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WILDLAND FIRE MANAGEMENT: ART OR SCIENCE?

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Abstract

Wildland fire management is defined as integration of fire-related technological, biological, physical and ecological information to meet land management objectives. This blend of science and art have raised rhetorical questions about the nature of fire management, that any answer would not make the field of fire management any less or more important. Answers could be found on basics of science and art, fire management issues (e.g., ecological role of fire, fire economics, fire engineering) and people's perspectives discussed in this paper.

Keywords: *Forest Fires;* Fire Ecology; Hypothesis Testing; Deductive Reasoning; Inductive Reasoning.

Introduction

Wildland fire management has been evolved into an academic, research and operational subject area for the last 30 years, first in North America and later world-wide. From the beginning, fire scientists and managers have utilized physico-chemical and bio-ecological methods of inquiry in combination with techno-empirical means of action to solve fire-related land use problems.

This blend of science and technology could potentially raise "philosophical" questions about the nature of fire management:

- Is wildland fire management an art or a science?
- Could someone answer the previous question based on evidence?
- What are definitions of fire management science and technology?

The present essay is an attempt not to definitely answer this sort of rhetorical questions but to give some information to the reader to formulate his/her own perspective on the theme, based on definitions of wildland fire management, an outline of the basics of science and a narrative open-ended list of current fire management issues.

Wildland Fire Management

Fire is an integral part of the forest management process; it plays a key and dichotomous role in the objectives modern societies manage for their natural resources and ecosystems (e.g., timber, wildlife, range, water, recreation). For example, if the objective is to manage fire for timber production all other forest resources will be inevitably influenced by fire as well.

When a fire manager ends up making a decision on planning a treatment or selecting an alternative, he/she has to function in an technocratic manner in the real world that is bounded by the biological, physical, economic, social, political and technological parameters (Figure 1). Managers do not want to make decisions outside these parametric boundaries and their decisions should increase the socio-economic benefits possible.

Within this scheme, wildland fire management could be defined as integration of fire-related technological, biological, physical and ecological information into land management in order to meet objectives. More specifically, fire management includes a number of tasks that are graphically depicted in Figure 2 and are: fire prevention, fuel management, prescribed burning, fire detection, fire suppression and fire effects. To accomplish these tasks, fire management utilizes extensively two tools, i.e., fire behavior and fire ecology (Figure 2).

Basics of Science

Science is in simple terms "knowledge gained by systematic study," whereas by art is meant "the application of skill and experience in doing something." Historical evidence credits classical Greeks with developing a scientific outlook in the world, based strongly on empirical observations; then, Pythagoras was responsible for denouncing the observable world as just a poor image of the true essence of nature.

Nowadays, the domain of the scientific inquiry (Figure 3) is determined at one end by a stochastic or theoretical approach to the world (e.g., *Everything is in flux, Heraclitus*) and at the other end a deterministic or quantitative way (e.g., Einstein's theory of relativity). In between, there is the probabilistic environment (e.g., statistical methods) where the discipline of fire and its subject areas more likely fit (Figure 3).

The classic scientific methodology involves a **descriptive phase** where gathering of facts and observations are made, a **narrative phase** where empirical evidence is summed up and a pattern is searched (inductive reasoning), and an **analytical phase** where some form of hypotheses are generated/tested and specific inferences are made from a general theory (i.e., deductive reasoning). Sometimes students are simplistically led to believe that the testing of hypotheses is the only respectable piece of the scientific method; in reality, scientific inquiries most commonly include part or all of the above phases (Leonard and Eddy 1973), as shown in the following examples.

Eratosthenes, a Greek philosopher of the 3rd BC century, calculated the Earth was a sphere with a circumference of 40,000 km (an error of less than 5%), based on the sun's position, shadow lengths and the distance between two places; Eratosthenes took specific new information, applied it to old "rules" and reasoned out a remarkable deduction. A typical example of induction is Darwin's theory of natural selection, for it has been derived from facts and observations of species' survival and heredity and evolved into the cornerstone of biology.

In modern scientific societies, there is a gap between what we understand and what we think we should understand (i.e., a black hole between data and knowledge) that creates an information anxiety (Vlachos 1992). Some scientists rather cynically claim that information is inversely proportional to knowledge; but realistically there is a long and tedious process for data to become knowledge and to eventually form paradigms, which is the "big picture" that makes sense. Transformation of data into knowledge progresses consecutively by data (like bricks added to a wall) and information (development of a pattern) that become knowledge (when everything fits together and has meaning); all these combine to produce wisdom through experience and common sense (Figure 4).

Current Issues of Fire Management

Ecological Role of Fire

Fire has an ecological role to play in the evolution of ecosystems, especially in ecosystems where biomass production is faster than natural decomposition due to climatic conditions. For example, wildfire is a significant disturbance factor in Mediterranean-type of ecosystems where the rate of fuel accumulation is greater than the decay rate; and that is one of the reasons why total fire exclusion from these ecosystems is an utopia even if there was the perfect and ideal fire suppression organization.

The ecological role of fire has also become evident in mid- to high-elevation forests where fire is normally a sporadic and intense event (e.g., low-frequency, high-intensity fires that occur in mountainous coniferous forests). There is another aspect of fire's universal ecology as depicted in large-scale wildfires that have dramatic impacts on global and regional climatic extremes and human health problems.

From Suppression to Management

Forest fire suppression alone has been overwhelmingly used for decades in most of the countries, but for the last few years there in not a parallel improvement in the effectiveness of forest protection against wildfires. Nowadays, it is time for all states to move forward from fire suppression to fire management (as described previously) in the form of all necessary general components, i.e., fire prevention, fire suppression and fire rehabilitation.

Application of only one component over the others creates a critical deficiency and handicap for the whole protection organization and voids any positive aspects that may exist individually. Importance of this issue becomes even greater in respect to the ecological role of fire—i.e., being a natural phenomenon that obeys to certain physico-chemical and biological laws.

FIRE MANAGEMENT DECISION-MAKING

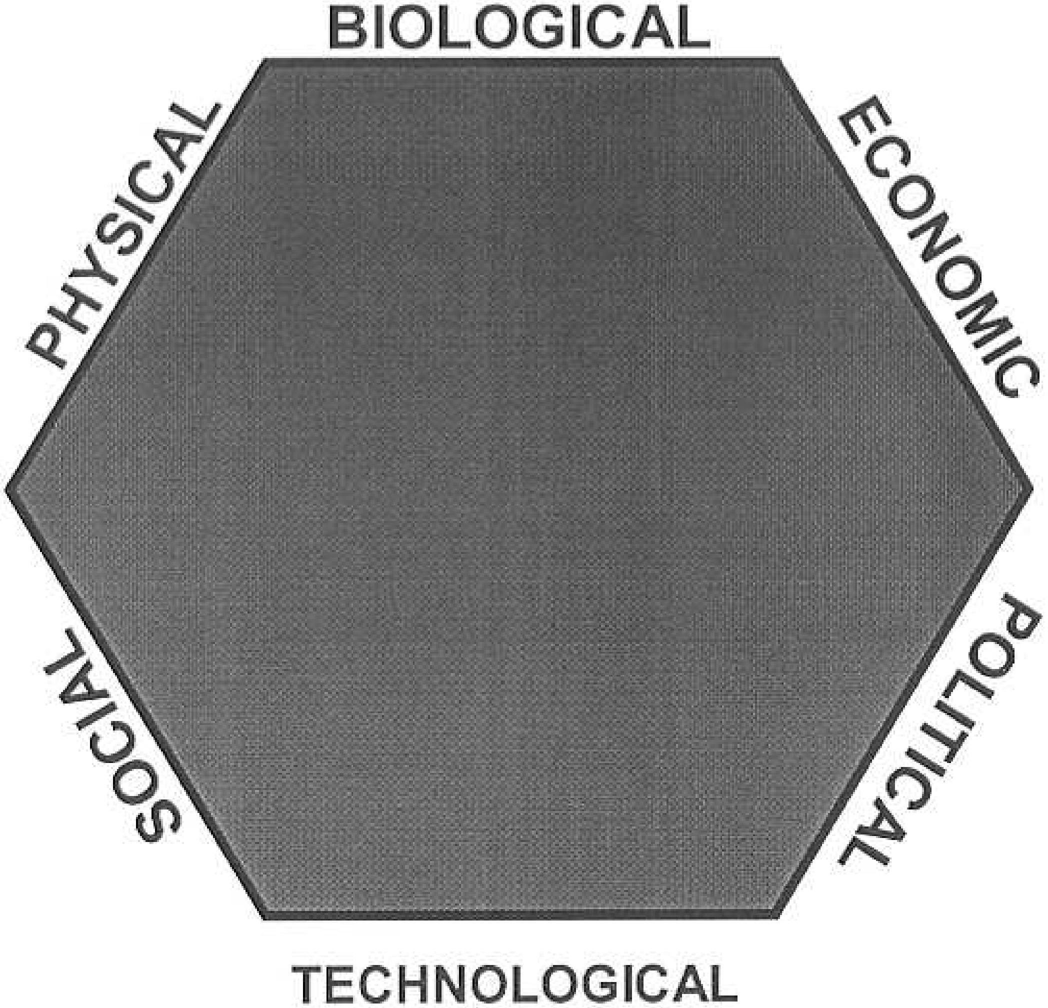

Figure 1. Decision chrono-space of fire management.

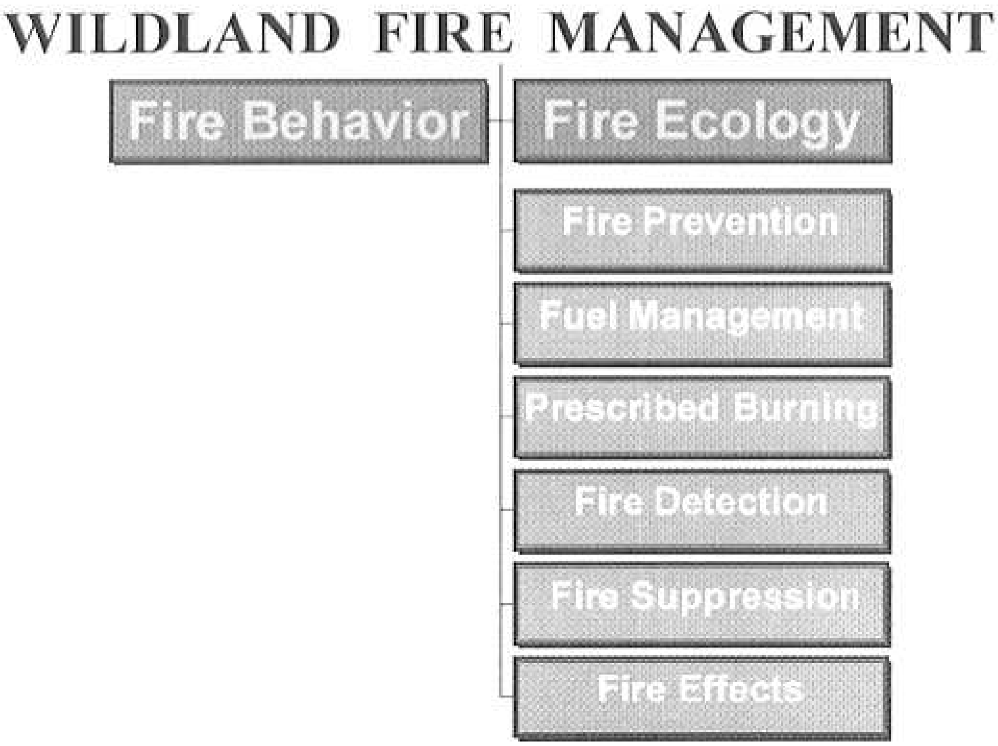

Figure 2. Tasks and tools of wildland fire management.

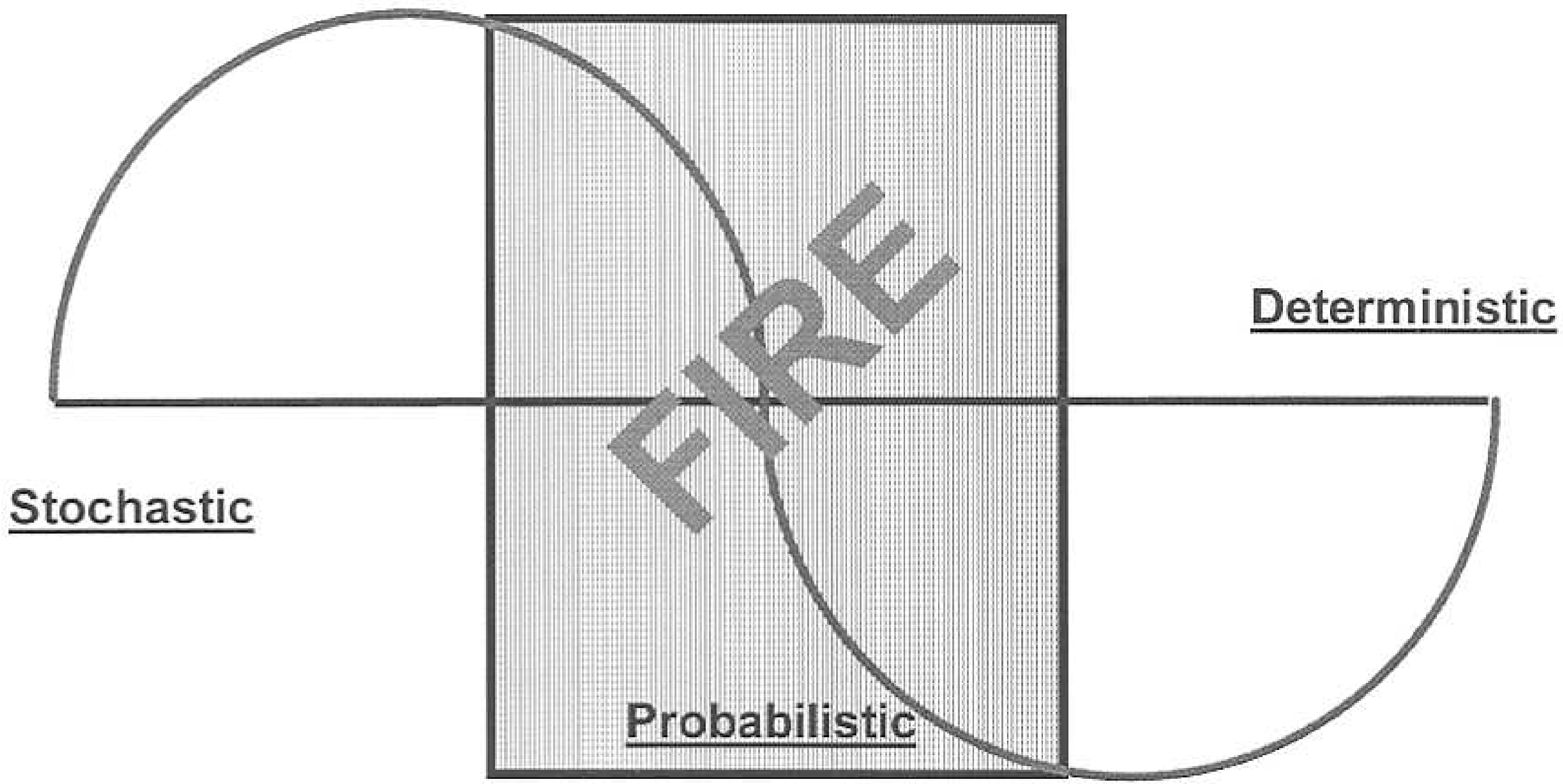

Figure 3. Domain of the scientific inquiry.

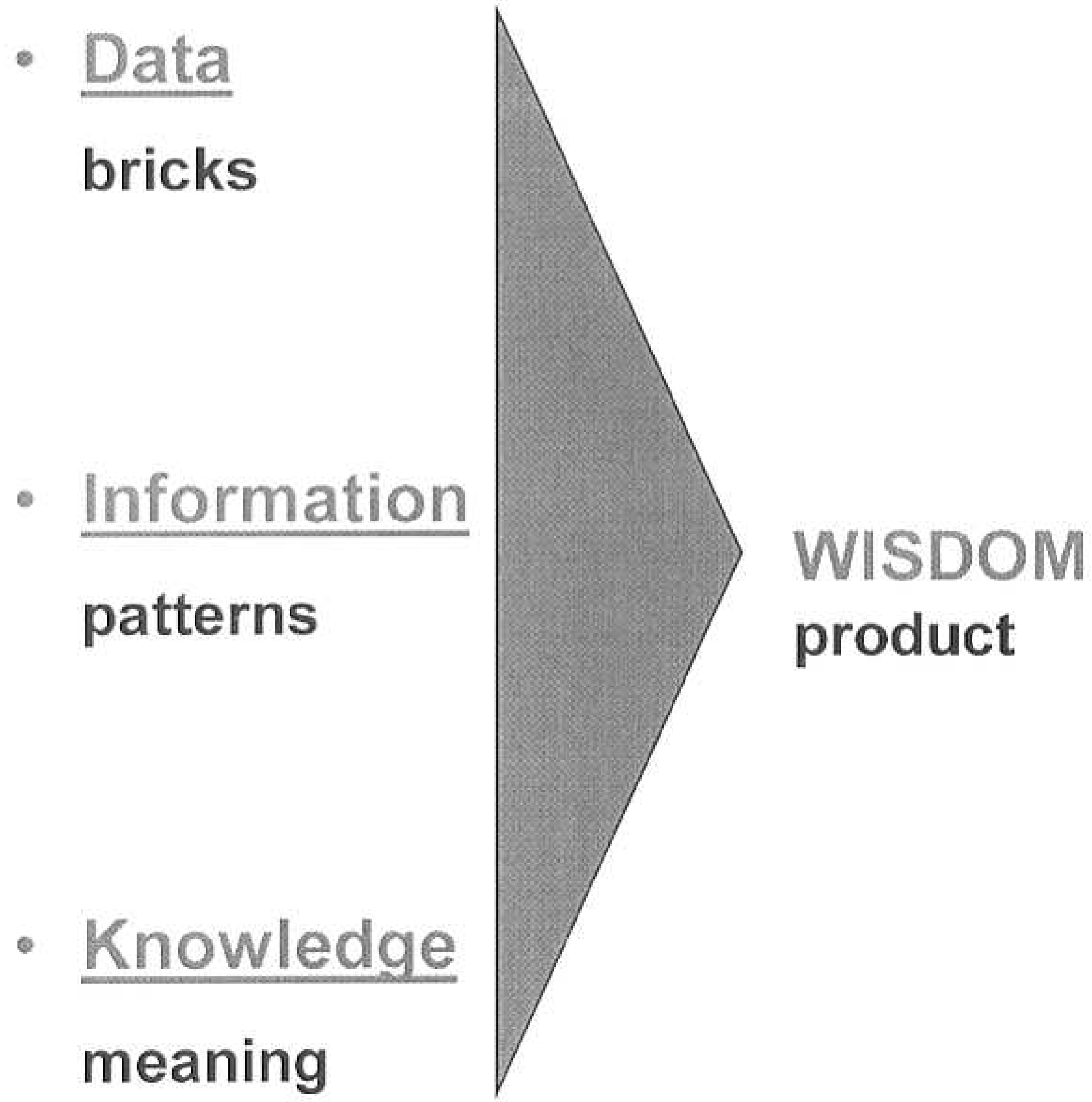

Figure 4. Transforming data into paradigms.

Fire Engineering

By fire engineering is meant the application of research, technology and development within a fire management environment. It does not necessarily considers only the machinery and equipment but it also includes the principles, the models, the systems, and the current techniques of fire management and technology that need to be essential elements of every modern wildfire protection organization.

This "bag of tools" aims in not only improving the efficiency of the wildland fire management system but also to aid in better, faster, and justified decisions made by fire managers. Nevertheless, there seems to be a certain level of inexcusable techno-phobia among some managers, that comes from limited exposure to modern technological developments along with peoples' inherent insecurities and fears of new practices replacing empiricism and "business-as-usual."

Law Enforcement

All of the above concepts and issues would be rendered insignificant if organized societies will not enact certain regulations, codes and actions to prevent anthropogenic and other accidental fires. Another step is the task of enforcement, as an attempt to regulate behavior under the threat of legal action with law and order.

Legal procedures should proactively target land ownership issues, land-use priorities, development codes and damage reimbursement standards on a basis of environmental and socio-economic criteria; these procedures need to be enacted into actions with appropriate mechanisms of enforcement by state authorities.

Prescribed Burning

Ecological and operational studies have shown that prescribed burning (i.e., prescribed use of fire which is confined to a pre-determined area, burns under pre-specified conditions and accomplishes site-specific objectives) in certain wildland ecosystems could help achieve several multiple-use management objectives (e.g., fire hazard reduction, range improvement, site preparation). The burning criteria are set precisely in an "environmental window," and thus, there is control over the prescribed fire spread, intensity, frequency and effects—parameters that are unmanageable in wildfires (Kalabokidis and Wakimoto 1992). Within this scheme, elements of an acceptable prescribed fire plan contain the treatment area and objectives, the fire prescription, the burning plan and the report.

Prudent prescribed fire programs have the potential to replace destructive wildfires that burn under adverse weather conditions, but wide implementation of such programs should be considered only when the existing fire management organization is already capable of effectively suppressing wildfires. Thorough analyses of the role of fire through history and ecology are also prerequisites for successful and beneficial prescribed burns.

Wildland-Urban Interface

Fire safety and protection have nowadays become essential with adverse physical phenomena, increased fire risks, and unique resource values in wildland ecosystems located adjacent to residential areas—the so called wildland-urban interface. Every year, forest and rangeland fires threaten thousands of homes and other structures worldwide and some of these wildfires are responsible for the loss of invaluable human life and property. The problem is epitomized in certain parts of the world with ecological and societal conditions prone to catastrophic fire outbreaks (e.g., Australia, southern Europe, western United States).

Conditions that are favorably contributing to increased fire hazards are: i) the urban spread into traditional wildland areas of highly flammable vegetation and/or mountainous topography; ii) large population densities and high land demand and pressure that unwittingly (either accidentally or criminally) may cause ignitions; and iii) certain fire-prone climatic regimes and/or anomalies (e.g., Mediterranean-type of climate).

Vegetation management (e.g., thinning or clearings for adequate defensible space around and within structures) based on potential fire behavior criteria, fire-safe building construction features, adequate water and road systems for fire protection, and technocratic land-use planning and zoning are the key measures that need to be implemented (Kalabokidis 1996). Homeowners should become aware that complete fire-proofing is not possible and residential developments are built at owner's risk in wildland surrounding; nevertheless, the above fire safety measures provide possibilities for proactively reducing fire hazards and protecting life and property.

Fire Economics

In current times of limited budgets and resources, one of the objectives of a sound and realistic fire management system would be to minimize the costs and damages of every individual fire outbreak; to succeed in this, the importance of non-market values (e.g., hygiene, recreation, wildlife, archeological sites, wilderness attributes) and a wildfire economic analysis based on productivity estimates (i.e., connection of costs plus net value changes or damage losses) should be realized.

By cost (C) is described what is given up or sacrificed to produce an action, whereas values describe the worth of goods or experiences to society. Net value changes (NVC) are the decreases (or increases) in resource values due to fire—i.e., damages minus benefits (Rideout and Omi 1990). An optimal fire management program should pursue minimization of the C+NVC, as indicated by the dashed line in Figure 5 (after Mills and Bratten 1982).

Conclusion

"Is wildland fire management an art or a science?" This is more of a rhetorical question and any answer would not make the field any less or more important. The answer of each scholar is subjective and could be based on a number of things that he/she already knows, heard and/or read in this paper. For the sake of this paper's arguments, an appropriate null hypothesis (H_o) would be:

H_o = *WILDLAND FIRE MANAGEMENT IS <u>NOT</u> A SCIENCE*

Since one can never prove a hypothesis but only fail to disprove it, if the above intentionally negative hypothesis passes different conceptual tests without being disproved it continues; if it fails then alternatives

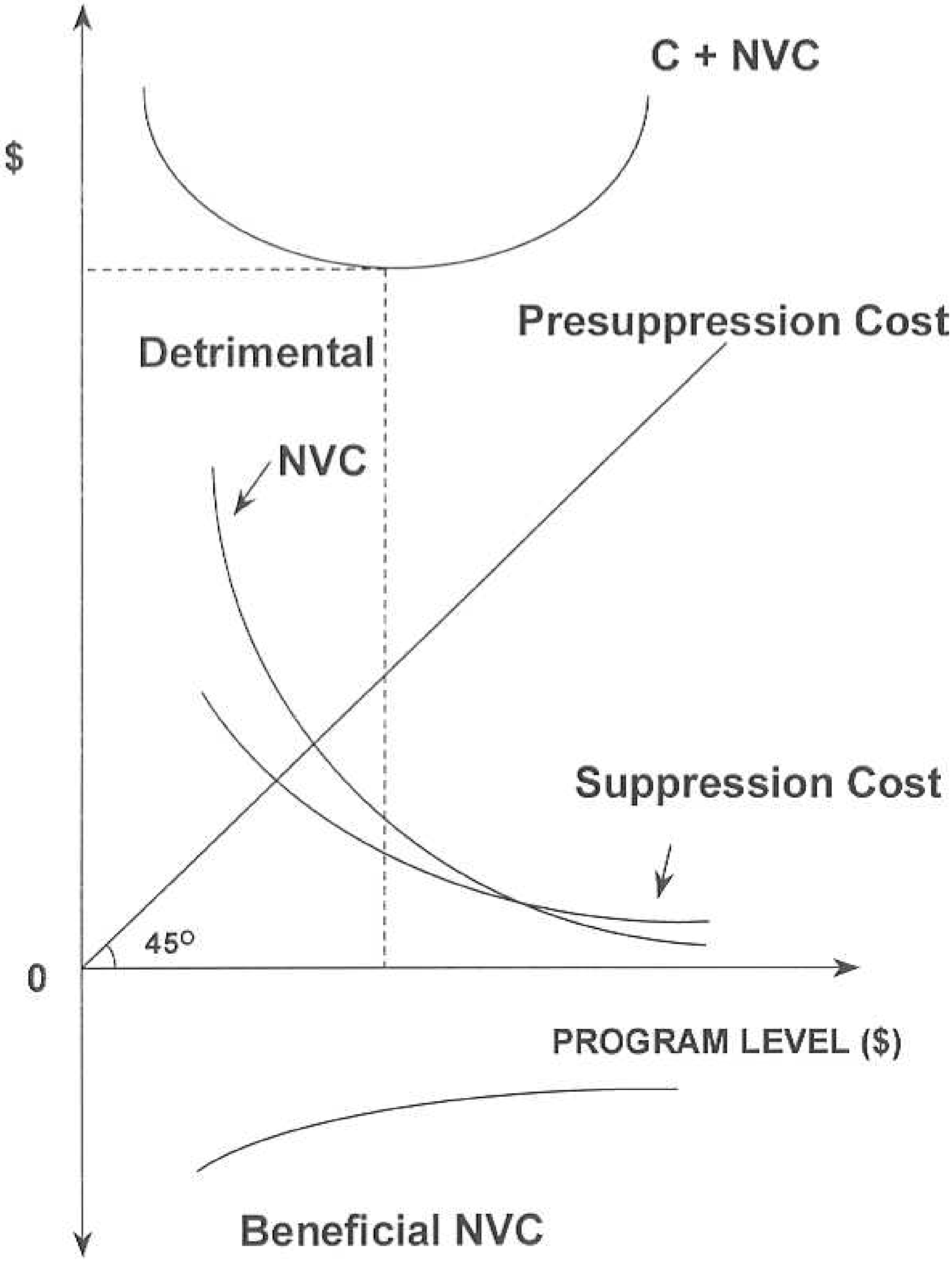

Figure 5. Optimal program level and cost plus net value change (C+NVC), as indicated by dashed lines (after Mills and Bratten 1982).

need to be tested. Keep in mind that a less favorable proposition should be put as a null hypothesis in order to control the type I error or significance level (α) of the test (i.e., the probability of rejecting a true hypothesis), versus the type II error (β) or the probability of accepting a false hypothesis.

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