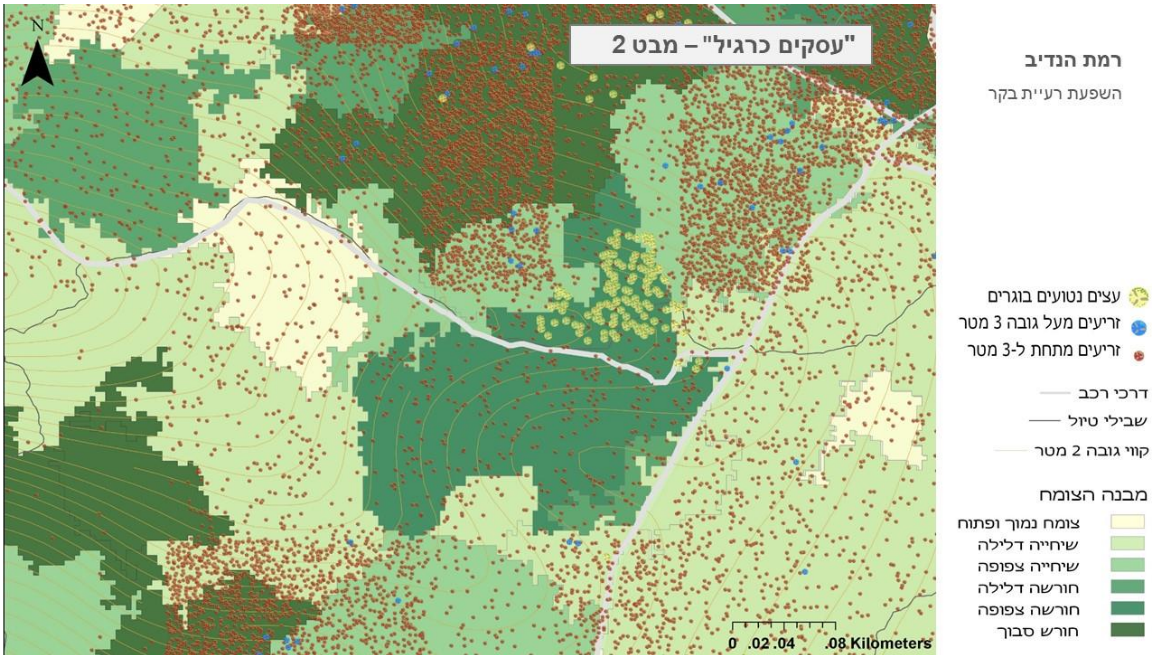
בחודש מאי 1980 פרצה באזור רמת-הנדיב שריפה גדולה שהתפשטה מקיבוץ מעיין צבי ושרפה חלקים ניכרים משטח הפארק. סקר היסטורי של צילומי אוויר הראה כי כעבור 21 שנה חזר הצומח לכיסוי דומה לזה שהיה לפני השריפה (ברוידא ועמיתיו, 1996).

עם זאת, המצב כיום שונה לעומת בעבר כתוצאה מהתהליך הדינאמי של התבססות האורנים בחורש הטבעי. תהליך זה הביא לשינוי בצפיפות האורנים המפיצים בשטח והשפיע באופן ניכר על אופי השריפה (שריפה בשטח שיש בו אורנים צפויה להגיע לעוצמות גבוהות יותר) ועל התפתחות הצומח שלאחריה, היות והעץ מפיץ זרעים בתגובה לחום ויובש.

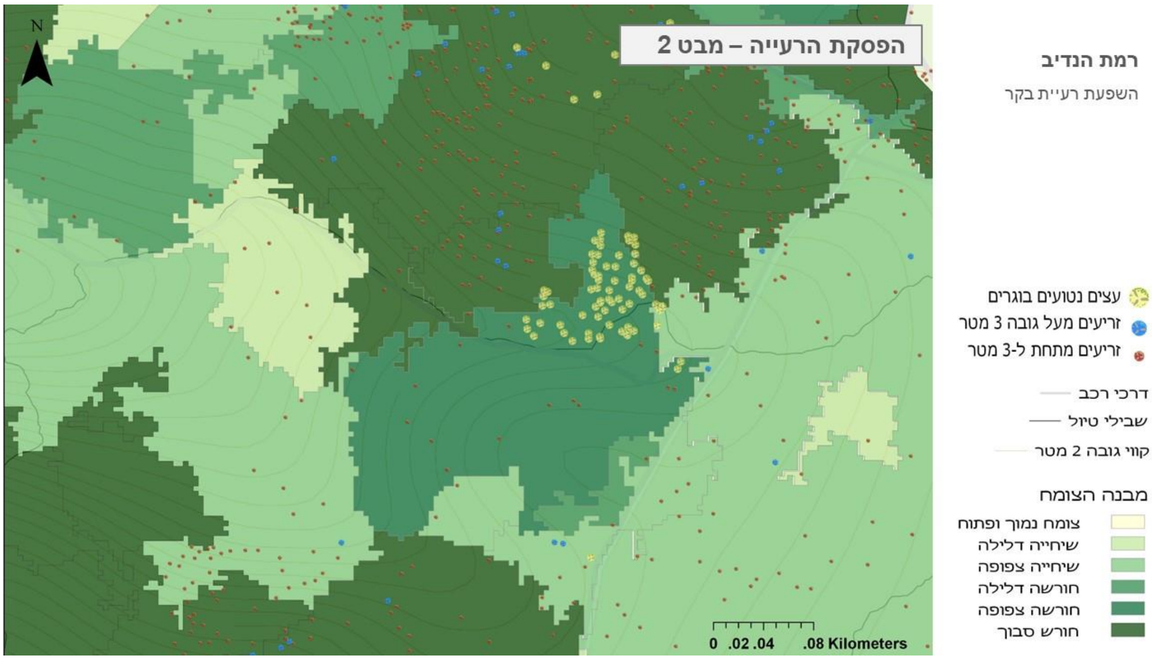
לסיכום: אירוע שריפה יכול לגרום לפיזור רב של זרעים מעצים שנשרפו וגם לסילוק הכיסוי הצמחי באותה יחידת שטח ובכך ליצור חלון הזדמנויות להתבססות מאסיבית של אורנים.

Appendix 4. Decision-making experiment: Example of GIS maps and visualization presented in the decision-making experiment, for one location and two scenarios (a). business as usual, including continued cattle grazing versus (b). cessation of all grazing in the area, 30 years provision)

(a).



(b).


הפסקת הרעייה – מבט 2
N
0 .02 .04 .08 Kilometers
רמת הנדיב
השפעת רעיית בקר
עצים נטועים בוגרים
זריעים מעל גובה 3 מטר
זריעים מתחת ל-3 מטר
דרכי רכב
שבילי טיול
קווי גובה 2 מטר
מבנה הצומח
צומח נמוך ופתוח
שיחייה דלילה
שיחייה צפופה
חורשה דלילה
חורשה צפופה
חורש סבוך

ויזואליזציה מבוססת מדע ככלי מנבא למראה הנוף בעתיד וככלי מסייע לקבלת החלטות ממשק ותכנון

תקציר

ערכם החזותי של נופים, כמו גם תפקודם, מושפעים באופן ישיר מהחלטות שנעשו לגבי אופן הניהול ומידת ההתערבות האנושית בהם. להחלטות אלה ישנו מרכיב סובייקטיבי, המתייחס לשאלות של הנוף הרצוי, איכויותיו החזותיות, האסתטיקה והתפקוד שלו תחת שימושים מגוונים.

מידע רב על מערכות אקולוגיות הנאסף למאגרי נתונים גדולים ומורכבים אינו מוכוון לפתרון בעיות יישומיות וברוב המקרים אינו נגיש למתכננים, מקבלי החלטות והציבור הרחב שאינם מומחים וזקוקים לשפה מוכרת יותר.

תיווך המדע למקבלי החלטות ולציבור הוא צורך חיוני ואתגר גדול בעידן של עומס מידע, חוסר בשקיפות וחוסר בכלים תומכים לתהליכי קבלת החלטות ולשיתוף הציבור בתכנון.

וויזואליזציה תלת-ממדית ממוחשבת פותחה ככלי להמחשת נופים עכשוויים ועתידיים תחת תרחישי ממשק חלופיים, ולתקשורת של תחזיות מדעיות לקהלים מגוונים.

מטרות המחקר היו (1) לפתח ויזואליזציה מבוססת מדע להמחשה, עבור מתכננים ומקבלי החלטות, של תהליכים מעצבי נוף ושל המשמעות הוויזואלית לטווח הארוך של חלופות ממשק שונות (2) לבחון את המידה בה הוויזואליזציה התלת ממדית מהווה ייצוג תקף של מראה הנוף במציאות ו (3) לחקור את תרומתה הייחודית של הוויזואליזציה לתהליכי קבלת החלטות בנוגע לניהול משאבי טבע, ואת יכולתה לתווך בין מאפיינים אובייקטיביים של נופים לבין האופן בו הם נתפסים על ידי קהלים שונים.

הוויזואליזציה שפיתחנו מבוססת על 30 שנות ידע מדעי ונתונים אקולוגיים שנצברו בפארק הטבע רמת הנדיב ומתארים תהליכים מעצבי נוף הרלוונטיים למערכת הים תיכונית ולמערכות אקולוגיות מורכבות נוספות בעולם.

בניסוי ולידציה שערכנו נמצא כי המודל מהווה ייצוג תקף של נופי הצומח של הפארק מנקודת המבט של הצופה.

תרומת הוויזואליזציה לקבלת החלטות והשפעתה על אופי ההחלטות ועל מידת הביטחון של נשאלים מרקע ושיוך ארגוני שונים נבחנה בהשוואה להצגת הנתונים המדעיים בכלים סטנדרטיים (טקסט, גרפים ומפות). בניסוי בו השתתפו 176 נבדקים בעלי רקע תכנוני, אקולוגי או ציבור רחב, נבחנה השפעת הכלי הוויזואלי על אופי ההחלטות עצמן ועל מידת הביטחון בהחלטות של הנבדקים.

בניסוי התבקשו הנבדקים לבחור בין מופעי נוף עתידי שונים, אשר שיקפו את התוצאה החזויה מדעית של חלופות ממשק שונות לטיפול בסוגיות מרכזיות בניהול נופים ים-תיכוניים: התבססות אורנים בחורש הטבעי, טיפולים אחרי שריפה, רעיית בקר והשפעתה או המשמעות הנופית לטווח הארוך של "לתת לטבע לעשות את שלו". בכל אחד מהמקרים, התבקשו הנבדקים לציין את מידת הביטחון שחשו בהחלטותיהם

בנוסף, על ידי שימוש בכלים איכותניים, נבחנה השפעתה של הוויזואליזציה על תפיסות של נבדקים בעלי רקע מקצועי וארגוני שונה ביחס לנושאים כמו התערבות בטבע, מורכבות נופית, ריאליזם והפשטה ולגבי הכלים השונים שהוצגו בפניהם על מנת לתקשר ידע מדעי.
הוויזואליזציה העלתה במובהק את מידת הביטחון בהחלטות, היות שאפשרה להתרשם מההשלכות הממשק לטווח הארוך על מראה הנוף והקטינה את אי-הוודאות. לפיכך, היא היוותה כלי תומך בקבלת ההחלטות. השערתנו כי המודל ישפיע על אופי ההחלטות לטובת התערבות רבה יותר בטבע (ממשק אקטיבי) לא נתמכה. הוויזואליזציה, כאשר השפיעה, היוותה דווקא גורם ממתן שהפחית את הבחירה בהתערבות.
עם זאת, הוויזואליזציה לא תפקדה כשפה אוניברסלית והחלטות הממשק כמו גם השפעת הוויזואליזציה עליהן, שיקפו במידה רבה את הרקע המקצועי ואת השיוך הארגוני של המשתתפים בניסוי. נמצא כי הוויזואליזציה השפיעה בעיקר על רמת הביטחון של נבדקים בעלי רקע תכנוני, לעומת בעלי הרקע המדעי אשר הציגו רמת ביטחון גבוהה גם ללא הוויזואליזציה ולא הושפעו ממנה.
בניגוד להשערתנו, הוויזואליזציה לא השפיעה על נבדקים מהציבור הרחב, אשר העדיפו את תקצירי המנהלים וביקשו עיבוד ותיווך נוספים של המידע המדעי.
אנו מציעים כי השפעת הוויזואליזציה על יכולת הצופה לגבש תפיסה ערכית לגבי הנוף ולקבל החלטות בהתאם לכך תלויה בשני גורמים: הניגודיות החזותית של הנוף המתקבל מחלופות הממשק השונות, כלומר, המידה בה הנופים המוצגים על ידי הוויזואליזציה שונים זה מזה במראם, והניגודיות התפקודית, שהיא המידה בה הנופים המוצגים שונים זה מזה מבחינת יכולתם לספק תועלות מוגדרות.
לנוכח השינויים הצפויים במערכות הטבעיות בעתיד וכחלק מהשיח הציבורי על קיימות, אנו טוענים כי היכולת להמחיש נופים עתידיים באמצעות נתונים מדעיים יכולה, בסיוע תיווך מתאים, לשלב מקורות מידע שונים, לגשר בין מדע האקולוגיה של הנוף ליישומו המעשי ולהוות בסיס לשיח ציבורי שוויוני ולקבלת החלטות מושכלת המשלבת טבע, סביבה ואדם.

מחקר זה נעשה בהנחיית:

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יועץ:
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בפקולטה לארכיטקטורה ותכנון ערים
המסלול לתכנון ערים ואזורים

אנו מודים לרמת הנדיב על התמיכה הכספית במחקר.

ויזואליזציה מבוססת מדע ככלי מנבא למראה הנוף בעתיד וככלי מסייע לקבלת החלטות ממשק ותכנון

חיבור על מחקר

לשם מילוי חלקי של הדרישות לקבלת התואר דוקטור לפילוסופיה

ליאת הדר בן אשר

הוגש לסנט הטכניון - מכון טכנולוגי לישראל

סיוון התשפ"א, חיפה, מאי 2021