# Long-term forest health implications of roadlessness

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LETTER

# Long-term forest health implications of roadlessness

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## Abstract

The 2001 Forest Service Roadless Rule prohibits roadbuilding in forests across an area equivalent to the combined states of New York and Maine (236 000 km$^2$). There have been recent assertions that roads are needed to prevent fire and to keep forests healthy. Despite twenty years of ongoing forest health monitoring and the unique scope and ecological significance of this network of roadless areas, there has to date been no integrated assessment of the relationship between roads and forest health. Here, this question was addressed by synthesizing different sources of nationally consistent, longitudinal monitoring data. Agency management records show that a lack of roads has not stopped fire prevention measures; fuel management activities in roadless areas have actually been more numerous on a per-square kilometer basis than elsewhere in the National Forest System, although activities in areas with roads cover larger areas. Historical fire maps indicate that forests with and without roads have burned at similar rates since the Rule took effect. The apparent neutrality of roads with respect to fire occurrence may be due to higher rates of human caused ignition near roads offsetting advantages related to more agile positioning of fire-fighting assets. Beyond the fire dimension of forest health, analysis of over 15 000 inventory plots showed that while tree root disease is only weakly correlated with proximity to roads, roads are strongly associated with the spread of invasive plant species in national forests. Non-native plants are twice as common within 152 meters (500 feet) of a road as farther away. Speculation that eliminating road prohibitions would improve forest health is not supported by nearly twenty years of monitoring data.

## 1. Introduction

The 2001 Roadless Rule (36 CFR Part 294) established prohibitions, with limited exceptions, on road construction and other management activities on 236 000 square kilometers of Inventoried Roadless Areas (IRAs) across the US National Forest System (NFS). The Rule's intent was to provide lasting protection for these areas in the context of multiple-use management (USDA 2001). The Rule added protection for low- and mid-elevation forests not well represented in existing National Parks, Designated Wilderness Areas, and Wildlife Refuges (Develice and Martin 2001, Crist *et al* 2005). IRAs are often relatively close to population centers, and they can provide critical habitat connectivity between wilderness areas (Belote *et al* 2016).

There have been several recent proposals to repeal or amend the Roadless Rule, particularly in the western states that contain the majority of inventoried roadless areas. In 2018, the US Secretary of Agriculture directed the Forest Service to initiate state-specific rulemaking for roadless area management in the Tongass National Forest in Alaska. State-specific rules have already been developed in Idaho and Colorado. In February of 2019, the state of Utah submitted a petition to the Department of Agriculture for the development of a Utah-specific replacement of the Rule, proposing to broaden the range of permissible management actions in many areas (Utah 2019). The reasoning behind this petition highlighted areas where 'the Roadless Rule has prevented the Forest Service from using the tools they need to promote the healthy, resilient forests that the Roadless Rule was meant to protect.' While Utah and the Forest Service have since entered into a shared stewardship agreement intended to address the state's concerns without involving the rule-making process, the petition remains open pending results of collaborative stewardship activities.

A key rationale in the Utah case is an assumption that forest management, and by extension a network of roads, is critical for maintaining forest health. This idea represents a broad challenge to roadless management in general and the Roadless Rule in particular. The agency's required use of the best available science (77 FR 21161) motivates a review of the Roadless Rule's implementation and impact with respect to forest health. Relevant long-term inventory and Agency management records do exist, but there has to date been no comprehensive evaluation of how roadbuilding restrictions have affected forest health management. This paper uses twenty years of nationally consistent monitoring data to assess the degree to which roads are really needed for the maintenance of healthy forests.

Specifically, Forest Service monitoring data is used here to evaluate: 1) how roads are correlated with fuel treatment and fire activity, as well as; 2) how roads are related to the spread of root disease and invasive species. The length of the fire season and the area affected by fire has increased in the United States in recent years (Cattau *et al* 2020), and since roads facilitate activities like fuel reduction and fire suppression, one might presume that there are substantially higher rates of fire in IRAs. While the location of a single fire can be considered random, studying all fires across all NFS forests over a period of decades informs us of overall fire risk both inside and outside the roadless network.

At the same time, there are other dimensions of forest health that one might expect to deteriorate in the presence of roads because of the potential role of human transport in spreading pathogenic agents. There is some evidence at local scales that roads facilitate the spread of both root disease fungus and invasive plant species. For example, Hessburg *et al* (2001) found black stain root disease (caused by the fungus *Leptographium wageneri* (Kendr.)) to be more common adjacent to roads and major skid trails than in the forest interior. Roads are also widely considered an important vector for Port Orford root disease, caused by *Phytophthora lateralis* (Tucker and Milbrath) (Goheen *et al* 2012). Several studies have found links between roadways and occurrence of invasive plants (e.g. Mortensen *et al* 2009, Joly *et al* 2011). These forest health problems are evaluated here as a function of distance from roads, using Forest Service national forest inventory data that are commonly the basis for broad-scale assessments across NFS (Wurtzebach *et al* 2019, Hoover *et al* 2020). It is expected that two decades of national-scale forest monitoring should clarify the impact of roads on individual health factors and inform discussion of the ecological implications of managing forests without roads.

## 2. Methods

### 2.1. The roadless rule and fire

There are several activities that forest managers may perform to diminish fire hazard by reducing or rearranging fuel material. While roads clearly facilitate most such activities, fuel treatment is not prohibited under the Roadless Rule (USDA 2001). Given questions about how the Rule may limit forest management, it is of interest to ask how much fuel treatment has taken place in IRAs since 2001. The Forest Service maintains a spatially referenced management activity record that can be used to compare fuel reduction efforts inside and outside of IRAs (USDA 2019a). This record is called the Forest Service Activity Tracking System, or 'FACTS.' The number and area of activities related to fuel treatment between 2001 and 2019 was queried, focusing upon the following activity types: prescribed broadcast burning; burning of piled material; chipping of fuels; compacting/crushing of fuels; fuel break; grazing and range management for hazardous fuel reduction; piling of fuels; pruning to raise canopy height; range piling slash; rearrangement of fuels; thinning for hazardous fuel reduction; underburn; and, yarding (removal of fuels by carrying or dragging). Activities were differentiated using IRA boundaries, accounting for recent changes in Colorado and Idaho (USDA 2019b).

The Monitoring Trends in Burn Severity project (MTBS; (Eidenshink *et al* 2007)) is a national, spatially explicit database that can tell us if fires are indeed more common in IRAs, as one might assume given reduced access for fire suppression. The areas of MTBS fire polygons from 1985 to 2016 (the years for which fire history is currently available) were summed inside and outside of IRA boundaries on National Forest land. Burn extent was subset for this analysis to only include areas of tree cover from any date since 2001 (omitting grassland and shrubland), using the National Land Cover Dataset (Homer *et al* 2015), and fire totals were recorded by level of mapped severity (unburned or underburned, low severity, moderate severity, and high severity).

### 2.2. Invasive species, root disease, and distance to roads

Systematic inventory data can support a data-driven assessment of the occurrence of invasive species and root disease as a function of distance from a road. The Forest Service Forest Inventory and Analysis Program (FIA) maintains a network of randomly located inventory plots across the United States at a nominal density of one plot per 2428 hectares. Distance from the nearest road is recorded in eight categorical bands, the largest of which is farther than 8.05 kilometers (5 miles). While FIA data have supported broad- and

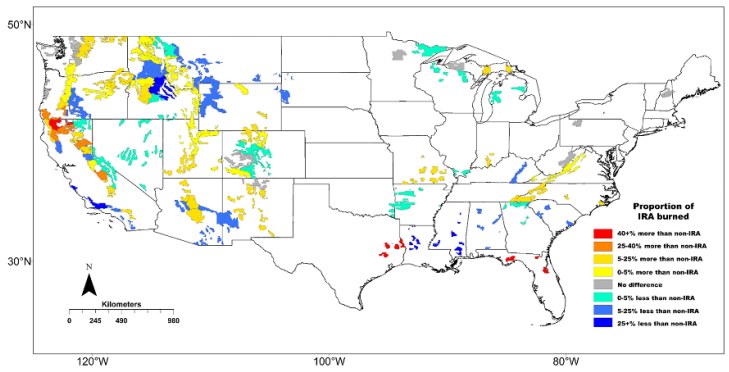


**Figure 1.** The difference in proportion of tree cover area affected by fire, summed annually across 1985–2016, inside and outside IRAs on national forest units. Units with no recorded fire are included in the gray 'no difference' category.

local-scale assessments of invasive species and root disease (Oswalt *et al* 2015, Healey *et al* 2016), this is among the first uses (see Riitters *et al* 2018) of that dataset to understand forest health effects of roads.

Since FIA's plots comprise a designed sample, estimation and calculation of standard error is straightforward, as described by Bechtold and Patterson (2005). The proportion of forests affected by both root disease and invasive species in each of the distance-to-road categories, and the standard error of each of these estimates, was calculated. The list of species considered invasive by FIA (and analyzed here) varies by state, and includes a range of woody, herbaceous, and grass species. While FIA is a national program, availability for some variables is only regional. Root disease measurements (occurrence and classification into severity classes within 15.25 meters of the plot) is evaluated only in the NFS Northern Region (national forests in Montana, Northern Idaho, and a small part of Eastern Washington). FIA records invasive species on all plots, but regional differences currently make it feasible to evaluate the effects of roads on only 9 Western states (Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, Wyoming). These states contain approximately 65% of all IRAs. FIA-based estimates of occurrence of root disease and invasive species on national forests (with sampling errors) were created for the above areas as a function of distance to road. These estimates were based upon 3669 and 15 267 randomly located inventory plots for root disease and invasive species, respectively.

## 3. Results and discussion

Between 1985 and 2016 (the years for which national fire boundaries are currently available), forests in roadless areas burned at similar frequencies as the rest of the NFS. Over 31 years, recorded fires cumulatively covered 19.0% of forests in the current roadless areas, compared to 17.7% of all other NFS forest cover. The severity class with the largest difference was high-severity fire, which burned 5.0% of all IRA forest areas (652 000 out of 13 million hectares) compared to 3.2% of non-IRA national forest land (1 591 000 out of 50 million hectares).

Even at the scale of individual national forests, where a single fire might substantially affect the comparison, almost half (47%) of units experienced similar (± 5%) cumulative fire occurrences inside and outside of IRAs (figure 1). The degree to which IRAs burn more or less frequently than other forests is relatively balanced within and across regions (figure 1). The national-level approximate balance between fire inside and outside IRAs was therefore not the result of trends in one region negating opposite trends in another.

The finding of historically similar rates of fire in national forest areas with and without roads echoes analysis of fire occurrence across different levels of protected status (Bradley *et al* 2016), and it challenges the assertion that roads must be built to reduce fire risk. While roads allow more agile positioning of firefighting assets, they are also the site of high rates of human-caused ignition (Narayanaraj and Wimberly 2012), which account for 84% of US wildfires (Balch *et al* 2017).

This tradeoff (better firefighting, more human-caused fires) partially explains why the presence of roads is relatively neutral with respect to the long-term occurrence of fire in national forests. Management records also indicated that a lack of roads did not prevent fuel reduction efforts in IRAs between 2001 and 2019. IRAs contain approximately 21% of the total tree cover across NFS (Homer *et al* 2015); those areas accounted for 34% of the total fuel treatment activities and 8% of the total area treated (USDA 2019a). A lack of roads in IRAs has not implied passive fire risk management.

While IRAs have burned at approximately the same rate as the rest of NFS in the twenty years since the Rule was implemented, it is important to

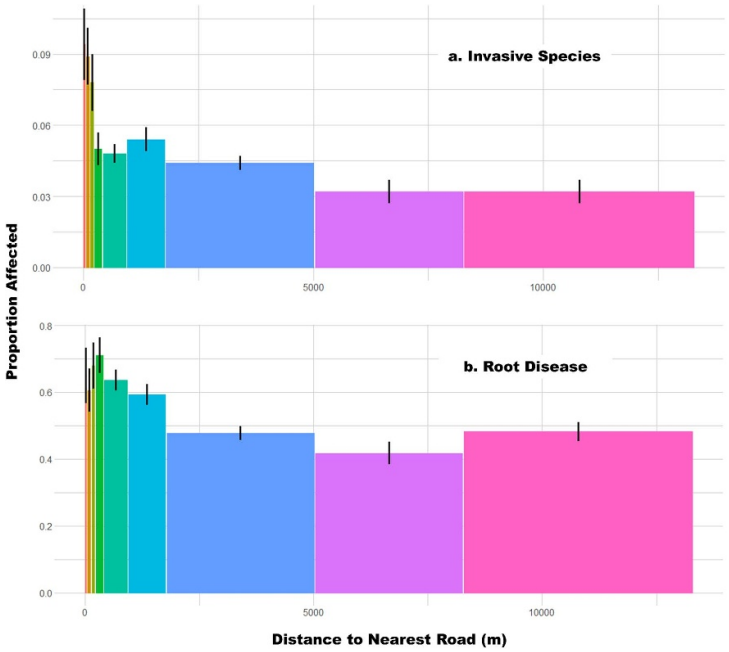


**Figure 2.** FIA estimates, with standard errors, for: the occurrence of invasive species on national forests in nine western states (a); and, the occurrence of root disease in national forests in Montana and Idaho (b).

look at other dimensions of forest health. The ecological effects of fire tend to be transient; most western tree species are adapted to either survive fires or to rapidly re-colonize burned areas. Other effects of roads, as observed in streambed sediment loads (Al-Chokhachy *et al* 2016) and wildlife movement patterns (Shepard *et al* 2008), are more permanent.

This analysis of extensive inventory data on western national forests suggested that road networks are not closely correlated with the occurrence of root disease. Root disease infection may be slightly higher within approximately 1.6 kilometers of roads (figure 2(b)), but results do not point to roads as drivers of root disease at the landscape level. This agrees with earlier regional studies that identified host distribution and local site factors as the primary determinants of root disease spread (Byler *et al* 1990).

The link between roads and invasive species, by contrast, was definitive across national forests in the nine states surveyed (figure 2(a)). At present, there seems to be an envelope of approximately 152 meters (500 feet) around roads in national forests where invasive species risk is significantly higher. Collapsing the distance categories in figure 2(a) using FIA estimation procedures, 8.6% (±1.4% Standard Error) of the land within 152 m of a road was the site of at least one inventoried invasive species, compared to 4.3% (±0.4%) beyond that distance. This corroborates observations from more local studies of the importance of roads to the spread of non-native plant species (Flory and Clay 2006).

As invasive populations radiate over time from current positions near roads, this threshold and the overall presence of invasive species are likely to rise. Invasive species can inhibit regeneration of native species (Oswalt *et al* 2007), affecting both economic and ecological services provided by the forest. There is also potential for a cross-over of forest health issues: invasive grasses usually increase fire frequency, and some invasive woody species can increase the risk of high-intensity fire (Mandle *et al* 2011).

Forest health risks exist across the National Forest System and elsewhere (Krist *et al* 2014), and good management can mitigate those risks. However, a lack of roads in IRAs has neither prevented fuel treatment nor led to substantially more fire. At the same time, collateral road effects such as the spread of invasive plant species pose long-term threats to ecosystem health. Continued comprehensive monitoring will be important in ongoing assessment of the Roadless Rule and other federal land management policies.

## 4. Conclusion

Policy decisions depend upon a variety of economic and social factors not considered here. For instance, debate about economic development in Alaska was central to Roadless Rule discussions in that state. Recent suggestions that roads are needed to maintain forest health present an inherently ecological and potentially broader challenge to the idea of managing federal roadless forests. This study found that, when considered across the entire National Forest System over a long period of time, fire risks are approximately equal inside and outside of roadless areas. Further, inventory data suggest that roads are key to the spread of invasive plant species, a long-term threat to the function and composition of federal forests.

With the benefit of twenty years of monitoring, the best available records do not support speculation that roads are needed in IRAs to maintain forest health.

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## Competing interests

The author declares no competing interests.

## Data availability statement

The data that support the findings of this study are available upon reasonable request from the authors.

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