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RH: Biodiesel Bear Attractant Test Biel et al.

## **Bear Attractant Test of the Alternative Fuel Rape Ethyl Ester**

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### Abstract

In 1994, over 3 million visitors toured Yellowstone National Park (YNP). These visitors, along with park concession and National Park Service administrative vehicles, burned over 7.6 million gallons of gasoline and diesel fuel in the park. Pollution from vehicle emissions can have harmful effects on both human and plant life. YNP, in cooperation with the Montana Department of Natural Resources and Conservation and the U.S. Department of Energy, Pacific Northwest and Alaska Regional Bioenergy Program, is participating in a pilot project to explore and evaluate the use of 100% *rape ethyl ester (biodiesel)* as a low pollution alternative to diesel fuel in environmentally sensitive areas. Biodiesel emits fewer hydrocarbons and particulates than fossil-based fuels and is derived from renewable resources. Biodiesel contains negligible levels of sulfur and reduces emissions of sulfur dioxide, one of the agents responsible for acid rain. Biodiesel is also part of the natural cycle (i.e., assimilation of CO<sub>2</sub> by plants for growth and development), and could lead to zero net gain in oxides of carbon emissions. The fuel is also biodegradable and will quickly break down, preventing long term damage to soil or water in the event of a spill. YNP is an environmentally sensitive area that brings humans and wildlife, such as grizzly bears (*Ursus arctos horribilis*) and black bears (*Ursus americanus*), into close proximity. Biodiesel fuel is a vegetable oil derivative that smells similar to cooking oil. The exhaust from a diesel engine fueled by biodiesel smells similar to a french fry cooker and thus, could act as a bear attractant. Having bears attracted to vehicles powered by biodiesel could draw bears into park developed areas and roadside corridors resulting in bear-human conflicts (bear-caused human injuries and property damages). This could lead to the potential removal of grizzly bears and black bears from the population. As a result of these concerns, tests were conducted to determine if the raw biodiesel fuel or its emissions were bear attractants. As part of the tests,

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bears were exposed to ambient air (standard) and to odor from raw biodiesel fuel, raw diesel fuel, deer meat/dog food (a known attractant), biodiesel exhaust, and diesel exhaust. Of 5 captive grizzly bears and 5 captive black bears tested, all displayed a significant non-attraction response to ambient air and a significant attraction and investigation response to deer meat/dog food. All bears were indifferent to biodiesel fuel and diesel fuel, but displayed a significant agitation/aggression response to biodiesel exhaust and diesel exhaust.\_\_\_\_\_

**Key words:** alternative fuel, attractant, biodiesel, black bear (*Ursus americanus*), grizzly bear (*Ursus arctos*), rape ethyl ester, Yellowstone National Park.

## Introduction

Yellowstone National Park (YNP) was established 1 March 1872, and “dedicated and set apart as a public pleasuring-ground for the benefit and enjoyment of the people” and “for the preservation, from injury or spoilation, of all timber, mineral deposits, natural curiosities, or wonders... and their retention in their natural condition. ”

In 1994, over 3 million visitors toured Yellowstone National Park (YNP). These visitors, in combination with park concession and National Park Service administrative vehicles, burned more than 7.6 million gallons of fuel within the park. Fuel consumption included 2.5 million gallons of gasoline and 57,000 gallons of diesel fuel purchased by park visitors (H. Broadhead, Yellowstone Park Serv. Stations, pers. commun.), 106,208 gallons of gasoline and 33,420 gallons of diesel fuel used by park concession vehicles (M. Vissage, TW Recreational Serv., pers. commun.), and 186,354 gallons of unleaded fuel and 134,742 gallons of diesel fuel used by National Park Service vehicles (P. Starkweather, Natl. Park Serv., pers. commun.).

Motor vehicles powered by gasoline and diesel fuels emit pollutants into the atmosphere. The vehicle pollutants of greatest concern to human health include carbon monoxide, nitrogen dioxide, and particulate matter emissions (Environmental Protection Agency 1992). These pollutants can effect human health in several ways, including impaired lung function, lung damage, increased respiratory illness, cancer, and birth defects (Environmental Protection Agency 1992). In addition, vehicle emissions contribute to the greenhouse effect and can be injurious to plant life and reduce yields of agricultural crops and native plants and forests (Environmental Protection Agency 1992).

YNP, in cooperation with the Montana Department of Natural Resources and Conservation and the U.S. Department of Energy, Pacific Northwest and Alaska Regional Bioenergy Program, is participating in a pilot project to explore and evaluate the use of 100% *rape ethyl ester (biodiesel)* as a low pollution alternative to diesel fuel in environmentally sensitive areas. Biodiesel emits fewer hydrocarbons and **particulates** than fossil-based fuels and is derived from renewable resources (Peterson and Reece 1995). Biodiesel contains negligible levels of sulfur and reduces emissions of sulfur dioxide, one of the agents responsible for acid rain (Peterson and Reece 1995). Biodiesel is also part of the natural cycle (i.e., assimilation of CO<sub>2</sub> by plants for growth and development), and could lead to zero

net gain in oxides of carbon emissions (Peterson and Reece 1995). The fuel is also biodegradable and will quickly break down (96% in 21 days), preventing long term damage to soil or water in the event of a spill (H. Haines. Mont. Dep. Environ. Quality. pers. comrnun.). YNP is an environmentally sensitive area that brings humans and wildlife, such as grizzly bears (*Ursus arctos horribilis*) and black bears (*Ursus americanus*), into close proximity. Biodiesel is a vegetable oil derivative that smells similar to cooking oil. The exhaust from a diesel engine fueled by biodiesel smells similar to a french fry cooker and thus, could act as a bear attractant. Having bears attracted to vehicles powered by biodiesel, could draw bears into park developed areas and roadside corridors resulting in bear-human confrontations, bear-caused property damages, and/or bear-inflicted human injuries. This could lead to the potential removal of grizzly bears and black bears from the population. As a result of these concerns, tests were conducted to determine if the raw biodiesel fuel or its emissions were bear attractants.

## Methods

Ten captive bears (5 grizzly bears and 5 black bears) housed at Washington State University at Pullman were used to test biodiesel fuel and biodiesel exhaust as potential bear attractants. As part of the test, the reaction of bears to odor of biodiesel fuel and biodiesel exhaust were compared to that of a standard (fresh air) and a known bear attractant (deer meat/dog food), as well as diesel fuel and diesel exhaust (Table 1). Diesel fuel has been used in YNP for decades and has not been known to act as a bear attractant.

The 10 bears tested consisted of both males ( $n=4$ ) and females ( $n=6$ ) as well as various age classes and locations of origin (Table 2). Tests were conducted within each bear's regular holding pen. Each pen consisted of a 2.4 m wide by 3.7 m long (8 ft wide by 12 ft long) indoor room connected by an open door to a 2.4 m wide by 5.6 m long (8 ft wide by 18.5 ft long) outdoor kennel (Figure 1). Each pen housed from 1 to 3 bears of the same species. Each outdoor portion of the kennel could be opened to allow access to a 2-1/2 acre outdoor exercise area. However, during the tests access to the exercise area was closed. Test procedures were modified from those described by Cushing (1980, 1983) for testing menstrual odor as a bear attractant. Samples of biodiesel fuel, diesel fuel, and deer meat/dog food, were placed in a bowl in a 10-gallon bucket. The bucket was located approximately 4.8 m (22.3 feet) from the nearest pen and on the other side of a cinder block wall (Figure 1). A fan was placed on top of the bucket which forced the odor from the sample being tested through 15 cm (6-inch) stove pipe into the indoor portion of each pen. For the standard test the fan was placed on an empty 10-gallon bucket and outdoor air was forced through the stovepipe. To divert biodiesel and diesel exhaust from running pickup trucks to the pens, a 10 - 15 cm (4 inch to 6 inch) stovepipe converter was placed on the truck exhaust pipe and then 15 cm stovepipe was hooked up to this and run to the indoor portion of each pen. The trucks were located outside and were 3.7 m (12 feet) from the nearest outside pen (Figure 1). Duct tape was used to seal the seams between the sections of stove pipe for all trials to prevent odor from leaking out before reaching the pen.

Due to the small number of bears available ( $n=10$ ) and the number of stimuli being

tested ( $n=6$ ), the same bears had to be used for testing more than 1 stimuli. In addition, multiple bears were held in 4 of the 5 pens used (Figure 1), thus tests in these pens were conducted on multiple bears at the same time. Due to these factors, tests did not meet criteria required for being random or independent and nonparametric statistics were used to test all hypotheses.

Each test was run for 15 minutes at each pen with the bears' reaction to the test stimulus recorded at the start of each minute of the 15 minute trial period. The stovepipe was flushed with ambient air between each trial. A minimum of 34 ( $\bar{x}=358 \pm 438$  SD) minutes elapsed between trials of different stimuli within the same pen. From 0 to 4 ( $\bar{x}= 2.0 \pm 1.4$  SD) tests were conducted per bear, per day.

Each 15-minute trial was video-taped and the bears' reactions were recorded. Reactions were grouped into categories as follows: 1) no attraction to the odor piped into the bear's pen as evidenced by the bear remaining in the outdoor kennel; 2) the bear came to the door to sniff the air in the indoor pen; 3) the bear entered the indoor pen to sniff the air; 4) the bear entered the indoor pen and came up to the vent to sniff the odor emanating from the stovepipe; 5) the bear entered the indoor pen and licked the vent, walls, door, or stovepipe, indicating a strong attraction to the odor; 6) the bear reacted to the stimulus by becoming agitated and aggressive as evidenced by pacing, vocalizations, and lunging at pen-mates or bears in adjacent pens.

In summarizing analysis of the data we use the terms no attraction, attraction/investigation and agitation/aggression. We define "no attraction" as bears that reacted to test stimuli as described in category # 1 above. "Attraction/investigation" is defined as bears that reacted to stimuli as defined in categories #'s 2, 3, 4, and 5. "Agitation/Aggression" is defined as bears that reacted to stimuli as described in category #6.

A heterogeneity G Log-likelihood test was used to test if bears' responses to the 6 stimuli were homogeneous or heterogeneous. Paired sample T-tests were used to test whether bears reacted the same or differently to biodiesel fuel versus diesel fuel and to biodiesel exhaust versus diesel exhaust. An independent T-test was used to test for differences in the agitation/aggressive response to biodiesel exhaust and diesel exhaust of grizzly bears as compared to black bears. For statistical analysis paired sample T-test, independent T-test, and heterogeneity G Log-likelihood tests followed procedures described by Zar (1974).  $P<0.05$  was considered to be significant. Hypotheses tested were:

$H_{o1}$  Bears' responses to the 6 stimuli presented were homogeneous.

$H_{o2}$  There was no difference in the number of minutes bears displayed agitated behavior to biodiesel exhaust as compared to diesel exhaust.

$H_{o3}$  There was no difference in bears' reactions to biodiesel fuel odor versus diesel fuel odor.

$H_{o4}$  There was no difference in bears' reactions to biodiesel exhaust versus diesel exhaust.

$H_{o5}$  There was no difference in the number of minutes grizzly bears versus black bears displayed agitated behavior to biodiesel exhaust.

H<sub>06</sub> There was no difference in the number of minutes grizzly bears versus black bears displayed agitated behavior to diesel exhaust.

## Results

### Response To Ambient Air

Nine of 10 (90%) bears reacted with indifference for the majority of the 15 minute trial period that ambient air was pumped into their pens (Table 3). One bear (#B2) displayed attraction/investigation behavior for over half of the trial period and 1 bear (#G5) briefly (6 min) displayed agitation/aggression behavior during the trial. In the case of bear #G5, her 2 cubs of the year (COY) were in the indoor pen playing and sleeping during the trial and she was becoming agitated presumably because the fan noise was loud and she felt her cubs were threatened. The fan was shut off at the request of facility managers for minutes 8, 9, and 10 so the sow could retrieve her cubs from the inside pen and take them to the outdoor portion of the pen. The fan was then turned back on for the remainder of the 15 minute trial period.

### Response To Deer Meat/Dog Food

All 10 bears (100%) displayed some level of attraction/investigation behavior when deer meat/dog food was pumped into their pens (Table 4). Three (30%) bears (#'s G3, G4, B1) exhibited a strong attraction as evidenced by licking the vent and walls of the indoor pen. Only 1 (10%) bear (#G1) displayed no reaction for a portion of the trial period. No (0%) bears became agitated/aggressive when this stimulus was presented.

### Response To Biodiesel Fuel

Eight of 10 (80%) bears displayed no reaction for the majority of the 15 minute trial with odor from biodiesel fuel pumped into their pens (Table 5). Two of the 10 (20%) bears (#'s G1, B3) displayed attraction/investigation behavior to this stimulus for the majority of the trial.

### Response To Diesel Fuel

All ten bears (100%) exhibited no reaction for the majority of the 15 minute trial with odor of diesel fuel pumped into their pens (Table 6). Four of 10 (40%) bears (#'s G5, B1, B3, B4) displayed a small degree of attraction/investigation behavior to this stimulus.

### Response To Biodiesel Exhaust

Four of 10 (40%) bears (#'s G3, B2, B4, B5) displayed no reaction for the majority of

the 15 minute trial period with biodiesel exhaust pumped into their respective pens (Table 7). Two of these 4 bears (#'s B4, B5) briefly licked the vent and walls of the pen at the 10 minute mark of the trial (7 minutes after the truck engine was shut off) suggesting a potential attraction to biodiesel exhaust residue. Four (40%) other bears (#'s G1, G2, G4, G5) exhibited agitated/aggressive behavior for the majority of the trials of this stimulus. The truck was shut off at minute 14 during the trial with bear G5. Bear G5 has 2 COY and she was exhibiting extreme agitation and vocalizations along with bears in adjacent pens. Two (20%) bears (#'s B 1, B3) demonstrated attraction/investigation behavior to this stimulus. At minute 3 of this trial with bears #B1, B2, B3, B4, and B5 the truck was shut off due to the test bears and bears in adjoining pens exhibiting agitation/aggression behavior.

### Response To Diesel Exhaust

Half (50%) of the bears (#'s G1, B1, B2, B4, B5) displayed no reaction for the majority of the 15 minute trial period with diesel exhaust pumped into their pens (Table 8). Four of the 10 (40%) bears (#'s G2, G3, G4, G5) exhibited agitation/aggression behavior for the majority, and 3 bears (#'s B2, B4, B5) for a brief period, of the trial of this stimulus. The trial was stopped at the 12 minutes point with bear #G5 due to agitation displayed by the sow. During the trial with bears #B4 and B5 the truck was shut off (at the request of facility managers) at the 8 minute point due to their agitation and agitation displayed by bear #G5 and other bears in adjacent pens. One (10%) bear (#B3) exhibited attraction/investigation behavior for the majority of this trial.

### Statistical Analysis

The responses of the 10 bears were not homogeneous, but were significantly different between the 6 stimuli ( $G=34.19, df=5, P<0.001$ ) presented. Whereas bears were indifferent to biodiesel fuel odor ( $G=0.40, df=1, P>0.05$ ) and diesel fuel odor ( $G=1.65, df=1, P>0.05$ ) they displayed a significant non-attraction response to ambient air ( $G=3.85, df=1, P<0.05$ ), a significant attraction and investigation response to the odor of deer meat/dog food ( $G=13.86, df=1, P<0.05$ ), and a significant agitation response to both biodiesel exhaust ( $G=13.86, df=1, P<0.05$ ) and diesel exhaust ( $G=7.36, df=1, P<0.05$ ).

Diesel fuel has been used in YNP for decades without resulting in any known bear-human conflict situations. Therefore, we compared bears' reactions to biodiesel fuel odor versus diesel fuel odor and biodiesel exhaust versus diesel exhaust. There was no significant difference between bears' reactions to biodiesel fuel odor and diesel fuel odor ( $G=1.86, df=1, P>0.05$ ) or between biodiesel exhaust and diesel exhaust ( $G=1.44, df=1, P>0.05$ ).

We were concerned that all 10 bears tested displayed at least some agitation behavior due to exposure to biodiesel exhaust. Since such a response could potentially lead to bear-human conflict situations, further analysis was warranted. The number of minutes bears displayed an agitation/aggressive reaction to biodiesel exhaust was compared to the number of minutes bears displayed a similar reaction to diesel exhaust. Results indicate that there was

no significant difference in the number of minutes either grizzly bears ( $t=0.33, df=4, P=0.76$ ) or black bears ( $t=-0.89, df=4, P=0.42$ ) displayed agitation to biodiesel exhaust as compared to diesel exhaust. Grizzly bears displayed significantly more agitation/aggression behavior to both biodiesel exhaust ( $t=-5.09, df=8, P=0.001$ ) and to diesel exhaust ( $t=-2.95, df=8, P=0.018$ ) than did black bears.

## Discussion

Bears displayed no reaction when ambient air was pumped into their pens and a significant strong attraction/investigation response when the odor of deer meat/dog food (their standard food stuff) was pumped into their pens. In contrast, bears did not display a significant attraction to biodiesel fuel odor, diesel fuel odor, biodiesel exhaust, or diesel exhaust. In addition, there was not a significant difference in bears' reactions to biodiesel fuel odor as compared to diesel fuel odor or to biodiesel exhaust as compared to diesel exhaust. Diesel fuel has been used for decades in YNP without any known significant influence on the number of bear-human conflict situations occurring in the park. These results suggest that biodiesel fuel and biodiesel exhaust are not any more or less of an attractant than are diesel fuel and diesel exhaust. Standard methods used to handle and store hazardous fuels make them largely unavailable to bears. If biodiesel fuel is stored, handled, burned, and spills cleaned-up in the same manner as diesel fuel currently is within YNP, then use of biodiesel fuel would not be expected to contribute to additional bear-human conflicts above existing levels.

Due to budget limitations this study was conducted with facilities and materials available at no cost. In addition, personnel time allocated to this project was also limited by available funding (20 person days total for design, experiment, analysis, poster presentation and final report). Due to these limitations, the study could not be designed to meet criteria required for random and independent tests. However, the 10 bears tested reacted as expected to ambient air (no response) and to deer meat/dog food (strong attraction), suggesting that the study design probably did not significantly alter each bear's reaction to the 4 test stimuli (biodiesel fuel odor, diesel fuel odor, biodiesel exhaust, diesel exhaust).

Potential study biases that may have influenced test results include:

- 1.) The noise from the fan may have influenced the bears' responses to the different stimuli.
- 2.) The same hose was used for all trials. There could have been residue of test stimuli left in the hose. However, the hose was flushed with ambient air between trials of different stimuli.
- 3.) Due to multiple bears being held in a single pen, tests between bears and different stimuli were not random.
- 4.) The same bears were used to test all stimuli, thus tests were not independent.
- 5.) Due to multiple bears being confined to a single pen, bears' responses may

have been influenced by the presence of other bears.

- 6.) Bears confined within limited space in captivity may react differently than bears in the wild.
- 7.) Bears in test pen were within view of bears in adjacent pens. their reaction to stimulus may have been affected by the bears in the adjacent pens.
- 8.) Bears in the test pen **were** within hearing distance of bears in adjacent pens and may have been influenced by vocalizations from other bears.
- 9.) Facility managers requested several trails with biodiesel exhaust and diesel exhaust be terminated early prior to the full 15 minutes after viewing how agitated and aggressive several of the grizzly bears became.

### **Management Implications**

Yellowstone National Park is an **environmentally** sensitive area and is home to several species of mammals, including grizzly bears and black bears. Each year millions of visitors tour the park in private vehicles or tour buses and consume thousands of gallons of diesel fuel and millions of gallons of unleaded and leaded fuel. Emissions from these fuels can potentially have negative impacts on plant, animal, and human life within the park. Biodiesel fuel is an environmentally sensitive fuel that would reduce these impacts.

During these tests there was no statistical evidence that bears were attracted to biodiesel fuel or biodiesel exhaust any more or less than to diesel fuel and diesel exhaust. We recommend continued field experimentation of biodiesel fuel in YNP maintenance vehicles. Field use should be closely monitored for any indication that bears are or are not attracted to biodiesel fuel and its emissions. If monitoring of field use suggests that bears are attracted to biodiesel fuel, then methods of making it unavailable or unattractive to bears would need to be investigated and developed.

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Biological Service), and C. Servheen (Grizzly Bear Recovery Coordinator, U.S. Fish and Wildlife Service) for review of and recommendations for the study design; R. Renkin (Management Biologists, YNP) for statistical analysis of the data; and C. Peterson (Department of Agricultural Engineering, University of Idaho) and D. Reece (Department of Agricultural Engineering, University of Idaho) for providing the diesel and biodiesel powered trucks, fuel, fan and stove pipe used in the experiment.

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Table 1. Test materials and description of materials tested as bear attractants, Biodiesel Fuel Bear Attractant Test, WSU, 1995.

Test material	Description
Ambient Air	Fresh outside air. Not expected to be a bear attractant.
Deer meat/dog food	A mixture of deer meat and dog food, the standard foodstuff normally fed to the captive bears in the facility. The deer meat/dog food mixture is known to elicit a well defined, strong behavioral response by the captive bears.
Biodiesel fuel	A bowl of raw rape ethyl ester (biodiesel) fuel placed in a bucket. The fuel smells similar to cooking oil and could act as a potential bear attractant.
Diesel fuel	A bowl of raw diesel fuel placed in a bucket. Diesel fuel has been used to power all diesel trucks in YNP for many years and is not known to elicit a response in bears in the wild.
Biodiesel exhaust	Exhaust from a biodiesel fuel-powered Dodge Cummins Diesel truck. Odor from biodiesel exhaust smells similar to that of a french fry cooker and could act as a potential bear attractant.
Diesel exhaust	Exhaust from a diesel fuel-powered truck. Diesel exhaust is odoriferous and an eye irritant and is not known to act as a bear attractant in wild bears within YNP.

Table 2. Species, sex, age class, and location of origin of bears tested in Biodiesel Fuel Bear Attractant Test, WSU, 1995.

Bear #	Species	Sex/Age Class	Location of Origin
G-1	Grizzly	Sub-adult Male	Born in Captivity
G-2	Grizzly	Adult Male	British Colombia
G-3	Grizzly	Adult Male	British Colombia
G-4	Grizzly	Adult Female	Near Glacier NP
G-5	Grizzly	Adult Female w/two COY	Near Glacier NP
B-1	Black Bear	Adult Female	Yellowstone NP
B-2	Black Bear	Adult Female	Alaska
B-3	Black Bear	Adult Female	Ketchikan, Alaska
B-4	Black Bear	Yearling Male	Born in Captivity
B-5	Black Bear	Yearling Female	Born in Captivity

Table 3. Number of minutes grizzly bears and black bears exhibited different response behaviors to ambient air during 15 minute trial period, Biodiesel Fuel Attractant Test, WSU, 1995.

Bear #	No Reaction <sup>a</sup>	At door sniffing air <sup>b</sup>	Behavior response (minutes)			
			Entered pen sniffing air <sup>c</sup>	Entered pen sniffed vent <sup>d</sup>	Entered pen licked vent <sup>e</sup>	Agitated <sup>f</sup>
G1	14	1	0	0	0	0
G2	15	0	0	0	0	0
G3	15	0	0	0	0	0
G4	15	0	0	0	0	0
G5	8	1	0	0	0	6 <sup>g</sup>
B1	13	0	1	1	0	0
B2	6	9	0	0	0	0
B3	14	0	0	1	0	0
B4	15	0	0	0	0	0
B5	15	0	0	0	0	0
$\bar{x}$	13.0	1.1	0.1	0.2	0.0	0.6
SD	$\pm 3.3$	$\pm 2.8$	$\pm 0.3$	$\pm 0.4$	$\pm 0.0$	$\pm 1.9$

<sup>a</sup> No reaction to test stimulus

<sup>b</sup> Sniffed at door but did not enter pen

<sup>c</sup> Entered pen and sniffed but did not approach vent

<sup>d</sup> Approached vent to sniff

<sup>e</sup> Licked walls, stovepipe, or vent

<sup>f</sup> Agitated and intraspecies aggression

<sup>g</sup> Fan was shut off for minutes 8, 9, and 10 so sow could get 2 COY out of indoor portion of pen. Fan turned on for remainder of trial once COYs outside.

Table 4. Number of minutes grizzly bears and black bears exhibited different response behaviors to deer meat/dog food during 15 minute trial period, Biodiesel Fuel Attractant Test, WSU, 1995.

Bear #	No Reaction <sup>a</sup>	At door sniffing air <sup>b</sup>	Behavior response (minutes)				
			Entered pen sniffing air <sup>c</sup>	Entered pen sniffed vent <sup>d</sup>	Entered pen licked vent <sup>e</sup>	Agitated <sup>f</sup>	
G1	5	9	1	0	0	0	
G2	0	15	0	0	0	0	
G3	0	14	0	0	1	0	
G4	0	12	1	0	2	0	
G5	0	14	1	0	0	0	
B1	0	2	4	7	2	0	
B2	0	7	4	4	0	0	
B3	0	8	3	4	0	0	
B4	0	12	0	3	0	0	
B5	0	13	2	0	0	0	
$\bar{x}$	0.5	10.6	1.6	1.8	0.5	0.0	
SD	$\pm 1.6$	$\pm 4.1$	$\pm 1.6$	$\pm 2.5$	$\pm 0.9$	$\pm 0.0$	

<sup>a</sup> No reaction to test stimulus

<sup>b</sup> Sniffed at door but did not enter pen

<sup>c</sup> Entered pen and sniffed but did not approach vent

<sup>d</sup> Approached vent to sniff

<sup>e</sup> Licked walls, stovepipe, or vent

<sup>f</sup> Agitated and intraspecies aggression

Table 5. Number of minutes grizzly bears and black bears exhibited different response behaviors to biodiesel fuel during 15 minute trial period, Biodiesel Fuel Attractant Test, WSU, 1995.

Bear #	No Reaction <sup>a</sup>	At door sniffing air <sup>b</sup>	Behavior response (minutes)				
			Entered pen sniffing air <sup>c</sup>	Entered pen sniffed vent <sup>d</sup>	Entered pen licked vent <sup>e</sup>	Agitated <sup>f</sup>	
G1	5	9	1	0	0	0	
G2	15	0	0	0	0	0	
G3	15	0	0	0	0	0	
G4	12	3	0	0	0	0	
G5	14	0	0	0	0	1	
B1	11	2	0	2	0	0	
B2	14	0	1	0	0	0	
B3	2	0	6	7	0	0	
B4	8	4	3	0	0	0	
B5	8	4	2	1	0	0	
$\bar{x}$	10.4	2.2	1.3	1.0	0.0	0.1	
SD	$\pm 4.5$	$\pm 2.9$	$\pm 1.9$	$\pm 2.2$	$\pm 0.0$	$\pm 0.3$	

<sup>a</sup> No reaction to test stimulus

<sup>b</sup> Sniffed at door but did not enter pen

<sup>c</sup> Entered pen and sniffed but did not approach vent

<sup>d</sup> Approached vent to sniff

<sup>e</sup> Licked walls, stovepipe, or vent

<sup>f</sup> Agitated and intraspecies aggression

Table 6. Number of minutes grizzly bears and black bears exhibited different response behaviors to diesel fuel during 15 minute trial period, Biodiesel Fuel Attractant Test, WSU, 1995.

Bear #	No Reaction <sup>a</sup>	At door sniffing air <sup>b</sup>	Behavior response (minutes)				
			Entered pen sniffing air <sup>c</sup>	Entered pen sniffed vent <sup>d</sup>	Entered pen licked vent <sup>e</sup>	Agitated <sup>f</sup>	
G1	15	0	0	0	0	0	0
G2	15	0	0	0	0	0	0
G3	15	0	0	0	0	0	0
G4	15	0	0	0	0	0	0
G5	12	3	0	0	0	0	0
B1	14	1	0	0	0	0	0
B2	15	0	0	0	0	0	0
B3	10	1	2	2	0	0	0
B4	10	4	0	1	0	0	0
B5	15	0	0	0	0	0	0
$\bar{x}$	13.6	0.9	0.2	0.3	0.0	0.0	0.0
SD	± 2.1	± 1.5	± 0.6	± 0.7	± 0.0	± 0.0	± 0.0

<sup>a</sup> No reaction to test stimulus

<sup>b</sup> Sniffed at door but did not enter pen

<sup>c</sup> Entered pen and sniffed but did not approach vent

<sup>d</sup> Approached vent to sniff

<sup>e</sup> Licked walls, stovepipe, or vent

<sup>f</sup> Agitated and intraspecies aggression

Table 7. Number of minutes grizzly bears and black bears exhibited different response behaviors to biodiesel exhaust during 15 minute trial period, Biodiesel Fuel Attractant Test, WSU, 1995.

Bear #	No Reaction <sup>a</sup>	At door sniffing air <sup>b</sup>	Behavior response (minutes)				
			Entered pen sniffing air <sup>c</sup>	Entered pen sniffed vent <sup>d</sup>	Entered pen licked vent <sup>e</sup>	Agitated <sup>f</sup>	
G1	1	0	0	0	0	0	14
G2	3	4	0	0	0	0	8
G3	9	1	0	0	0	0	5
G4	3	4	0	0	0	0	8
G5	2	1	0	0	0	0	12 <sup>g</sup>
B1	6	0	8	0	0	0	1 <sup>h</sup>
B2	12	2	0	0	0	0	1 <sup>h</sup>
B3	5	1	7	1	0	0	1 <sup>h</sup>
B4	9	0	1	1	3	1 <sup>h</sup>	1 <sup>h</sup>
B5	11	0	1	0	2	1 <sup>h</sup>	1 <sup>h</sup>
$\bar{x}$	6.1	1.3	1.7	0.2	0.5	5.2	
SD	± 3.9	± 1.6	± 3.1	± 0.4	± 1.1	± 5.0	

<sup>a</sup> No reaction to test stimulus

<sup>b</sup> Sniffed at door but did not enter pen

<sup>c</sup> Entered pen and sniffed but did not approach vent

<sup>d</sup> Approached vent to sniff

<sup>e</sup> Licked walls, stovepipe, or vent

<sup>f</sup> Agitated and intraspecies aggression

<sup>g</sup> Engine shut off at minute 14 due to agitation/vocalizations exhibited by bear #G5

<sup>h</sup> Engine shut off at minute 3 due to agitation exhibited by test bears and bears in adjacent pens

Table 8. Number of minutes grizzly bears and black bears exhibited different response behaviors to diesel exhaust during 15 minute trial period, Biodiesel Fuel Attractant Test, WSU, 1995.

Bear #	No Reaction <sup>a</sup>	At door sniffing air <sup>b</sup>	Behavior response (minutes)				
			Entered pen sniffing air <sup>c</sup>	Entered pen sniffed vent <sup>d</sup>	Entered pen licked vent <sup>e</sup>	Agitated <sup>f</sup>	
G1	15	0	0	0	0	0	0
G2	4	0	0	0	0	0	11
G3	4	0	0	0	0	0	11
G4	4	0	0	0	0	0	11
G5	6	1	0	0	0	0	8 <sup>g</sup>
B1	12	2	1	0	0	0	0
B2	11	2	0	0	0	0	2
B3	6	3	6	0	0	0	0
B4	12	0	0	0	0	0	3 <sup>h</sup>
B5	12	0	0	0	0	0	3 <sup>h</sup>
$\bar{x}$	8.6	0.8	0.7	0.0	0.0	0.0	4.9
SD	± 4.2	± 1.1	± 1.9	± 0.0	± 0.0	± 0.0	± 4.8

<sup>a</sup> No reaction to test stimulus

<sup>b</sup> Sniffed at door but did not enter pen

<sup>c</sup> Entered pen and sniffed but did not approach vent

<sup>d</sup> Approached vent to sniff

<sup>e</sup> Licked walls, stovepipe, or vent

<sup>f</sup> Agitated and intraspecies aggression

<sup>g</sup> Engine shut off at minute 12 due to agitation/vocalizations exhibited by bear #G5

<sup>h</sup> Engine shut off at minute 3 due to aggressive behavior displayed by bear #B4 and B5 and bears in adjacent pens

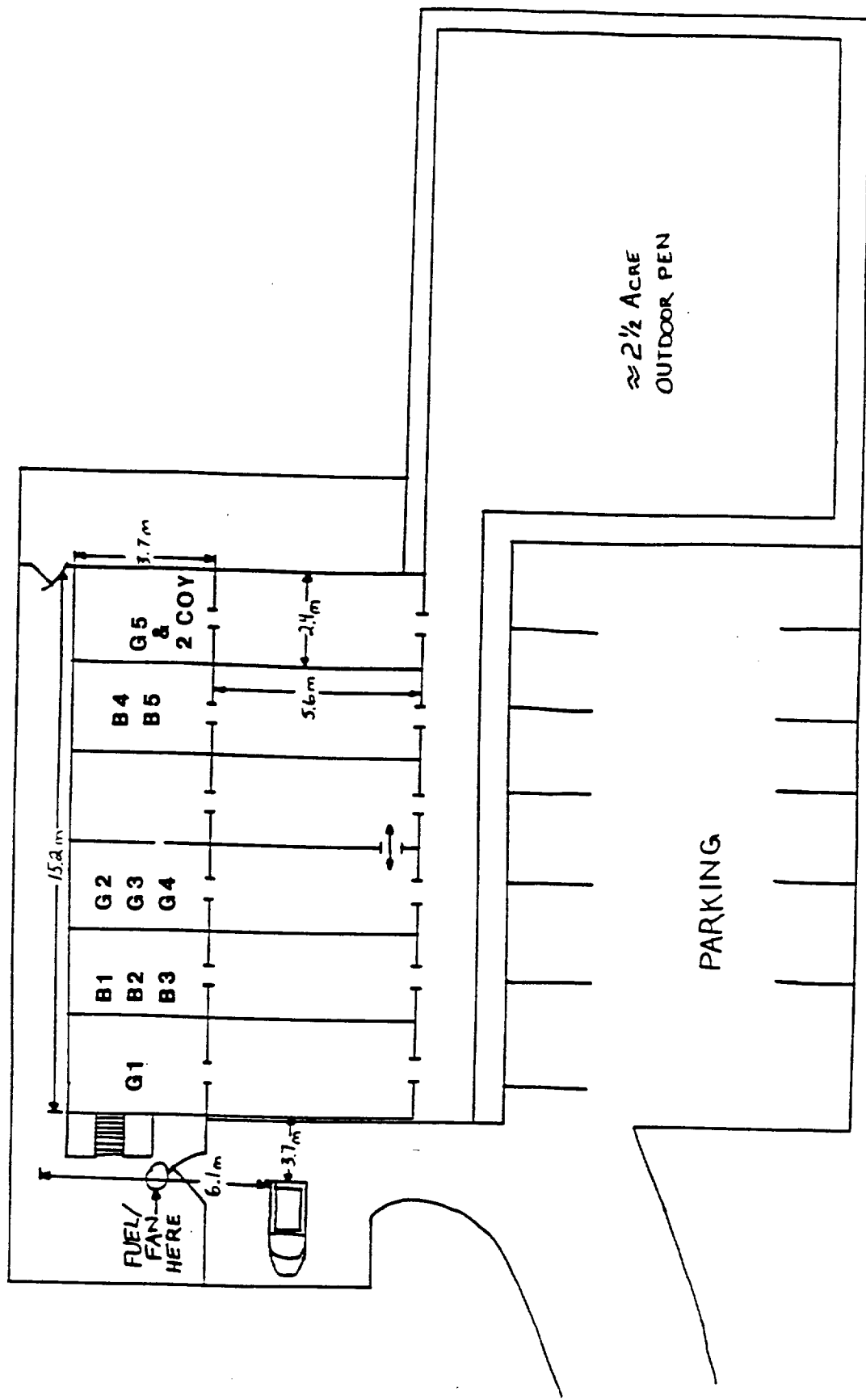


Figure 1. Diagram of bear facilities used in Biodiesel Fuel Attractant Study, Washington State University, 1995.