Advantage

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Contents

Evaluating the fire ignition potential of all terrain vehicles in Alberta forests

Abstract

The Forest Engineering Research Institute of Canada (FERIC) evaluated the potential for all terrain vehicles (ATVs) to ignite fires in certain types of wildland fuels. Researchers documented exhaust system temperatures, interviewed ATV riders about their riding habits, and inspected ATVs to identify where potentially flammable debris could accumulate on the vehicles.

Keywords

All terrain vehicles, ATV, Wildfire, Fire ignition, Exhaust systems, Wildfire cause, Alberta.

Author

Greg Baxter,
Wildland Fire Operations Research Group

Introduction

In 2002, Alberta Sustainable Resource Development (SRD) asked FERIC to investigate all terrain vehicles (ATVs) as a cause of forest fires. FERIC produced a report detailing the fire history of ATV-caused fires in Alberta since 1990 (Baxter 2002). This report listed two possible processes leading to fire starts—fuels accumulating on the vehicle's exhaust system, and sparks from the muffler. The author hypothesized that fine fuel accumulations of sphagnum moss and grass coming into contact with the exhaust system of an ATV could be ignited if the fuels were to stay in contact long enough for the initial combustion to take place.[1] Then, should any of the burning debris fall from the exhaust system to the ground surface, the potential exists for a wildfire to occur. The report also presented several recommendations to reduce the potential for fires ignited by ATVs.

Baxter (2002) created much discussion within the ATV community and, as a result, FERIC proposed to physically demonstrate the process of ignition of forest and wildland fuels by ATVs. During the summer of 2003, FERIC researchers initiated a second evaluation of ATV-caused wildfires by examining the processes involved in ATVs as potential ignition sources for fire starts.

Objectives

The main objectives of the second evaluation of ATV-caused wildfires were to find answers to the following questions:

- What surface temperatures are produced at various locations on an ATV's exhaust system during normal riding? How long are these temperatures maintained above the ignition thresholds for the fuels involved?
- What types of vegetative matter or forest fuels in Alberta are most likely to accumulate on an ATV and where do they accumulate?
- Can forest fuels ignite from exhaust system heating? If so, how long do they take to ignite?

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[1] Gonzales (2001) reported the ignition threshold of forest fuels ranging from 204 to 260°C. Temperatures higher than this level were found by Baxter (2002). Other research (Johnson et al. 1980, Babrauskas 2003) reported ignition temperatures ranging from 250 to 280°C.

Methodology

The study involved three components:

- collecting surface temperatures on ATV exhaust systems
- testing three ATVs equipped with temperature sensors in normal fuels and riding conditions to identify where the fuels accumulated and the types of fuels involved
- surveying ATV users to determine their experience and level of awareness with respect to wildfires, and their knowledge regarding ATVs as a potential ignition source

Exhaust system surface temperatures

FERIC researchers collected surface temperature data on four different makes of ATVs as they were driven through various fuel types involving both recreational riding and work-related conditions. ATV engine displacements ranged from 350 to 500 cm^3. Thermocouples (Type J Size 24) were attached to four different locations on the exhaust system:

- on the exhaust pipe directly out of the manifold
- halfway along the exhaust pipe under the heat shield
- on the exhaust pipe directly before the muffler
- on the outlet end of the muffler

Some of the dataloggers used had in effect a maximum temperature limit of 475°C—well above the ignition temperature of forest fuels (204–260°C). This temperature was exceeded many times during the monitoring activities. Dataloggers recorded information in one-second time periods. Temperature data were obtained over 16 days in the summer of 2003.

Trail rides

Two daytime rides were undertaken by FERIC in September 2003, one in the Lac La Biche Forest and the second in the Whitecourt region. The objectives of the rides were to collect exhaust system surface temperatures, and to observe the type of material most likely to collect on an ATV and the location of the accumulations. A third objective was to quantify the time required to dry and to potentially ignite debris on the exhaust system. Three ATVs of different makes that are popular for recreational and work use in Alberta were chosen. Riders rode the same ATVs on both rides.

Spot checks using an Omega HH506 handheld thermometer were taken during the rides to verify the temperature data being collected by the sensors and dataloggers. The second ride was undertaken using the same ATVs for experimental replication purposes. A night ride was also done to see if any carbon particles could be observed escaping from the muffler.

User survey

A questionnaire was developed to collect general information from ATV users throughout the province about wildfires. The survey population included recreational riders, hunters, and workers from the forest, oil, and gas industries. The questions were related to the riders' experience, knowledge of fire reporting, and experience or knowledge about the combustion of materials on the exhaust systems of ATVs. During the course of the interviews, visual inspections of the ATVs were made of the types and locations of fuel accumulations. Twenty-nine interviews were performed during the summer and fall at rallies, popular recreation sites, and hunting areas.

Forest Engineering Research Institute of Canada (FERIC)

Find us Online! www.feric.ca

Eastern Division and Head Office
580 boul. St-Jean
Pointe-Claire, QC, H9R 3J9
(514) 694-1140
(514) 694-4351
admin@mtl.feric.ca

Western Division
2601 East Mall
Vancouver, BC, V6T 1Z4
(604) 228-1555
(604) 228-0999
admin@vcr.feric.ca

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Results

Exhaust system surface temperatures

All of the sampling at the four surface locations on the exhaust systems attained temperatures above the ignition thresholds associated with forest fuels. During extended, uninterrupted rides (i.e., greater than 15 minutes of sustained riding), three areas of the exhaust system—the manifold, halfway along the exhaust pipe, and directly before the muffler—maintained temperatures consistently above this threshold (Figure 1). Over the course of both trail rides that were conducted, the end of the muffler was the only one of the four locations sampled whose time-temperature profile showed that temperatures fluctuated above and below the accepted ignition threshold. The temperature at this location only exceeded the threshold value when the ATVs were driven at high speeds on good trails or roads.

The temperature profile in Figure 1 was common to all the makes of ATVs tested. The highest recorded temperatures occurred right out of the manifold, the second highest were halfway along the exhaust pipe to the muffler, and the third were right before the muffler. The lowest temperatures were recorded at the end of the muffler.

Table 1 shows the surface temperature ranges for the four sampled locations along the exhaust system. These temperatures peaked during normal riding conditions. The ranges all contained values above the ignition threshold for forest fuels. The greatest ranges in surface temperatures occurred at the end of the muffler, and this occurred when the ATVs were driven at high speeds on good trails or roads.

Table 1. Range in surface temperature at four locations along the exhaust system

Exhaust system location	Surface temperature range (°C)
Manifold	339–585
Halfway along exhaust pipe	232–469
Before muffler	240–469
End of muffler	64–468

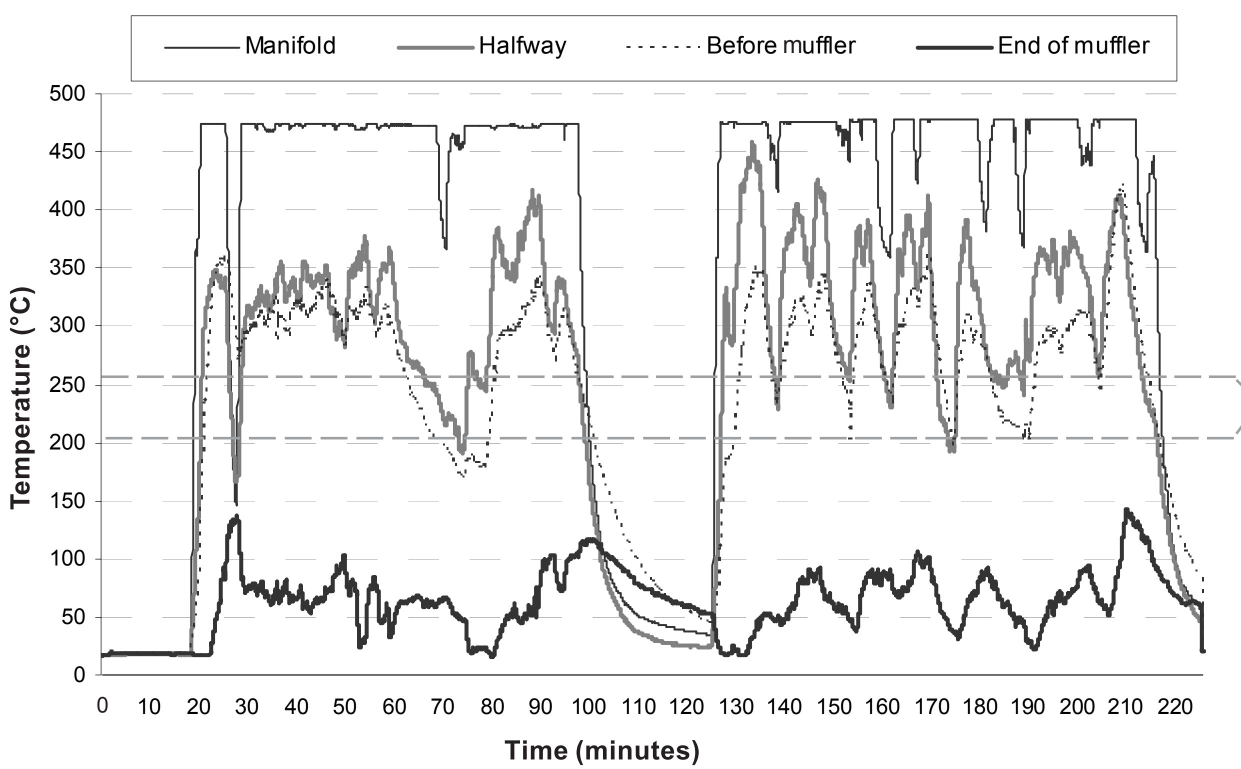

Figure 1. Time-temperature traces for four locations on the exhaust system of an ATV during an extended ride. The datalogger only recorded temperatures to a maximum of 475°C.

Figure 2. Muskeg fuel complexes.

Figure 3. Grass-dominated fuels adjacent to a trail system.

Figure 4. The accumulation of organic material on the rear axle of an ATV as a result of travelling across a muskeg trail.

Figure 5. Steam observed on the exhaust system of an ATV. Note that the rear of the muffler is already dry.

Several general observations can be made based on the results of the temperature monitoring part of the study:

- Temperatures can change very quickly both above and below the ignition thresholds.
- The type of rider, terrain, and trail conditions can affect the temperature pattern.
- Speed of travel has the greatest influence on the temperatures at the end of the muffler.
- Temperatures greater than the ignition threshold of forest fuels were recorded at all locations on the exhaust system.

Trail rides

Vegetation

Two vegetation or fuel complexes were of interest in this study—muskeg bogs (Figure 2) and grass covered areas (Figure 3). Both fuel types are hypothesized as coming in direct contact with an ATV's exhaust system. Grass also provides an ideal fuel bed for burning debris that falls from the ATV, especially during the spring or fall when the grass is cured or nearly cured.

Ride One

On September 10, 2003, FERIC researchers rode a 16 km route north of Lac La Biche through an area characterized by jack pine stands, grassy trails, and lowland muskeg. Air temperatures were about 15°C and rain had fallen the day before. Abundant debris accumulated on all three ATVs as they passed through the stretches of muskeg. The debris consisted almost entirely of partially decomposed sphagnum moss and other organic material originating from the muskeg. These fuels collected in abundance on the exhaust system, particularly the muffler; the rear axle, including shocks (Figure 4); the front shocks; front skid plate; and brake cables.

After travelling through muskeg, the first visible sign of high temperatures on the exhaust system surface was the steam resulting from the drying of the accumulated debris (Figure 5).

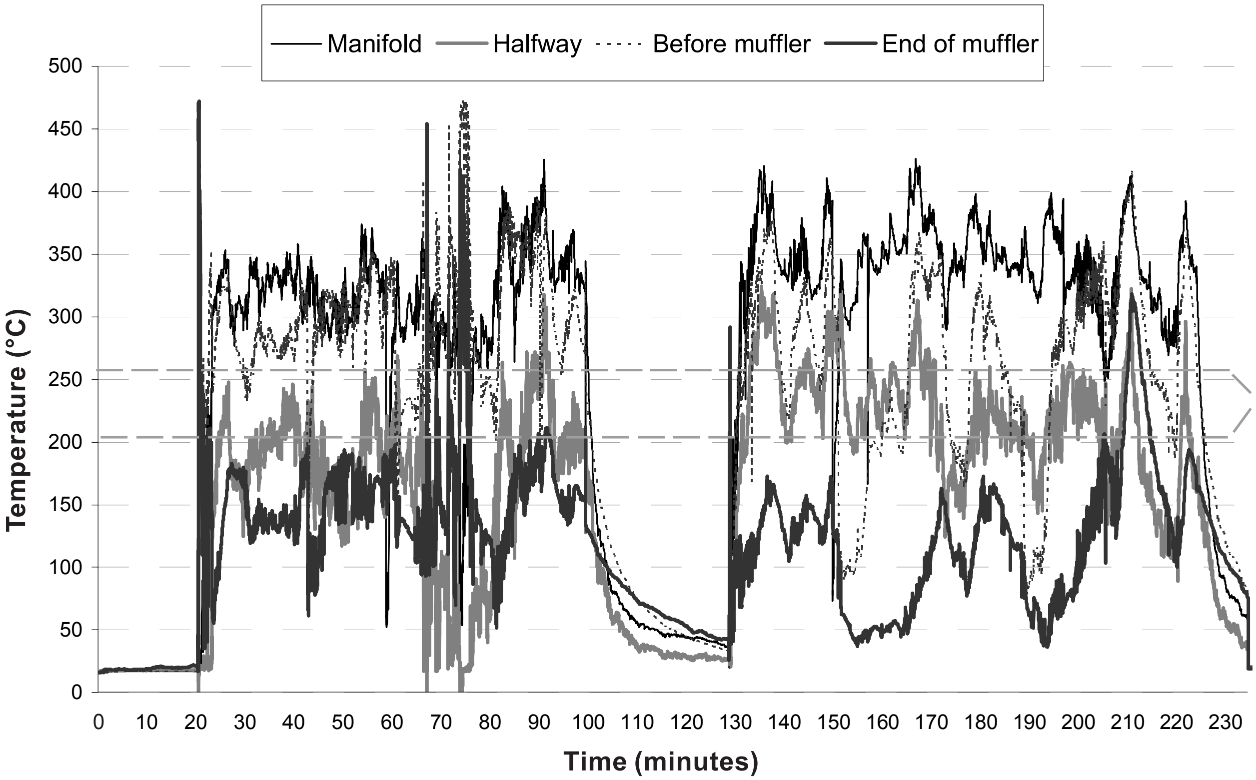

Figure 6. The time-temperature traces from ATV 3 for the first trail ride. Combustion occurred on the rear of the muffler between minutes 210 and 220.

Time for debris to dry. Part of the study was to investigate the length of time required for debris to dry on the exhaust system and thus become susceptible to ignition. By using the data collected by the thermocouples and from observations taken during the ride, the drying process time can be quantified. For example, combustion was observed on ATV 3. Its time-temperature profile is presented in Figure 6.

While returning to the trailhead, ATV 3 became stuck in the muskeg on two occasions. When this occurred, the temperatures at the end of the muffler dropped below 50°C while other points on the exhaust system remained high. Between minutes 160 and 190, the temperatures at the end of the muffler dropped below 50°C while at other locations temperatures were above 200°C. The ATV was still operating, but the back end of it was at, or close to, the waterline, thus cooling the muffler and wetting the accumulated debris.

Figure 7. Dried muskeg matter on the muffler of an ATV. This initially wet material was dry after 25 minutes of riding.

The organic material that adhered to the muffler from partial submersion in the muskeg dried completely (Figure 7) between minutes 199 and 220 (see explanation in next section). Previous research data collected by FERIC[2] have shown that mid-muffler system temperatures can easily rise above

[2] Unpublished FERIC data, collected on March 21, 2003, on file at the Wildland Fire Operations Research Group offices in Hinton, Alberta.

250°C during normal riding conditions. In Figure 8, dried organic material from a muskeg is shown on the muffler outlet of ATV 1. Temperatures at the end of the muffler for this machine hovered around 100°C which is sufficient to dry out the accumulated material.

An important characteristic of the wet muskeg vegetative matter, or "muck" as it is commonly called, is its ability to adhere to the ATV surfaces. The muskeg stuck to the exhaust system can stay in place, dry out, and potentially ignite.

Smouldering combustion. FERIC documented ignition and smouldering combustion caused by the exhaust system of ATV 3 during this study. The smouldering was filmed on video and still pictures were taken with a digital camera (Figure 9). The process or sequence of events was as follows (with times related to Figure 6):

Figure 8. Dried muskeg debris at the end of ATV 1's muffler.

Figure 9. Two smouldering points and scorched areas on the muffler from which debris had fallen to the ground. Some smoke is visible as well.

- Steaming was observed on the ATV (at minute 200).
- The ATV was driven at a high speed for approximately 2 km thereby heating up the exhaust system (between minutes 203 to 211).
- A burning smell was noticed (at minute 211).
- Smouldering was observed on numerous points along the length of the muffler (at minute 212).
- Bits of smouldering material were observed falling to the ground beneath the ATV (at minute 215).

The sequence of events from sinking the ATV in the muskeg to dropping smouldering embers from the exhaust system to the ground surface took about 15 minutes.

Ride Two

A second outing was made on September 30, 2003 to see if the results from the first ride could be repeated. ATVs were ridden on seismic lines and hunting trails west of Whitecourt. A heavy frost had occurred and most muskegs were partly frozen. Little surface water was found. These conditions did not allow the accumulation of debris on the ATVs. When the ride began, the sky was clear and temperatures were around 5°C. Again, ATV 3 experienced combustion, but this time it occurred directly out of the manifold and initiated in muskeg material that had accumulated from a previous outing and that was positioned against the exhaust pipes. Temperature data from that location were collected by the thermocouples to relate those temperatures to the combustion process.

There was an extended period with temperatures above 350°C for the manifold thermocouple (Figure 10). The piece of muskeg that ignited was approximately 7 × 4 × 2 cm (Figure 11) and much larger than the debris that ignited during the first ride. As well, a longer time at high temperatures was required before the material ignited.

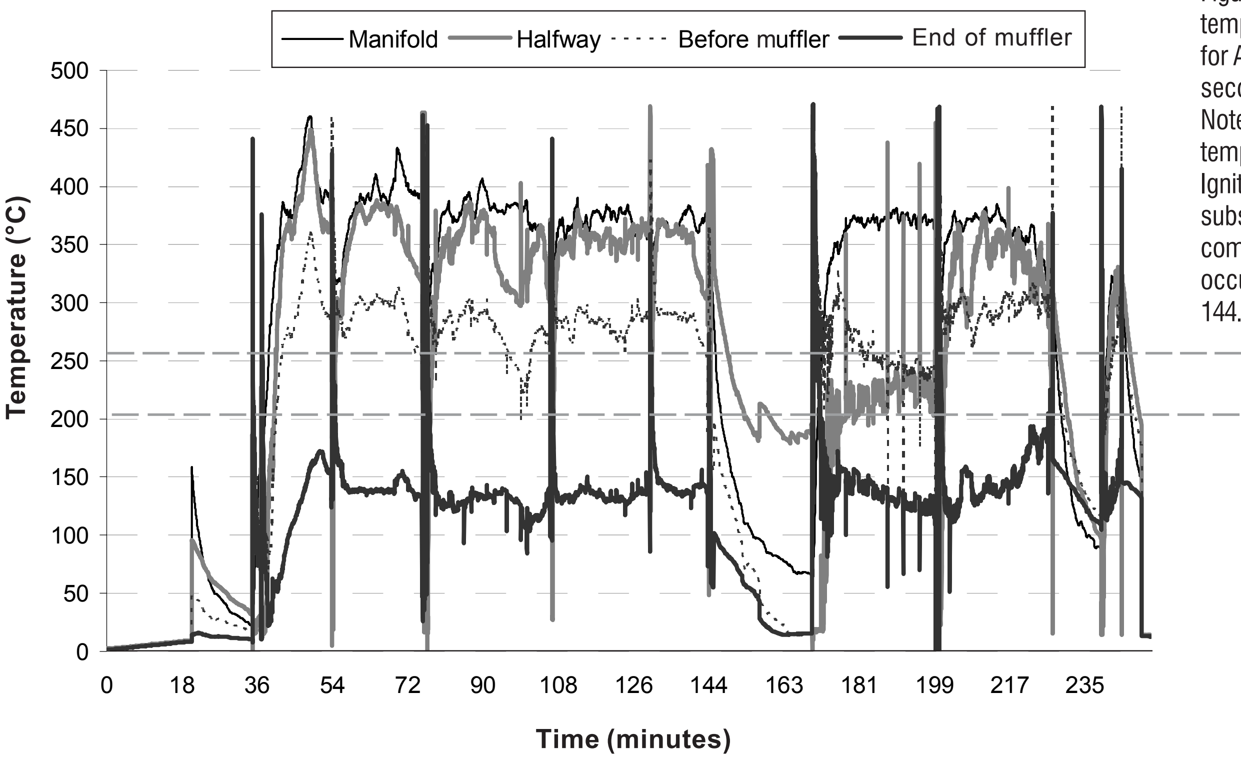

Figure 10. Time-temperature traces for ATV 3 for the second trail ride. Note the manifold temperatures. Ignition and subsequent combustion occurred at minute 144.

A night ride was also undertaken on September 29, 2003. The speeds required to produce high muffler temperatures did not occur or could not be attained. Therefore, no carbon particles were seen leaving the muffler.

User survey

The outcome of the ATV rider survey is summarized as follows:

Rider experience: ranged from new to 30 years (mean was 14).

Maintenance of ATV: 28 of 29 respondents stated that they do regular maintenance on their ATVs (mostly cleaning them following rides).

Experienced a burning smell: 15 of 29 have detected a burning smell at some time from either their own or a partner's ATV.

Observed sparks from mufflers on night rides: 9 of 9 have not seen sparks while night riding (note only 9 had gone night riding).

Figure 11. A smouldering piece of dried muskeg debris resulting from the ride near Whitecourt. This firebrand source was lodged against exhaust pipes, directly out of the manifold. This piece fell from the ATV after a few minutes.

Tools: 20 of 29 carried some tools that could be used for firefighting, which included fire extinguishers, axes, shovels, and pulaskis.

Fire reporting: 14 respondents would call 911; 7 would call the old SRD Fire Reporting Number - 427-FIRE; 1 would call the new 310-FIRE number; and 2 respondents did not know whom they would call. The remaining 5 respondents would call their company or the local SRD office.

Note:
The phone number to call to report a wildfire in Alberta is 310-FIRE. The 427-FIRE number is being phased out.

Based on the respondents' comments, most riders were aware that fires occur in Alberta's forests from many causes. FERIC believes routine maintenance and cleaning of ATVs is an important component in preventing fires caused by ATVs. Therefore, the fact that most respondents stated that they regularly maintained their ATV, primarily by cleaning them, is positive. Nevertheless, more public relations work by SRD may be necessary if its new 310-FIRE telephone line is to become more generally recognized by the public.

A visual inspection of each surveyed user's ATV was made to identify the debris types that accumulated on the vehicles. Little information was obtained as most of the sampled ATVs were involved in rallies. Because rallies are usually operated on well-maintained trails, the ATVs did not collect the same kind of debris encountered in the simulated rides. Some of the other ATVs were ridden in areas with sandy soils and therefore they accumulated little or no debris.

Discussion

This study has demonstrated that ATV exhaust systems, when combined with the right debris conditions, can result in the ignition and combustion of organic material. It has shown the potential of an ATV to serve as a "match" or ignition agent. However, in order for a forest fire to result, fuel conditions must be just right. A receptive fuel bed exists only on occasion as dictated primarily by its moisture status (e.g., Lawson and Dalrymple 1996), assuming there is favourable surface materials for ignition and there is reasonable continuity of the fuels. All makes of ATVs tested produced temperatures from their exhaust systems that were high enough to ignite fires, and they were all susceptible to debris accumulations on their exhaust systems. In the author's opinion, fire ignition was possible from all four makes of ATVs used in this study.

The fire history study completed by FERIC (Baxter 2002) showed that the majority of ATV-caused fires occur during the spring when the fuel bed consists primarily of dry cured grasses and other herbaceous vegetation. These materials can provide the ideal fuel bed if smouldering debris falls onto them from an ATV. The spring fire season also favours the potential for extreme fire behaviour due to the prevalence of critical fire weather conditions and other fuel-related factors.

Muskeg "muck" has the ability to adhere to many surfaces on an ATV and is also capable of igniting after short periods of exposure to the high temperatures experienced by the exhaust systems. Areas of muskeg are common in Alberta and provide an ATV rider with a challenging ride. However, ATV riders need to recognize that organic material will accumulate on an exhaust system simply from the vehicle being driven across muskeg areas. Frequent stops after travelling through muskeg areas and the cleaning of debris from the exhaust system could reduce the risk of producing firebrand materials that could lead to wildfire occurrences.

Baxter (2002) stated that sparks from the muffler are a potential cause of fire ignition. However, most new ATVs are equipped with spark arrestors and these are capable of trapping most expelled carbon particles, thereby lowering the probability of fires caused by carbon sparks.

The second trail ride demonstrated the importance of cleaning ATVs after use, especially following rides in muskeg areas. The piece of muskeg that ignited was not collected during the second ride, as the ground conditions were not conducive to abundant debris accumulating on the exhaust system.

The two main outcomes from the user survey dealt with current legislation and enforcement. Firstly, is the current legislation adequate and does it address the majority of concerns? The interviewed riders questioned whether the current legislation requires ATVs to have spark arrestors and fire extinguishers, and to carry firefighting tools. Current legislation prohibits altering mufflers but does not include a requirement to carry firefighting tools. Secondly, some of the ATV riders surveyed suggested the SRD should take the initiative of transferring the information generated by FERIC's research on the potential of ATV-caused fires to various user groups. For example, rallies and safety nights held by ATV clubs constitute excellent opportunities to present fire prevention messages. Vehicles could be checked and information could be given on the various firefighting tools available. The forest industry requires its employees to carry basic fire suppression equipment with them while using ATVs for work purposes—recreation users could do the same.

FERIC believes the quantitative data collected on exhaust system surface temperatures and the observations made during this study, including video footage and still photos, prove that accumulated fuels on the exhaust systems of existing models of ATVs are a potential ignition source for wildfires in Alberta forests and wildlands. Future efforts should focus on working with ATV manufacturers to mitigate this problem. For example, a tool that cleans exhaust systems should be developed for ATV users, especially for travel in muskeg-dominated areas.

Conclusions

- The exhaust systems on ATVs are susceptible to certain types of fuel or vegetative debris accumulating on them, and this material can remain in contact with the exhaust systems over an extended period of time.
- All points along an ATV's exhaust system produce high surface temperatures for extended time periods, and these temperatures are sufficient to dry out, heat, and ignite this debris.
- The time required to generate firebrand material from an ATV (i.e., dry out, heat, and ignite fuel or vegetative material) can be as short as 15 minutes.
- Under the right conditions, smouldering pieces of debris falling to the ground from an ATV exhaust system may ignite surface fuels in a wildland environment which can lead to wildfire occurrences.

Implementation and recommendations

- ATV riders should stop and clean their vehicles of debris, especially after travelling through muskeg areas. Special care should be taken during the spring when grasses are dry and cured. ATV riders should carry a cleaning tool to remove the debris from the exhaust system.
- SRD should use the information in this report for fire prevention purposes. It can be published in fishing and hunting guides and presented at ATV club meetings. The 310-FIRE number should be better publicized.
- ATV riders should carry some firefighting tools in their vehicles, e.g., fire extinguishers, shovels, axes, or pulaskis.
- FERIC and SRD need to convey the information generated from this study to the ATV manufacturers. These groups need to work together to address either the high heat issues associated with the exhaust systems or the debris accumulation issues.

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