U.S. Forest Fires: Key Drivers & Prevention

Timberland Investment Group

November, 2019

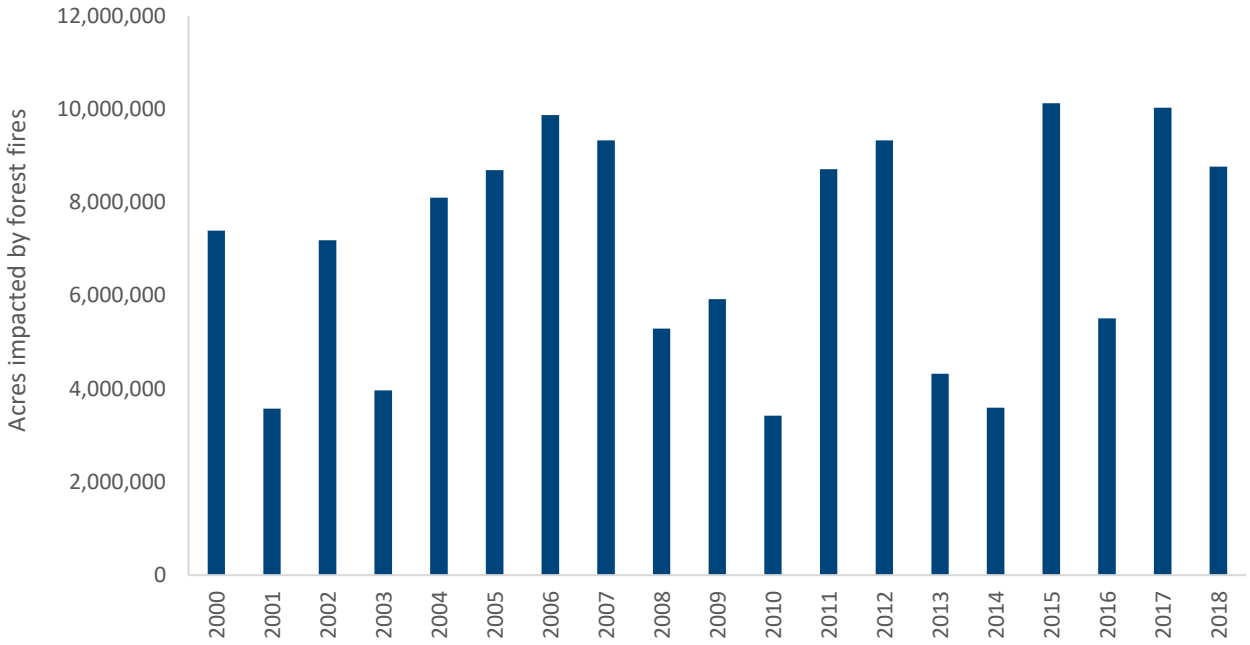
Table of Contents

U.S. Forest Fires: Key Drivers & Prevention

Institutional investors often inquire about forest fires and associated impacts on commercial timberland investments. In the last few years, these inquiries have increased as the last several fire seasons in the United States have been some of the most severe on record, particularly on the West Coast.

Beyond the tragic loss of human life, and significant damage to local, often rural, communities, forest fires can have significant, negative environmental and financial impacts. In 2018, for example, between 8.5-9.0 million acres burned throughout the U.S., resulting in a loss of at least US$ 23 billion (Figure 1).[1]

Figure 1: Acres impacted per year by forest fires since 2000 in the U.S.



Sources: National Interagency Fire Center; TIG Analysis

What Causes Forest Fires?

Most forest fires in the U.S. are caused by human activities. On average, human activities have been responsible for 86% of the total number of forest fires in the U.S. since 2001 (Figure 2). Leading causes of such fires include arson, burning of waste, improper disposal of smoking materials, electrical discharges, sparks from equipment, vehicles towing trailers, and vehicles driving off-road in tall grass. At the same time, while lightning has only accounted for 14% of the total number of forest fires in this time period, it has been responsible for close to 60% of the total timberland acres affected by fires, often because lightning strikes can occur in forest interiors

[1] Insurance Information Institute; 2018 insurance claims are still being processed as of the writing of this paper

far from access roads, and therefore may not be discovered as quickly, nor can resources be as easily deployed to contain them (Figure 3). Further, fire management on public lands (such as national forests and national parks) has favored allowing fires in remote areas to burn so long as they do not present a threat to life or property.

Figure 2: Forest fire causation (number of fires)

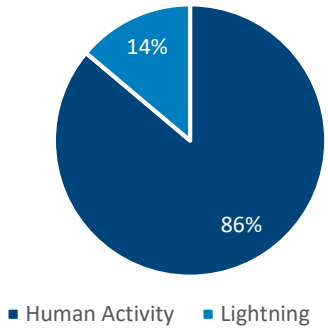
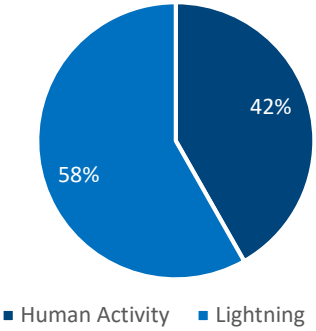


Figure 3: Acres affected

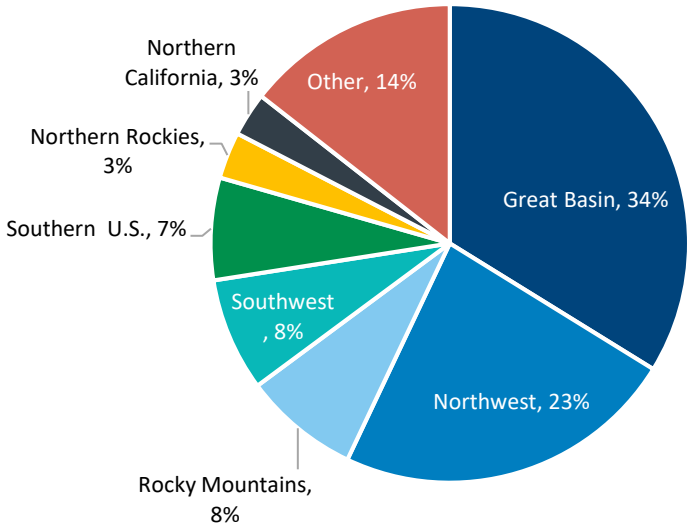


Sources: National Interagency Fire Center; TIG Analysis

Where do Forest Fires Occur?

On an acreage basis, 34% of U.S. forest fires caused by lightning emanate from the Great Basin (primarily Utah, Nevada, and Idaho) while the Northwest (Washington and Oregon) accounts for 23%. The Rocky Mountains and Southwest account for 8% each (Figure 4).

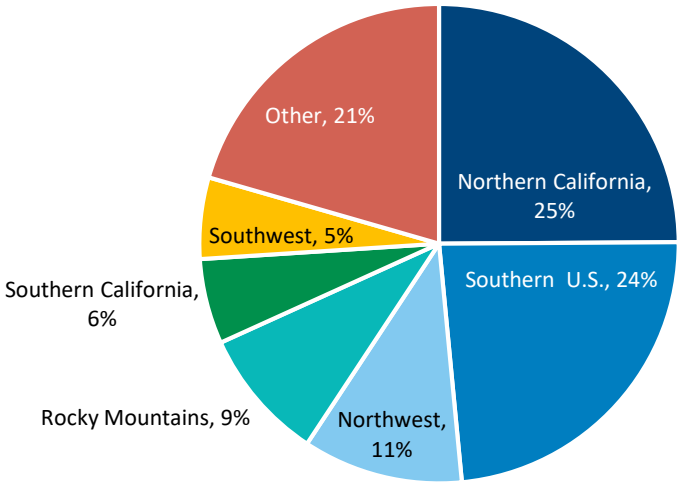
Figure 4: Regional breakdown of lightning forest fires (by number of acres impacted)



Sources: National Interagency Fire Center; TIG Analysis

With respect to human-caused U.S. forest fires on an acreage basis, 25% emanate from Northern California alone, whereas 24% come from the entire Southern U.S. (Figure 5).

Figure 5: Regional breakdown of human-caused forest fires (by number of acres impacted)



Sources: National Interagency Fire Center; TIG Analysis; "Other" includes Alaska, Northern Rockies, and Great Basin

For context, the U.S. has a total land area of nearly 2.4 billion acres.[2] Public timberland ownership tends to be concentrated in the western U.S. while private timberland ownership (corporate, investor, and non-corporate entities such as small, independent landowners) is highest in the U.S. South. The U.S. South, specifically, has by far the largest area of private corporate ownership, including institutional investors.

At the same time, the U.S. West (Washington, Oregon, and California) has a significantly greater proportion of forest fires relative to the U.S. South. Since 2001, around 0.5%-1.0% of the total timberland acres in the U.S. South have been burned annually as compared to around 2.0-3.0% of the total acres in the U.S. West and around 0.08% of the total acres for TIG, which we believe is broadly representative of the loss ratio for many professional timberland managers.[3] In TIG's view, the aforementioned ownership dispersion is one of the primary drivers for the difference in magnitude of forest fires affecting the U.S. South and West, as corporate, investor and privately-owned timberland tends to be more intensively managed versus publicly-owned land. Active management, as practiced on these ownership types, is often far less susceptible to forest fires as a primary goal is to maximize biological growth to achieve a financial return, and consequently risk mitigation and fire prevention receive more financial and operational resourcing. Accordingly, flammable debris is more likely to be monitored and managed by thinning, the process of removing smaller trees from an existing stand while retaining larger, healthier trees, thereby increasing the amount of space between trees and their crowns. Thinning also reduces ladder fuels, vegetation in the understory that allows a fire to climb up to the tree crown. Meanwhile, active management

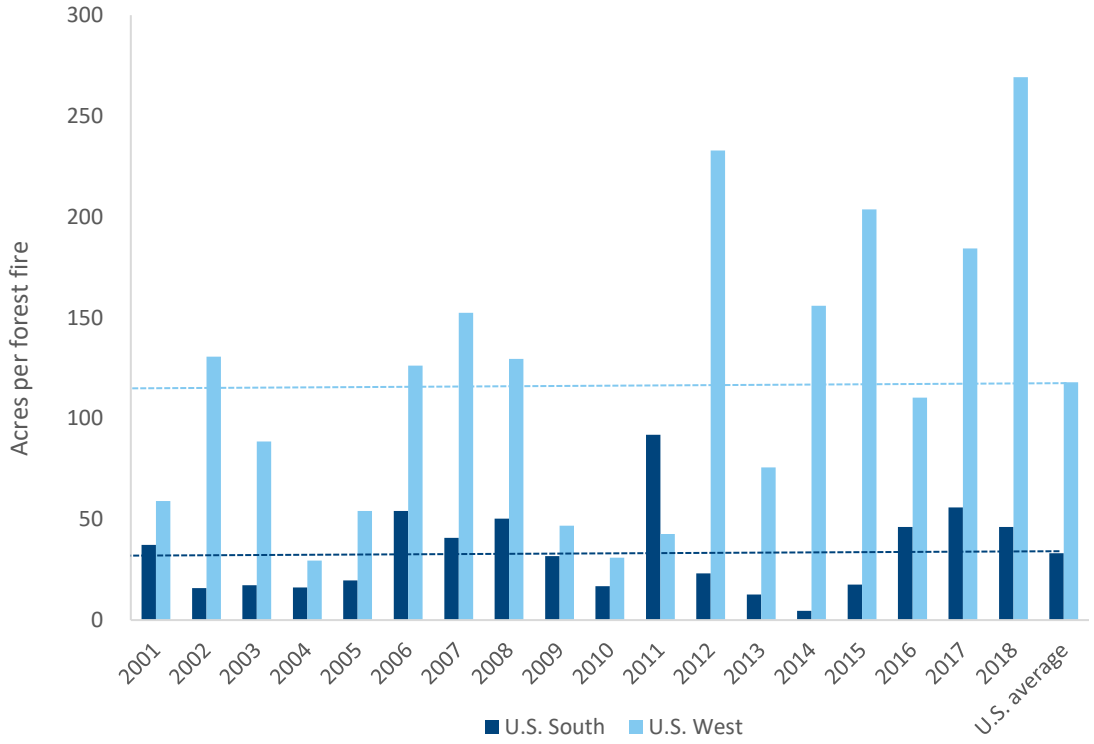
[2] Food and Agriculture Organization, U.S. Forest Resources Assessment 2015
[3] U.S. Forest Service – Forest Resources of the United States; National Interagency Fire Center

periodically allows for whole-stand harvesting (e.g., final felling or clearcutting), which results in the removal of densely populated stands and creates a landscape that minimizes large-scale fire impacts, while maintaining a forest's ecological and environmental integrity (e.g., increasing sunlight which promotes tree health, fewer forest floor disturbances, etc.). Further, active management uses roads to improve forest access and contain potential fires, serving as breaks (natural or constructed barriers used to help combat forest fires) and as a secure location for firefighting in the event of a fire.

Other significant factors driving forest fire occurrence are topography, weather, and population density. In the Northwest, the topography tends to have steeper contours, which can allow fires to grow and spread in a vertical manner, creating challenges to containment. Alternatively, ground in the U.S. South tends to be flatter. Moreover, the Northwest (and U.S. West more broadly) has a greater propensity for dry weather as certain areas receive little to no rain during the summer months versus the U.S. South, which tends to receive summer rain. Further, parts of the Northwest (and U.S. West more broadly) have higher population densities versus the U.S. South, driving the expansion of urban centers into more rural settings and thereby increasing the risk of forest fires.

Since 2001, in aggregate and for the aforementioned reasons, the U.S. South has averaged 33 acres of impact per fire per year while the U.S. West has averaged 118 acres, a factor of ~4x (Figure 6).

Figure 6: Average acres impacted per fire per year



Sources: National Interagency Fire Center; TIG Analysis; 2012 was a particularly challenging year with high to extreme fires occurring in late summer and fall. In July 2012 alone, Southeast Oregon would burn over 1.1 million acres, including the Long Draw fire, which blackened 557,628 acres

Why do Forest Fires Occur?

While forest fires can occur for a myriad of reasons, there are four principle causes in the U.S.: 1) inadequate management regimes, 2) seasonality, 3) climate change, and 4) increase of the wildland-urban interface.

Inadequate Management Regimes

One of the primary causes of U.S. forest fires is the lack of proper management, including a lack of thinning and whole-stand harvesting, a failure to reduce the amount of slash (debris left after logging, thinning, or brush cutting), a lack of fire breaks, non-existent / poor road access, and finally, regulation and litigation. This lack of proper management occurs more notably on publicly-owned land (national forests, parks, state forests, etc.) and unmanaged private land, and much less frequently on actively-managed commercial timberland and other intensively managed private land. In California, fires are 2-3x more common on federally owned land versus non-federally owned land, partly driven by less aggressive fire containment and greater fuel loads (vegetation, underbrush, and other flammable materials) given regulations on timber harvesting and forage removal.[4] Specifically, firefighting on federally-owned land is centered on fire management (e.g., suppression, analyzing risks, time of year, whether fires should be allowed to burn, etc.), which might be considered reactive when compared to active management, thereby typically resulting in larger, longer duration fires.[5]

As mentioned previously, actively-managed timberland is much less susceptible to forest fires as flammable debris is constantly monitored and managed by thinning and whole-stand harvesting, and roads are used to improve forest access and contain potential fires. With unmanaged natural forests, thinning tends to be infrequent given legal, operational, and administrative constraints.[6] In particular, thinning may not be permitted on roadless areas, may not be economically or operationally feasible in distant areas with difficult terrain (e.g., steep ground, smaller trees), and is prohibited in areas with special designations such as sensitive species or riparian buffer zones. Further, whole-stand harvesting is generally not practiced on publicly-owned land given pushback from segments of the environmental non-governmental organization ("NGO") community that have concerns related to environmental impacts from such practices (e.g., potential to reduce habitats, and in some cases, a broad aversion to timber harvesting).

With respect to forest fire prevention, there also appears to be a misalignment of budget incentives.[7] The U.S. Forest Service receives annual dedicated appropriations from Congress to suppress forest fires, which gets supplemented by emergency funding. Yet at the same time, thinning programs and other actions such as prescribed burning (controlled fires) are part of a more limited prevention fund, which typically gets utilized primarily during severe forest fires to pay for firefighting. As such, many natural forests are afforded limited resources for fire prevention, which in turn results in massive fires and then, in order to address those fires, prevention funds are used leaving little, if any, financial resources remaining for prevention.

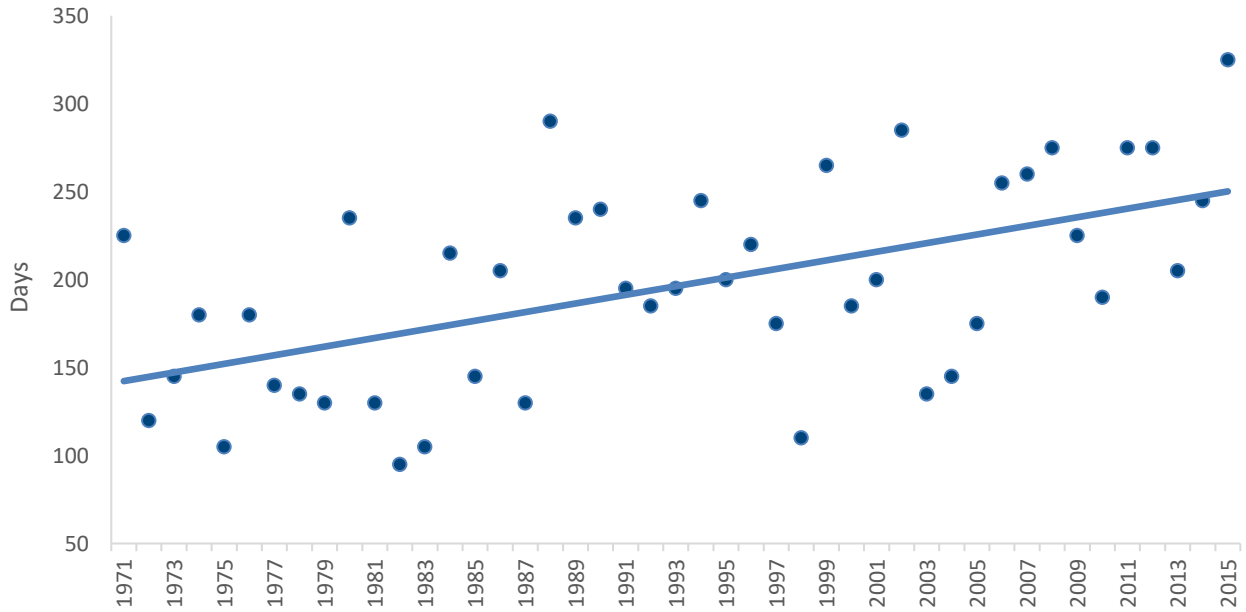
[4] The impact of land ownership, firefighting, and reserve status on fire probability in California - Carlin Frances Starrs et al 2018 Environ. Res. Lett. 13 034025
[5] Fire suppression is a fire management policy that actively involves containing the spread of forest fires for fear of uncontrollable conflagrations
[6] Fire & Fuels Management: Constraints on Mechanized Treatment Significantly Limit Mechanical Fuels Reduction Extent in the Sierra Nevada
[7] Congressional Research Service – Wildfire Suppression Spending: Background, Issues, and Legislation in the 115th Congress

Historically, fire has been a natural part of most seasonally-dry forests in the U.S. and most natural (non-human caused) forest fires were more frequent and lower in intensity. However, there has been a 100+ year policy of fire suppression in the western third of the U.S. (New Mexico to Montana and to the West) which has resulted in forests becoming increasingly dense (with some containing stressed, sick, diseased, and dying trees), thereby contributing to greater amounts of combustible material in the forest and leading to more intense, catastrophic forest fires.[8] This trend has also been exacerbated by climate change, drought, and disease (please refer to the Climate Change section on page 9). Further, as these dense forests deteriorate, increasing amounts of methane ("CH_4"), which is more than 25x stronger than carbon dioxide ("CO_2") over a 100-year period, is released into the atmosphere.[9]

Seasonality

Forest fires can also be caused by seasonality (Figure 7). As one would expect, forest fires are more prone to occur during late summer / early fall, particularly as the weather begins to change. During this period of time in the western U.S., dry winds have the potential to accelerate from the north. In southern California, seasonality is compounded by Santa Ana winds (strong, extremely dry downslope winds emanating from the deserts). On average, around 80-85% of forest fires in California occur between the months of June and September.[10]

Figure 7: Forest fire seasons have extended in the western U.S. since the early 1970s



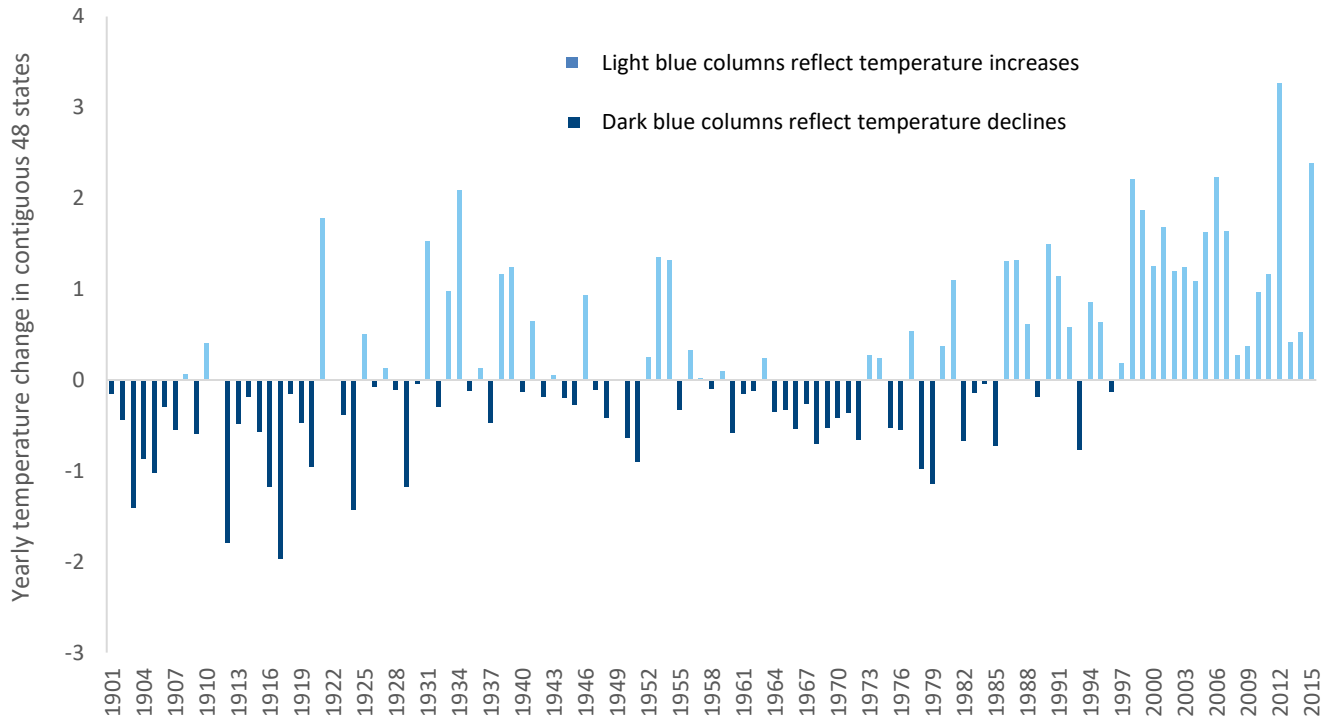
Sources: United States Geological Service; Climate Central; Western U.S. is comprised of California, Washington, Oregon, Arizona, New Mexico, Colorado, Utah, Nevada, Idaho, Wyoming, and Montana

[8] Fire Ecology - The History and Evolution of Wildland Fire Use – Jan W. Van Wagtendonk
[9] U.S. Environmental Protection Agency
[10] California Department of Forestry and Fire Protection

Climate Change

Temperature and weather patterns have also changed over time, impacting the amount and intensity of forest fires, in particular by causing fire seasons to begin earlier and end later than they had historically. In turn, warmer temperatures have resulted in increasing droughts and fires in certain regions have become a significant source of CO_2 and CH_4 emissions, further exacerbating climate change (Figure 8). That said, active timberland management can partially mitigate these sources of climate change as commercial plantations are often more effective at carbon sequestration than older, unmanaged natural forests; trees with faster growth rates can absorb more carbon from the atmosphere than older, slower-growing trees. In unmanaged natural forests, growth rates tend to be slower because trees are typically older, and face a high degree of competition for nutrients and sunlight, hindering their ability to sequester carbon as efficiently as commercial plantations, for example. Moreover, commercial plantations tend to convert salvaged timber (timber damaged from fires, wind, insects, or other events) into wood products, creating yet another carbon sink, whereas salvaged timber in unmanaged natural forests tends to remain on the forest floor and decompose over time.

Figure 8: Annual temperature change in contiguous 48 states



Sources: U.S. Environmental Protection Agency; TIG Analysis

Meanwhile, dry seasons have extended over time, reducing the availability of water, and making forests more susceptible to forest fires. Corresponding reductions in the snowpack (earlier winters / spring snowmelt) have also reduced the flow of streams during the summer and autumn seasons, thereby increasing the likelihood of fires.

Increase of Wildland-Urban Interface

The growth of urban centers has also been a factor influencing the spread of forest fires. As populations have grown, urban centers have expanded beyond their traditional boundaries into historically rural settings, increasing the risk of human-caused forest fires. Between 1940 and 2000, close to 10 million housing units were built in California with the mere presence of additional homes increasing the chance of fires as a large part of housing's materials (e.g., wood shingles, wood shakes, etc.) are flammable.[11] Further, forest fires can spread from house to house due to burning embers traveling through the air.

What Can Be Done to Minimize Forest Fires?

While some of the factors causing forest fires are difficult to control, active timberland management can greatly reduce the risk of forest fires and minimize the degree of damage done to timberland and surrounding property. Such practices include: 1) thinning and whole-stand harvesting, 2) minimizing debris on the forest floor, 3) controlled fires, 4) fire breaks, and 5) road maintenance.

Active timberland management involves proactively managing tree density by thinning stands. Thinning reduces ladder fuels while also reducing stress among the remaining trees, thereby generally making them more resistant to pests, disease, and fire. Moreover, smaller trees tend to be removed and larger trees tend to be more fire resistant given their thicker bark. Generally, larger, older trees tend to have greater survival rates than younger trees especially when contending with low-intensity fires that don't extend into tree crowns. For example, Rocky Mountain Douglas-fir tends to develop fire-resistant bark at around 40 years.[12] Periodic whole-stand harvesting can also be helpful by removing densely populated stands that may be more prone to large-scale fires while maintaining a forest's ecological and environmental integrity. Meanwhile, failure to reduce the amount of slash accentuates forest fires by leaving easily combustible materials in the forest. Removing slash, often done in actively-managed forests, reduces potential flame lengths, making fires easier to control and minimizing the risk that fires reach into the tree crown.

While potentially counterintuitive to those not familiar with its benefits, prescribed burning is another method of reducing fire risk whereby specific stands are carefully burned to reduce the amount of flammable material in the forest and the likelihood of more serious forest fires in the future (this is also done to create wildlife/natural habitats). In recent years, many NGOs and other groups have also become more receptive to the use of prescribed burning. For example, in Georgia, the state created a Prescribed Fire Council comprised of state and federal organizations, NGOs, and private landowners and managers to share information about and seek input on prescribed burning.[13] Prescribed burning often allows for the regeneration of native vegetation and the return of nutrients to the soil, while increasing seedling vitality and eliminating unwanted species or invasive vegetation. Conversely, publicly-owned forests can become increasingly dense relative to commercial plantations, partially due to natural fire suppression contributing to greater amounts of combustible material in the forest and leading to more intense forest fires.

[11] Modeling Residential Development in California from 2000 to 2050 – Integrating wildfire risk, wildland, and agricultural encroachment – M.L. Mann, et al.
[12] U.S. Department of Agriculture - Fire Resistance and Regeneration Characteristics of Northern Rockies Tree Species
[13] Sustainability Report for Georgia's Forests – January 2019

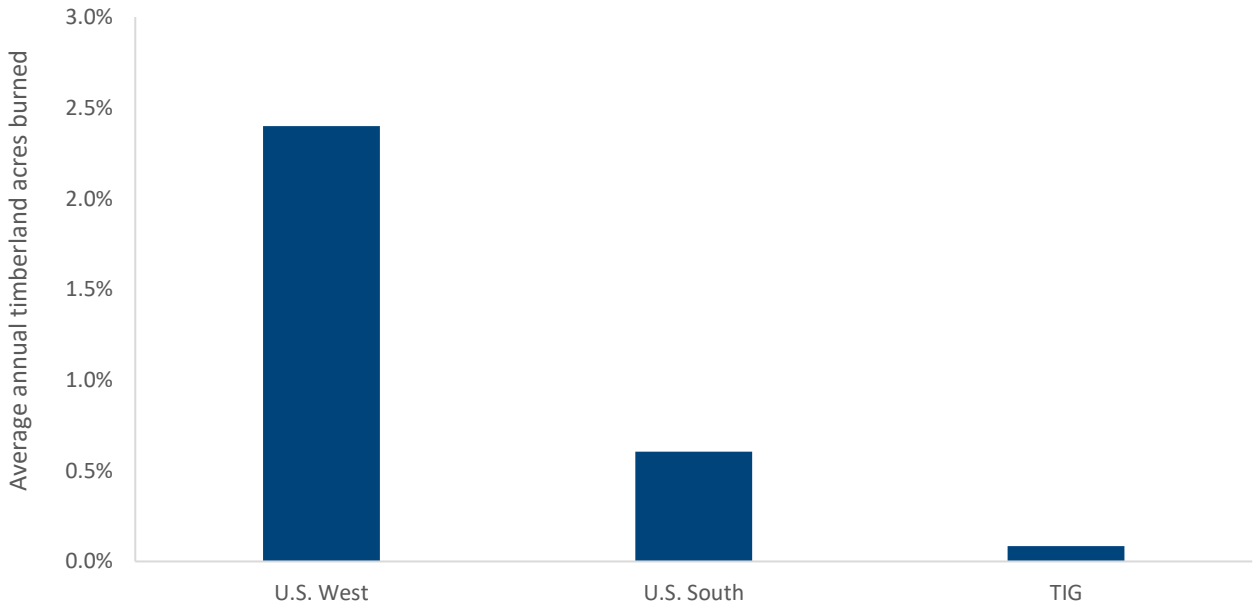
Fire breaks are useful tools to mitigate forest fires by serving as control lines from which to operate in case forest fires occur. These breaks typically don't include any vegetation or combustible materials thereby serving to contain fires within prescribed boundaries. Moreover, such breaks are situated strategically throughout the landscape, typically in a honeycomb pattern along roads and on ridgetops to maximize effectiveness. This network of breaks provides multiple vantage points to address forest fires, affording firefighters safety and the ability to set backfires (a fire that is deliberately set in front of an active fire to consume some of the combustible material and create a fire belt that the forest fire has trouble crossing).

Road maintenance, found in actively-managed timberland, is also a practice that can be used to assist with forest fire prevention. In this regard, one of the most important preventative measures is reducing fuel loads on roads that the public has access to, particularly given the propensity of fires to emanate from such locations. Moreover, not only can roads serve as fire breaks to mitigate the spread of forest fires, but they can also improve forest access, thereby increasing the opportunity for fire containment.

Separately, from an investor vantage point, actively-managed timberland tends to be comprised of non-contiguous multiple tracts, which provide an inherent hedge against fire risk. That said, unmanaged natural forests tend to consist of large continuous blocks that are more fire prone.

Clearly, there is a high correlation between active management and a reduced risk of forest fires. As mentioned previously, since 2001, around 0.5%-1.0% of the total timberland acres in the U.S. South have been burned annually as compared to around 2.0-3.0% of the total acres in the U.S. West and around 0.08% of the total acres for TIG (Figure 9).

Figure 9: Average annual timberland acres burned in publicly-owned vs. actively-managed forests



Sources: National Interagency Fire Center; U.S. Forest Service – Forest Resources of the United States; TIG Analysis

Conclusion

There is a growing consensus around practices that could be implemented to reduce fire impacts and severity from forest fires. Beyond the tragic loss of human life, and significant damage to local, often rural, communities, forest fires can have significant, negative environmental and financial impacts. Notably, the incidence of forest fires is greater on unmanaged land compared to actively-managed timberland. There are four principle reasons why forest fires occur: 1) improper management regimes, 2) seasonality, 3) climate change, and 4) increase of the wildland-urban interface. While some of the factors causing forest fires are difficult to control, active timberland management, as utilized in the management of commercial plantations, can greatly reduce the risk of forest fires and minimize the degree of damage done to timberland and surrounding properties. Such practices include: 1) thinning and whole-stand harvesting 2) minimizing debris on the forest floor 3) controlled fires 4) fire breaks and 5) road maintenance.

Disclaimer

This document has been prepared by BTG Pactual Asset Management US, LLC and BTG Pactual Timberland Investment Group, LLC (collectively, "BTG Pactual") for the exclusive use of the party to whom BTG Pactual delivers this material (together with its subsidiaries and affiliates, the "Company") using information provided by the Company and other publicly available information. This material does not constitute a Research Report according to Regulation AC, FINRA Rule 2241 and 2242 and should not be considered as such. Although the information herein is believed to be reliable and has been obtained from sources believed to be reliable, as of the date on which this material was issued and obtained from public sources, neither BTG Pactual nor any of its affiliates makes any representation or warranty, expressed or implied, with respect to the fairness, correctness, accuracy, reasonableness or completeness of the information and opinions. Prices in this material are believed to be reliable as of the date on which this material was issued and are derived from one or more of the following: (i) sources as expressly specified alongside the relevant data; (ii) the quoted price on the main regulated market for the security in question; (iii) other public sources believed to be reliable; or (iv) BTG Pactual's proprietary data or data available to BTG Pactual. BTG Pactual has no obligation to update, modify or amend this material and communication or to otherwise notify a recipient in the event that any matter stated herein, or any opinion, projection, forecast or estimate set forth herein, changes or subsequently becomes inaccurate. All and any information, opinions and amount indicated are subject to change, without prior warning. Any estimates or projections as to events that may occur in the future (including projections of revenue, expense, net income and stock performance) are based upon the best judgment of BTG Pactual from the information provided by the Company and other publicly available information as of the date of this material. Certain information contained in this material constitutes forward-looking statements, which can be identified by the use of forward-looking terminology such as "may," "will," "should," "expect," "anticipate," "target," "project," "estimate," "intend," "continue," or "believe," or the negatives thereof or other variations thereon or comparable terminology. The analysis contained herein, as projections, scenarios, investments, etc. are based on numerous assumptions. Different assumptions could result in materially different results. Additional information relating to the financial instruments, models, projections and scenarios discussed in this material are available upon request. There is no guarantee that any of these estimates or projections will be achieved. Actual results may vary from the projections and such variations may be material. The figures contained in performance charts refer to the past; past performance is not a reliable indicator of future results. BTG Pactual does not undertake that investors will obtain profits, nor accept any liability for any investments losses. Performance information and/or results, unless otherwise indicated, are un-audited and their appearance in this material reflects the estimated returns net of all expenses, including the management and performance fees. Past performance is not indicative of future results. Due to various risks and uncertainties, actual events or results or the actual performance of the investments described herein may differ materially from those reflected or contemplated in such forward-looking statements. This material reflects the economic conditions at the time it was created and there is no guarantee that any future transaction will be under the same economic levels specified here. BTG Pactual expressly disclaims any and all liability relating or resulting from the use of this material. BTG Pactual makes no warranty or representation, whether express or implied, and assumes no legal liability for the accuracy, completeness or usefulness of any information contained herein. BTG Pactual does not accept any responsibility or liability whatsoever caused by any action taken in reliance upon this material and/or its attachments. Neither BTG Pactual nor any of its affiliates, nor any of their respective directors, employees or agents, accepts any liability for any loss or damage arising out of the use of all or any part of this report. Any opinion and/or projection in this material is related to the authors opinions; and do not represent the BTG Pactual institutional opinion. This material has been prepared solely for informational purposes and is not to be construed as a solicitation, offer, invitation or inducement to buy or sell any securities or related financial instruments. Any such offer or solicitation may only be made by means of delivery of an approved offering memorandum and only in those jurisdictions where permitted by law. The Company should not construe the contents of this material as legal, tax, accounting or investment advice or a recommendation. Before making an investment decision, investors are advised to (i) obtain independent financial advice on their own particular circumstances; (ii) thoroughly and carefully review the offering memorandum with their financial, legal and tax advisers to determine whether an investment such as this is suitable for them. This material does not purport to be all-inclusive or to contain all of the information that the Company may require. This material should not be the only source of information in any investor's decision-making process. In all cases, investors should conduct their own investigation and analysis of such information before taking or omitting to take any action in relation to securities or markets that are analyzed in this report. The material should not be regarded by recipients as a substitute for the exercise of their own judgment. Investors are advised to carefully analyze all information and its risks vis-à-vis their personal objectives and its risk profile ("Suitability"). Nothing in this material constitutes a representation that any investment strategy or recommendation contained herein is suitable or appropriate to a recipient's individual circumstances or otherwise constitutes a personal recommendation. An investment in the products described is not suitable for all investors. The information contained herein does not take into account the particular investment objectives or financial circumstances of any specific person who may receive it. BTG Pactual assumes that by acceptance of this material and/or attachments that the recipient understands the risks involved – including the loss of some or all of any investment that the recipient or the entity that he/she represents. Investments involve risks and investors should exercise prudence in making their investment decisions. If a financial instrument is denominated in a currency other than an investor's currency, a change in rates of exchange may adversely affect the value or price of or the income derived from any security or related instrument mentioned in this report, and the recipient of this report assumes any currency risk. The physical assets are subject to nature events, weather damage, fire or market changes that can impact the property and returns. BTG Pactual, its subsidiaries and/or employees may hold long or short positions, trade on their own behalf, coordinate or manage transactions or offerings involving issuers discussed herein or make any other relevant investment. BTG Pactual and its affiliates have in place arrangements to manage conflicts of interest that may arise between them and their respective clients and among their different clients. Business areas within BTG Pactual and among its affiliates operate independently of each other and restrict access by the particular individual(s) responsible for handling client affairs to certain areas of information where this is necessary in order to manage conflicts of interest or material interests. BTG Pactual and its affiliates are involved in a full range of financial and related services including banking, investment banking, private equity and the provision of investment services. As such, BTG Pactual or its affiliates may have a material interest or a conflict of interest in any services provided to clients by BTG Pactual or such affiliate. This material has been prepared on a confidential basis solely for the use and benefit of the Company; provided that the Company and any of its employees, representatives, or other agents may disclose to any and all persons, without limitation of any kind, the tax treatment and tax structure of the transaction and all materials of

any kind (including opinions or other tax analyses) that are provided to the Company relating to such tax treatment and tax structure. Distribution of this material to any person other than the Company and those persons retained to advise the Company, who agree to maintain the confidentiality of this material and be bound by the limitations outlined herein, is unauthorized. This material is approved and issued by BTG Pactual; reproduction or transcription of this material by any means, in whole or in part is strictly prohibited, without BTG Pactual's prior written authorization, and BTG Pactual accepts no liability whatsoever for the actions of third parties in this respect.

This report is not directed at you if BTG Pactual is prohibited or restricted by any legislation or regulation in any jurisdiction from making it available to you. If you are not the intended recipient of this document, you are hereby notified that disclosing, copying, distributing or taking any action in reliance on the contents of this document is strictly prohibited.

If you have any questions or wish to no longer receive these research report distributions, please email us at the address below:
BTGPactual.TimberlandResearchDistrib@btgpactual.com