



**National Park Service  
Fire Ecology Annual Report  
Calendar Year 2004  
Mammoth Cave National Park**

## **Introduction**

During 2004, the NATR Fire Effects Monitoring (FEM) crew worked in 13 plots at Mammoth Cave National Park (MACA), completing 8 immediate postburn reads, 3 year one postburn reads, and 1 year two postburn read. The units that were burned in calendar year 2004 included Chaumont, Bruce Hollow, and Jim Lee. This report will summarize the fire effects monitoring data available through 2004. The purpose of this report is to inform fire and resource management personnel of the trends associated with prescribed fire, thereby facilitating the first steps of adaptive management.

The FEM program is undergoing transition from the current DOS-based data management program Fire Monitoring Handbook (FMH) to a Microsoft Access-based data management program referred to as the Fire Ecology Assessment Tool (FEAT). FEAT will allow for increased flexibility in data handling and analysis. Perhaps most importantly, FEAT will allow for the easy export of data into readily-available statistical software packages such as Minitab. The transition to FEAT is expected to be completed by September, 2005. Once the transition is complete, data will be analyzed using inferential statistics. Data presented here is analyzed descriptively.

## **Fire Effects Monitoring Methods**

The fire effects monitoring that occurs at MACA is adapted from the NPS Fire Monitoring Handbook protocol (see [http://www.nps.gov/fire/fire/fir\\_eco\\_science\\_monitoring\\_FMH.html](http://www.nps.gov/fire/fire/fir_eco_science_monitoring_FMH.html)). In general, the monitoring consists of installation of permanent vegetation plots in representative monitoring types<sup>1</sup>. Currently, there are 14 plots at MACA in 5 different monitoring types (Table 1). The form referred to as the FMH-4 describes the characteristics, goals, and objectives of prescribed fire in the particular monitoring type. The FMH-4s for each monitoring type are given in Appendix 1. The FMH-4s are fluid documents, and are meant to be refined as more information is gained regarding appropriate burn prescriptions, seasons, and intervals. Input from the research community, resource management, fire managers, and local experts is also of the utmost importance in refining the FMH-4s.

The general goal is to install 10 plots in each monitoring type, and then to reevaluate the need for additional plots. Ideally there will be monitoring plots in each burn unit, but limitations of time and money can prevent installations in every unit.

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<sup>1</sup> A monitoring type is defined as a major fuel-vegetation complex or vegetation association subject to a particular burn prescription.

**Table 1. Plot Monitoring and Install Schedule for MACA**

| Monitoring Type | GANGE                    | GANGE                    | GANGE                    | FJUVI                     | FJUVI                     | FJUVI                     | FJUVI                     | FJUVI                     | FJUVI            | *FQUMO                                  | BSONU                                                      | BSONU                                                      | BSONU                                                      | FQUSP**               |
|-----------------|--------------------------|--------------------------|--------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|------------------|-----------------------------------------|------------------------------------------------------------|------------------------------------------------------------|------------------------------------------------------------|-----------------------|
| Plot #          | 1                        | 2                        | 3                        | 20                        | 21                        | 22                        | 23                        | 24                        | 25               | 31                                      | 40                                                         | 41                                                         | 42                                                         | 1                     |
| Burn Unit       | Wondering Woods/Chaumont | Wondering Woods/Chaumont | Wondering Woods/Chaumont | Bruce Hollow              | Bruce Hollow              | Bruce Hollow              | Bruce Hollow              | Jim Lee                   | Floating Mill    | Temple Hills                            | Great Onyx Meadows                                         | Great Onyx Meadows                                         | Great Onyx Meadows                                         | Crystal Cave          |
| Install Date    | October-00               | October-00               | October-00               | September-02              | September-02              | September-02              | September-02              | October-03                | May-05           | October-00                              | October-02                                                 | October-02                                                 | October-02                                                 | Mar-05                |
| Burn Status     | March-04                 | March-04                 | March-04                 | March-04                  | March-04                  | March-04                  | March-04                  | April-04                  | Waiting for Burn | April-02                                | March-03                                                   | March-03                                                   | March-03                                                   | May-05                |
| 00Pre           | October-02               | October-02               | October-02               | September-02              | September-02              | September-02              | September-02              | October-03                | May-05           | October-00                              | October-02                                                 | October-02                                                 | October-02                                                 | Mar-05                |
| 01Post          | March-04                 | March-04                 | March-04                 | March-04                  | March-04                  | March-04                  | March-04                  | April-04                  |                  | June-02                                 | May-03                                                     | May-03                                                     | May-03                                                     | May-05                |
| 01Mo04          | Not Done                 | Not Done                 | Not Done                 | Not Done                  | Not Done                  | Not Done                  | Not Done                  | Not Done                  |                  | September-02                            | October-03                                                 | October-03                                                 | October-03                                                 | Not Done              |
| 01Yr01          | To Be Done October 2005  | To Be Done October 2005  | To Be Done October 2005  | To Be Done September 2005 | To Be Done September 2005 | To Be Done September 2005 | To Be Done September 2005 | To Be Done September 2005 |                  | Oct-03                                  | (1) March 2004 (Incorrect Read Date)<br>(2) September 2004 | (1) March 2004 (Incorrect Read Date)<br>(2) September 2004 | (1) March 2004 (Incorrect Read Date)<br>(2) September 2004 | To Be Done March 2006 |
| 01Yr02          |                          |                          |                          |                           |                           |                           |                           |                           |                  | September-04                            | To Be Done October 2005                                    | To Be Done October 2005                                    | To Be Done October 2005                                    |                       |
| 01Yr03          |                          |                          |                          |                           |                           |                           |                           |                           |                  | To Be Done October 2005 (See (1) Below) |                                                            |                                                            |                                                            |                       |

**\*Note: Several plots were read such that the season of read did not coincide with the season of the 00Pre Read). The subsequent read dates were rescheduled to coincide with the season of the 00 Pre-Read.**

**\*\*Monitoring type descriptions and data summary for the QUSP monitoring type not included in this report since it was installed in 2005.**

**(1) Only read 50m herb transect and nested subplot. This data may be compared against 01 yr 03 herbaceous data from QUMO plots at LIRI**

## Mammoth Cave National Park

**Table 2. Burn units at MACA and associated plot information (through 2004).**

| <b>Burn Unit</b>         | <b>Number of Plots</b> | <b>Year Plots Established</b> | <b>Year of Burn(s)</b> |
|--------------------------|------------------------|-------------------------------|------------------------|
| Wondering Woods/Chaumont | 3                      | October 2002                  | March 2004             |
| Bruce Hollow             | 4                      | September 2002                | March 2004             |
| Jim Lee                  | 1                      | October 2003                  | April 2004             |
| Temple Hills             | 1                      | October 2000                  | October                |
| Onyx Meadows             | 3                      | October 2002                  | March 2003             |

# Mammoth Cave National Park

## Results and Discussion

Results for objective variables are given in Table 3. All results shown are 80% confidence intervals of the mean unless otherwise noted. Fuel reduction objectives/results are mean percent reduction from preburn to immediate postburn, unless otherwise stated. An underlined number of plots denote that minimum sample sizes have been achieved. Figures associated with each objective variable can be found in Appendix 2.

**Table 3. Management Objectives and Monitoring Results 2004**

| Monitoring Unit                                                                    | Management Objective (Restoration)                                                                     | Monitoring Results (80% confidence interval)                                                                                 | Objective Achieved? (minimum plots achieved/needed) |
|------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------|
| <b>MACA<br/>BSONU1T02<br/>Indian grass grassland<br/><i>Sorghastrum nutans</i></b> | Reduce density of shade tolerant seedlings 30% to 60% one year after second fire.                      | Seedling reduction = 47% by Year 1 (n=3 plots, 1 fire)<br><b>Figure 1</b>                                                    | Yes- but minimum sample size not met (3/14)         |
|                                                                                    | Reduce density of shrubs 30% to 60% one year after second fire.                                        | Shrub density reduction = 27% by Year 1 (n=3 plots, 1 fire)<br><b>Figure 2</b>                                               | No- but minimum sample size not met (3/14)          |
|                                                                                    | Cause no net gain in percent cover of exotic plants (Japanese honeysuckle) after five years of burning | Average reduction =71% by Year 1. (n=3, 1 fire)<br><b>Figure 3</b>                                                           | Yes- but minimum sample size not met (3/14).        |
|                                                                                    | Increase relative cover of <i>Sorghastrum nutans</i> 15% after five years of burning                   | Increase of 19% by 4 months postburn <sup>2</sup> (n=3 plot, 1 fire)<br><b>Figure 4</b>                                      | Yes- but minimum sample size not met (3/14)         |
| <b>MACA<br/>FQUMO1D09<br/>Chestnut oak forest<br/><i>Quercus montana</i></b>       | Decrease density of shade tolerant pole trees by 30-90%                                                | Average reduction 55% by Year 2 ( <i>Cornus florida</i> and <i>Fagus grandifolia</i> ) (n=1 plot, 1 fire)<br><b>Figure 5</b> | Yes- but minimum sample size not met                |
|                                                                                    | Limit mortality of overstory trees to less than 20%                                                    | Average density reduction 4% by Year 2. (n=1, 1 fire)<br><b>Figure 6</b>                                                     | Yes- but minimum sample size not met                |
|                                                                                    | Reduce total fuel load by 25-50% after 3 burns                                                         | Total fuel load reduction 32% by Year 2. (n=1 plot, 1 fire)<br><b>Figure 7</b>                                               | Yes- but minimum sample size not met                |

<sup>2</sup> No available data for Year 1 postburn until October 2005 (plots burned in March, 2004).

## Mammoth Cave National Park

| Monitoring Unit                                                                                              | Management Objective (Restoration)                           | Monitoring Results (80% confidence interval)                                                                      | Objective Achieved? (minimum plots achieved/needed) |
|--------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------|
| <b>MACA</b><br><b>FQUMO1D09</b><br><b>Chestnut oak forest</b><br><i>Quercus montana</i>                      | Increase native grass and forb cover by 10-25% after 3 burns | Average percent cover increase for grasslike and forb species was 77% by Year 2. (n=1, 1 fire)<br><b>Figure 8</b> | Yes- but minimum sample size not met                |
| <b>MACA</b><br><b>FJUVI1D09</b><br><b>Red cedar glade forest</b><br><i>Juniperus virginiana</i> <sup>3</sup> | Reduce litter/duff and downed woody fuel load by 25-50%      | Average reduction was 4% immediately postburn. (n=5, 1 fire)<br><b>Figure 9</b>                                   | No, but minimum sample size not met (5/12)          |

### *Sorghastrum nutans* Monitoring Type

The Indian grass monitoring type is characterized largely by the calcareous subxeric habitat class, found in areas of developed karst landscape around 6-800 feet in elevation. Terrain is mainly flat (sinkhole depressions common) with gradual slopes of 0-20% Campbell (1999). Within MACA, these areas are limited to the Wondering Woods, Crystal Cave, and Great Onyx Cave meadows. Some small (<0.1 ac) disturbed areas of native grassland remain. Woody vegetation dominated by *Juniperus virginiana*, *Liquidambar styraciflua*, *Smilax* spp., *Symphoricarpos orbiculatus* and mixed deciduous forest. Herbaceous layer dominated by *Sorghastrum nutans*, *Andropogon gerardii*, *Schizachyrium scoparium*, and *Solidago* spp.

Results from the preliminary analysis appear to reflect that the density woody species is decreasing. Density of seedlings within the Indian grass monitoring type decreased by 47%, which is within the objective range of 30-60% (Figure 1). Shrub density also reflected a trend of decrease by 27%, which was 3% less than the minimum desired reduction (Figure 2). Cover of exotics, namely Japanese honeysuckle, appeared

<sup>3</sup> Pole density reduction and overstory mortality objectives for the red cedar monitoring type cannot be examined until Year 1 data has been collected. Data from the *Andropogon gerardii* monitoring type (woody species density, fuel load and exotic cover) cannot be analyzed on the monitoring type until Year 1 data has been collected. (2005)

## Mammoth Cave National Park

to decrease by 71% (Figure 3). While all of these trends are desirable, they should be viewed with caution because the sample size is small (n=3 plots).

### Quercus montana Monitoring Type

The *Quercus montana* monitoring type is characterized by acid or calcareous subxeric habitat class with elevation of 500-900 feet (all aspects). Generally, the vegetation is comprised of approximately 30-40% canopy cover of chestnut oak. Other canopy species include scarlet oak (*Q. coccinea*), shortleaf pine (*Pinus echinata*), southern red oak (*Q. falcata*), black jack oak (*Q. marilandica*), white oak (*Q. alba*), black oak (*Q. velutina*), post oak (*Q. stellata*), pignut hickory (*Carya glabra*), mockernut hickory (*C. tomentosa*), and Virginia pine (*P. virginiana*). Common midstory species include American beech (*Fagus grandifolia*), sourwood (*Oxydendron arboreum*), blackgum (*Nyssa sylvatica*), red maple (*Acer rubrum*), and dogwood (*Cornus florida*). The shrub layer is not uniform, but includes blueberry (*Vaccinium* spp.), blackberry (*Rubus* spp.), and catbriar (*Smilax rotundifolia* and *S. glabra*). Herb layer is sparse with striped wintergreen (*Chimaphila maculata*), bracken fern (*Pteridium aquilinum*), little blue stem (*Schizachrium scoparium*), and *Dicanthelium* spp.

Results from the single chestnut oak monitoring plot indicate a trend toward pole density reduction. Although management objective for this monitoring type involves the density reduction of shade-tolerant species, the only two species of pole-sized trees within the monitoring plot were *Cornus florida* and *Fagus grandifolia*. A density reduction of 55% was observed for these two species (Figure 5). Overstory mortality was approximately 4%, which was within the tolerable range of less than 20% (Figure 6). Total fuel load was reduced by approximately 32%, which is 7% more than the desired minimum reduction (Figure 7). Percent cover of native grasslike species increased by approximately 240%, while native forb species cover decreased by 85% (Figure 8). The objective for cover increase of native grasses and forbs was 10-25%, and the average change observed after one burn was an increase of 77%. Again it should be noted that this data is from only one plot, and additional plots are needed before conclusive statements can be made about the effects of fire.

### Juniperus virginiana Monitoring Type

The *Juniperus virginiana* monitoring type consists of cedar glades, defined as climax plant communities on shallow, rocky limestone soils dominated by a combination of annual or perennial forbs and grasses. Canopy cover of red cedar is approximately 40%. In these cedar glades, eastern red cedar is not successional; inherent dryness of the site limits growth of deciduous trees other than drought-tolerant species such as chinkapin oak and blue ash.

## **Mammoth Cave National Park**

However, invasion by mesic species due to fire suppression is evident. The main objectives for fire management in this monitoring type involve the reduction of fuel load and pole-sized tree density.

The results indicate a 4% reduction in the total fuel load for this monitoring type (Figure 9). Although the trend of fuel reduction is evident, the minimum objective of a 25% fuel load reduction was not met. Analysis of pole density and overstory mortality for this monitoring type cannot be conducted until the Year 1 data has been collected in Fall of 2005.

One possible explanation for the lack of fuel reduction in this monitoring type relates to the behavior of fire in this ecosystem. Operationally, it is difficult for fire to carry in the cedar glades. Due to the increased density and shading of small trees, little fuel is available on the forest floor to carry the fire. Therefore, fire alone is not likely to allow for the attainment of management objectives. It appears likely that mechanical thinning would be beneficial for two reasons. First, thinning would increase light to the forest floor, thereby enhancing germination. Second, small thinned trees left on site could act as fuel to carry the surface fire. After restoration of the glades to a structure more reminiscent of non-fire suppressed cedar glades, fire could be used as a maintenance tool.

### **Conclusion**

Fire effects monitoring at MACA indicates desirable trends associated with use of prescribed fire. Although adequate sample sizes have not been attained for most monitoring types, preliminary data suggests that fire is successful in reducing fuel load and pole-sized tree density, and increasing herbaceous species cover.

### **Status of Planning Documents**

As stated in RM-18 Chapter 11, fire monitoring plans are required for all park units using prescribed fire or wildland fire use. These plans are necessary in order to ensure that treatments are effective and that management goals and objectives are met. The fire monitoring plan is an appendix to the Fire Management Plan, which is tiered to both the Resource Management Plan and the General Management Plan. Currently, a fire monitoring plan for MACA is scheduled for completion during FY05. It is anticipated that a draft version of the plan should be forwarded to the appropriate personnel at MACA in Fall, 2005, so that the document can become collaborative in nature. Continued input from MACA fire resource management personnel is critical.

# **Mammoth Cave National Park**

## **Appendix 1**

### **Monitoring Type Descriptions**

# Mammoth Cave National Park

## JUVI FMH-4 Monitoring Type Description Sheet

*Note: Monitoring Type Descriptions are in review. Suggestions for improvement are welcomed. Final descriptions will be available in the MACA Fire Monitoring Plan. A draft of the MACA Fire Monitoring Plan is planned for Fall 2005. Areas in red need particular attention.*

**FMH-4**

**PARK: MACA**

**Monitoring Type Code:** FJUVIIG09<sup>4</sup>

**Date Described:** 3/22/04

**Monitoring Type Name:** Eastern red cedar-oak glade forest

**Preparer:** Lisa McInnis

**Burn Prescription:** Burning of units will occur between March and October.

Flame lengths 0.5-6 feet, Optimum - 2 feet

Air Temperature 32-95 degrees, Optimum - 65-85 degrees

Relative Humidity 20-75%, Optimum - 25-30%

1 hour fuel moisture 3-12%, Optimum - 4%

10 hour fuel moisture 4-14%, Optimum - 5%

100 hour fuel moisture N/A

Rate of spread 0.5-15 ch/hr

**Fire Management Objective(s):** Reduce pole-sized trees by 40-90%. Reduce downed woody fuel load by 25-50%. Limit mortality to overstory species to less than 20%.

**Fire Monitoring Objective(s):** Measure density of overstory trees, pole trees and woody fuel load with an adequate sample size to be 80% confident that the sample mean will be within 25% of the population mean.

**Fire Monitoring Variable(s):** Overstory and pole tree density and downed woody fuel load.

**Physical Description:** Dry limestone (Girkin) habitat types (calcareous xeric and sub-xeric), especially on south to west facing slopes (approximately 700 ft elevation).

**Biological Description:** Cedar glades, consisting of a climax plant communities on shallow, rocky limestone soils dominated by a combination of annual or perennial forbs and grasses. Canopy cover of red cedar approximately 40%. These sites are those in which eastern red cedar is not successional; inherent dryness of the site limits growth of deciduous trees other than drought-tolerant species such as chinkapin oak and blue ash. However, invasion by mesic species due to fire suppression is evident.

**Rejection Criteria:** Exclude areas within 20 m of riparian areas, greater than 30% average slope, pine beetle outbreaks, anomalous vegetation, recently thinned areas, areas within 10 m of interior roads and trails, and areas within 25 m of Park boundary.

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<sup>4</sup> Each monitoring type code is named by the type of plot (Grass, Brush, or Forest; forest in this case), the dominant species (*Juniperus virginiana* abbreviated JUVI1), phase of growth (Greenup, Transition, or Dormant) and the fuel model (in this case fuel model 9). See Fire Monitoring Handbook (2003) pg 35 for a complete description on coding.

# Mammoth Cave National Park

## JUWI FMH-4 Monitoring Type Description Sheet

| GENERAL PROTOCOLS                |     | Yes/No                                                                  |
|----------------------------------|-----|-------------------------------------------------------------------------|
| <b>Preburn</b>                   |     |                                                                         |
| Control Plots                    |     | No                                                                      |
| OP/Origin Buried                 |     | No                                                                      |
| Voucher Specimens                |     | Yes                                                                     |
| Abbreviated Tags                 |     | Yes                                                                     |
| Herb Fuel Load                   |     | No                                                                      |
| Brush Fuel Load                  |     | No                                                                      |
| Stakes (REBAR) Installed: 17     |     |                                                                         |
| <b>Burn</b>                      |     |                                                                         |
| Duff Moisture                    |     | No                                                                      |
| Flame Depth                      |     | No                                                                      |
| FOREST PLOT PROTOCOLS            |     |                                                                         |
| <b>Preburn Read (00 Pre)</b>     |     |                                                                         |
| <b>Overstory</b>                 |     |                                                                         |
| Trees Tagged                     | Yes | Area Sampled: 50 x 20 m<br>Quarter(s) Sampled: All 4 quarters (Q1-Q4)   |
| Trees Mapped                     | Yes |                                                                         |
| DBH                              | Yes |                                                                         |
| Dead Recorded                    | Yes |                                                                         |
| Live Crown Position Coded        | Yes |                                                                         |
| Live Damage Coded                | Yes |                                                                         |
| Dead Crown Position Coded        | Yes |                                                                         |
| Dead Damage Coded                | No  |                                                                         |
| <b>Pole-Size</b>                 |     |                                                                         |
| Trees Tagged                     | Yes | Area Sampled: 25 x 20 m<br>Quarter(s) Sampled: 2 quarters (Q1 and Q2)   |
| Trees Mapped                     | Yes |                                                                         |
| DBH                              | Yes |                                                                         |
| Dead Recorded                    | Yes |                                                                         |
| Height Code Recorded             | Yes |                                                                         |
| <b>Seedling</b>                  |     |                                                                         |
| Seedlings Mapped                 | No  | Area Sampled: 5 x 10 m (adjacent to origin line)<br>Quarter Sampled: Q1 |
| Dead Recorded                    | No  |                                                                         |
| Height Code Recorded             | Yes |                                                                         |
| Tally Count                      | Yes |                                                                         |
| <b>Herbaceous</b>                |     |                                                                         |
| Point Intercept Method           | Yes | Point Intercept Recorded for full length of Q4-Q1 (start tape @ Q4)     |
| Tallest Species Height Recorded  | Yes |                                                                         |
| All Species Intercepted Recorded | Yes |                                                                         |
|                                  |     |                                                                         |

# Mammoth Cave National Park

## JUVI FMH-4 Monitoring Type Description Sheet

Nested subplots (in 1 quarter) to augment the herbaceous transect. These are taken as 1m x 1m, 10m x 10m, 10m x 25m. In Q1 and Q3, the 1x1 is near the origin, in Q2 it is near P2 and in Q4 it is near P1. Record the quarter with the most sample reads (e.g. If Q1,Q2,Q3, and Q4 were recorded @ 00Pre, Q1,Q3, and Q4 were recorded @ 01yr1, Q1 and Q3 were recorded at 01 yr2 then choose between either Q1 or Q3 (not Q2 or Q4) next time the plot is monitored).

### FOREST PLOT PROTOCOLS    Yes/No    [continued]

#### Preburn Read (00 Pre) [continued]

##### Fuel

##### Loadings

Sampling Plane Lengths along Brown's Transects:

1 hour fuels: 0-6 feet

10 hour fuels: 0-6 feet

100 hour fuels: 0-12 feet

1,000 hour fuels (rotten and solid): 0-50 feet

Litter and Duff Measurements: 1,5,10,15,20,25,30,35,40, and 45 feet

#### Immediate Postburn Read (01 Post, 02 Post, 03 Post, etc...)

##### Overstory

|                                                            |     |                                        |
|------------------------------------------------------------|-----|----------------------------------------|
| Record Tag #                                               | Yes | Area Sampled: 50 x 20 m                |
| Record Tree Status<br>(alive, dead,<br>resprout, consumed) | Yes | Quarter(s) Sampled: 4 quarters (Q1-Q4) |
| DBH                                                        | No  |                                        |
| Maximum Scorch Height                                      | Yes |                                        |
| % Crown Scorched                                           | Yes |                                        |
| Char Height                                                | Yes |                                        |

##### Pole-Size

|                        |     |                                            |
|------------------------|-----|--------------------------------------------|
| Record Tag #           | Yes | Area Sampled: 25 x 20 m                    |
| Live and Dead Recorded | Yes | Quarter(s) Sampled: 2 quarters (Q1 and Q2) |
| DBH                    | No  |                                            |
| Height                 | No  |                                            |
| Maximum Scorch Height  | Yes |                                            |
| % Crown Scorched       | Yes |                                            |
| Char Height            | Yes |                                            |

##### Fuel

##### Loadings

Sampling Plane Lengths along Brown's Transects:

1 hour fuels: 0-6 feet

10 hour fuels: 0-6 feet

100 hour fuels: 0-12 feet

1,000 hour fuels (rotten and solid): 0-50 feet

Litter/Duff Measurements along Brown's Transects: 1,5,10,15,20,25,30,35,40, and 45 feet

##### Burn

##### Severity

Burn severity recorded along all 4 Brown's Transects: 1,5,10,15,20,25,30,35,40, and 45 feet

#### Post Burn Reads (01 yr 01, 01 yr 2, 02 yr 01 etc...)

**\*Same as 00 Pre-Read**

# Mammoth Cave National Park

## ANGE FMH-4 Monitoring Type Description Sheet

FMH-4

Park: MACA

Date Described: 6/2/2003

Monitoring Type Code: B A N G E 1 T 02

Monitoring Type Name: Big Bluestem Grassland

Preparer: Lisa McInnis

**Burn Prescription (Restoration):** Proposed Ignition: January – April (February and March preferred). Maintenance burn prescriptions to be developed after evaluation of restoration burns.

| Parameter                    | Acceptable Range | Optimum |
|------------------------------|------------------|---------|
| Temperature (°F)             | 35-85            | 70      |
| Relative Humidity (%)        | 30-60            | 40      |
| Wind Direction               | E, S, W          | SW      |
| Mid-flame Wind Speed (mph)   | 0-6              | 2-3     |
| 1 Hour Fuel Moisture (%)     | 8-14             | 10      |
| 10 Hour Fuel Moisture (%)    | 10-25            |         |
| 100 Hour Fuel Moisture (%)   | 12-30            |         |
| Rate of Spread (chains/hour) | 1-10             | 3       |
| Flame Length (feet)          | 1.2-3.1          | 1.7     |

**Management Objectives (Restoration):** Decrease density of invading woody species by 30% as measured 1 year post burn. Cause no net gain in percent cover of exotic plants as measured one year and five years post burn.

**Management Objectives (Maintenance):** To be further refined after consultation with research community.

### Fire Monitoring Objectives:

1. Monitor woody species density in order to be 80% confident of detecting a 30% reduction in woody species density, accepting a 20% chance of saying a change took place when it did not.
2. Monitor percent cover of exotic species in order to be 80% confident of detecting a 20% change in exotic species cover, accepting a 20% chance of saying a change took place when it did not.

**Fire Monitoring Variables:** Woody species density, percent cover of exotic species.

**Physical Description:** Characterized largely by the calcareous subxeric habitat class, found in areas of developed karst landscape around 6-800 feet in elevation. Mainly flat terrain (sinkhole depressions common) with gradual slopes of 0-20%.

**Biological Description:** Areas of grassland on gentle slopes, plains, and flats, as described by Campbell (1999). Within MACA, these areas are limited to the Wondering Woods, Crystal Cave, and Great Onyx Cave meadows. Some small (<0.1 ac) disturbed areas of native grassland remain. Woody vegetation dominated by *Juniperus virginiana*, *Liquidambar styraciflua*, *Smilax* spp. and mixed deciduous forest. Herbaceous layer dominated by *Andropogon gerardii*, *Sorghastrum nutans*, *Schizachyrium scoparium*, and *Solidago* spp. Known rare species include the Federally-threatened Eggert's Sunflower, *Helianthus eggertii*, a perennial member of the aster family.

# Mammoth Cave National Park

## ANGE FMH-4 Monitoring Type Description Sheet

**Rejection Criteria:** Exclude areas within 20 m of riparian areas, greater than 20% average slope, pine beetle outbreaks, anomalous vegetation, recently thinned areas, areas within 10 m of interior roads and trails, and areas within 25 m of Park boundary.

| GENERAL PROTOCOLS                                                                                                                                                   |                                                                                    | Yes/No |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------|--------|
| <b>Preburn</b>                                                                                                                                                      |                                                                                    |        |
| Control Plots                                                                                                                                                       |                                                                                    | No     |
| 0P/Origin Buried                                                                                                                                                    |                                                                                    | No     |
| Voucher Specimens                                                                                                                                                   |                                                                                    | Yes    |
| Abbreviated Tags                                                                                                                                                    |                                                                                    | Yes    |
| Herb Fuel Load                                                                                                                                                      |                                                                                    | No     |
| Brush Fuel Load                                                                                                                                                     |                                                                                    | No     |
| Stakes (REBAR) Installed: 2                                                                                                                                         |                                                                                    |        |
| <hr/>                                                                                                                                                               |                                                                                    |        |
| <b>Burn</b>                                                                                                                                                         |                                                                                    |        |
| Duff Moisture                                                                                                                                                       |                                                                                    | Yes    |
| Flame Depth                                                                                                                                                         |                                                                                    | No     |
| <hr/>                                                                                                                                                               |                                                                                    |        |
| GRASS PLOT PROTOCOLS                                                                                                                                                |                                                                                    |        |
| <b>Preburn Read (00 Pre) and Post Burn Reads (01YR01, 01YR02, etc....)</b>                                                                                          |                                                                                    |        |
| <b>Brush</b>                                                                                                                                                        |                                                                                    |        |
| Tally Count                                                                                                                                                         |                                                                                    | Yes    |
| Age <small>(immature, resprout, mature)</small>                                                                                                                     |                                                                                    | Yes    |
| Live and Dead Recorded                                                                                                                                              |                                                                                    | Yes    |
| Area Sampled: 0P-30Pm (0-1 m and 1-3 m belts to right of 0P-30P when facing 30P). Separate tallies for 0-1m and 1-3m belts <i>(until 10 plots of data achieved)</i> |                                                                                    |        |
| <br>                                                                                                                                                                |                                                                                    |        |
| <b>Herbaceous</b>                                                                                                                                                   |                                                                                    |        |
| Point Intercept Method                                                                                                                                              |                                                                                    | Yes    |
| Tallest Species Height                                                                                                                                              |                                                                                    | Yes    |
| Recorded                                                                                                                                                            |                                                                                    |        |
| All Species Intercepted                                                                                                                                             |                                                                                    | Yes    |
| Recorded                                                                                                                                                            |                                                                                    |        |
| Point Intercept Recorded for full length of 0P-30P                                                                                                                  |                                                                                    |        |
| <b>Immediate Postburn Read (01 Post, 02 Post, 03 Post, etc...)</b>                                                                                                  |                                                                                    |        |
| <b>Burn</b>                                                                                                                                                         | 0P-30P <i>(Rate burn severity (scale 0-5) every 0.3 meters from 0.3 to 30.0 m)</i> |        |
| <b>Severity</b>                                                                                                                                                     |                                                                                    |        |

**Notes:** Monitoring schedule: Preburn, immediate postburn, year one, year two, year five.

References: Campbell, Julian. 1999. Physical environment, terrestrial ecosystems, and fire history (Mammoth Cave National Park). The Nature Conservancy.

# Mammoth Cave National Park

## SONU FMH-4 Monitoring Type Description Sheet

FMH-4

Park: MACA

Date Described: 6/2/2003

Monitoring Type Code: B S O N U 1 T 02

Monitoring Type Name: Indian grass Grassland

Preparer: Lisa McInnis

**Burn Prescription (Restoration):** Proposed Ignition: January – April (February and March preferred . Maintenance burn prescriptions to be developed after evaluation of restoration burns.

| Parameter                    | Acceptable Range | Optimum |
|------------------------------|------------------|---------|
| Temperature (°F)             | 35-85            | 70      |
| Relative Humidity (%)        | 30-60            | 40      |
| Wind Direction               | E, S, W          | SW      |
| Mid-flame Wind Speed (mph)   | 0-6              | 2-3     |
| 1 Hour Fuel Moisture (%)     | 8-14             | 10      |
| 10 Hour Fuel Moisture (%)    | 10-25            |         |
| 100 Hour Fuel Moisture (%)   | 12-30            |         |
| Rate of Spread (chains/hour) | 1-10             | 3       |
| Flame Length (feet)          | 1.2-3.1          | 1.7     |

**Management Objectives (Restoration):** Decrease density of invading woody species by 30% as measured 1 year post burn. Cause no net gain in percent cover of exotic plants as measured one year and five years post burn.

**Management Objectives (Maintenance):** To be further refined after consultation with research community.

### Fire Monitoring Objectives:

1. Monitor woody species density in order to be 80% confident of detecting a 30% reduction in woody species density, accepting a 20% chance of saying a change took place when it did not.
2. Monitor percent cover of exotic species in order to be 80% confident of detecting a 20% change in exotic species cover, accepting a 20% chance of saying a change took place when it did not.

**Fire Monitoring Variables:** Woody species density, percent cover of exotic species.

**Physical Description:** Characterized largely by the calcareous subxeric habitat class, found in areas of developed karst landscape around 6-800 feet in elevation. Mainly flat terrain (sinkhole depressions common) with gradual slopes of 0-20%.

**Biological Description:** Areas of grassland on gentle slopes, plains, and flats, as described by Campbell (1999). Within MACA, these areas are limited to the Wondering Woods, Crystal Cave, and Great Onyx Cave meadows. Some small (<0.1 ac) disturbed areas of native grassland remain. Woody vegetation dominated by *Juniperus virginiana*, *Liquidambar styraciflua*, *Smilax* spp., *Symphoricarpos orbiculatus* and mixed deciduous forest. Herbaceous layer dominated by *Sorghastrum nutans*, *Andropogon gerardii*, *Schizachyrium scoparium*, and *Solidago* spp.

# Mammoth Cave National Park

## SONU FMH-4 Monitoring Type Description Sheet

**Rejection Criteria:** Exclude areas within 20 m of riparian areas, greater than 20% average slope, pine beetle outbreaks, anomalous vegetation, recently thinned areas, areas within 10 m of interior roads and trails, and areas within 25 m of Park boundary.

| GENERAL PROTOCOLS                                                   |                                                                                    | Yes/No |
|---------------------------------------------------------------------|------------------------------------------------------------------------------------|--------|
| Preburn                                                             |                                                                                    |        |
|                                                                     | Control Plots                                                                      | No     |
|                                                                     | 0P/Origin Buried                                                                   | No     |
|                                                                     | Voucher Specimens                                                                  | Yes    |
|                                                                     | Abbreviated Tags                                                                   | Yes    |
|                                                                     | Herb Fuel Load                                                                     | No     |
|                                                                     | Brush Fuel Load                                                                    | No     |
|                                                                     | Stakes (REBAR) Installed: 2                                                        |        |
| Burn                                                                |                                                                                    |        |
|                                                                     | Duff Moisture                                                                      | Yes    |
|                                                                     | Flame Depth                                                                        | No     |
| GRASS PLOT PROTOCOLS                                                |                                                                                    |        |
| Preburn Read (00 Pre) and Post Burn Reads (01YR01, 01YR02, etc....) |                                                                                    |        |
| Brush                                                               |                                                                                    |        |
|                                                                     | Tally Count                                                                        | Yes    |
|                                                                     | Age <small>(immature, resprout, mature)</small>                                    | Yes    |
|                                                                     | Live and Dead Recorded                                                             | Yes    |
|                                                                     | Area Sampled: 0P-30Pm (0-1 m and 1-3 m belts to right of 0P-30P when facing 30P)   |        |
|                                                                     | Separate tallies for 0-1m and 1-3m belts <i>(until 10 plots of data achieved)</i>  |        |
| Herbaceous                                                          |                                                                                    |        |
|                                                                     | Point Intercept Method                                                             | Yes    |
|                                                                     | Tallest Species Height Recorded                                                    | Yes    |
|                                                                     | All Species Intercepted                                                            | Yes    |
|                                                                     | Point Intercept Recorded for full length of 0P-30P                                 |        |
| Immediate Postburn Read (01 Post, 02 Post, 03 Post, etc...)         |                                                                                    |        |
| Burn                                                                |                                                                                    |        |
| Severity                                                            | 0P-30P <i>(Rate burn severity (scale 0-5) every 0.3 meters from 0.3 to 30.0 m)</i> |        |

**Notes:** Monitoring schedule: Preburn, immediate postburn, year one, year two, year five.

# Mammoth Cave National Park

## QUMO FMH-4 Monitoring Type Description Sheet

**Monitoring Type Code** F Q U M O 1 D 0 9

**Date Described:** 03/16/00

**Revised:** 6/24/2005

**Monitoring Type Name** Chestnut Oak Woodland

**Preparers:** Rick Olson / Rich Caldwell / Bob Dellinger / Tim Sexton and Doug Wallner

**Revisor:** Lisa McInnis

### **Burn Prescription Burn Prescription:**

Burning of units will occur between March and October.

Flame lengths 0.5-6 feet, Optimum - 2 feet

Air Temperature 32-95 degrees, Optimum - 65-85 degrees

Relative Humidity 20-75%, Optimum - 25-30%

1 hour fuel moisture 3-12%, Optimum - 4%

10 hour fuel moisture 4-14%, Optimum - 5%

Rate of spread 0.5-15 ch/hr

### **Fire Management Objective(s)**

- 1) Decrease density of shade tolerant pole trees by 30-90%
- 2) Limit mortality of overstory trees to less than 20%
- 3) Reduce total fuel load by 25-50% after 3 burns.
- 4) Increase native grass and forb cover by 10-25% after 3 burns.

### **Fire Monitoring Objective(s)**

Sample monitoring variables with an adequate sample size to be 80% confident of detecting the following: a 25% reduction in pole-sized tree density; a 20% change in overstory tree density; a 25% reduction in fuel load; and a 10% increase in native herbaceous species cover.

**Fire Monitoring Variable(s)** Overstory and pole tree density, total fuel load, and native herbaceous species cover.

**Physical Description** Acid or calcareous subxeric habitat type with elevation of 500-900 feet (all aspects).

**Biological Description** Forests comprised of approximately 30-40% canopy cover of chestnut oak (*Quercus montana*). Other canopy species include scarlet oak (*Q. coccinea*), shortleaf pine (*Pinus echinata*), southern red oak (*Q. falcata*), black jack oak (*Q. marilandica*), white oak (*Q. alba*), black oak (*Q. velutina*), post oak (*Q. stellata*), pignut hickory (*Carya glabra*), mockernut hickory (*C. tomentosa*), and Virginia pine (*P. virginiana*). Common midstory species include American beech (*Fagus grandifolia*), sourwood (*Oxydendron arboreum*), blackgum (*Nyssa sylvatica*), red maple (*Acer rubrum*), and dogwood (*Cornus florida*). The shrub layer is not uniform, but includes blueberry (*Vaccinium* spp.), blackberry (*Rubus* spp.), and catbriar (*Smilax rotundifolia* and *S. glabra*). Herb layer is sparse with striped wintergreen (*Chimaphila maculata*), bracken fern (*Pteridium aquilinum*), *Danthonia* sp., little blue stem (*Schizachrium scoparium*), and *Dicanthelium* spp.

**Rejection Criteria** Areas less than 20 m from a trail, road or riparian area, anomalous vegetation patches, or highly disturbed areas.

# Mammoth Cave National Park

## QUMO FMH-4 Monitoring Type Description Sheet

| GENERAL PROTOCOLS                |     | Yes/No                                                                |
|----------------------------------|-----|-----------------------------------------------------------------------|
| <b>Preburn</b>                   |     |                                                                       |
| Control Plots                    |     | No                                                                    |
| OP/Origin Buried                 |     | No                                                                    |
| Voucher Specimens                |     | Yes                                                                   |
| Abbreviated Tags                 |     | Yes                                                                   |
| Herb Fuel Load                   |     | No                                                                    |
| Brush Fuel Load                  |     | No                                                                    |
| Stakes (REBAR) Installed: 17     |     |                                                                       |
| <b>Burn</b>                      |     |                                                                       |
| Duff Moisture                    |     | No                                                                    |
| Flame Depth                      |     | No                                                                    |
| FOREST PLOT PROTOCOLS            |     |                                                                       |
| <b>Preburn Read (00 Pre)</b>     |     |                                                                       |
| <b>Overstory</b>                 |     |                                                                       |
| Trees Tagged                     | Yes | Area Sampled: 50 x 20 m<br>Quarter(s) Sampled: All 4 quarters (Q1-Q4) |
| Trees Mapped                     | Yes |                                                                       |
| DBH                              | Yes |                                                                       |
| Dead Recorded                    | Yes |                                                                       |
| Live Crown Position Coded        | Yes |                                                                       |
| Live Damage Coded                | Yes |                                                                       |
| Dead Crown Position Coded        | Yes |                                                                       |
| Dead Damage Coded                | No  |                                                                       |
| <b>Pole-Size</b>                 |     |                                                                       |
| Trees Tagged                     | Yes | Area Sampled: 25 x 10 m<br>Quarter(s) Sampled: 1 quarter (Q1)         |
| Trees Mapped                     | Yes |                                                                       |
| DBH                              | Yes |                                                                       |
| Dead Recorded                    | Yes |                                                                       |
| Height Code Recorded             | Yes |                                                                       |
| <b>Seedling</b>                  |     |                                                                       |
| Seedlings Mapped                 | No  | Area Sampled: 10 x 5 m belt along P1-P2 line<br>Quarter Sampled: Q1   |
| Dead Recorded                    | No  |                                                                       |
| Height Code Recorded             | Yes |                                                                       |
| Tally Count                      | Yes |                                                                       |
| <b>Brush</b>                     |     |                                                                       |
| Tally Count                      | N/A |                                                                       |
| Age (immature, resprout, mature) | N/A |                                                                       |
| Live and Dead Recorded           | N/A |                                                                       |
| Area Sampled: none               |     |                                                                       |
| Quarters Sampled: none           |     |                                                                       |

# Mammoth Cave National Park

## QUMO FMH-4 Monitoring Type Description Sheet

### FOREST PLOT PROTOCOLS    Yes/No    [continued]

#### Preburn Read (00 Pre) [continued]

##### Herbaceous

Point Intercept Method                      Yes  
Tallest Species Height                      Yes  
Recorded  
All Species Intercepted                      Yes  
Recorded  
Point Intercept Recorded for full length of Q4-Q1 (start tape @ Q4)  
Nested subplots (in **1** quarter) to augment the herbaceous transect. These are taken as 1m x 1m, 10m x 10m, 10m x 25m. In Q1 and Q3, the 1x1 is near the origin, in Q2 it is near P2 and in Q4 it is near P1. Record the quarter with the most sample reads (e.g. If Q1,Q2,Q3, and Q4 were recorded @ 00Pre, Q1,Q3, and Q4 were recorded @ 01yr1, Q1 and Q3 were recorded at 01 yr2 then choose between either Q1 or Q3 (not Q2 or Q4) next time the plot is monitored)

##### Fuel Loadings

Sampling Plane Lengths along Brown's Transects:  
1 hour fuels: 0-6 feet  
10 hour fuels: 0-6 feet  
100 hour fuels: 0-12 feet  
1,000 hour fuels (rotten and solid): 0-50 feet  
Litter and Duff Measurements: 1,5,10,15,20,25,30,35,40, and 45 feet

#### Immediate Postburn Read (01 Post, 02 Post, 03 Post, etc...)

##### Overstory

Record Tag #                                      Yes                      Area Sampled: 50 x 20 m  
Record Tree Status (alive, dead, resprout, consumed)                      Yes                      Quarter(s) Sampled: 4 quarters (Q1-Q4)  
DBH                                                      No  
Maximum Scorch Height                      Yes  
% Crown Scorched                              Yes  
Char Height                                          Yes

##### Pole-Size

Record Tag #                                      Yes  
Live and Dead Recorded                      Yes  
DBH                                                      No  
Height                                                      No  
Maximum Scorch Height                      Yes  
% Crown Scorched                              Yes  
Char Height                                          Yes

##### Fuel Loadings

Sampling Plane Lengths along Brown's Transects:  
1 hour fuels: 0-6 feet  
10 hour fuels: 0-6 feet  
100 hour fuels: 0-12 feet  
1,000 hour fuels (rotten and solid): 0-50 feet

Litter/Duff Measurements along Brown's Transects: 1,5,10,15,20,25,30,35,40, and 45 feet

##### Burn Severity

Burn severity recorded along all 4 Brown's Transects: 1,5,10,15,20,25,30,35,40, and 45 feet

#### Post Burn Reads (01 yr 01, 01 yr 2, etc...)

**\*Same as 00 Pre-Read**

**Mammoth Cave National Park**  
**QUMO FMH-4 Monitoring Type Description Sheet**

## **Appendix 2**

### **Monitoring Results/Figures**

For each objective in each monitoring unit, minimum prefire plots and change over time were calculated. Exceptions are noted in Table 3. For all objectives, the 80% confidence interval was used. Average and minimum desired objectives are reported for each variable.

## Mammoth Cave National Park

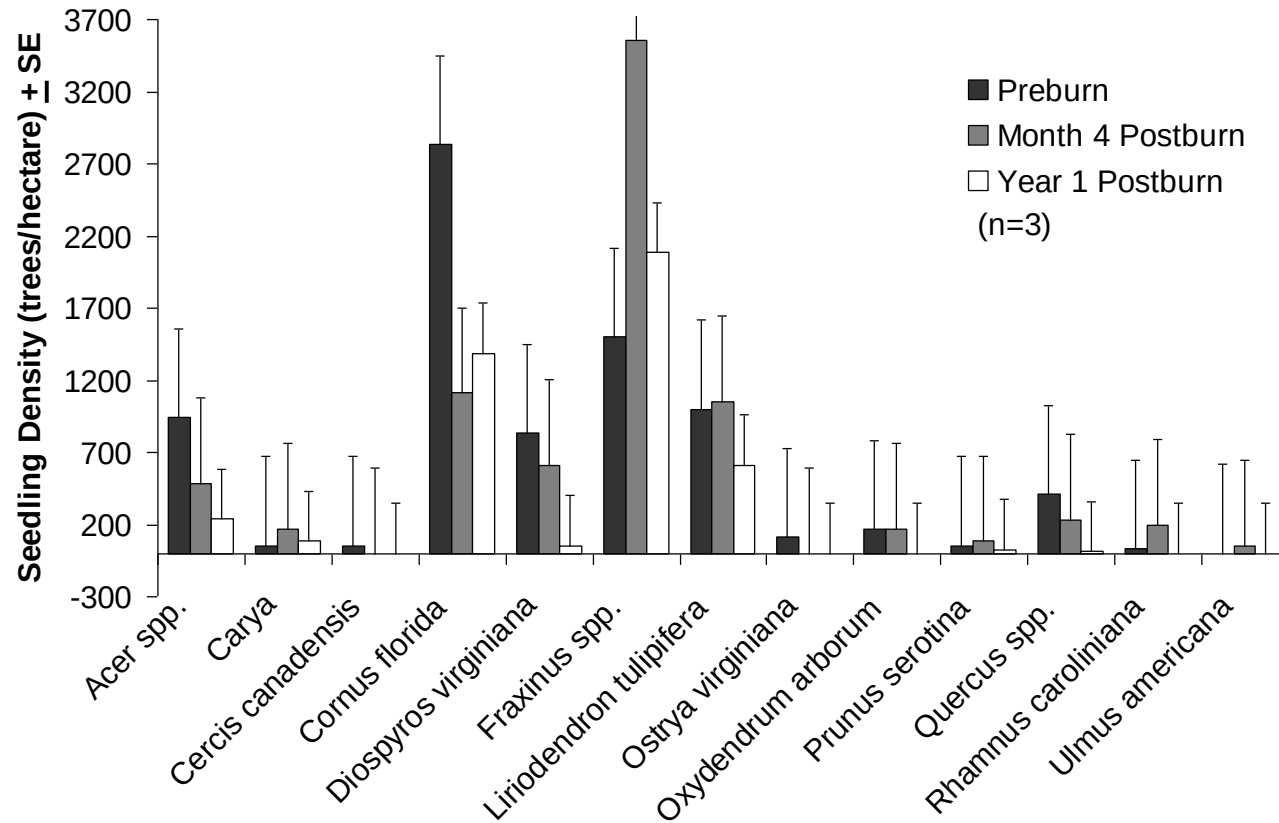


Figure 1. Average density of 13 shade-tolerant seedling species on 3 *Sorghastrum nutans* transects at MACA ( $\pm$  average standard error). Data shown compares seedling cover collected at one and two years after the second fire. Objective for seedling reduction is 30%; actual change was a decrease of 47% by Year 1.

## Mammoth Cave National Park

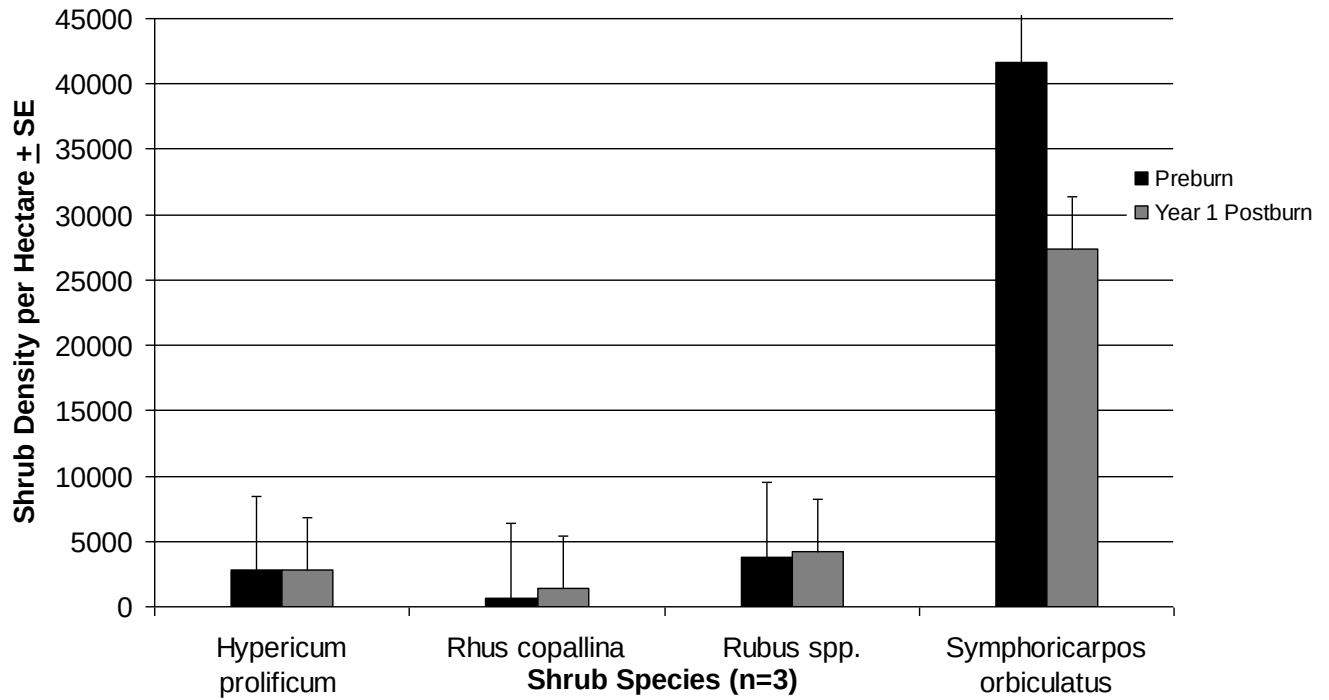


Figure 2. Average shrub density for 3 *Sorghastrum nutans* transects at MACA ( $\pm$  average standard error). Data shown compares shrub density collected at one year postburn. Objective for shrub density reduction is 30-60%; actual decrease was 27%.

## Mammoth Cave National Park

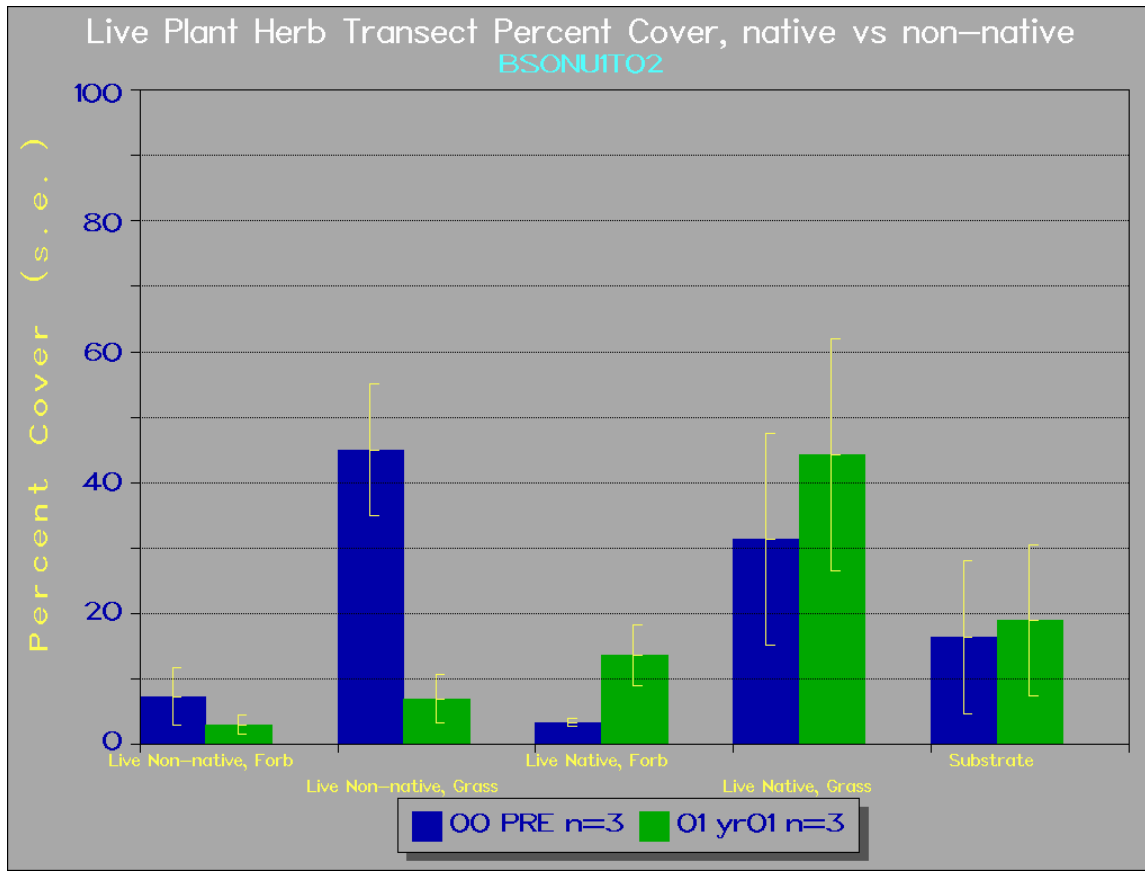


Figure 3. Percent cover of native versus non-native herbaceous species on 3 *Sorghastrum nutans* transects at MACA ( $\pm$  average standard error). Data shown compares herbaceous cover collected preburn and at one year postburn. Objective is to cause no net gain in cover of non-species, and average reduction for non-native forb and grass cover was 71%.

## Mammoth Cave National Park

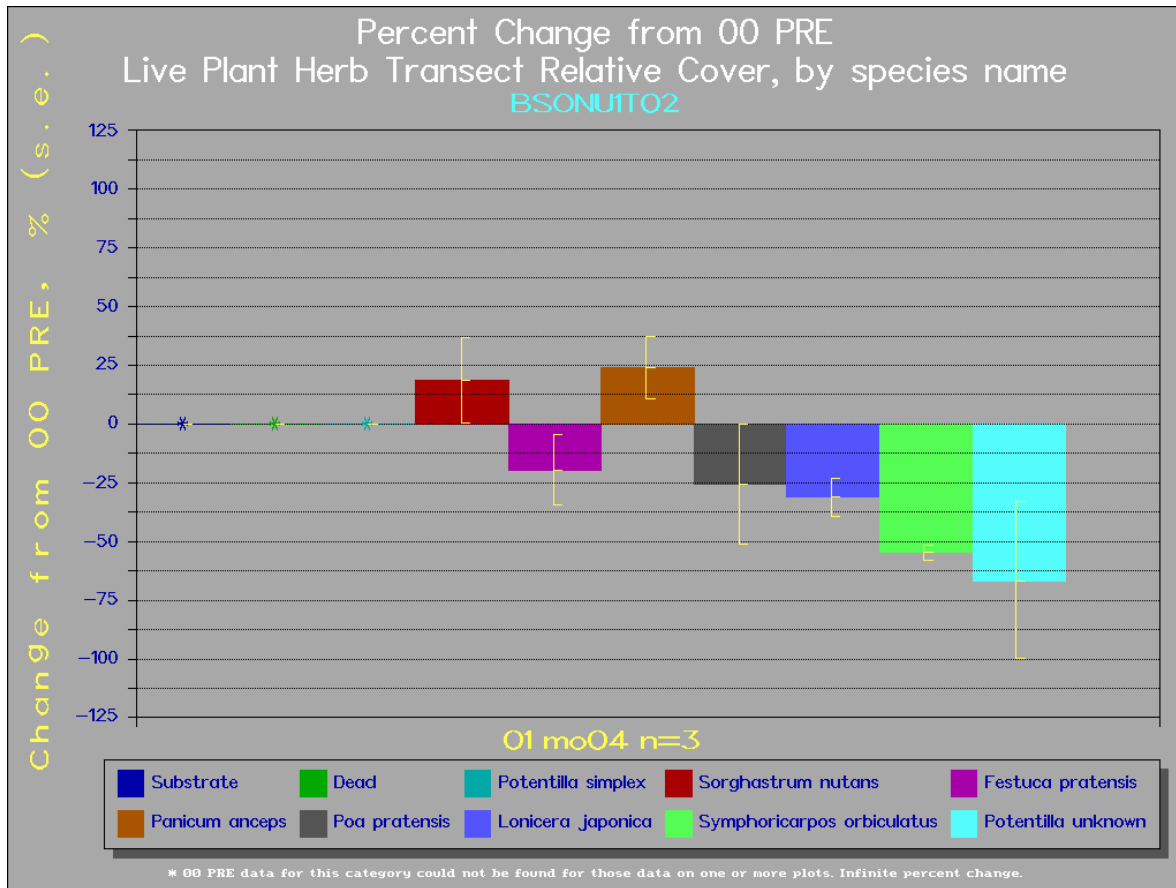


Figure 4. Increase in cover of *Sorghastrum nutans*  $\pm$  SE (red bar) on three plots at MACA. Average increase in relative cover was 19%, and minimum objective increase was 15% after 5 years of burning.

## Mammoth Cave National Park

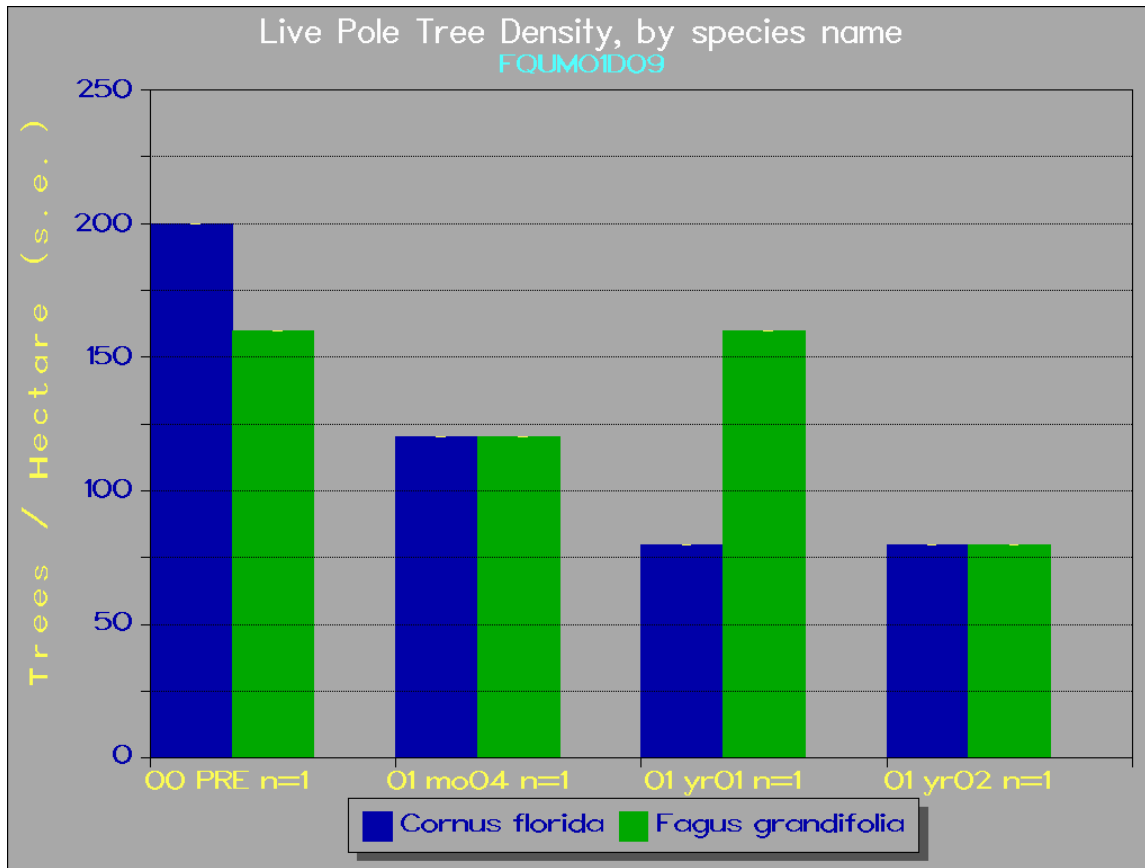


Figure 5. Average density of pole-sized trees per acre for 1 *Quercus montana* plot at MACA ( $\pm$  average standard error). Data was collected 4 months, 1 year and 2 years postburn. Objective for pole reduction is 30-90%; actual reduction was approximately 55% by Year 2.

## Mammoth Cave National Park

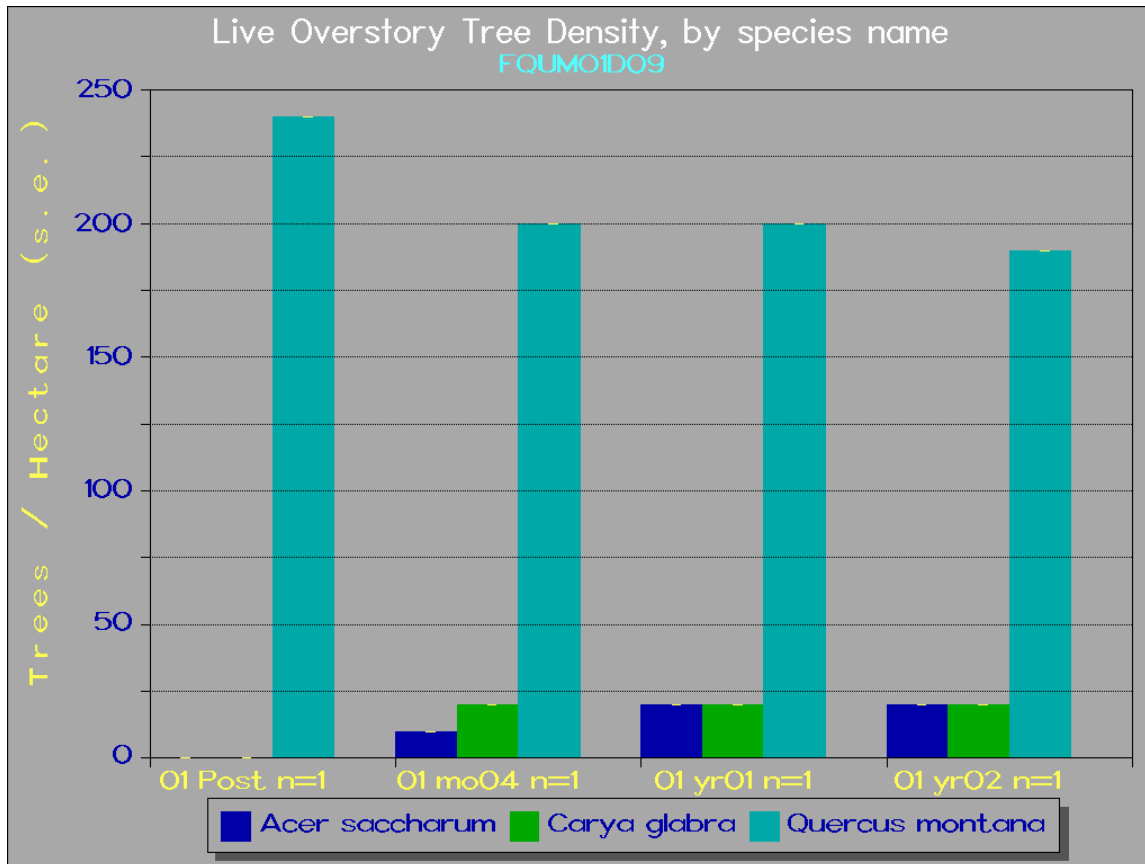


Figure 6. Average density of overstory trees per hectare for 1 *Quercus montana* plot at MACA ( $\pm$  average standard error). Data was collected 4 months, 1 year and 2 years postburn. Objective for overstory mortality is 20% or less; actual reduction was approximately 4% by Year 2

## Mammoth Cave National Park

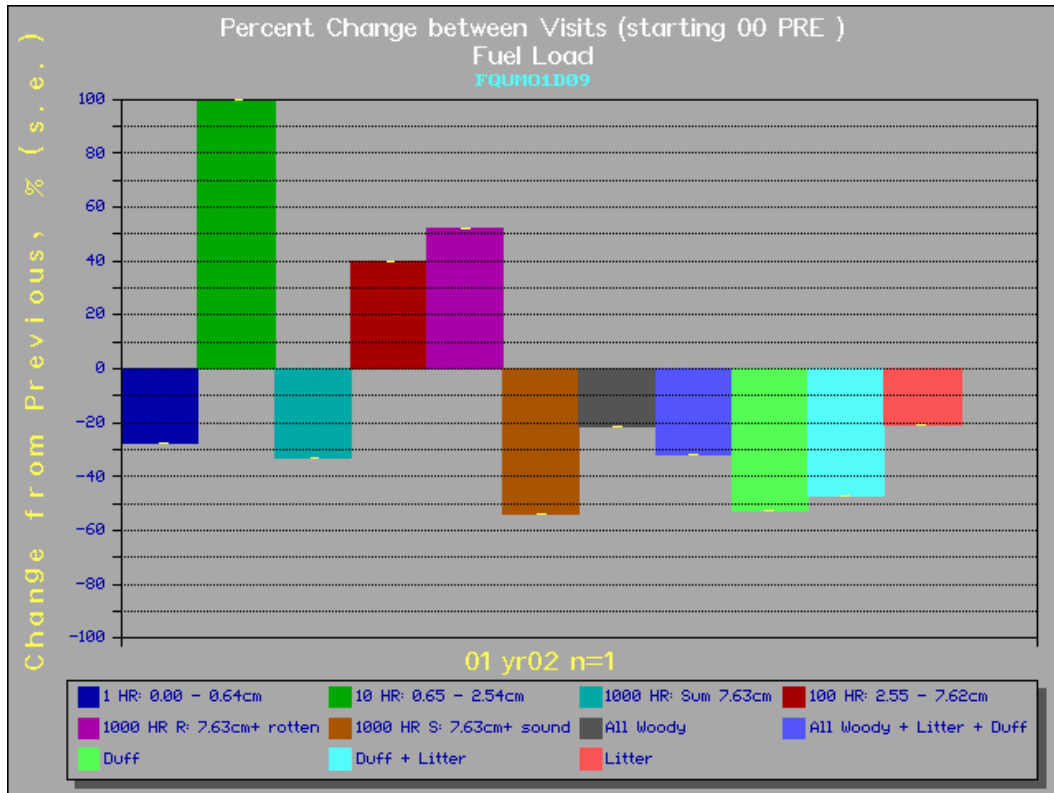


Figure 7. Fuel load change for 1 *Quercus montana* plot at MACA. Data was collected 2 years postburn. Objective for fuel reduction was 25-50% or less; actual reduction was approximately 32% by Year 2.

# Mammoth Cave National Park

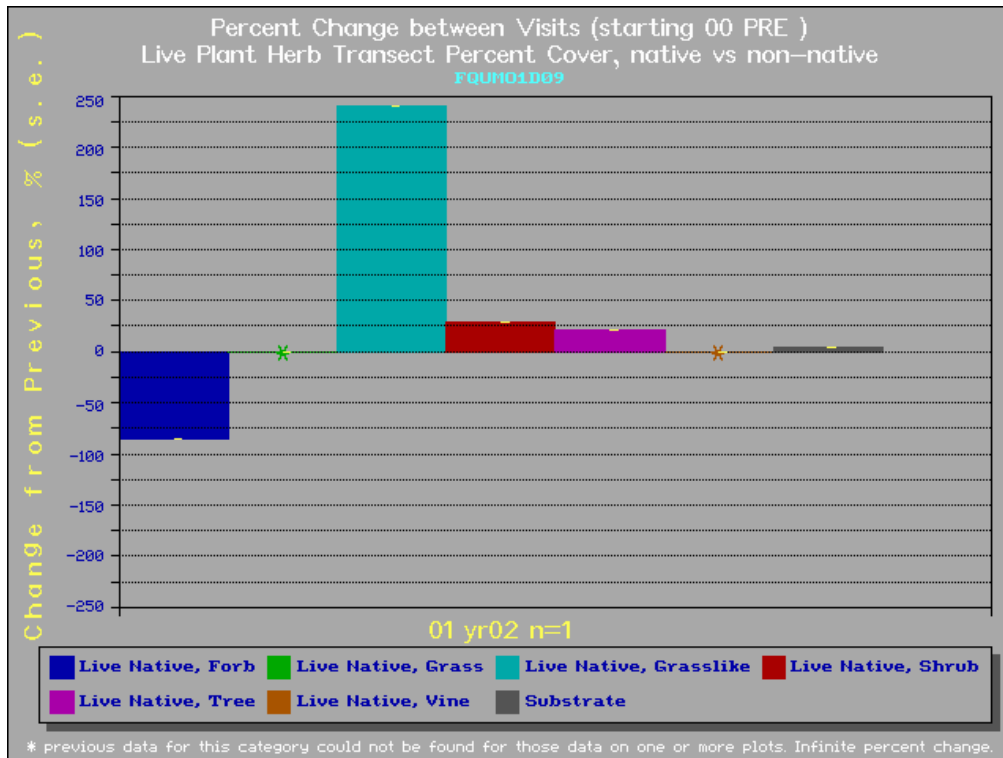


Figure 8. Percent cover change of native herbaceous species for 1 *Quercus montana* plot at MACA. Data was collected 2 years postburn. Objective for cover increase was 10-25% after three burns; average percent cover increase for grasslike and forb species was 77% was approximately by Year 2.

## Mammoth Cave National Park

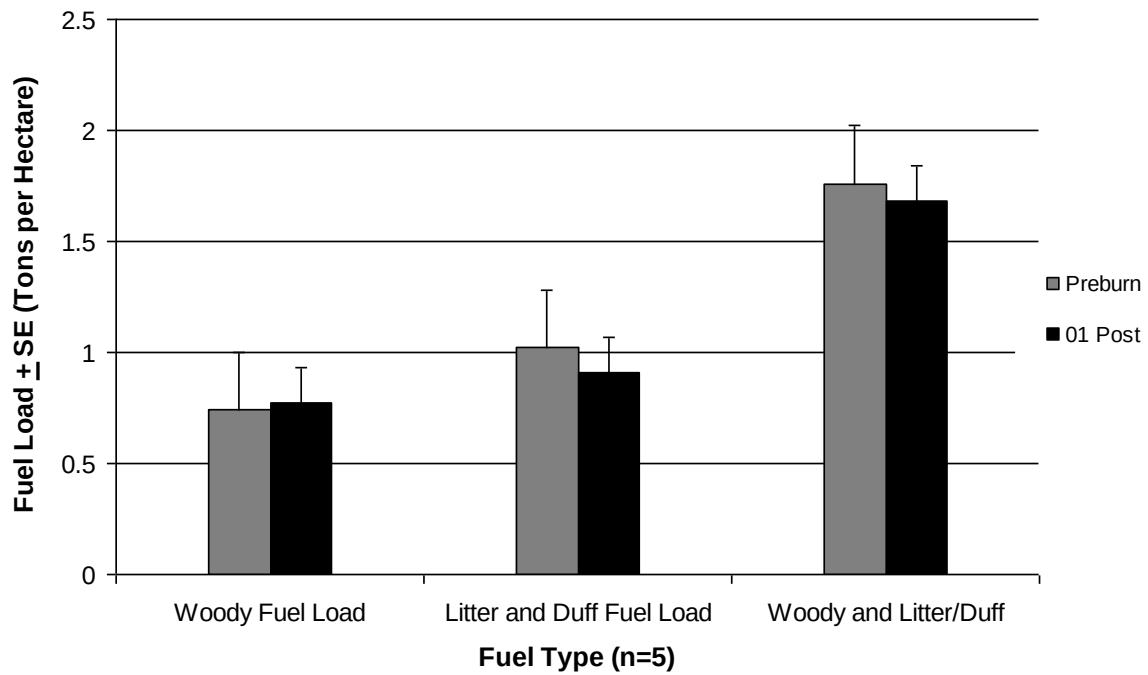


Figure 9. Fuel load for 5 *Juniperus virginiana* plots at MACA ( $\pm$ SE). Objective for fuel load reduction was 25-50%, and observed reduction was 4% immediately postburn.

# **Mammoth Cave National Park**

## **Literature Cited**

Campbell, Julian. 1999. Physical environment, terrestrial ecosystems, and fire history (Mammoth Cave National Park). The Nature Conservancy.

USDI National Park Service. 2003. Fire Monitoring Handbook. Boise (ID): Fire Management Program Center, National Interagency Fire Center. 274p.