Modification and Validation of Fuel Consumption Models for Shrub and Forested lands in the Southwest, Pacific Northwest, Rockies, Midwest, Southeast and Alaska

Final Report
JFSP Project 98-1-9-06

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Joint Fire Science Program Project: 98-1-9-06

Final Report to the Joint Fire Science Program

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ABSTRACT

The Fire and Environmental Research Applications Team has completed Consume version 3.0 (http://www.fs.fed.us/pnw/fera/products/consume.html). This system is the principle science delivery product for the Joint Fire Science Program-funded project entitled: "Modification and Validation of Fuel Consumption Models for Shrub and Forested Lands in the Southwest, Pacific Northwest, Rockies, Midwest, Southeast and Alaska" JFSP 98-1-9-06.

Consume v 3.0 predicts the amount of fuel consumption, emissions, and heat release from the burning of activity fuels, piled debris, and natural fuels based on weather information, fuel loading, fuel moisture, and a number of other factors. Using these predictions, resource managers can determine when and where to conduct a prescribed burn or plan for a wildland fire for use to achieve desired objectives while reducing impacts on other resources. Consume v 3.0 was developed in coordination with the Fuel Characteristic Classification System (FCCS). Fuel loading values from the FCCS fuelbed reference library can be accessed directly in Consume or imported from customized FCCS fuelbeds. With its built-in link to the FCCS, Consume v 3.0 can be used for most forest, shrub and grasslands in North America and may be applicable to other areas of the world. Other deliverables include a Consume v 3.0 User's Guide with scientific documentation (proposed as a general technical report) and a journal manuscript in preparation describing the fuel consumption equations.

INTRODUCTION

Land managers use prescribed fire and wildland fire for use to maintain and restore ecosystems, reduce fuel loadings, expose mineral soil, improve wildlife habitat, and reduce the hazard of wildfire. In the past, a fire that consumed most of the organic material on a site was thought to have met management objectives. As understanding of forest ecosystems has increased, forest managers have become more discriminating in their use of prescribed fire and managing wildland fire. Fires are now applied to satisfy forestry management objectives and benefit forest ecosystems as a whole.

Fuel consumption is one of the key variables in the modeling of fire effects and in understanding when and how fire should be applied to meet site and landscape objectives. Until recently, much

of the research on fuel consumption focused on prescribed burning following forest harvest (Sandberg 1980, Sandberg and Ottmar 1983, Brown et al. 1991, Ottmar et al. 1993, Reinhardt et al. 1997, Albini and Reinhardt 1997).

The primary focus of this project was to improve our understanding of fuel consumption in wildland fuels by developing new fuel consumption models for shrublands (including chaparral, sageland and palmetto/galberry types), hardwood forests (including southern and eastern regions of the U.S.), and boreal forests (including white spruce, black spruce and hardwood forests of Alaska) and incorporating them into Consume v 3.0. We also resolved differences in fuel consumption between the relatively short flaming phase of combustion and the longer smoldering phase of combustion that generally contributes the majority of wildland fire emissions.

Consume v 3.0, released for beta testing in the fall of 2005, reflects our improved understanding of fuel consumption and emissions in wildland fire throughout major fuel types in the United States. Consume v 3.0 is a decision-making tool, designed to assist resource managers in planning for prescribed fire, wildland fire for use, and wildfire. Consume predicts fuel consumption, pollutant emissions, and heat release based on a number of factors including fuel loadings, fuel moisture, and other environmental factors. Using these predictions, resource managers can determine when and where to conduct a prescribed burn or plan for a wildland fire to achieve desired objectives, while reducing the impact on other resources.

OBJECTIVES

The objectives of this project were to modify and improve exiting models that predict fuel consumption during wildland fires, specifically in regions of the United States where prescribed burning is increasingly used to reduce fire hazard. We also designed field consumption trials to resolve differences in fuel consumption between flaming and smoldering stages of consumption in fuel types where residual smoke is a problem.

The study was composed of six major tasks: (1) a needs assessment; (2) study plan development; (3) field data collection and analysis; (4) new and modified model implementation into the software project Consume v 3.0; (5) user manual and training package completion; and (6) scientific documentation.

In developing Consume 3.0, we surpassed our original objectives by developing a sophisticated software tool that is fully compatible with the Fuel Characteristics Classification System and can be used by a broad client base. The user interface requires a Microsoft Windows operating system. Calculations are handled in a Java-based engine and they can be run separately, in batch mode detached from the user interface, on a wide variety of operating systems including Macintosh, Unix, and Linux, and which supports a large number of clients including BlueSky, Fire Effects Tradeoff Model (FETM), Fire Emissions Production Simulator (FEPS), and Fuel Analysis, Smoke Tracking, and Report Access Computer System (FASTRACS).

METHODS

This project was divided into six major task items:

(1) Needs assessment
(2) Study design
(3) Field data collection and analysis
(4) Development of Consume 3.0 software
(5) User's Guide and training package
(6) Scientific documentation.

Each task is addressed separately in this section.

TASK 1: NEEDS ASSESSMENT

Our needs assessment highlighted the major fuel types for which increased wildland fire is expected and fuel consumption data are limited. In five national and regional fuels workshops, six Fuel Characteristics Classification System workshops, and 35 fire effects, smoke management and burn boss national training classes, we surveyed several hundred fire and fuel managers to determine which fuelbed types should be prioritized in our study. Participants in this informal survey included managers from the USDA Forest Service, Bureau of Land Management, National Park Service, U.S. Fish and Wildlife Service, Bureau of Indian Affairs, and Department of Defense Air Force and Army. Based on survey responses, the following fuelbed types were selected for further study:

(1) Sage (Intermountain, Pacific Northwest, Rockies), west coast and interior chaparral and oak brush (Southwest, Rockies), and palmetto-galberry (Southeast);
(2) Ponderosa pine / fir (Intermountain, Pacific Northwest, Rockies, Southwest);
(3) Black spruce, white spruce and birch/aspen hardwoods (Alaska);
(4) Longleaf pine / sandhill-hardwood pine transition (south); and
(5) Marsh grass, tall grass prairie (south, Midwest).

TASK 2: STUDY PLAN DEVELOPMENT

The broad array of fuel characteristics in our selected fuel types required a flexible study design that allowed tailoring of consumption measures for each fuel type and their associated variables. In devising our study plan, we conducted a thorough literature review of potential fuel consumption methods and prepared a design document (**Appendix A**). Table 1 summarizes the methods used to measure fuel consumption and the variables that were determined likely to control the fuel consumption for the fuelbed types targeted by this study.

Table 1. Fuel consumption trial methods by fuelbed type. Independent variables were selected as the most likely variables to influence fuel consumption for each of the five fuelbed types. Forest types include Ponderosa pine / fir, Black spruce and white spruce, and Longleaf pine / sandhill / hardwood – pine transition.

Fuelbed type	Independent variables	Method	Dependent variable	Method
Sage/chaparral	Pre-fire nonwoody (grass and forb) and shrub loading	Pre-fire clipping of 18 1-m^2 subplots	Fuel consumption	Post-fire clipping of 18 1-m^2 subplots
	Fuel moisture content	10 fuel moisture samples by fuel category including 1-, 10-, and 100-hr woody fuels, litter and duff		
	Live fuel moisture	Fuel moisture of live shrub foliage		
	Weather (relative humidity, temperature, days since rain, wind speed)	Weather station or belt weather kit		
	Live/dead ratio	Pre-fire clipping of 18 1-m^2 subplots		
	Lighting pattern, topography	Maps, field observations		
Forest types	Pre-fire loading, woody fuels, shrubs and forest floor	Pre-fire fuels inventory with 18 plots; line intercept method (4000 ft), clipping, forest floor depth measurement	Woody fuel consumption	20 wired logs, post-fire inventory using the line intercept method.
	Moisture content	≥ 10 fuel moisture samples by fuel category including 1-, 10-, 100-, and 1000-hr woody fuels, litter and duff *	Litter and forest floor consumption	300 duff pins
	Weather (relative humidity, temperature, days since rain, wind speed)	Weather station or belt weather kit		
Marsh grass / tall grass prairie	Pre-fire grass and forb loading	Pre-fire clipping of 18 1-m^2 subplots	Fuel consumption	Pre-fire clipping of 18 1-m^2 subplots.
	Live moisture content	20 fuel moisture samples of live and dead grass		
	Weather (relative humidity, temperature, days since rain, wind speed)	Weather station or belt weather kit		
	Live/dead ratio	Pre-fire clipping of 18 1-m^2 subplots		
	Lighting pattern, topography	Maps, field observations		

* Upper duff only in black spruce and white spruce forest types.

TASK 3: FIELD DATA COLLECTION AND ANALYSIS

A total of 106 sites were inventoried and burned for this project. Table 2 summarizes the number and location of study sites by fuel type. In addition, 32 units burned prior to this project (1994-1997) were reanalyzed and incorporated into development of fuel consumption models in Consume v 3.0.

Table 2. Study site locations by fuel type.

Fuel Type	Location/Agency	Units burned and inventoried in FYs 1998-2003	Units burned and inventoried in FYs 1994-1997
Sagebrush / Chaparral /Palmetto-galberry	West (BLM, NPS, USFWS, USFS) – California, Montana, Nevada, Oregon, and Wyoming	27	0
Ponderosa pine / fir	Intermountain and Pacific Northwest (USFS) – Oregon and Montana	43	10
Black spruce/hardwoods	Alaska (BLM, USFWS)	15	5
Longleaf pine / sandhill / hardwood-pine transition	Southeast (USFS/DOD) – Florida, Georgia, South Carolina, and Tennessee)	18	12
Marsh grass / tall grass prairie	Southeast and Midwest (USFS, USFWS, DOD) – Florida and Minnesota	3	5
TOTAL		106	32

Linear regression models were developed using SPlus® to predict fuel consumption for all fuelbed types. For forested types, woody fuel consumption was predicted by timelag category (i.e., 1-, 10-, 100-, 1000- and 10,000-hr), and litter and duff consumption was predicted pre-burn loading and modeled forest floor reduction. In most cases, generalized linear models were created to model proportion of loading consumed to confine modeled results to a positive value between 0 and 1. Equations are summarized in table 3 and in further detail in the scientific documentation section of the Consume v 3.0 User's Guide (Prichard et al. 2005).

Table 3. Sample fuel consumption algorithms by fuelbed component. All loading and consumption units are in tons/acre. Proportion deviance explained refers to the proportion of the null deviance of the consumption data explained by the modeled equation.

Stratum/Category	Consumption (tons/acre) Equations	Sample size (n) r^2 or proportion deviance explained	Applicable Region(s)
Shrub	Consumption = Proportion consumed $_{Shrubs}$ x Preburn loading $_{Shrubs}$ *Where*: Proportion consumed $_{Shrubs}$ = EXP (y) / (1 + EXP (y)) y = -2.6573 + (0.0956 x Preburn loading $_{Shrub}$) + (0.0473 x Percent Black) Percent black (percent) = Percent of surface fuel area blackened by burn (input variable)	n = 17 proportion deviance explained = 0.82	All
Nonwoody (grasses and other herbs)	Consumption = 0.9274 x Preburn loading $_{Nonwoody\ vegetation}$ *Where:* 0.9274 = proportion of preburn loading consumed (see documentation below)	n = 10 r^2 = 0.99	All
Woody	n/a		
Sound wood	Sum of consumption by sound wood size class		
1 to 3 inches	Consumption = 0.7844 x Preburn loading $_{1\text{-}3\ inch\ wood}$	n = 56 r^2 = 0.89	Western/Boreal
3 to 9 inches	Consumption = Preburn loading $_{3\text{-}9\ inch\ sound\ wood}$ x Proportion consumed $_{3\text{-}9\ inch\ sound\ wood}$ *Where*: Proportion consumed $_{3\text{-}9\ inch\ sound\ wood}$ = EXP (y) / (1 + EXP (y)) y = 3.1052 - (0.0559 x 1000hr FM) 1000 hr FM = fuel moisture of 3-9 inch fuels	n = 51 proportion deviance explained = 0.45	Western/Boreal
9 to 20inches	Consumption = Preburn loading $_{9\text{-}20\ inch\ sound\ wood}$ x Proportion consumed $_{9\text{-}20\ inch\ sound\ wood}$ *Where*: Proportion consumed $_{9\text{-}20\ inch\ sound\ wood}$ = EXP (y) / (1 + EXP (y)) y = 0.7869 - (0.0387 x 1000hr FM) 1000 hr FM = fuel moisture of 3-9 inch fuels	n = 48 proportion deviance explained = 0.45	Western/Boreal
Rotten wood (sum)	Sum on consumption by rotten wood size class		
3 to 9 inches	Consumption = Loading $_{3\text{-}9\ inch\ rotten\ wood}$ (tons/acre) x Proportion consumed $_{3\text{-}9\ inch\ rotten\ wood}$ *Where*: Proportion consumed $_{3\text{-}9\ inch\ rotten\ wood}$ = EXP (y) / (1 + EXP (y)) y = 4.0139 - (0.0600 * Duff FM) + (0.8341 * Loading $_{3\text{-}9\ inch\ rotten\ wood}$) Duff FM = fuel moisture of duff (input variable)	n = 42 proportion deviance explained = 0.63	Western/Boreal
9 to 20 inches	Consumption = Loading $_{9\text{-}20\ inch\ rotten\ wood}$ (tons/acre) x Proportion consumed $_{9\text{-}20\ inch\ rotten\ wood}$	n = 35 proportion	Western/Boreal

Stratum/Category	Consumption (tons/acre) Equations	Sample size (n) r^2 or proportion deviance explained	Applicable Region(s)
	Where: Proportion consumed $_{9\text{-}20 \text{ inch rotten wood}}$ = EXP (y) / (1 + EXP (y)) y = 2.1218 - (0.0438 * Duff FM) Duff FM = fuel moisture of duff (input variable)	deviance explained = 0.69	
> 20 inches	Consumption = Loading $_{>20 \text{ inch rotten wood}}$ (tons/acre) x Proportion consumed $_{>20 \text{ inch rotten wood}}$ *Where*: Proportion consumed $_{>20 \text{ inch rotten wood}}$ = EXP (y) / (1 + EXP (y)) y = 0.8022 - (0.0266 x Duff FM) Duff FM = fuel moisture of duff (input variable)	n = 22 proportion deviance explained = 0.66	Western/Boreal
Ground Fuels	Sum of duff, squirrel midden and basal accumulation consumption		
Duff	Consumption = Forest Floor Reduction (inches) * Bulk density $_{Duff}$ (tons/acre-inch) Reduction $_{\text{Ground Fuel Type}}$ (inches) = Forest floor reduction Bulk density $_{Duff}$ (tons/acre-inch) = Bulk density of duff *Where* Forest Floor Reduction (inches) = Pre-burn forest floor depth x Proportion Forest Floor Reduced Preburn forest floor depth (inches) = ∑Depths (Litter, Lichen, Moss, Duff) Proportion forest floor reduced = EXP (y) / (1 + EXP (y)) *Where*: Y = 1.2383 - (0.0114 x Duff FM) Duff FM = fuel moisture of upper duff layer	N = 38 proportion deviance explained = 0.44	Boreal

TASK 4: CONSUME 3.0 SOFTWARE

Consume version 3.0 is a user-friendly computer program designed for resource managers with some working knowledge of Microsoft Windows® applications. The software predicts the amount of fuel consumption, emissions, and heat release from the burning of logged units, piled debris, and natural fuels based on weather data, the amount and fuel moisture of fuels, and a number of other factors. Using these predictions, resource managers can determine when and where to conduct a prescribed burn or plan for a wildland fire for use to achieve desired objectives while reducing impacts on other resources. The Fuel Characteristic Classification System (FCCS) was developed in coordination with Consume. Fuel loading values from the FCCS national fuelbed reference library can be accessed directly in Consume or imported from customized FCCS fuelbeds. With its built-in link to the FCCS, Consume can be used for most forest, shrub and grasslands in North America and may be applicable to other areas of the world.

APPLICATION

Consume predicts fuel consumption, pollutant emissions, and heat release based on a number of factors including fuel characteristics and environmental conditions. Using these predictions, users can determine when and where to conduct a prescribed burn or plan for a wildland fire to achieve desired objectives, while reducing the impact on other resources. For example, if a management objective for a harvested unit with logging slash was to retain an average duff depth of two inches on the unit, the manager could use Consume to determine the 1000-hour fuel moisture at which a burn could take place and meet the objective. Another management objective might be to produce less than 100 tons of particulate matter not exceeding 2.5 micrometers in diameter ($PM_{2.5}$) from a prescribed burn. By adjusting fuel and weather input variables, the manager could determine whether the prescribed burn will meet the 100-ton objective.

Some potential users, including our BlueSky clients, will require Consume to be run in batch mode as part of a larger modeling effort. The Java-based calculator engine of Consume can be run in a command line environment and provides comma-delimited output file that can be imported into other models or further analyzed in spreadsheet or statistical software.

AVAILABILITY

Consume is available for downloading from http://www.fs.fed.us/pnw/fera/products/consume.html. The installation guide and software is also on a CD attached to this report (**Appendix E**). The Java-based calculator engine in Consume requires at least one update be added to Microsoft Windows operating systems. Administrative privileges are required for program installation and the Windows update(s).

FUTURE DEVELOPMENT

As the FCCS adds additional fuelbeds to its system, Consume will be periodically updated to reflect changes in the FCCS. Scientific documentation and a journal manuscript are in preparation describing the fuel consumption equations. As new shrub consumption algorithms are developed (JFSP 03-1-3-06), they will be incorporated into this version of Consume 3.0. Little fuel consumption work has been completed in the northeast and Midwestern hardwoods. Future fuel consumption data collection should and will be concentrating in those regions. Finally, a comparison between the First Order Fire Effects Model will be accomplished in the near future.

TASK 5: USER'S GUIDE AND TRAINING PACKAGE

The Consume v 3.0 User's Guide is attached as **Appendix B** in this report. The User's Guide was adapted to create an on-line help in Consume v 3.0. Topics are searchable under the Help Menu in Consume. Context-senstive help is also available by pressing F1 in any screen in Consume.

A tutorial on Consume v 3.0, available for viewing in any web browser and also for use in Powerpoint presentations, is under development and will be completed by April 2006 (JFSP 04-4-1-19).

TASK 6: SCIENTIFIC DOCUMENTATION

Scientific documentation is included as an appendix in the User's Guide (**Appendix B**). The User's Guide will be submitted as a general technical report, and the fuel consumption research and resulting algorithms will be submitted as a research paper and peer-reviewed scientific paper (expected completion date is Spring 2006).

DELIVERABLES

CONSUME 3.0 SOFTWARE PACKAGE

The primary deliverable product for this project is the updated version of the Consume software complete with a User's Guide and online help. Additional products and technology transfer have been completed that exceeded the scope of the project (table 5). Consume has been designed to closely reflect the FCCS and incorporate fuel loadings from the FCCS fuelbed reference library (JFSP 98-1-1-06). Available results from the shrub consumption trials (JFSP 03-1-3-06) have been incorporated into the consumption algorithms of Consume, and further updates are expected in the near future. A tutorial for Consume software is available (JFSP 04-4-1-19).

Table 5. Comparison of proposed and actual deliverables.

Proposed	Delivered	Status
Consume v 3.0 software application	Consume is available for downloading from http://www.fs.fed.us/pnw/fera/products/consume.html. The Java-based calculator engine in Consume requires at least one update be added to Microsoft Windows operating systems. Administrative privileges are required for program installation and the Windows update(s). The system provides fuel consumption, heat release, and emissions estimates from wildland fire.	Done
Needs assessment	Completed December 1999. Our needs assessment highlighted the major fuel types for which increased wildland fire is expected and fuel consumption data are limited. In five national and regional fuels workshops, six Fuel Characteristics Classification System workshops, and 35 fire effects, smoke management and burn boss national training classes, we surveyed several hundred fire and fuel managers to determine which fuelbed types should be prioritized in our study. Participants in this informal survey included managers from the USDA Forest Service, Bureau of Land Management, National Park Service, U.S. Fish and Wildlife Service, Bureau of Indian Affairs, and Department of Defense Air Force and Army.	Done
Program design	Completed June 13, 2002. A manager's workshop was held in December 2000 to assist us in the design of Consume v 3.0. Although the final design, specification, and requirements documents were completed by FERA, Air Sciences Inc. completed a preliminary working version which was used extensively to finalize the product. (**Appendix B)**	Done

Documentation and publication	User's Guide is completed and available within the Consume v 3.0 software. It will be submitted for publication as a general technical report in late 2006. Consumption trial data have been summarized and analyzed and a PNW Research Paper and 1 journal article to be submitted to the Journal of Wildland Fire are in preparation and will be forwarded to the Board when complete.	In progress; December 2006
JFSP progress reports	JFSP progress reports were completed for each year starting in 1999 and ending in 2005	Done
Not Proposed But Delivered	Consume 3.0 predicts fuel consumption, emissions, and heat release for three rather than two combustion phases (flaming, smoldering, and residual) and all fuelbed strata, categories, and subcategories referenced in the Fuel Characteristic Classification System (FCCS) (**Appendix E**).	Done
	Consume was presented to 35 participants as part of a 3-day train-the-trainer workshop at Ichauway, Georgia, November 7-9, 2005, Hilo Hawaii, February 28-march 2, 2006, and May 16-18, 2006, Sunriver, Oregon.	Done
	Two GTR publications with chapters on fuel consumption (Sandberg et. al 2002 and Hardy et. al 2001, **Appendix D**)	Done
	1 Consume 3.0 factsheet (**Appendix C)**	Done
	8 posters, presentations, reports, published abstracts and manuscripts (**Appendix D**).	Done
	40 Consume demonstrations at RX 410 (Smoke Management), RX 300, (Burn Boss), RX 310 (Fire Effects) national and regional training sessions, and at 5 Technical Fire Management modules.	Done
	Web-based and downloadable self-taught tutorial is available at http://www.fs.fed.us/pnw/fera/products/tutorials/index.html (JFSP #04-4-1-19, **Appendix E**).	Done

WEB PAGE

A web page describing Consume and including downloads, publications, and contacts was established at http://www.fs.fed.us/pnw/fera/products/consume.html.

PUBLICATIONS

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INSTRUCTOR'S GUIDES

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DEMONSTRATIONS

Consume v 3.0 Demonstration and Beta Test (JFSP 04-4-1-19)

The 3-day train-the-trainer Southern Regional Fuels workshop (November 7-9, 2005), Hawaii Regional Fuels workshop (February 28-March 2, 2006), and the Pacific Northwest Regional Fuels workshop (May 114-16, 2006 showcased a beta version of Consume 3.0 along with the FCCS and the digital photoseries. Individuals participated in this first Consume v 3.0 demonstration and workshop. The software for this demonstration was a beta release version for testing. The workshop consisted of a series of short presentations, question and answer sessions, a practicum led by the Consume team, and a hands-on use of the system. Questions and comments were collected during the demonstration. These comments were used to improve the Consume software. Four additional workshops within the scope of this JFSP proposal in 2006 and 2007 will also demonstrate Consume 3.0

TRAINING

The principal investigator teaches fuel combustion and consumption classes 12 times a year at national training courses including Rx 300 Burn Boss, Rx 310 Fire Effects, Rx 410 Smoke Management, and Technical Fire Management. The course work includes discussion of new fuel consumption models developed from this study and a demonstration of Consume v 3.0.

CONSULTATIONS

The principle investigator consults with several land managers, regulators, and scientist each year with regard to the best available fuel consumption models for various fuelbed types throughout the country. The principle investigator is also the lead scientist in directing the use of fuel consumption models for a National Wildland Fire Emissions Tracking System being implemented by the EPA. The fuel consumption models from the study will be used by the EPA emissions tracking system.

TUTORIAL

A web-based self-taught tutorial along with an instructor's guide and student workbook for Consume 3.0 has been developed (JFSP # 04-4-1-19. The Consume 3.0 tutorial can be accessed through a web-browser or down-loaded directly from http://www.fs.fed.us/pnw/fera/products/tutorials/index.html. The final report for this project is in preparation.

LITERATURE CITED

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APPENDIX A

CONSUME DESIGN DOCUMENT

CONSUME 3.0 System Design

Prepared for

USDA Forest Service

Fire and Environmental Research Applications (FERA)

Pacific Northwest Research Station

Seattle, Washington

Prepared by

Michael Calvin

Acacia Services

for

421 SW 6th Avenue, Suite 1400

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June 13, 2002

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The Joint Fire Sciences Program has sponsored this CONSUME 3.0 design project through a grant with the Fire and Environmental Research Applications (FERA) team, Pacific Northwest Research Station, USDA Forest Service.

Participants at the December 2001 CONSUME 3.0 requirements analysis meeting in Portland, Oregon provided input into this design document. The participants represented a wide spectrum of users and key role players.

Document Purpose

The purpose of this document is to describe and depict the design for CONSUME 3.0, a major update to the current CONSUME 2.1 application. This blueprint represents the requirements of the project's sponsor and the needs of the CONSUME user community.

Intended Audience

The primary users of this document will be the persons responsible for building the CONSUME 3.0 application and associated products. FERA will also use it to prepare a contract for the actual construction of CONSUME 3.0.

1. Introduction

Overview

CONSUME is an application used to estimate the amount of fuel consumed and pollutant emissions produced by a prescribed or wildland fire. It is a decision-making tool designed to assist land managers in achieving prescribed burn objectives while minimizing the impact of prescribed fire on air quality, soil, water, wildlife, and other resources.

History

In the early 1980s, the Fire and Environmental Resource Application Group (FERA) of the Pacific Northwest Research Station began to develop fuel-consumption models and emission factors for prescribed burning situations in the Pacific Northwest. The first application, called CONSUME 1.0**,** incorporated a set of consumption algorithms formulated from data collected during operational burns.

During the 1990s, FERA began developing models of fuel consumption by combustion stage for other fuel types beyond the Pacific Northwest and different configurations of fuels. In addition, FERA began developing a new system called the Fuel Characteristic Classification (FCC) system to characterize fuels. The FCC system allows managers to select different fuel loadings. This feature was incorporated into the current CONSUME 2.1 application.

CONSUME 2.1 also introduced calculations for piled and non-piled activity fuels, and natural fuels. CONSUME 2.1 allows measured 1000-hour, adjusted 1000-hour, or NFDRS 1000-hour fuel moisture contents to be used to calculate fuel consumption for non-piled activity fuels. These changes enhanced CONSUME's flexibility and utility. Finally, emission factors were added to CONSUME 2.1, allowing pollutant emissions to be estimated.

Change Motivators

FERA received a grant from the Interagency Joint Fire Science Project (JFSP) to provide enhancements to the CONSUME application that will allow it to predict fuel consumption and smoke emissions in all wildland fuel beds in the United States. This objective is made possible by the following events:

- FERA has recently completed a series of fuel consumption trials during the flaming and smoldering combustion phases in various fuel bed types in the United States and modeling of consumption has begun. This modeling effort will produce modified and new algorithms that will be part of CONSUME 3.0.
- FERA has contracted with a vendor to produce a prototype FCC system. This prototype is to be delivered in April 2002. The production version of the FCC system will be integrated as a front end to CONSUME 3.0 allowing the user to populate CONSUME 3.0 inputs via a wizard interface.

Requirements Meeting

A series of meetings were held on December 3rd and 4th, 2001, in Portland, Oregon to obtain information related to the design of CONSUME 3.0. The meeting objectives were to:

- Understand the motivation, expectations, issues, and requirements from FERA, the project's sponsor.
- Interview current users of CONSUME 2.1 to determine what improvements they would like to see in CONSUME 3.0.

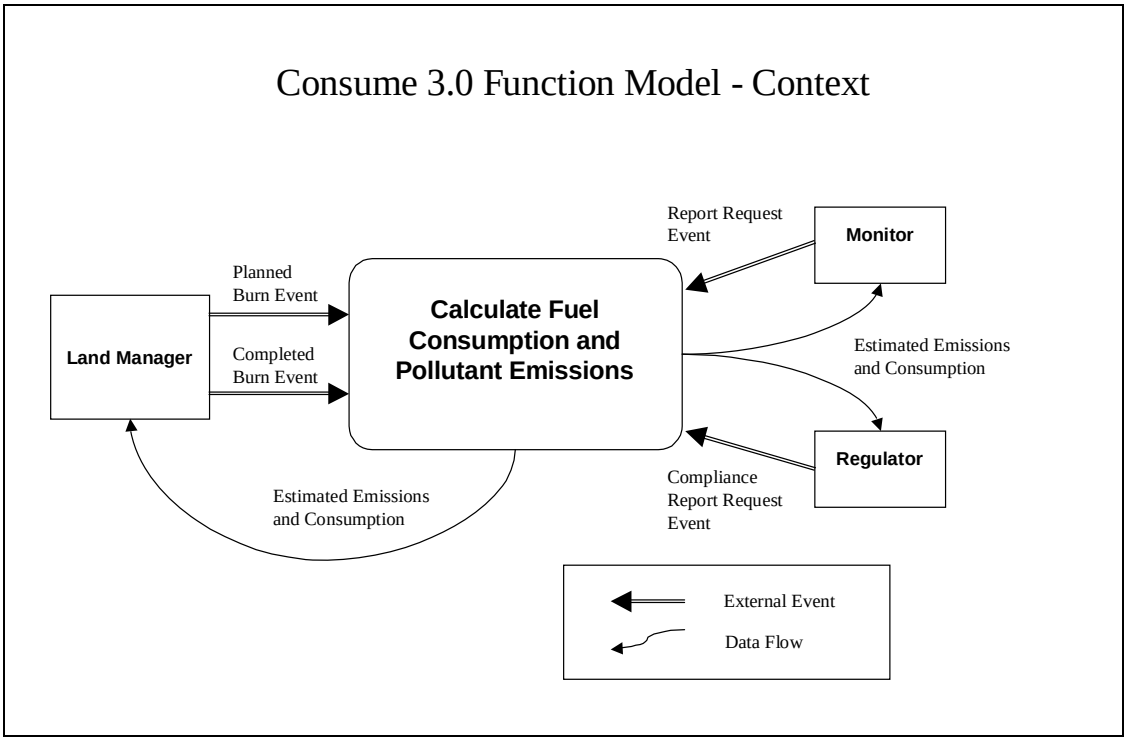
The raw notes included over 120 items. These items were then classified and prioritized by FERA for inclusion into the design of CONSUME 3.0.

2. Business Model

Conceptual Function Business Model

The primary goal of CONSUME 3.0 is to provide accurate estimates of fuel consumption and emissions in order to support the land manager's use of prescribed fire to maintain and restore ecosystems, reduce fuel loadings, expose mineral soil, improve wildlife habitat, and to reduce the hazard of wildfire.

The function model, depicted in the context diagram below, describes the functions that CONSUME 3.0 will perform in order to meet this goal. This model is meant to reflect the high level process within the scope of CONSUME 3.0.



Any one of four principle events would trigger the use of CONSUME 3.0:

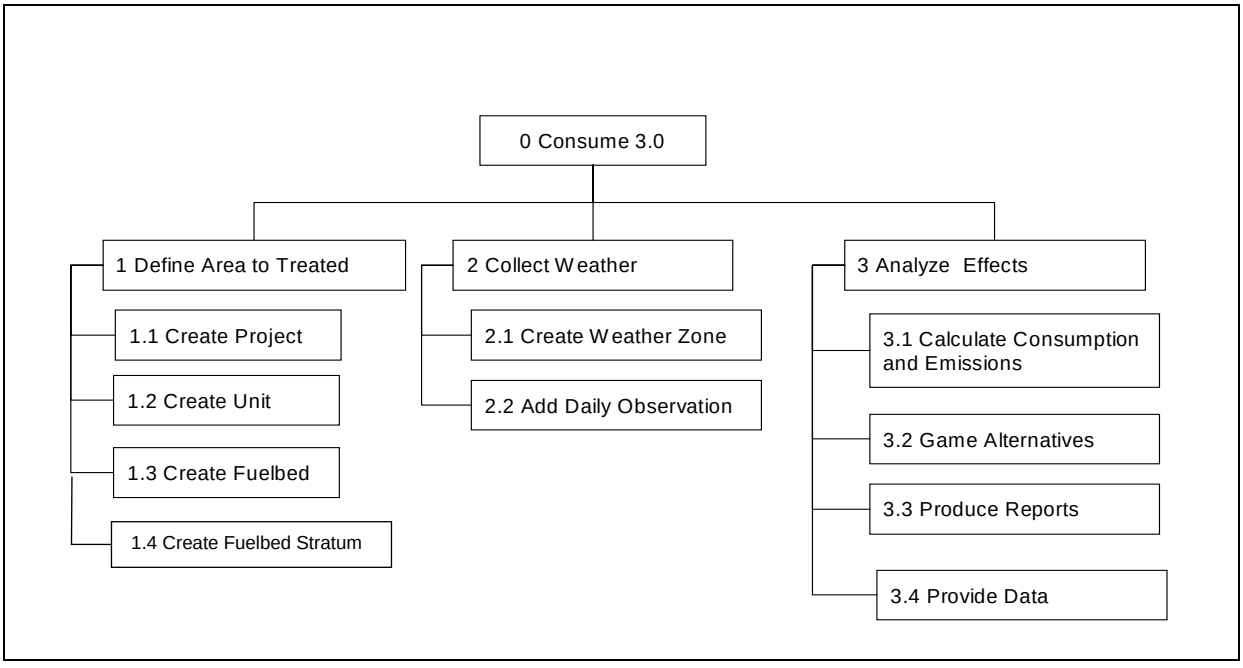
Planned Burn Event. An event where the land manager is either contemplating or planning the use of prescribed fire to treat an area of vegetation, and the manager needs to evaluate the conditions required to achieve the desired fuel consumption or emissions.

Completed Burn Event. An event where the land manager has executed a prescribed fire, and needs to estimate the actual fuel consumption and emissions.

Compliance Report Event. An event where a regulatory agency requires information on emissions from a prescribed or wildland fire.

Report Request Event. An event where a monitor (for example, a Forest Service regional office) requires a report summarizing emissions for a group of National Forests.

The following diagram illustrates the basic functional elements of CONSUME 3.0. It provides a business view of what is to be done, not how it is to be done. The order of the boxes does not necessarily depict the sequence for implementing the technology.



Function descriptions for the above diagram:

1. Define Area to Be Treated. A function to describe the area of vegetation to be treated by prescribed fire or an

area involved in a wildfire.

1.1 Create Project. A process to identify the project (wildfire or prescribed fire) in terms of the responsible organization and other identifying information.

1.2 Create Unit. A process to associate distinct areas of prescribed fire or wildland fire with a project.

1.3 Create Fuel bed. A process to associate a distinct area of fuel bed characteristics within a unit.

1.4 Create Fuel bed Stratum. A process to associate a layer of unique combustion environments with a fuel bed.

2. Collect Weather. A function to collect weather to help predict the 1000-hour fuel moisture content required for some CONSUME calculations.

2.1 Create Weather Zone. A process to identify a representative weather station for one or more prescribed fires or wildland fire units.

2.2 Add Daily Observation. A process to insert daily weather observations for a weather zone.

3. Analyze Effects. A function to compute consumption and emissions for a unit within a project, and to produce reports and other outputs.

3.1 Calculate Consumption and Emissions. A process to compute the quantities of fuel consumed and pollutants emitted for a unit within a project.

3.2 Game Alternatives. A process to allow the systematic examination of a range of environmental conditions, fuel bed conditions, or treatment alternatives for a unit within a project.

3.3 Produce Reports. A process to generate textual and graphical reports for projects and units.

3.4 Provide Data. A process to make data available to programs external to the CONSUME 3.0 application.

Conceptual Data Model

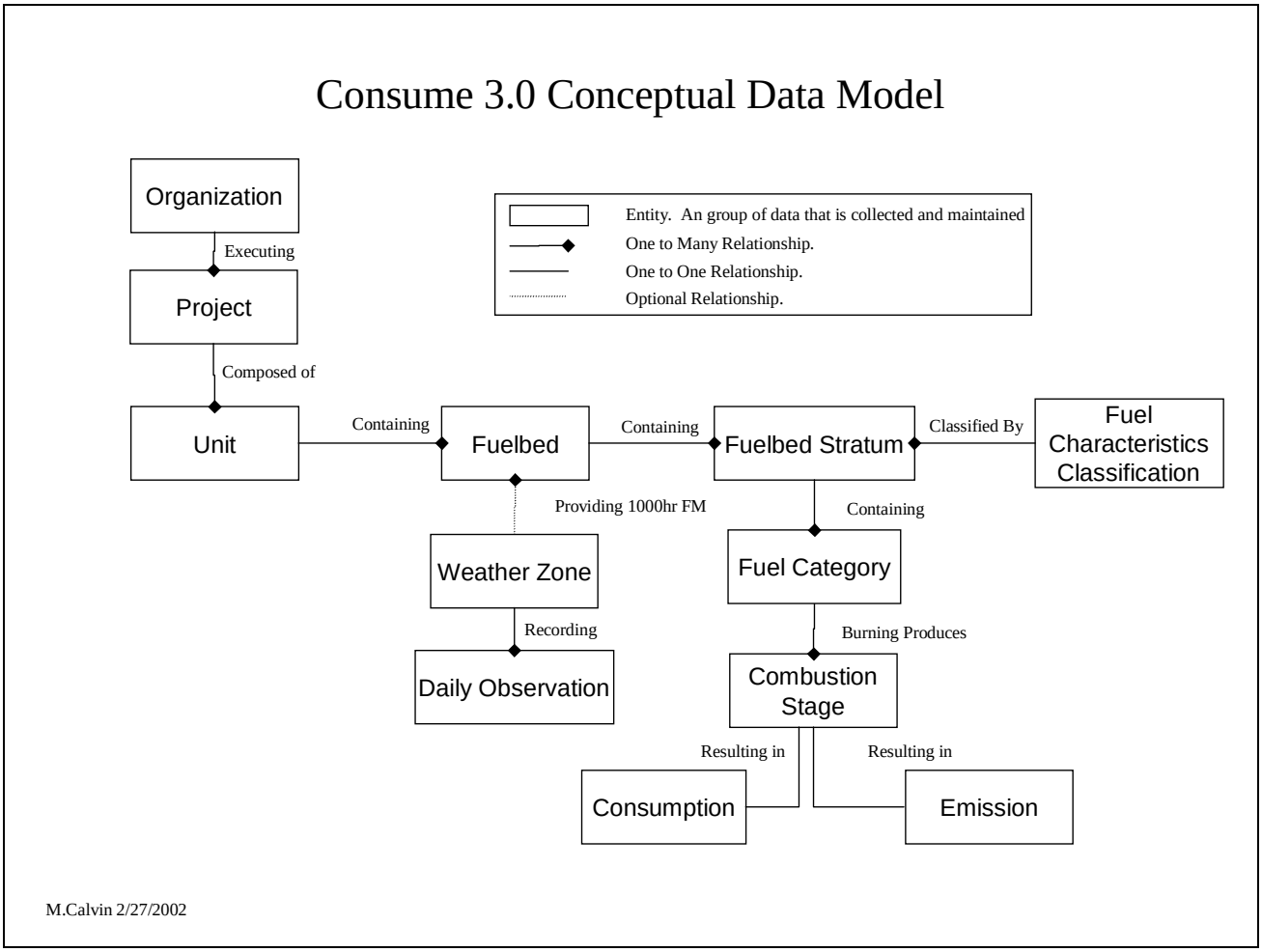
The purpose of the conceptual data model is to display important groups of information (entities) and their relationships. The data model is primarily a business view of CONSUME 3.0 data requirements and is independent of any implementation mechanism. From the conceptual model

a design for a specific implementation technology will be built.

This data model encompasses the following new features agreed to for CONSUME 3.0:

- Ability to have multiple units within one project.
- Ability to have multiple fuel bed types within a unit.
- Ability to have one or more fuel bed strata within a fuel bed.
- Ability for each fuel bed stratum to store emissions and consumption by combustion stage.

Entity Relationship Diagram



Entity Definitions

Project. A project consists of one or more units that are organized and managed as a single endeavor. Projects may be planned (prescribed burn) or unplanned (wildfire). Projects are managed by an organization.

Unit. A unit encompasses the area to be treated by fire or the area involved in a wildfire. A Unit consists of one or more fuel beds that are burned together. Units are assigned to a single project. Units can be planned and

accomplished independently of other units within the same project. Units can be spatially contiguous or spatially separated. A unit is the principle entity in CONSUME 3.0.

Fuel bed. A fuel bed is an area of similar fuel characteristics within a unit. There may be one or more fuel beds within a unit. A fuel bed may contain either piles or non-piled material, but not both. Non-piled materials include natural fuels or human-altered fuels. The structure of a fuel bed is further described in a fuel bed stratum.

Fuel bed Stratum. A fuel bed stratum describes a horizontal layer of a fuel bed that represent a more or less independent combustion environment. Fuel bed strata may consist of canopy, shrub, low vegetation, woody fuel, moss, lichen, litter, and ground fuels elements. A fuel bed contains one or more fuel bed strata.

Fuel Category. Each fuel bed stratum is composed of one or more fuel categories, each of which comprises a unique combustion environment. A fuel category is described by both physiognomic and gradient variables. Examples of fuel categories in the ground fuel stratum include duff and basal accumulation.

Organization. A government or private entity that is responsible for managing projects.

Combustion Stage. A unique burn environment composed of specific types of fuel bed stratum. These stages are flaming, smoldering, and residual.

Consumption. The amount of fuels by weight consumed within a specific combustion stage for a fuel category within a fuel bed stratum.

Emissions. Pollutants produced within a specific combustion stage for a fuel category within a fuel bed stratum such as carbon monoxide and particulate matter that are released to the atmosphere from the combustion of biomass.

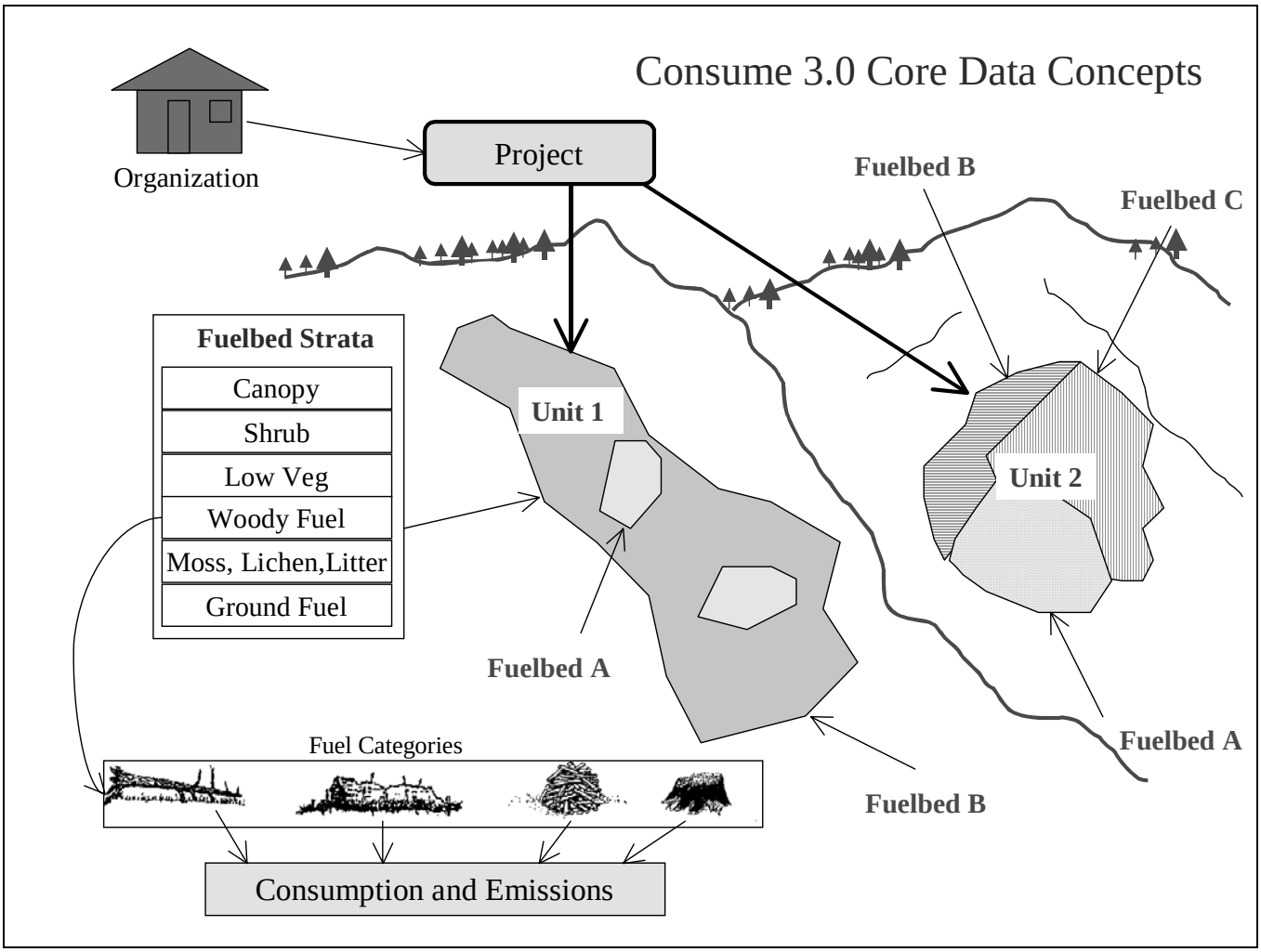
Fuel Characteristic Classification. A fuel bed is derived from a unique combination of ecological descriptors with assigned physical and derived fuel bed variables required for the operation of various fires, ecosystem, and global change models.

Weather Zone. An unspecified area containing a weather station that is representative of the Unit's area, and used to estimate the 1000-hour fuel moisture content of woody fuels. The relationship to Unit is optional as the 1000-hour fuel moisture content can be entered directly without entering using daily observations from a Weather Zone.

Daily Observation. A record of daily weather conditions within a Weather Zone.

Diagrammatic View – Data Model

The diagram below presents a "real world" view of the Entity Relationship Diagram as an aid to understanding the principal data entities and their relationships.



3. System Architecture

Features

During the course of the analysis and design process many new or improved features were identified to be included CONSUME 3.0. These features are listed below:

A. New Algorithms. The recent work by FERA to include a broader spectrum of fuel types will be incorporated into CONSUME 3.0. This will be a major enhancement to the application. The work to convert the data collected from the field trials into new algorithms has not yet begun and exact input requirements and outputs are not known at this time.
B. New FCC Interface. The new FCC system will be integrated into CONSUME 3.0. A FCC prototype is to be delivered in April 2002, but the production version of the FCC system will not be available until 2003. FCC data will populate CONSUME 3.0 vegetation input. The exact method will be determined after the FCC production version is stabilized.
C. CONSUME 3.0 DLL. The CONSUME 3.0 dynamic link library (CONSUME.dll) will contain all computational elements for the calculation of fuel consumption and emissions. The CONSUME dll is a shared component used by other applications such as the Fire Emissions Trade-off Model (FETM) and FASTRACS. This product was introduced with CONSUME 2.1 and will need to undergo many changes for version 3. Among the many changes are:

- Removal of all direct connections to the MS Access database. This will provide greater flexibility for users of the CONSUME.dll.
- Inclusion of new consumption and emission algorithms.
- Treatment of CONSUME.dll as a distinct and important product of the CONSUME 3.0 project.
- Improved development documentation and support.
- Implementation of a new object model that will include the use of collections to create a robust relational structure.

D. Improved Gaming Support. Means to quickly test various combinations of input parameters and see the immediate results will be provided. Various input scenarios can be calculated and optionally plotted for comparison.
E. Improved Reporting. The primary improvement to the reporting facility will be the addition of graphs. Graphs will allow the user to visualize outputs such as graphs that show various emissions or consumption variables plotted by a range of 1000-hour fuel moistures. Reports will be capable of displaying a user-selected level of detail including output summaries by Project, Unit, or Fuelbed. Unit and Fuelbed level reports will be capable of displaying outputs by combustion stage and by Fuelbed Strata
F. Metric/English Units. A user will be able to enter and display data in either metric or English units of measure. A default option for new projects can be set in the Preferences screen. In addition, units of measure can be changed dynamically for existing projects.

G. Improved User Aids. In addition to the online help system other mechanisms will be used to assist the user. These will include "tool tips" for every control with clearly worded labelling and on screen instructions, and the use of mini wizards or helper tools where appropriate.
H. GIS Support. CONSUME 3.0 will not provide direct support for GIS, but will provide mechanisms that will allow GIS applications to access the CONSUME database or the CONSUME computational library (CONSUME.dll). In order to facilitate this GIS support CONSUME 3.0 will provide:

- Testing of the CONSUME.dll for GIS support as part of CONSUME 3.0 development.
- Documentation for use of the CONSUME.dll that is targeted at GIS users.
- Organization, Project, and Unit identifiers that can be used as GIS layer tags.

I. Data Migration Utility 2.1 to 3.0. If possible, CONSUME 3.0 will provide a mechanism to convert data from the present CONSUME 2.1 format. The feasibility of this feature will be assessed toward the later stages of CONSUME 3.0 construction.
J. CONSUME 3.0 Tutorial. An online tutorial for CONSUME 3.0 will be provided in lieu of formal classroom training. The tutorial will supply case studies along with accompanying text and graphics. Attention should be paid to teaching the basic core elements of CONSUME 3.0 (Projects, Units, Fuel beds) and how they can be used in real-world situations.
K. Improved Help System. The CONSUME 3.0 help system will be implemented using Windows HTML Help, or WinHelp. This will allow the user to browse by content or index and perform keyword searches. In addition, each CONSUME 3.0 screen will have context-sensitive help that will take the user into the section of the help system specific to that screen.
L. Improved Web-based Support. A CONSUME 3.0 and CONSUME DLL website will be established that includes a summary of capabilities and uses of each product, notification of available downloadable updates and support files, a list of reported problems and fixes, and contact information, and a process for reporting problems and getting additional help.

System Design Assumptions and Dependencies

The design of CONSUME 3.0 is based on several assumptions valid at the time of publication. These are:

- Customer satisfaction with the CONSUME 2.1 application. Every effort was made to design CONSUME 2.1 familiarity into CONSUME 3.0, while adding new features to the interface.
- Stable Forest Service technology environment. Hardware and software recommendations are based on current and projected technology available to the U.S. Forest Service users.
- Field use of CONSUME 3.0. There is a requirement that CONSUME 3.0 can run stand-alone in the field without a modem or network connection.
- Web-based FCC system. The FCC system will be accessed via the Internet as in the FCC design document.

CONSUME 3.0 is highly dependent on the outcome of two other projects that are not yet completed. The first and most important of these is the completion of the new algorithms, which are the core of CONSUME 3.0. Work has not yet started on this project. Until the work on the algorithms is completed, the exact list of inputs and their

specifications will not be known although it can be assumed that they will be similar to CONSUME 2.1. Because of this, detailed input screens could not be produced for this design document. It is recommended that this design document be reviewed and modified as needed once the algorithms are finished.

The second important dependency is the FCC system. The FCC system will provide a method to populate CONSUME fuel inputs by using an interface that will assist the user in the selection of the most appropriate fuel type. The FCC is currently under development and only in the prototype phase. Strictly speaking, the user does not need the FCC system to provide CONSUME inputs since they can be entered manually; however, the FCC system is seen as an integral part of CONSUME 3.0. Until a stable version of the FCC system is produced, it will be difficult to design the CONSUME 3.0 interface to include the FCC system. There is also a dependency between the new algorithms and the FCC system. The FCC system will have to be capable of supplying the correct types of data, and coordination between the two projects will be required.

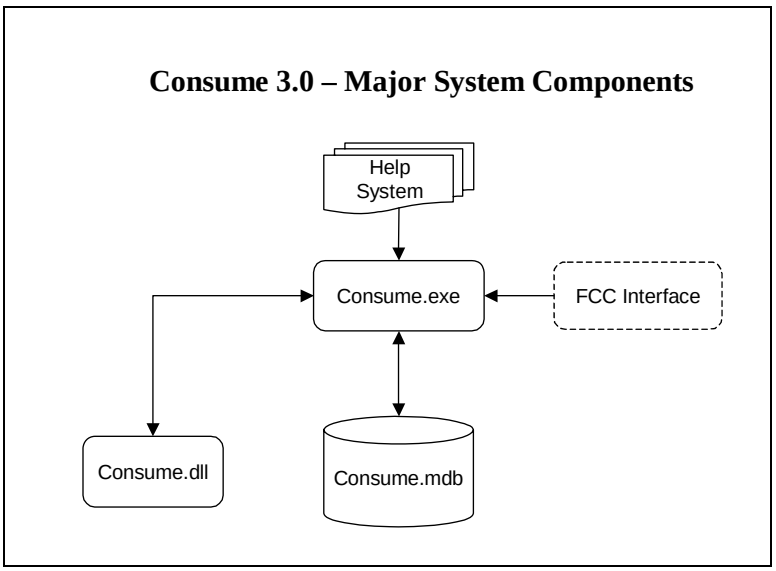
Technology Recommendations

The CONSUME 3.0 application will not require extensive computational, storage or graphical capabilities. The typical user of CONSUME 3.0 will use it both in an office and field setting. Because of the field operational requirement, CONSUME 3.0 will need to be operated in a stand-alone capacity on a notebook or laptop platform. However, CONSUME 3.0 will need Internet connectivity in order to use its FCC system interface to download fuel parameters. It is envisioned that the user will interact with the FCC system in the office before going into the field. Based on this environment the following are technology for CONSUME 3.0 is recommended:

- Hardware. Intel-based desktop or notebook systems per typical Forest Service configuration. Note: Forest System is used as a model since it is representative of most other user's systems.
- Operating System. CONSUME 3.0 should be able to run on Microsoft's Windows 98/Me/NT 4.0/2000/XP.
- Programming Tools. Microsoft Visual Basic (VB) version 6. This version is the current standard used for fire management applications. It is not recommended to use a newer version due to compatibility issues with older versions of Windows.
- Database Management System. Microsoft Access 2000.

System Schematic

CONSUME 3.0 is composed of the following major components:



CONSUME.exe. The CONSUME.exe application contains the primary visible elements of CONSUME 3.0 including user interfaces, reporting and graph functions, navigation, data input, and other business logic.

CONSUME.dll. The CONSUME dll contains all the consumption and emissions algorithms. It also will include the pile wizard and its interfaces.

Help System. The help system will contain all user assistance information.

FCC Interface. The FCC interface contains all the screens and processes needed by the user to select the appropriate fuel type and import the data into CONSUME 3.0.

CONSUME.mdb. The CONSUME database will contain all data related to CONSUME 3.0 projects.

4. Internal Design

Application Design

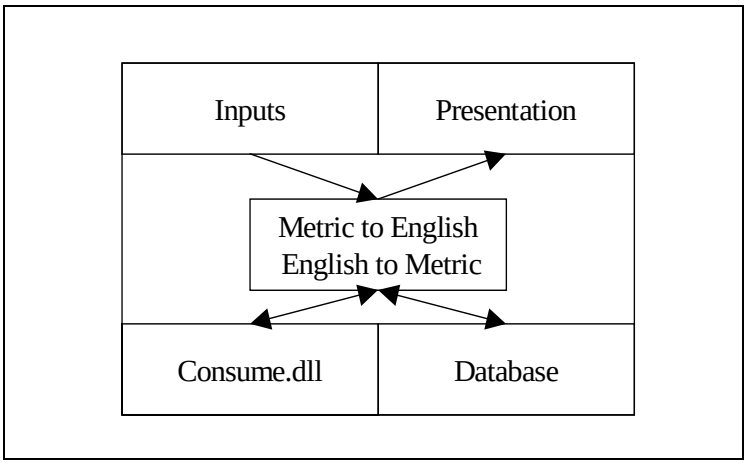
The following are important considerations for the internal design of CONSUME 3.0:

Data Access. CONSUME 3.0 will access the Microsoft Access database using ActiveX Data Objects (ADO). This method introduced with Visual Basic 6.0 features a simpler object model, better integration with other Microsoft and non-Microsoft technologies, a common interface for both local and remote data access, a user-accessible data binding interface, and hierarchical record sets.

Error Handling. Error handling in CONSUME 3.0 should follow these guidelines:

- Prevention of user input errors through the use of range checks, lists, and other means to restrict the user's choices to valid values should be used.
- The application should be able to recover from most errors.
- Error messages should be clear and suggest how to correct the problem.
- Every Visual Basic module or forms shall have an error handler.

Metric Conversion. CONSUME 3.0 will be able to switch between English and metric units. The preferred approach is to designate English units as the native measurement system for CONSUME 3.0. This means that the data is always stored in English units and that all calculations are also performed using English units. If the user selects metric units, the data will be input in metric values, and all outputs to the screen and in reports will be in metric units.



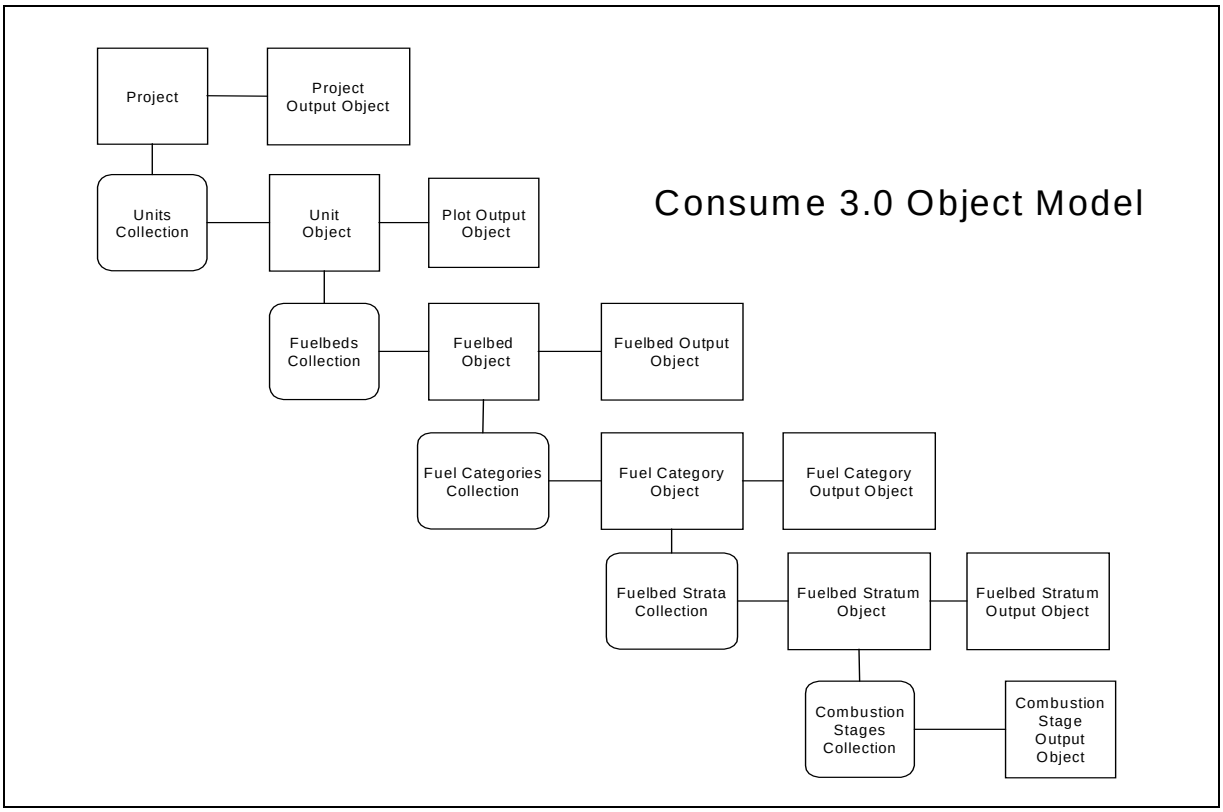
Every label on every screen and report that involves a measurable unit will need to have two unit notations, one for metric units and one for English units. Range checking shall be performed in English units, but if the user selects the metric mode, all warning or error messages will be displayed using metric units.

CONSUME Dynamic Link Library

The new CONSUME dynamic link library (dll) will contain all the processes required to calculate consumption and emissions. In addition, it will contain the pile wizard from CONSUME 2.1. The principal reason for building this dll is to allow other applications to access the library of algorithms. This concept was first introduced in CONSUME 2.1, and the dll has since been used in the FETM model and in the FASTRACS application. For CONSUME 3.0, including new algorithms, more robust architecture, and better documentation will greatly enhance the dll for use in other applications, especially GIS applications. Coordination during the construction of the dll should take place with the FETM and FASTRACS project teams.

CONSUME DLL Architecture

The CONSUME 2.1 dll provided access to its processes using an object-oriented methodology. This approach provided applications using the dll with a consistent and easy-to-use interface. For CONSUME 3.0, additional features of the object oriented programming model will be used to increase the robustness of the dll. The principal new feature to be included is the concept of collections. Collections will allow multiple occurrences of an object allowing implementation of a one to many relational models. This will increase ability to handle datasets of very large sizes and simplify the programmer's use of the dll. The model for CONSUME 3.0 objects and collections is depicted below.


Project
Project Output Object
Units Collection
Unit Object
Plot Output Object
Consume 3.0 Object Model
Fuelbeds Collection
Fuelbed Object
Fuelbed Output Object
Fuel Categories Collection
Fuel Category Object
Fuel Category Output Object
Fuelbed Strata Collection
Fuelbed Stratum Object
Fuelbed Stratum Output Object
Combustion Stages Collection
Combustion Stage Output Object

CONSUME 3.0 objects roughly correspond to the data model presented earlier. Output objects are provided in order to simplify the programmer's task and provide quick access to emissions and consumption totals for all object levels.

Properties

A complete list of object properties is not possible at this time due to lack of input specifications from the new algorithms.

Methods

Start Pile Group Wizard

This method will start the Pile Group Wizard. The wizard will allow the user full control over pile groups for a given unit. The user may create, edit and delete pile groups before saving the changes and returning to the client product.

Calculate

This method will perform the consumption and emissions calculation. A flag will be passed to ensure the correct algorithms are used. The data will be checked by the validate method if not already validated by the user.

Validate

This method will validate all the current property values. Any property value that is out of range or not presently assigned a value will be listed in a dialog box that the user must reply to. This prompt will provide the user with a complete list of properties that are invalid and the reason that they are invalid. If this method determines that one or more invalid properties exist, then the Valid property will be set to Invalid (default). Only when all Unit properties are determined to be Valid will the Valid property be set to Valid.

Events

Calculate Completed

This event is raised when the calculate method is complete. This allows the client program to know when the output objects properties are available for use.

Pile Group Wizard Complete

This event is raised when the user has completed the Pile Group Wizard and the Pile Group properties have been validated and assigned.

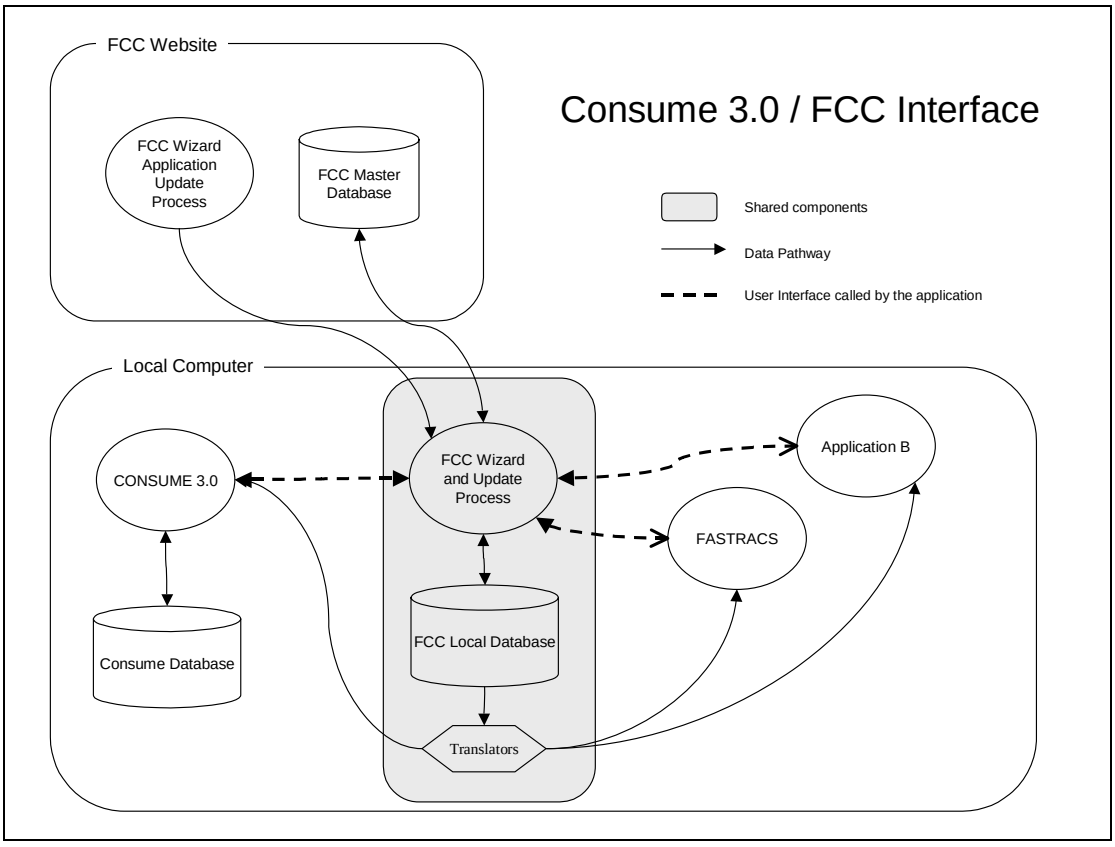
Error

This event is raised when an error occurs from the method called. Information is passed back via the Visual Basic Err object.

FCC System Interface

At this point, the design for the CONSUME 3.0/FCC interface cannot be accurately described since the FCC is only in the prototype development stage. However, a design based on the FCC system design document and the needs of CONSUME 3.0 is proposed. This proposed design is based on the premise that the FCC system's primary purpose is to serve applications that use fuel characteristic class data as inputs. CONSUME 3.0 will be the first application to use the FCC system in this way. The objective is to design a method that fits the needs of CONSUME 3.0. The user of CONSUME 3.0 will not necessarily distinguish between the FCC system and CONSUME 3.0 and will expect the interface to be easy to use. The method proposed is different from the recommendations contained in the FCC system design document due to the different perspective described above. This recommendation consists of a local FCC-like capability featuring the following:

- Use of shared components from CONSUME 3.0 and other follow on applications that use FCC data. This will save a great deal of time and money since every application that uses FCC data won't have to build their own interface. These components would interact with the central web-based FCC system and could be easily integrated into CONSUME 3.0
- Shared local database to store FCC datasets retrieved from the central web-based FCC system.
- Shared components that consist of a lightweight version of the web-based FCC system selection wizard, but act on the local database. This would provide consistency to all applications that use FCC system data.
- Capability of downloading multiple sets of FCC system records from the web-based database to the local database.
- Primary FCC system fuel bed prototype creation and management only on the web-based system.
- A translator for each application that needs to convert native FCC system data to a different format.
- A means to synchronize local data with changes in the web-based FCC database.



In the above diagram, users of FCC client applications like CONSUME 3.0 would see the local FCC wizard if they choose to populate fuel bed parameters using the FCC system. The wizard would allow them to search the local FCC database for stored fuel bed prototypes or allow them to access the web-based FCC system (if connection is available) to build or download prototypes to the local database. Once a fuel bed prototype is chosen, it would be imported via a translator into CONSUME 3.0 and its parameters stored in the CONSUME database.

The major components of this recommendation are:

Local FCC Wizard and Update Process. A wizard that provides interfaces to the local and web-based FCC system databases and allows the users to select a fuel bed prototype. It will be contained in shareable component or DLL

that can be called through CONSUME 3.0 or other applications. It will also contain a mechanism to update itself if newer versions are available.

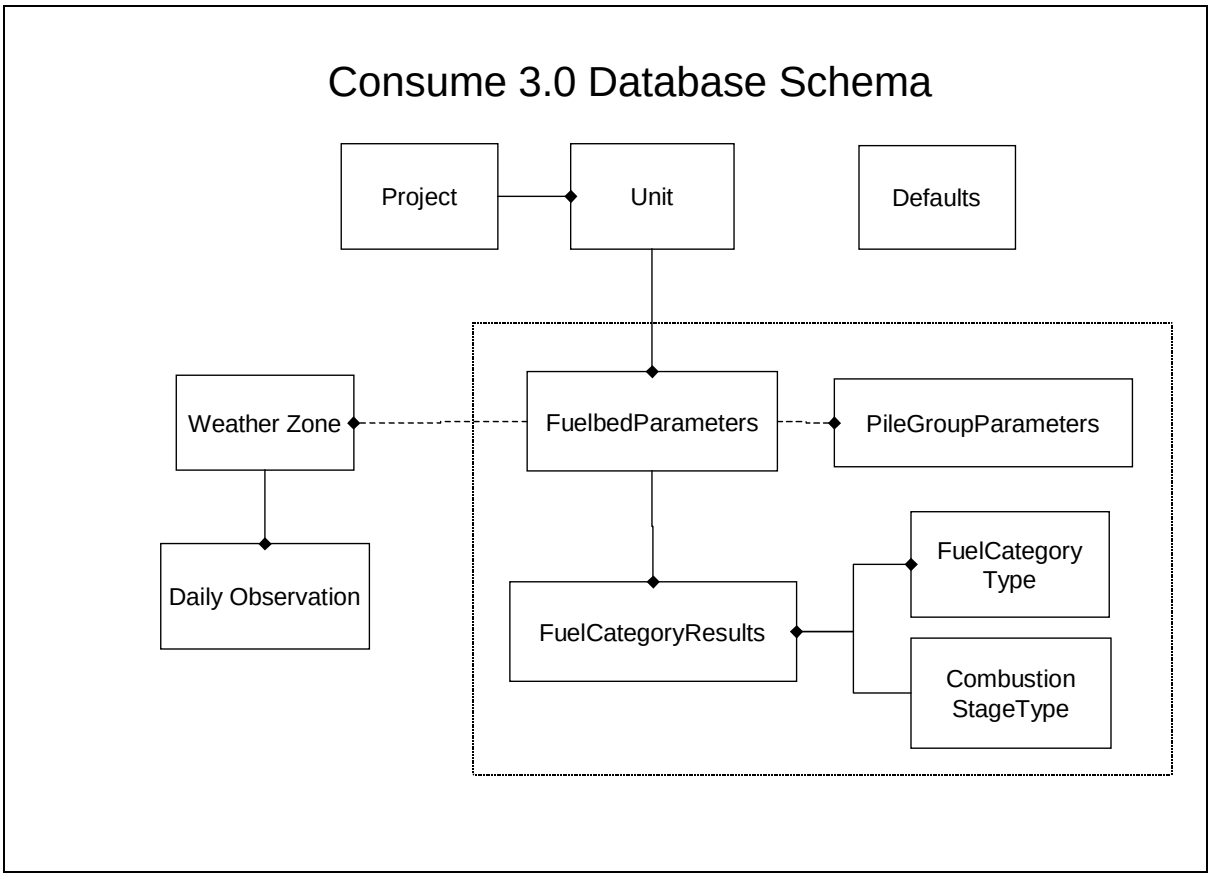
Local FCC Database. A database used to store FCC fuel bed prototypes. Only one database will be on any one system and will be shareable by all FCC client applications.

Translator. A mechanism to convert raw FCC fuel bed prototype data into a data stream that is compatible with client application.

Once the FCC system is stabilized (expected in late 2002 or early 2003), a final interface design can be built. This particular design might be quite different from the one proposed. In the meantime, the FCC system project should closely coordinate its work with the CONSUME 3.0 effort. If the concept of a locally shared FCC component is adopted (as recommended above), a decision will have to be made on how to build it. The most logical decision would be to let the FCC system project build it or to include its construction within the scope of CONSUME 3.0

Database Schematic

The following database schematic describes the organization of the CONSUME 3.0 database. This design is based on the conceptual data model presented earlier and has been de-normalized substantially in order to simplify the database structure and improve efficiency and performance. The following diagram depicts the CONSUME 3.0 database tables and their relationships.



Database Tables

Table: Preferences	
This table contains user defined defaults for new projects and system options	
Attribute Name	**Description**
OrganizationName	The name that will be used for a new project default.
OrganizationCode	A code used to identify the organization.
UnitsOfMeasure	A code to identify the measurement system to use (English or Metric). The default for new projects.

Table: Project	
This table contains information about the project	
Attribute Name	**Description**
ProjectID	A unique system-generated project key
ProjectName	The project's name.
OrganizationName	The organization's name that is responsible for the project.
OrganizationCode	The organization's code that is responsible for the project.
UnitsOfMeasure	A code to identify the measurement system used (English or Metric) by the project.
ProjectStartDate	The date the project started or planned to start if status is planned.
ProjectEndDate	The date the project ended.
ProjectStatus	Status of the project (planned, active, completed).

Table: Weather Zone	
This table contains information about Weather Zones	
Attribute Name	**Description**
WeatherZoneID	A unique system-generated key
WeatherZoneName	The weather zone's name.
StartingDate	The date of the initial weather reading for the weather zone. The date must be within the last twelve months.
Initial1000hrFM	The moisture content of cured, woody 1000-hour (3- to 9-inch-diameter) fuels on the weather zone's starting date
Latitude	A measurement of the distance of a site from the equator. Each degree of latitude runs in an east-west direction parallel to the equator
HoursOfRain	The hours of total rainfall in the 24-hour observation period of the starting date.
MaxTemp	The highest air temperature during the 24-hour observation period.
MinTemp	The lowest air temperature during the 24-hour observation period.
MaxHumidity	The highest humidity during the 24-hour observation period.
MinHumidity	The lowest humidity during the 24-hour observation period.

DaysSinceRain	The number of days since a significant amount of rain fell in a 48-hour period. A significant amount of rainfall is 0.25 inches

Table: Daily Observations	
This table contains weather observations for a weather zone.	
Attribute Name	**Description**
ObsID	A unique system-generated key
WeatherZoneID	The observation's weather zone's ID.
ObsDate	The date of the observation.
HoursOfRain	The hours of total rainfall in the 24-hour observation period of the starting date.
MaxTemp	The highest air temperature during the 24-hour observation period.
MinTemp	The lowest air temperature during the 24-hour observation period.
MaxHumidity	The highest humidity during the 24-hour observation period.
MinHumidity	The lowest humidity during the 24-hour observation period.
SignificantRain	Indicates whether the specified day received significant rain. A significant amount of rainfall is 0.25 inches

Table: Unit	
This table contains information about the unit of a project	
Attribute Name	**Description**
UnitID	A unique system-generated unit key.
ProjectID	The key of the unit's assigned project.
UnitName	The unit's name.
BurnDate	The date the unit was burnt.
HarvestDate	The date the unit was harvested (if applicable).
UnitCompleted	Indicates if unit was completed.
LengthOfIgnition	The duration of the ignition in minutes.
SnowOffDate	The date on which all snow has been melted.
MidflameWindSpeed	Wind speed (mph).
Slope	Slope in percent.
DaysSinceRain	The number of days since the last rain.
10HrFuelMoisture	.26" - 1.0" diameter fuel moisture.
100HrFuelMoisture	1.01" - 3.0" diameter fuel moisture.
1000HrFuelMoisture	3.01" - 9.0" diameter fuel moisture.
DuffHrFuelMoisture	Duff fuel moisture.
1000HrFuelMoistureSource	Source of 3.01" - 9.0" diameter fuel moisture.

The following are interim tables (indicated by the dashed line in the schematic diagram) pending the completion of the new CONSUME algorithms. Once the algorithms are complete these tables should be reviewed and fully attributed.

Table: FuelbedParameters	
This table contains information about the fuel bed's composition.	
Attribute Name	**Description**
FuelbedParametersID	A unique system-generated key.
UnitID	The key of the fuel bed's assigned unit.
PileFlag	Indicates if this fuel bed involves piles. If so then the PileGroupParameters table contains data and the attributes below are not used.
FuelType	Natural or human-altered fuel classification.
Size	Size of fuel bed in acres.
DuffDepth	Depth of forest floor duff layer.
FCCNumber	Fuel Characteristic Classification number.
FuelLoading10000Hr	9.01" - 20.0" diameter fuel loading (sound material).
FuelLoading1000Hr	3.01" - 9.0" diameter fuel loading (sound material).
FuelLoading100Hr	1.01" - 3.0" diameter fuel loading.
FuelLoading10Hr	.26" - 1.0" diameter fuel loading.
FuelLoading1Hr	0" - .25" diameter fuel loading.
FuelLoadingOver10000Hr	Over 20" diameter fuel loading (sound material).
FuelLoadingOver3Rotten	Rotten over 3" diameter fuel loading.
GeneralSpecies	Dominant overstory species in the fuel bed.
GrassHerbs	Understory herbaceous fuel loading (tons/acre).
LitterDepth	Litter depth.
LoadCategory	Relative mass of fuel in the fuel bed.
ShrubLoading	Shrubs fuel loading.

Table: PileGroupParameters	
This table contains information about pile group composition for a fuel bed.	
Attribute Name	**Description**
PileGroupParametersID	A unique system-generated key.
FuelbedParametersID	The key of the pile group's assigned fuel bed.
PileFlag	Indicates if this fuel bed involves piles. If so the PileGroupParameters table contains data and the attributes below are not used.
PileDensity1	Woody density of species 1.
PileDensity2	Woody density of species 2.
PileGroupId	Pile group number.
PileGroupName	Name of pile group.
PileHeight1	Height of small end of pile.

PileHeight2	Height of large end of pile.
PileLength1	Length of small side of pile.
PileLength2	Length of large side of pile.
PileMassPer	Consumable (oven-dry) mass of pile.
PilePackRatio	Ratio of wood volume to pile volume.
PilePS1	Primary species in pile.
PilePS1Percent	Percent of pile that is composed of primary species.
PilePS2	Secondary species in pile.
PileQuality	Relative amount of soil in pile.
PileQuantity	Number of piles of this size and type.
PileSoil	Percentage of soil in pile.
PileTable **	Name of the client product table for Pile Groups.
PileTotalMassCONSUMEd	Total mass of piled fuel consumed by burn.
PileType	Pile shape (1-7).
PileVolumePer	Gross pile volume.
PileWidth1	Width of small end of pile.
PileWidth2	Width of large end of pile.

Table: FuelCategoryResults

This table contains emissions and consumption data by fuel category.

Attribute Name	**Description**
FuelCategoryResultsID	A unique system-generated key.
FuelbedParametersID	The key of the fuel category's assigned fuel bed.
FuelCategoryTypeID	The key of the fuel category.
CombustionStageTypeID	The key of the combustion stage.
Cons10000Hr	9.01" - 20.0" diameter fuel consumption (tons).
Cons1000Hr	3.01" - 9.0" diameter fuel consumption (tons).
Cons100Hr	1.01" - 3.0" diameter fuel consumption (tons).
Cons10Hr	.26" - 1.0" diameter fuel consumption (tons).
Cons1Hr	0" - .25" diameter fuel consumption (tons).
ConsDate	Date that consumption was calculated.
ConsDiameterReduction	Diameter reduction (inches).
ConsDuff	Duff fuel consumption (tons).
ConsDuffReduction	Duff reduction (inches).
ConsForestFloor	Forest floor fuel consumption (tons).
ConsGrassHerbs	Grass and herbs fuel consumption (tons).
ConsLitter	Litter fuel consumption (tons).
ConsOver10000Hr	Over 20" diameter fuel consumption (tons).
ConsOver3Rotten	Rotten over 3.0" diameter fuel consumption (tons).
ConsShrubs	Shrubs fuel consumption (tons).
ConsSound	Sound woody fuel consumption (tons).
ConsTotal	Total unit fuel consumption.
EmisCH4	CH4 emissions (tons).
EmisCO	CO emissions (tons).
EmisCO2	CO2 emissions (tons).
EmisNMHC	NMHC emissions (tons).
EmisPM10	PM10 emissions (tons).
EmisPM25	PM25 emissions (tons).
EmisPM	Total PM emissions (tons).
EmisTotal	Total Emissions (tons).

HeatLoad	BTU/Ton X Ton/Acre = BTU/Acre

Table: FuelCategoryType	
This table contains a list of the fuel category types	
Attribute Name	**Description**
FuelCategoryTypeID	A unique system-generated key.
FuelCategoryName	The name of the fuel category.
Stratum	The name of the stratum the fuel category is in.

Table: CombustionStageType	
This table contains a list of the combustion stage types	
Attribute Name	**Description**
CombustionStageTypeID	A unique system-generated key.
CombustionStageName	The name of the combustion stage.

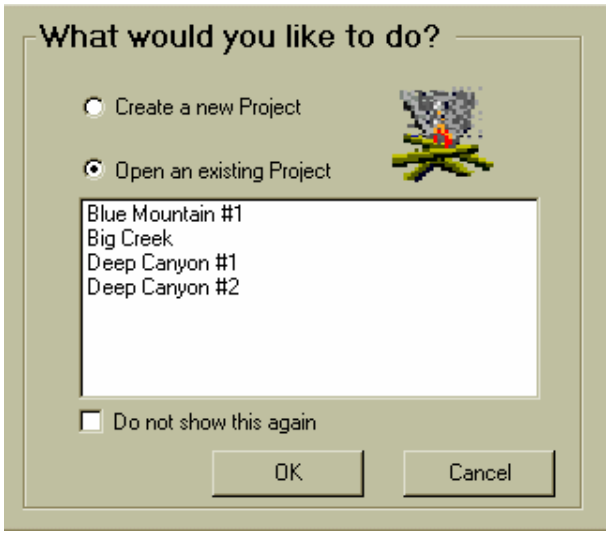
5. User Interface

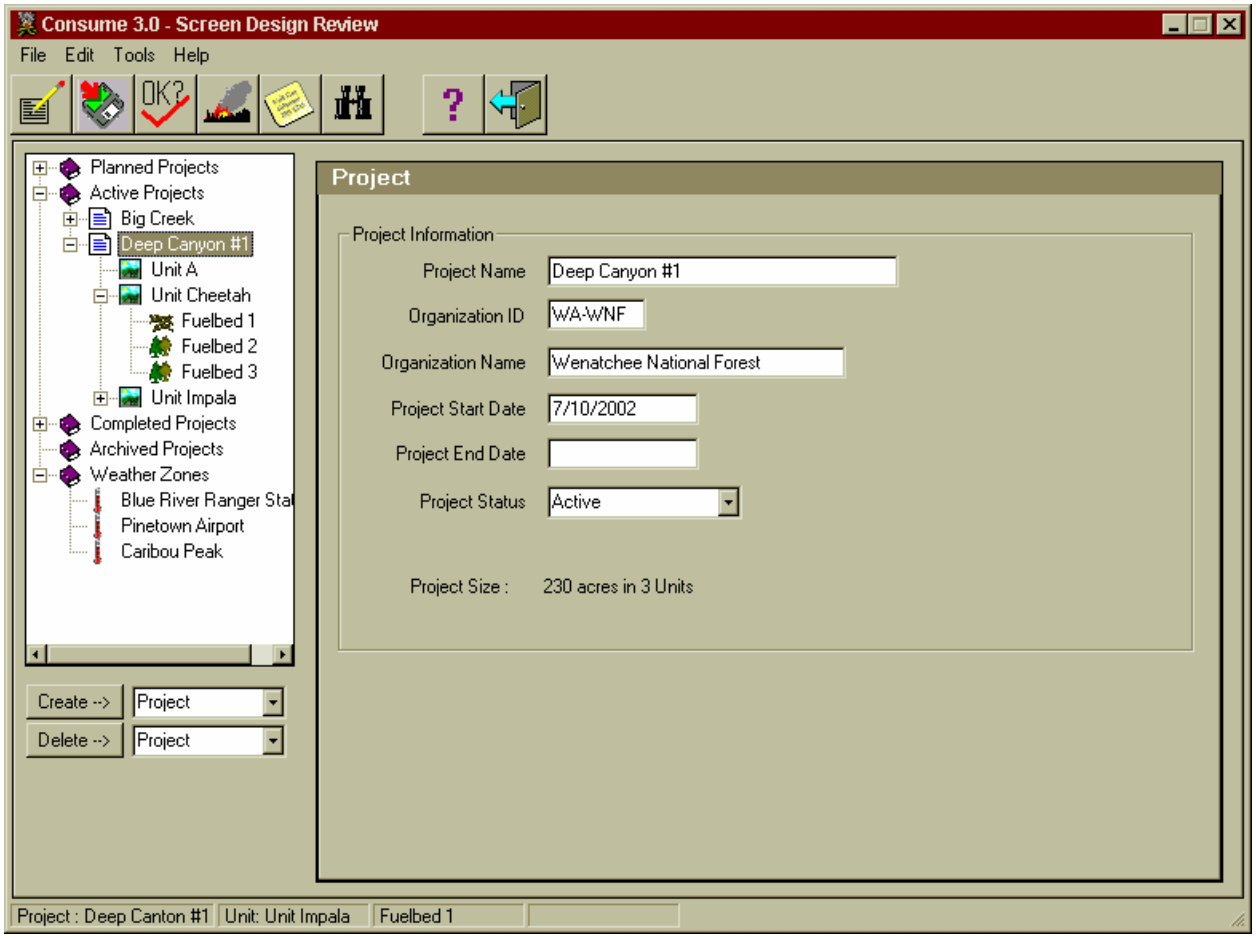
Introduction

The following section contains samples of screens of the envisioned CONSUME 3 application, which were obtained from a mock-up application. This mock-up was a working MS Visual Basic application without underlying code and was used to evaluate interface approaches, application navigation, and information organization.

Entrance Screen

The following screen is presented to the user as a convenience to allow them quick access to an existing project or to create a new project. The user may elect to not have this screen appear by checking the "Do not show this again" check box.





Main Screen Layout

The CONSUME 3 workspace contains the following key elements:

Organizer Window. The white area on the left side of the window allows the user to easily view and navigate between key items. The items are organized in a tree-like hierarchical manner. The items displayed are projects, units, fuel beds, and weather zones. Projects may be organized by planned, active, completed, or archived. Projects may also be dragged and dropped into another status category. Icons are used to visually identify item types. Items may also be cut, copied, and pasted using a pop-up right mouse click menu or via the edit menu. Clicking on an item in the list brings up the appropriate data input screen. Pasting a copy of any item also copies all child items. For example, copying a project will copy all the

projects units and fuel beds.

Activity Window. To the right of the organizer window is an area that will change based on the context of what item was clicked in the list or if the reports or gaming options were requested.

Menus. All functions are accessible via the menu bar at the top of the application.

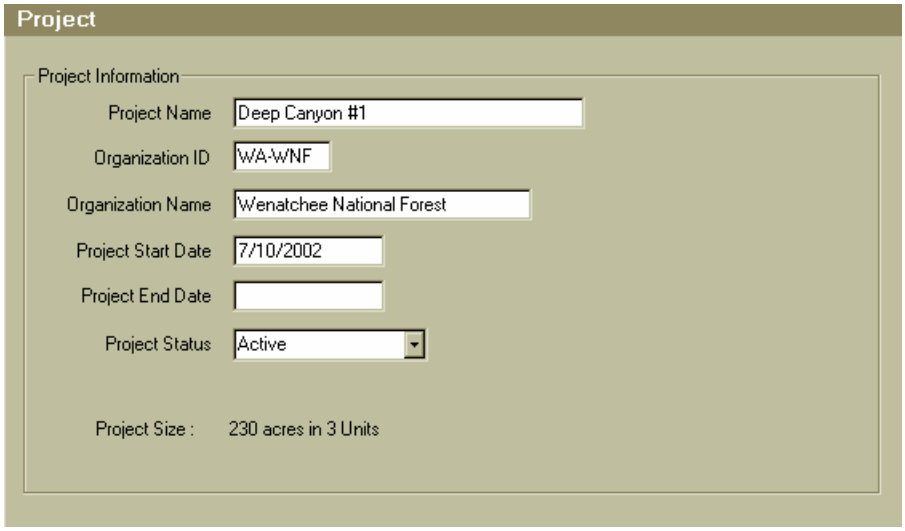
Shortcut Buttons. A number of shortcuts on the upper toolbar are available for frequently used functions.

Status Bar. On the very bottom of the application is an area used to provide information to the user, including warning and error messages.

Creation/Deletion Buttons. In the lower left corner are buttons that allow the user to create and delete projects, units, fuel beds, and weather zones. Units and fuel beds are created in the currently selected project or unit.

Activity Windows

The activity window will change based on the function selected by the user or the item selected in the organizer window. The following are samples for each activity screen:

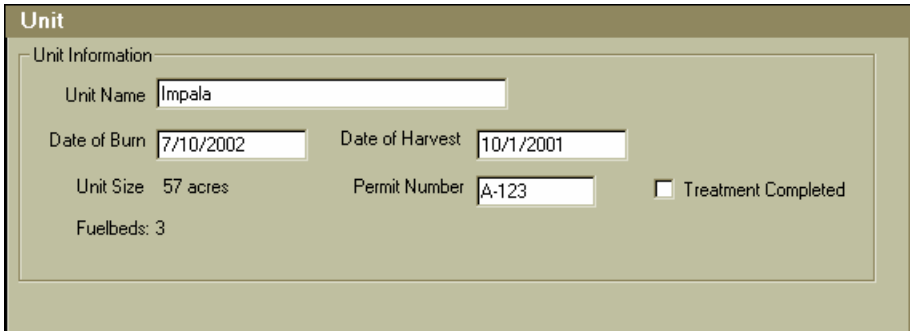


Project Screen

The project screen is used to enter project level information.

Field specifications and notes:

- Project Name. Name must be unique among all projects in the database.
- Organization ID. A code that identifies the organization when data is consolidated for upward reporting purposes. When a new project is created this field is filled in from the user's default.
- Organization Name. The name of the organization. When a new project is created this field is filled in from the user's default.
- Project End and Start dates. Standard U.S. format dates.
- Project Status. Any of the following: Planned, Active, Completed, and Archived. The default for new projects is "Planned." When a project is dragged and dropped into a new status category in the organizer screen the above status is changed automatically.
- Project Size. This is the sum of all acres in the project and is automatically calculated whenever fuel bed size is changed in any of the projects units.

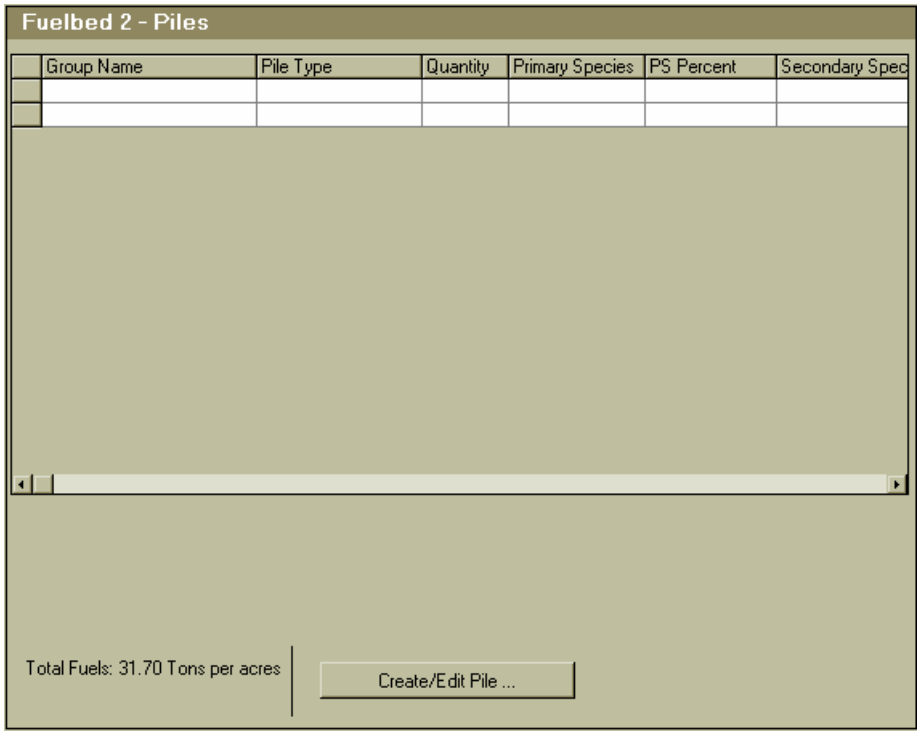


Unit Screen

The unit screen is used to enter unit level information.

Field specifications and notes:

- Unit Name. Name must be unique among all units in the selected project.
- Date of Burn. Standard U.S. date format.
- Date of Harvest. Standard U.S. date format. Only applicable for activity fuels.
- Permit Number. The permit numbered issued by the organization authorizing the burn. Optional entry.
- Treatment Completed. Checked if burning is completed on the unit.
- Unit Size. Automatically calculated sum of all fuel beds in the unit.
- Fuel beds. Total fuel beds in the selected unit.

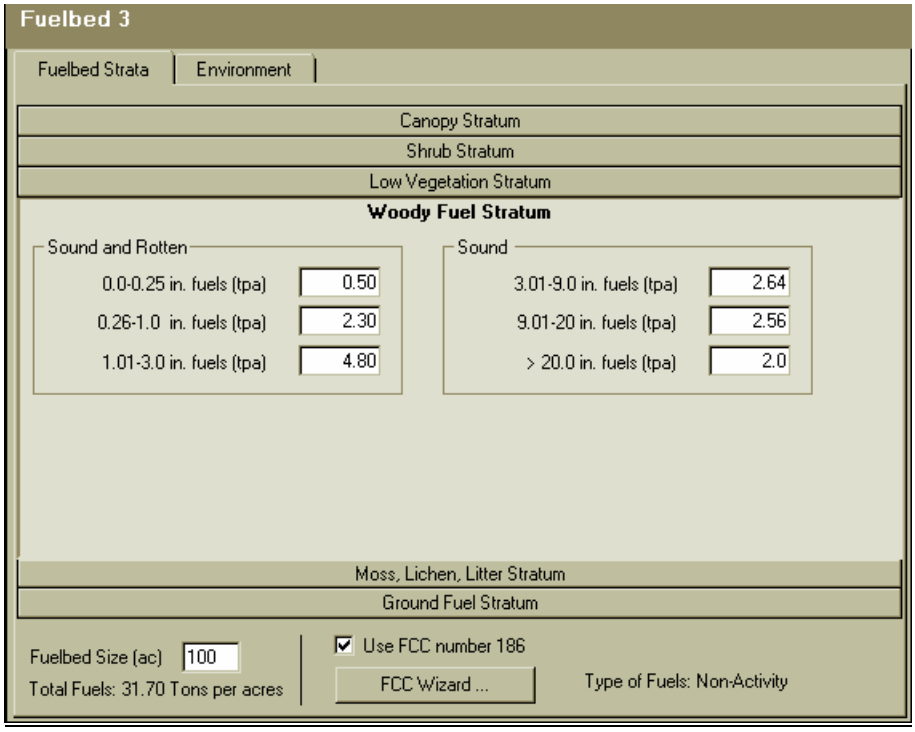


Fuel bed - Piles Screen

The piles screen is used to enter, create, and edit pile information. Fuel beds that contain piles are treated as separate and distinct from non-piled fuel beds. The actual screens for guiding the user in defining pile groups are provided by the CONSUME 2.1 pile wizard and are not shown here.

Field specifications and notes:

- Pile Grid. The grid area displays pile group parameters for the fuel bed created by the pile wizard.
- Create/Edit Pile Button. This button activates the CONSUME 2.1 pile wizard.
- Total Fuels. This total is automatically updated when changes are made to the fuel bed.



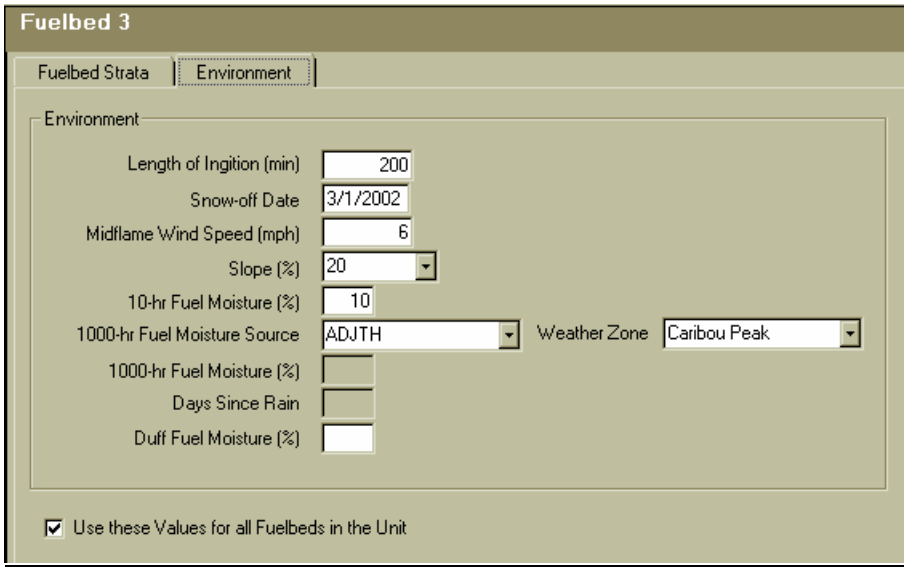
Fuel Bed (Non-Piled) Screen

The fuel bed screen is used to enter, create, and edit fuel bed parameters by fuel bed stratum, as well as environmental values for the fuel bed. User may enter the values manually or use the FCC wizard to populate the fuel categories for all appropriate strata. The FCC wizard is not shown here due to development work on the FCC system. A complete list of required fields for each stratum is not available pending the completion of the new algorithms. Once the fields are finalized, the above screen could be simplified by placing all inputs within a single visible frame.

Fuel Bed Strata Tab - Field specifications and notes:

- Fuel Bed Strata. The visual appearance of the strata area was designed to simulate the concept of fuel bed strata and allow for placement of all the values on one screen. Clicking on a stratum button opens the input screen for that stratum and displays the appropriate fuel category inputs.

- FCC Wizard Button. This button activates the FCC wizard.
- Use FCC number. If checked then the strata values are native to the FCC system and cannot be modified by the user. If unchecked the user may modify the acquired FCC values.
- Fuel Bed Size. The area represented by this fuel bed.
- Total Fuels. This total is automatically updated when changes are made to the fuel bed.
- Type of Fuels. Indicates if this fuel bed contains activity or non-activity fuels. This value is set when the fuel bed is created.

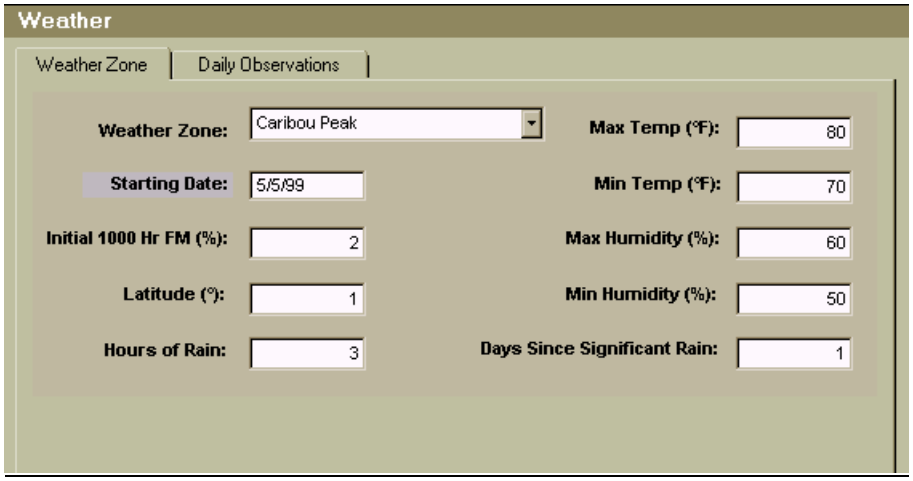


Environment Tab - Field specifications and notes:

The environment parameters are essentially the same as in CONSUME 2.1 except they are linked to the fuel bed and not the unit. This allows greater precision in that fuel beds may be given discrete environmental values that reflect differences in exposure, elevation, and slope, among others.

- Length of Ignition. The amount of time, in minutes, that it will take to ignite the area to be burned.
- Snow-off Date. The approximate date that snow melted from the fuel bed. If only the month and year are known enter the day as the 15th of the month.
- Mid-flame Wind Speed. The prescribed mid-flame wind speed, in miles per hour, during the burn. The maximum wind speed is 35 miles per hour.
- Slope. The average vertical change (rise) in the fuel bed ground surface over a given horizontal distance (run). Slope is expressed in percent (%).
- 10-hour Fuel Moisture Content. The moisture content of 10-hour fuels (0.26- to 1-inch-diameter round wood fuels). 10-hour fuel moisture is expressed as a percentage of the ovendry weight of the fuel.
- 1000-hour Fuel Moisture Source. The source of the 1000-hour fuel moisture data for the fuel bed, either directly measured (MEAS-TH), or estimated using the ADJ-TH or NFDRS-TH fuel moisture models.
    - Measured – The directly measured fuel moisture that represents the average fuel bed fuel moisture of large woody fuels. Input this value directly.
    - NFDRS-TH – National Fire Danger Rating System's 1000-hour fuel moisture content, and represents the moisture condition of large woody fuels.
    - ADJ-TH – The adjusted 1000-hour fuel moisture content is the NFDRS-TH times an empirically derived factor of 1.4. This option requires the user to select a weather zone and to input daily weather information.

- Weather Zone. A weather zone is an area of one or more fuel beds that share the same daily weather conditions. Weather data is optional. To use daily weather information to calculate the adjusted 1000-hour Fuel Moisture (ADJ-TH) rather than using measured fuel moisture (Measured) or the National Fire Danger Rating System's 1000-hour Fuel Moisture (NFDRS-TH), requires a weather zone. A weather zone must be created before it is assigned to a fuel bed.
- 1000-hour Fuel Moisture. The measured or estimated 1000-hour fuel moisture for the fuel bed. 1000-hour fuel moisture is the moisture content of sound, woody material 3-8 inches in diameter and can be directly measured or estimated using the ADJST-TH or NFDRS-TH fuel moisture models. Fuel moisture is expressed as a percent of the oven-dry weight of the fuel. The value for 1000-hour fuel moisture must be an integer between 1 and 500. Blank if ADJ-TH fuel moisture is used.
- Days Since Rain. The number of days since significant rainfall. Significant rainfall is one-quarter inch. The ADJ-TH fuel moisture is used.
- Duff Fuel Moisture. The duff fuel moisture of the area of the fuel bed that will be treated. This field is optional. When available, it allows CONSUME to use a double parameter equation to calculate consumption of large natural fuels.
- Use These Values for all Fuel Beds in the Unit Checkbox. If this is checked then the above values will be used for all the fuel beds in the unit. The objective is to simplify user inputs if appropriate for the unit.

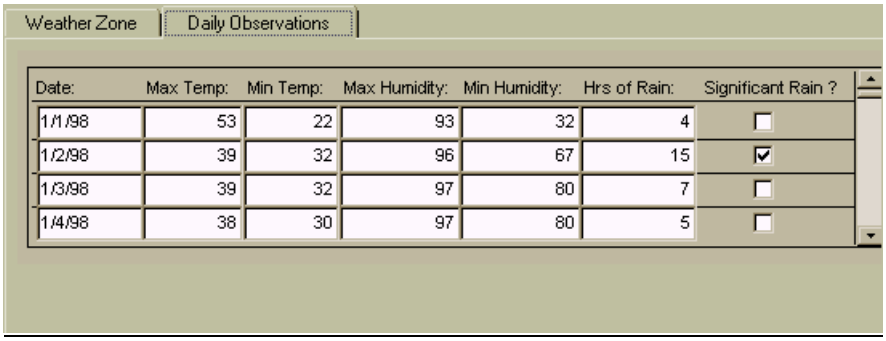


Weather Screen

The weather screen allows user to create and edit weather zone values and its daily observations. This screen is essentially the same as in CONSUME 2.1.

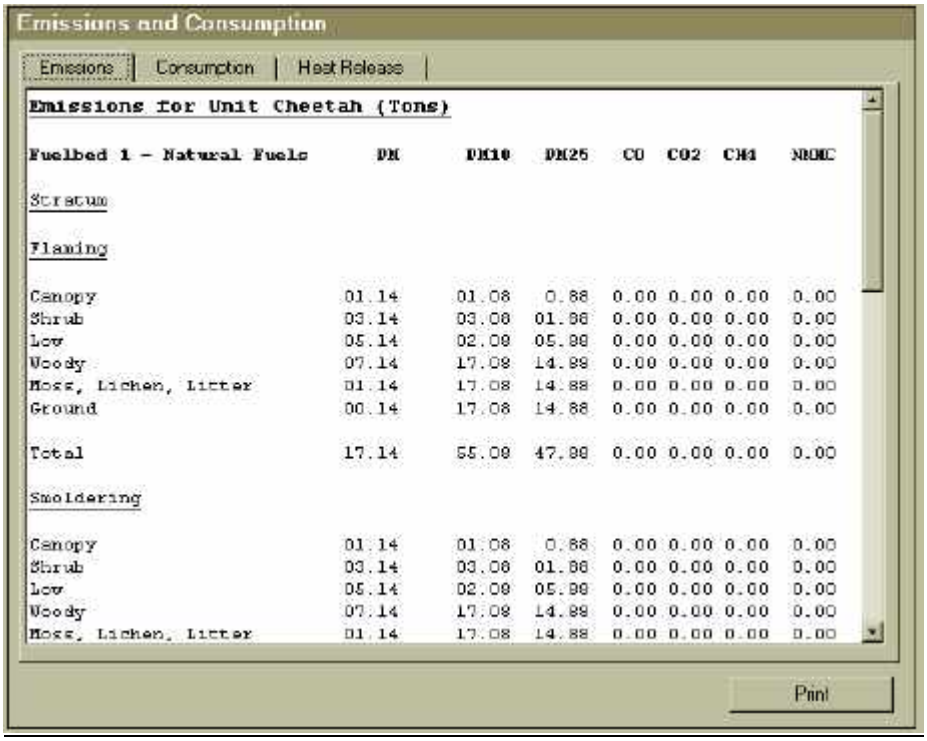
Weather Zone Tab - Field specifications and notes:

- Weather Zone. A unique name for the weather zone.
- Starting Date. The date of the initial weather reading for the weather zone. The date must be within the last twelve months.
- Initial 1000-hr FM. The moisture content of cured, woody 1000-hour (3- to 9-inch-diameter) fuels on the weather zone's starting date.
- Latitude. A measurement of the distance of a site from the equator. Each degree of latitude runs in an east-west direction parallel to the equator. There are 180 degrees of latitude from pole to pole.
- Hours of Rain. The hours of total rainfall in the 24-hour observation period of the starting date.
- Max and Min Temp. The highest and lowest air temperature during the 24-hour observation period.
- Max and Min Humidity. The highest and lowest relative humidity, during the 24-hour observation period.
- Days Since Significant Rain. The number of days since a significant amount of rain fell in a 48-hour period. A significant amount of rainfall is 0.25 inches.



Daily Observations Tab - Field specifications and notes:

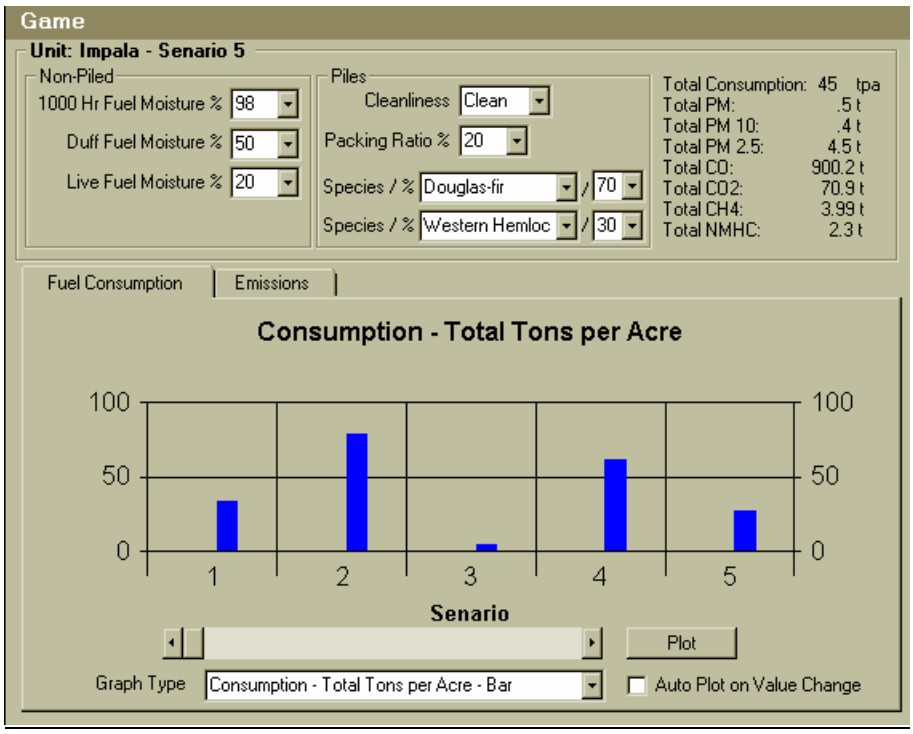
- Date. The date on which the daily weather readings were collected. You must create new records in date order.
- Max and Min Temp. The highest and lowest air temperature during the 24-hour observation period for the date in the Date field.
- Max and Min Humidity. The highest and lowest relative humidity during the 24-hour observation period for the date in the Date field.
- Hours of Rain. The hours of total rainfall in the 24-hour observation period of the date in the Date field.
- Significant Rain? Indicates whether the specified day received significant rain. A significant amount of rainfall is 0.25 inches.
- Import WIMS Data Button (not shown). Allows the user to populate daily observations with WIMS weather records. Data must begin with the date specified in the weather zone definition must be complete and date sequential.


Emissions and Consumption
Emissions
Consumption
Heat Release
Emissions for Unit Cheetah (Tons)
Fuelbed 1 - Natural Fuels
PM
PM10
PM25
CO
CO2
CH4
NMHC
Stratum
Flaming
Canopy 01.14 01.08 0.88 0.00 0.00 0.00 0.00
Shrub 03.14 03.08 01.88 0.00 0.00 0.00 0.00
Low 05.14 02.08 05.88 0.00 0.00 0.00 0.00
Woody 07.14 17.08 14.88 0.00 0.00 0.00 0.00
Moss, Lichen, Litter 01.14 17.08 14.88 0.00 0.00 0.00 0.00
Ground 00.14 17.08 14.88 0.00 0.00 0.00 0.00
Total 17.14 55.08 47.88 0.00 0.00 0.00 0.00
Smoldering
Canopy 01.14 01.08 0.88 0.00 0.00 0.00 0.00
Shrub 03.14 03.08 01.88 0.00 0.00 0.00 0.00
Low 05.14 02.08 05.88 0.00 0.00 0.00 0.00
Woody 07.14 17.08 14.88 0.00 0.00 0.00 0.00
Moss, Lichen, Litter 01.14 17.08 14.88 0.00 0.00 0.00 0.00
Print


Emissions and Consumption
Emissions
Consumption
Heat Release
Consumption for Unit Cheetah
Fuelbed 1 – Natural Fuels
Flaming Phase
Canopy Stratum 5 Tons Per Acre
Shrub Stratum 4 Tons Per Acre
Low Vegetation 8 Tons Per Acre
Woody Vegetation 10 Tons Per Acre
Moss, Lichen, Litter Stratum 2 Tons Per Acre
Ground Fuel Stratum 9 Tons Per Acre
Smoldering Phase
Canopy Stratum 10 Tons Per Acre
Shrub Stratum 9 Tons Per Acre
Low Vegetation 14 Tons Per Acre
Woody Vegetation 20 Tons Per Acre
Moss, Lichen, Litter Stratum 2 Tons Per Acre
Ground Fuel Stratum 9 Tons Per Acre
Total
Print

Emissions and Consumption Screens

The above screens provide a quick way to view consumption, emissions, and heat release for a unit and its fuel beds. List of output variables are as illustrated above. The information is presented in a scrollable region to allow for multiple fuel beds. A button is provided to allow the printing of the contents.



Gaming Screen

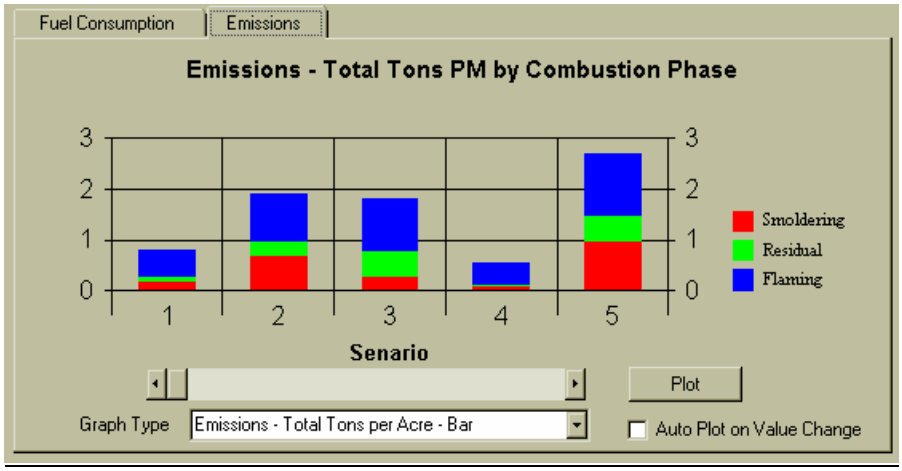
The gaming screen provides a means for the user to test various combinations of input parameters for piled and non-piled fuel beds within a unit. The parameters were chosen based on their significance to effect consumption and emissions. The top part of the screen contains the gaming variables and the resulting outputs of the gaming scenario and the bottom half contains side by side comparison of user-plotted scenarios. The gaming takes place at the unit level and the inputs will apply uniformly to all fuel beds, overriding fuel bed specific values. The gaming function only provides the user with a rough idea of what various combinations of values will produce.

Field specifications and notes:

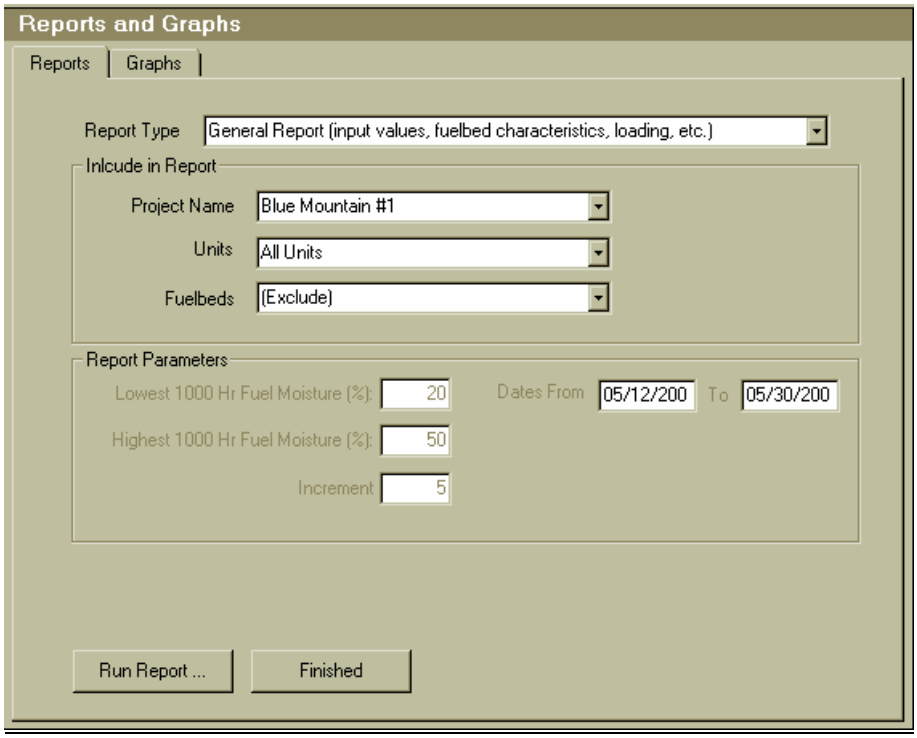
- Non-Piled Group. The variables in this frame will only be displayed if the unit has one or more non-piled fuel beds.
- Piled Group. The variables in this frame will only be displayed if the unit has one or more piled fuel beds.

- Plot Button. Pushing the plot button causes the current scenario to be plotted.
- Auto Plot on Value Change Checkbox. If this box is checked then every time a gaming value is changed the scenario is plotted.
- Graph Type. The type of graph may be selected using this drop-down list.

Notes: Any number of scenarios may be plotted. If more than 10 scenarios are plotted they scroll off the graph to the right and may be recalled by using the scroll bar. If the user clicks on one of the bars, the gaming variables for that scenario will be displayed.



If the user clicks on the Emissions tab, the emissions by combustion phase are displayed.



Reports and Graphs Screen

The reports and graphs screen allows the user to select a variety of reports or graphs that can be viewed on screen, saved, or printed.

Field specifications and notes:

- Report/Graph Type. The user selects the report or graph from this drop-drown list.

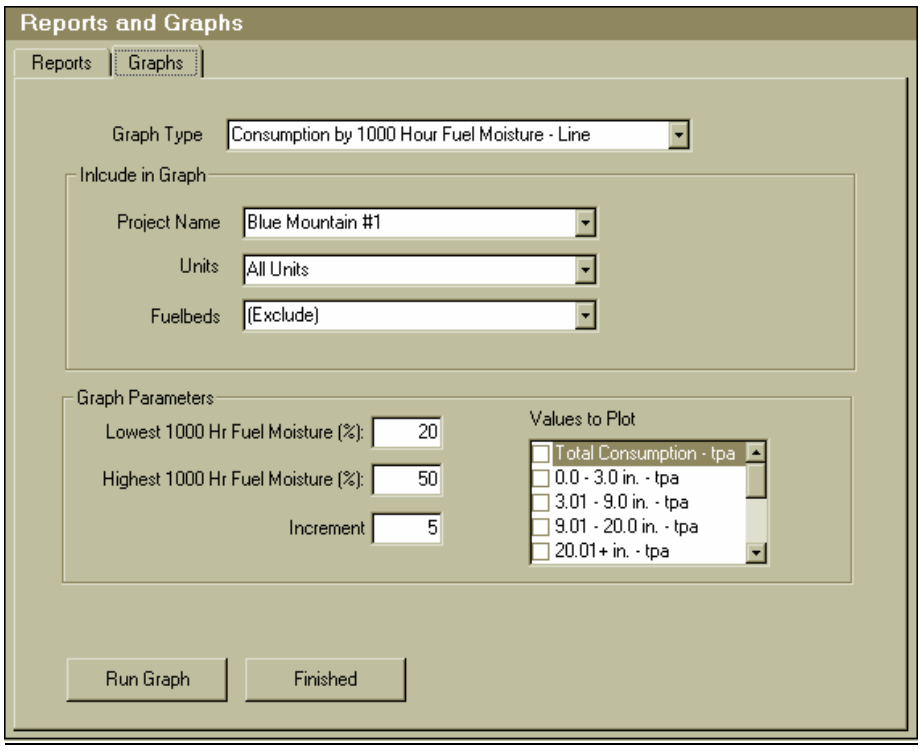
- Include in Report/Graph Group. The user can control the level of detail in a report or what is to be graphed by selecting options from the project, units, and fuel beds drop-downs. Possible options are:

1. Named project, unit or fuel bed.
2. All: include all projects, units, or fuel beds.
3. Exclude: Do not display detail for units or fuel beds.

Example settings for drop-down values:

Desired Report	**Projects**	**Units**	**Fuelbeds**
Summary of all Projects	All	Exclude	Exclude
Summary Report on Blue Ridge Unit of Project ABC	ABC	Blue Ridge	Exclude
Summary of ABC Project	ABC	Exclude	N/A
Detailed reported for ABC Project	ABC	All	All

- Report/Graph Parameters Group. This frame contains parameters required to run certain reports and graphs. If the report type requires these parameters they will become accessible, else they will be disabled.



The above screen is displayed when the user clicks on the graphs tab.

List of Reports

- General Report. This report displays all input values for the selected project, unit, and fuel bed. The fuel bed section of the report will display fuel category values by stratum and environment. No report parameters are required.
- Consumption by 1000 Hour Fuel Moisture. The consumption by 1000-hour fuel moisture report is only valid for Activity-non-piled units since natural fuel and pile consumption algorithms do not require 1000-hour fuel moisture content as an input variable. A range for the 1000-hour fuel moisture content and an increment must be set before the report can be run. The result is presented as both a graph and text as in CONSUME 2.1.
- Consumption by Date. Displays consumption for units treated (burnt) between a range of dates. A range of dates must be set before running the report.
- Consumption by Combustion Phase. Displays consumption by combustion phase for the selected unit and fuel bed.
- Emissions by 1000-Hour Fuel Moisture Content. The report on emissions by 1000-hour fuel moisture content is only valid for Activity-non-piled units since natural fuel and pile emissions algorithms do not require 1000-hour fuel moisture content as an input variable. A range for the 1000-hour fuel moisture content and an increment must be set before the report can be run. The result is presented as both a graph and text as in CONSUME 2.1.
- Emissions by Date. Displays emissions for units treated (burnt) between the ranges of dates. A range of dates must be set before running the report.
- Emissions by Combustion Phase. Displays emissions by combustion phase for the selected unit and fuel bed.
- Heat Release by Combustion Phase. Displays heat load by combustion phase for the selected unit and fuel bed.
- Weather Zone. Weather Information report summarizes weather zone and daily weather data that has been entered into CONSUME, and resulting adjusted 1000–hour fuel moisture values for units represented by each weather zone. No additional parameters are required.

List of Graphs

- Consumption by 1000 Hour Fuel Moisture – Line. A line graph that plots consumption over a user defined range of 1000-hour fuel moisture contents. The following series may be plotted in tons per acre: total consumption, consumption by size class, and consumption by stratum.
- Emissions by 1000-Hour Fuel Moisture – Line. A line graph that plots emissions over a user defined range of 1000-hour fuel moisture contents. The following series may be plotted in tons per acre: total emissions, emissions by size class, and emissions by stratum.

Report and Graph Viewing Screen (not shown)

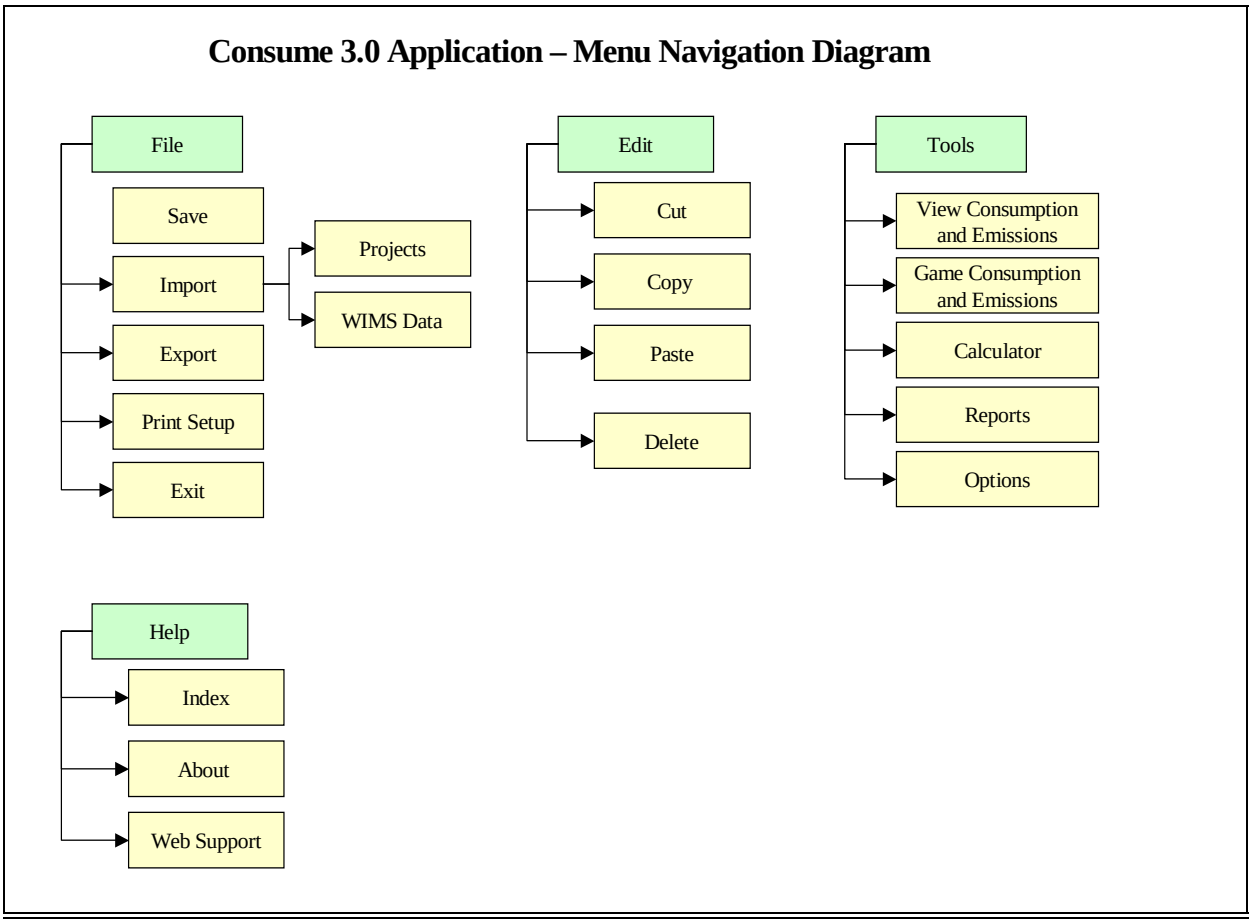
When a report or graph is run the output will be displayed in a separate window that can be maximized to fit the entire screen of the monitor for easy viewing. Each text report can be saved in rich text format or printed. Each graph can be saved as an image file (bit map, Jpeg, etc.) or printed.

Tool Bar

The tool bar provides shortcuts to the following functions (left to right):

- Access notes.
- Save changes to the databases.
- Check to see if all entries are valid for the selected unit.
- View emissions and consumption for selected unit.
- Access reports and graphs generation screen.
- Access gaming screen for selected unit.
- Access to HELP system.
- Exit application.

Menu Structure



File

Save. Saves changes to the database.

Import.

Projects. Imports CONSUME 3.0 project export files.

WIMS Data. Imports WIMS daily observations into the selected weather zone.

Export. Creates a text file of the selected project and all its unit and fuel beds.

Print Set Up. Access the Windows printer set up window.

Exit. Closes the CONSUME application.

Edit

Cut. Moves a project, unit, or fuel bed to another list item in the organizer window by removing it from its current location and placing it on the Windows clipboard where it can be relocated.

Copy. Creates a copy of the selected project, unit, or fuel bed and places it on the Windows clipboard.

Paste. Pastes a project, unit, or fuel bed into an appropriate item in the organizer window.

Delete. Deletes the selected project, unit, or fuel bed.

Tools

View Consumption and Emissions. Display the consumption and emissions screen for the selected unit.

Game Consumption and Emissions. Display the gaming screen for the selected unit.

Calculator. Access the Windows calculator.

Reports. Access the reports and graphs screen.

Options. Access the options and defaults screen.

Help

Index. Access the index function of the help system.

About. Display information about the application.

Web Support. Access the CONSUME 3.0 support website.

Accelerator Keys

Each menu item or command will have a designated accelerator (shortcut) key.

6. Testing Guidelines

Testing verifies that CONSUME 3.0 deliverables conform precisely to the functional and design specifications that have been agreed to by FERA and the users. The goal of testing is to detect and reduce the number of bugs in a deliverable so that the system is completely operable. Testing is an integral and complementary part of the development process and should be carried out at specific points to ensure that deliverables are correct. Testing should also be used to solicit ideas for improvements.

Types of Tests

Due to the nature of modern visual and event driven programming a modified approach to testing is recommended. This approach consists of the following types of tests:

Destruction. In this type of testing, the application is tested until it does something it's not supposed to, often in a totally unstructured fashion.

Window Design. This kind of test verifies that each window in the system has been designed and built according to project design standards. A checklist should be used for this purpose. Each screen should be checked for the following items:

- Correct and consistent use of colors, fonts, positioning, alignment, borders and other formatting devices.
- Correct positioning of data entry fields, combo boxes, lists.
- Labels are clear and concise.
- Tabbing order is set correctly.
- Complete functionality as per design.

Navigational. This test determines that each screen or window can be navigated to in the manner described in the design. The best format for this test is a checklist. This list of navigational actions and results can be easily retested and verified by the test reviewer. The following are examples of checklist items:

Location	Action	Result
Menus	File: New Project Reports	Project identity screen displayed, fields initialized. Report generation screen is displayed.
Input Error Checks	All user inputs	Test for incorrect values
Generator	Run Print	Selected report is run and displayed. Print dialog is displayed

Functional. Functional testing ensures that the functions of the system are actually tested. For example, when you initiate the Compute Emission function for a project (regardless of how you do it: via the mouse, the keyboard mnemonic keys, or a keyboard accelerator key), are the resulting calculations correct and properly displayed? Functional testing is also designed to test the usability of the deliverable. This is different from navigational testing. A checklist should be prepared by function or process to be tested. The following are examples of functional checklist items:

Function	Location	Check
Compute Consumption	Toolbar Button Compute Emissions Button	Check screen and report Results.
Input Error Checking	All user inputs	Test each user input for the correct range of values
Printing	Report Display Screen	Check to ensure reports are formatted and will print on a range of typical printers.

Testing Roles and Responsibilities

Testing of CONSUME 3.0 will require the participation of three groups of people: the application builder, the user, and the sponsor (FERA). Each group will play an important part in the testing and ultimate delivery of CONSUME 3.0. The roles and responsibilities for each group are:

Application Builder. The builder of CONSUME 3.0 is responsible for producing the components (modules, screens, etc.) for testing according to the development/test plan. For each test, the builder will provide personnel to support the testing and record findings for later review.

User. The user is vital to the testing of CONSUME 3.0 and will play the following roles:

1. Ensures the needs of the CONSUME user-community are being met.
2. Suggests changes that increase the usability and capability of CONSUME.
3. Locates programming faults and other errors.

Sponsor (FERA). FERA is responsible for ensuring that adequate testing is done and will participate as necessary in actual testing sessions. The developer will provide FERA with a list of suggested enhancements and unresolved issues. FERA will process the list making decisions on each item.

Testing Sequence

The order and timing of testing is a critical part of application building. Users can provide valuable comments if given the opportunity during the development phase. Once the design starts to become a real-life set of windows, dialog boxes, reports and charts that the user can manipulate, ideas often start to flow. It is inevitable that further findings that could benefit the overall usability or efficiency of the finished result will be forthcoming. This type of user involvement should be encouraged throughout the first half of the development phase. In order to take advantage of these benefits the development of CONSUME 3.0 must be planned to deliver testable units of work as early as possible, even if they are not fully functional. This should be done in a way that evolve toward a working system. The following is a recommended sequencing of testable deliverables:

Test	Testable Deliverable	Test Objectives	Type of Test
1	Working set of windows without underling code and simulated outputs.	- Confirm screen design - Confirm navigation and menus	- Window design - Navigational
2	CONSUME algorithms and modules connected to screens with input and outputs. Minimum error checking, help, and reports.	- Confirm results from CONSUME algorithms.	- Functional - Window design - Navigational
3	Reports	- Confirm results and format	- Functional - Window design - Navigational
4	Help and error checks	- Confirm help messages and errors are intercepted.	- Window design - Functional
5	Completed application	- Final test of all elements	- Functional - Window design - Navigational - Destruction

Processing Test Results

During each test it is important to take accurate notes. These notes should be categorized into faults and suggestions. Faults are problems and errors in the deliverable. Suggestions are ideas for improvements to the deliverable. Because these will likely have an impact on the delivery schedule, it will be important to assess each item and determine the action to be taken. FERA should approve all decisions made.

7. Support Guidelines

The purpose of a user support system is to provide assistance when a problem or question arises and to communicate information about CONSUME 3.0. Support begins before the application is put into production and continues through the life of the application. The goals of support are to:

- Enhance User Productivity. The support system should attempt to minimize loss of productivity due to resolution of problems.
- Promote User Education. The support system should increase the ability of the user to solve their own problems.
- Improve User Satisfaction. Users that are satisfied will be more productive as the two are closely linked. It is the goal of the support system to keep users satisfied with responsive and thorough assistance.

CONSUME 3.0 support should be oriented toward self-help and self-training. Studies show that when help desk personnel solve problems for users, the users don't learn much and often can't reproduce the steps in the solution. But when users follow clear, step-by-step instructions to fix their own problems they increase their productivity.

Support Components

Recommendations for CONSUME 3.0 support system components include:

- Awareness Campaign. An effort should be undertaken to increase the visibility of CONSUME 3.0 to potential users, including an article for the Fire Management Today publication, presentations at relevant meetings, and use of the CONSUME 3.0 website to provide information on CONSUME. These actions should take place no later than six months before the planned release and should continue during the first year of the initial release.
- CONSUME 3.0 Website. A CONSUME 3.0 website should be implemented so there is a central location to obtain the latest information about software, updates, known problems and fixes, customer service contacts, and documentation.
- CONSUME 3.0 Tutorial. A tutorial consisting of step by step instructions should be supplied with the distribution package. The tutorial should include several examples of the most common usage scenarios. This tutorial will serve as the primary means of user training. A special tutorial database will contain data used in the examples.
- CONSUME 3.0 User Guide. A comprehensive user guide should be produced that can be distributed electronically with the distribution package and by hardcopy. The CONSUME 2.1 manual can be used as a model.
- CONSUME 3.0 Online Help. An online help system provides instant assistance to a user. The system should allow the user to control how the information is, either by allowing page-by-page entry, entry via an index or table of contents, and entry by keyword searching. Access to the website support page should also be facilitated from the application.
- CONSUME 3.0 User Assistance. Assistance should be provided via e-mail or phone for problems that users cannot solve themselves. These contact address and numbers should be made visible in the help system and on the website.

FCC Support Integration

CONSUME 3.0 will use the FCC system via an interface. The FCC system is a new system and CONSUME 3.0 will be one of the first applications to use it. It is possible that the FCC system will generate more questions than CONSUME 3.0. From a user's perspective the FCC system will be seen as part of CONSUME 3.0, not a separate system. When a problem or question arises concerning the FCC system, the user will access the CONSUME 3.0 support system looking for an answer. In order to support the user the following should be considered:

- Distribute FCC online help system with CONSUME 3.0.
- Distribute FCC user guide with CONSUME 3.0.
- Provide telephone contacts for FCC help.

Support Role

Responsibility for support of CONSUME 3.0 should be carefully considered. CONSUME 2.1 support was easily handled by FERA due to its modest user base. With CONSUME 3.0 the user base is planned to greatly expand as a wider range of fuel types are included in the software. The capacity for FERA to handle support for CONSUME 3.0, especially during the initial release, could be too limited. A better option is to make CONSUME 3.0 a national application supported by Fire and Aviation Management's National Information Systems Team (NIST) in Boise. NIST provides comprehensive support for "national" systems such as Behave and FOFEM with a help desk and other support mechanisms. FERA should explore this option with NIST

8. Maintenance Guidelines

Maintenance of systems is problematic and difficult to estimate in terms of workload; however, studies show that maintenance can absorb 60 to 80 percent of the total workload over an application's lifetime. Faulty design, defective programming, changes in business needs, complex source code, and inadequate system documentation can affect even a well-built application.

Maintenance consists of two distinct but related objectives: correction of application problems and improvement of the application through planned enhancements. These objectives can be met in the following way:

- Record problems and suggestions. This task should be part of the support system so that when a service call is received, it is logged and the details of the problem recorded.
- Identify and evaluate problem severity. Problems should be evaluated to identify their source, what is needed to correct them, and their impact on users. Major impacts consist of problems that cause the application to crash or produce erroneous results. Minor impacts consist of problems that do not cause a breakage, computational error or a problem that can be overcome by workarounds.
- Evaluate suggestions for improvement. When an idea for improvement is put forth, it should be analyzed immediately in sufficient detail so it can be used at a later date. These suggestions can be allowed to accumulate unless judged to warrant immediate inclusion into the application.
- Prioritize corrective actions and suggestions. The impact of each proposed maintenance action should be analyzed to determine its effect on the current application, the effort to complete the task, the effect of the change on the user and the urgency of the action. Care should be taken to balance the need to update the application versus frequent updates, which cause extra work for the user. Maintenance items can be accumulated, if possible, and incorporated in periodic updates. Identified issues should be posted on the CONSUME support website along with workarounds and planned corrective action.
- Perform Maintenance. Carryout the maintenance identified, perform tests as required, prepare installation packages, release notices and technical notes. Ensure the user guide and training packages are updated to reflect changes to the application.
- Distribution and Notification. The corrected application or components should be delivered through the most expedient means. The user community should be notified through the support system when a problem has been identified and a fix issued.

Maintenance Issues Related to the FCC System

Due to the dependency of CONSUME 3.0 on the FCC system it is very susceptible to changes to the FCC. Changes to the FCC system can easily trigger CONSUME 3.0 maintenance in the form of redistribution of components or even reprogramming.

The CONSUME project team should coordinate closely with the FCC project team, and all changes to the FCC system should consider the potential impacts on CONSUME 3.0 before any actions are taken.

Implementation Maintenance

Responsive reaction to problems encountered during the delivery phase of a new system is important to its overall and long-term success. When CONSUME 3.0 is first put into production, unforeseen problems are likely to occur. Measures should be provided to ensure that the software installation (including upgrades) is smooth and trouble free and that if a problem occurs it is dealt with promptly and the solution distributed to all users. These measures should include:

- Comprehensive instructions for the installation and setup of CONSUME 3.0.
- Transition instructions for users of CONSUME 2.1.
- Rapid response to problems and delivery of solutions.

Implementation Support

Consideration should be given to retaining programming support for a period of four to six months after the delivery of CONSUME 3.0 in order to provide fast turn around solutions to program faults and change requests.

9. Recommendations

Next Steps

There are several tasks that need to take place before the actual building of CONSUME takes place. These are covered in the main body of the report, but summarized here for convenience:

1. Develop new consumption algorithms. These are the core of the new CONSUME system and must be completed and stabilized in order to design their computational processes into code.
2. FCC system stabilization. The FCC system design must be stabilized first before the CONSUME interface design can be developed and finalized.
3. Mini-design. A separate design effort should be undertaken to finalize the design for the above components.

Deliverables

The following deliverables are presented here to help in the planning for the construction of CONSUME 3.0. They have been synthesized from this design document.

1. Design for new algorithms and FCC interface. A document that provides a representation of how the new algorithms will be transformed into objects and modules within the CONSUME DLL. In the same document, a design describing how the interface will work along with illustrations of the user interface.
2. Delivery of the CONSUME 3.0 application. This includes all coding, testing, and system documentation. This of course is the principal deliverable in the CONSUME 3.0 project. Specific sub-deliverables include:
    - The CONSUME 3.0 executable (Visual Basic 6).
    - The CONSUME 3.0 database (MS Access database).
    - The CONSUME 3.0 computational library as a Dynamic Link Library (DLL).
    - A CONSUME interface with the FCC system.
    - A revamped Pile Wizard as a DLL.
    - A MS Windows styles help system.
    - All un-complied code used.
    - System documentation in sufficient detail to assist the maintenance of the code by another party.
    - CONSUME 2.1 to 3.0 conversion utility or support (if feasible).
3. User Guide. A printable and online user guide using the CONSUME 2.1 guide as a model. Should be done in conjunction the help system.
4. Tutorial. An online tutorial will be provided in lieu of formal classroom training for CONSUME 3.0. The tutorial will supply case studies along with accompanying text and graphics.
5. CONSUME 3.0 Website. A CONSUME 3.0 and CONSUME DLL website will be established that includes a summary of capabilities and uses for each product, notification of available downloadable updates and support files, a list of reported problems and fixes, and contact information, and a process for reporting problems and getting additional help.
6. CONSUME DLL Programmer's Guide. A document that provides details on the use of the CONSUME DLL. This document should contain a diagram of all the objects in the DLL, and a list and description of all properties, methods, and events.

7. GIS Guide to CONSUME 3.0. Documents with examples on how to use the CONSUME output and the CONSUME DLL with GIS systems.
8. Support and Maintenance Plan. A document that describes how user support and software maintenance will be accomplished.

Future CONSUME Features

The following ideas were deferred from CONSUME 3.0 and will be considered for future implementation.

Internationalization. Add consumption models as they become available for countries outside the United States such as the work that has been done in Brazil.

Crowning Outputs. Develop the methodology to estimate the contribution of crown fires to consumption and emissions and incorporate in CONSUME.

Suggest Function. Provide a function that allows the user to specify a range of consumption targets and have CONSUME suggest environmental parameters that will produce the desired result for the selected unit and its fuel beds.

Fuel Arrangement in Piles. Look at how the accuracy of the pile consumption algorithms can be improved by accounting for fuel arrangement.

Palm Top Version. Look into the possibility of creating a palm or handheld version of CONSUME using Windows/CE or equivalent.

Port CONSUME DLL to UNIX. Develop a UNIX equivalent of the CONSUME 3.0 algorithms contained in the CONSUME Dynamic Link Library.

Web-based CONSUME. Investigate the feasibility of developing a web-based version of CONSUME 3.0.

APPENDIX B
CONSUME USER'S GUIDE

APPENDIX C

http://www.fs.fed.us/pnw/fera/products/consume/factsheet_consume.pdf

FERA
Fire and Environmental Research Applications

CONSUME v. 3.0

http://www.fs.fed.us/pnw/fera

Introduction

Fire is a natural process in many ecosystems, and managers are increasingly expected to use fire as a landscape-level fuel treatment to improve ecosystem health and reduce the likelihood of catastrophic fires. Fuel consumption is the key variable in the modeling of fire effects. It is one of the most critical attributes for understanding when and how fire should be applied to meet site and landscape objectives, and assessing wildland fire consequences.

Research has provided a wealth of information on fuel consumption, however, the emphasis has been on forested landscapes and little effort has been directed toward the non-forested fuel types such as chaparral, sagebrush, grasses, and palmetto/gallberry types in the West, Hawaii and South; pinyon-juniper in the Southwest; Alaska boreal forest types; and hardwood types in the East and South. Additionally, relatively little work has been accomplished to characterize long duration fuel consumption from the burning of large, rotten logs, stumps, or deep concentrations of organic material such as duff or moss, often prevalent in forested areas where natural fire has been eliminated for the past 80 to 100 years. Fire is becoming an important landscape-level fuel treatment tool in these fuel types. In order for managers to develop improved wildland fire plans that meet specific land management objectives, research is required to better characterize both the fuel loading and fuel consumed during wildland fires in these fuel types.

Fuel Consumption Research

Seventy-one sites have been inventoried and burned in black and white spruce/hardwood forests (Alaska), chaparral (California), ponderosa pine/mixed-conifer forests

(Oregon), and pine/hardwood forests (South Carolina, Tennessee, and Florida). Additionally, thirty-five sites were inventoried and burned in sagebrush on BLM, National Park Service, and U.S. Fish and Wildlife Service lands in eastern Oregon, Nevada, Wyoming, Utah, and California. Data from all burns have been compiled and analyzed. Consumption models have been built for fuel categories within the following fuelbed types: black and white spruce/hardwoods; longleaf and loblolly pine; ponderosa pine; grass; and sagebrush.

CONSUME Software

CONSUME is a user-friendly software application designed for resource managers with some working knowledge of Microsoft Windows® applications. Land managers and researchers input fuel characteristics, lighting patterns, fuel conditions, and meteorological attributes, then CONSUME outputs fuel consumption and emissions by combustion phase and by fuelbed category. CONSUME 3.0 is designed to import data directly from the Fuel Characteristic Classification System (FCCS), and the output is formatted to feed other models and provide usable outputs for burn plan preparation and smoke management requirements. Additionally, training and a user's manual are available. CONSUME can be used for most forest, shrub and grasslands in North America. CONSUME 2.1 is currently available for use, and CONSUME 3.0 will be released in November 2006.

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Visit the CONSUME Website at:

http://www.fs.fed.us/pnw/fera/products/consume.html

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