

Spread of Invasive Plants From Roads to River Systems in Alaska: A Network Model

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Abstract

Alaska has relatively few invasive plants, and most of them are found only along the state's limited road system. One of the most widely distributed invasives in the state, *Melilotus alba* Medik., or sweetclover, has been sown both as a forage crop and as a roadside stabilization species. *Melilotus* has recently been found to have moved from roadsides to the flood plains of at least three glacial rivers. This species has aggressively colonized the lower Stikine River flood plain and occurs there in dense, monospecific stands. It is at an earlier stage of colonization of the Matanuska River and Nenana River flood plains as well. We are developing a network model to examine the spatial relationships among roads, river crossings, and downstream public lands of high conservation significance in interior and south-central Alaska. In 2005 and 2006, we documented the distribution of *Melilotus* on roadsides and near river crossings in this part of the state; we present these data combined with other records of *Melilotus* distribution downloaded from the Alaska Exotic Plant Information Clearinghouse database. When considered together, the distribution data and the network model identify certain road-river interfaces as critical control points for preventing the movement of *Melilotus* toward public land downstream. To illustrate how the model might be used by land managers, results are presented for major crossings upstream of the Kanuti National Wildlife Refuge. When complete, the network model will function as a generally applicable tool to identify the critical control points upstream from land under various ownerships and

for any future invasive species that can disperse via roads and river networks in Alaska.

Keywords: Invasive plants, Alaska, modeling, networks, roads.

Introduction

Alaska has relatively few invasive plants. The state's isolation, lack of development, and cold climate limit the introduction and success of many invasive species. Invasive species often disperse along road networks (Gelbard and Belnap 2003; Koch and Smith, this volume; Lugo and Gucinski 2000; Parendes and Jones 2000), and Alaska has only 0.02 miles of road per square mile of land area, compared to California's 1.08 miles (Jeff Roach. 2002. Personal communication. Alaska Department of Transportation, 2301 Peger Rd., MS-2550, Fairbanks, Alaska 99709).

Melilotus alba Medik., or sweetclover, has recently become a species of concern in Alaska. *Melilotus* has been grown as a crop in some parts of the state and used in a number of mining and industrial area reclamation efforts. *Melilotus* is widely distributed along roadsides around Alaska, a result of both intentional sowing as a roadside stabilization species, and unintentional transport of seed via contaminated soil and gravel. In recent years, *Melilotus* appears to be spreading rapidly along these roadsides. *Melilotus* has been found on roadsides in Denali National Park and Preserve and near several other national parks in Alaska, lands of unquestionably high conservation value (Densmore and others 2001).

Melilotus has been found on several glacial flood plains. It has aggressively colonized the flood plain of the lower Stikine River in southeast Alaska, the lower Matanuska River in south-central Alaska, and portions of the middle and lower Nenana River in interior Alaska (Figure 1). On all three flood plains, *Melilotus* is a major component of the vegetation on recently deposited silt and gravel bars. Although the sources of these populations aren't known for certain, it's likely that *Melilotus* spread onto the flood plains from roads, mines, and agricultural developments upstream. There are vast areas of glacial silt flood plain in interior



Figure 1—The map of Alaska shows the flood plains of three rivers (the Stikine, the Matanuska, and the Nenana) known to have been colonized by *Melilotus alba*. The Nenana is a tributary of the Tanana, which, in turn, is the largest tributary of the Yukon.

Alaska. For example, about 40 percent of the entire Yukon Basin is drained by glacial melt-water dominated rivers (Brabets and others 2000; Paul Schuster. 2006. Personal communication. USGS, National Research Program, 3215 Marine Street, Suite E-127, Boulder, CO 80303). Though many of Alaska's most valuable public lands are located off the road system, they may be vulnerable to invasion by species that gain access to river flood plains from upstream roadside environments.

This project has two objectives. The first is to document the current distribution of *Melilotus alba* on roadsides and on river flood plains near bridges in interior and south-central Alaska. The second is to develop a network model to examine the spatial relationships among roads, rivers, and public lands of high conservation value in the same part of the state. We use the *Melilotus* distribution data as a case

study in the application of the network model, focusing on major crossings upstream of the Kanuti National Wildlife Refuge as an example of how land managers might use model output to prevent the introduction of new invasive plants to the lands they manage.

Methods

Case Study Using *Melilotus alba*

In 2005 and 2006, we surveyed 1,780 miles of eight major highways in interior and south-central Alaska for *Melilotus alba*. These surveys focused on two areas: roadsides and major river crossings. For the roadside surveys, we stopped every 10 miles at State of Alaska Highway milepost markers, and recorded whether or not *Melilotus* was visible on the roadside. We included both sides of the road and as far as we could see in either direction in these rapid

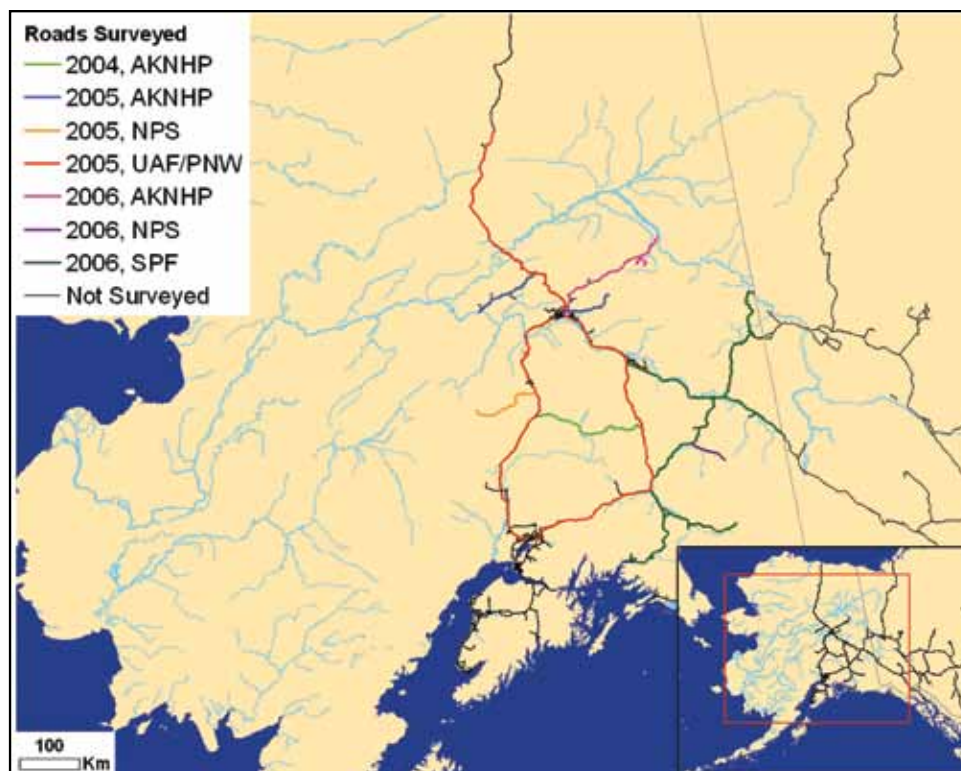


Figure 2—Alaska highways surveyed for *Melilotus alba* between 2004 and 2006. AKNHP = Alaska Natural Heritage Program, NPS = National Park Service, UAF/PNW = University of Alaska Fairbanks/USDA Forest Service, Pacific Northwest Research Station, SPF = USDA Forest Service, State and Private Forestry.

assessments. We acquired *Melilotus* distribution data for several additional highways from the Alaska Exotic Plant Information Clearinghouse database (Alaska Natural Heritage Program, n.d.) (Figure 2).

In addition, we surveyed for the presence or absence of *Melilotus* at 192 major crossings along these highways. We did not survey other types of road-river interfaces (see below). At each crossing, we recorded the presence or absence of *Melilotus* on the roadside immediately adjacent to the bridges and on natural flood-plain surfaces below and in the vicinity of the bridge. We considered both upstream and downstream flood-plain surfaces in making the flood-plain assessments.

We characterized each downstream flood-plain surface in the vicinity of the bridge on its apparent vulnerability to invasion by *Melilotus*, based on our observations of the rivers shown in Figure 1. For example, densely vegetated surfaces were given a score of low, whereas bare silt or

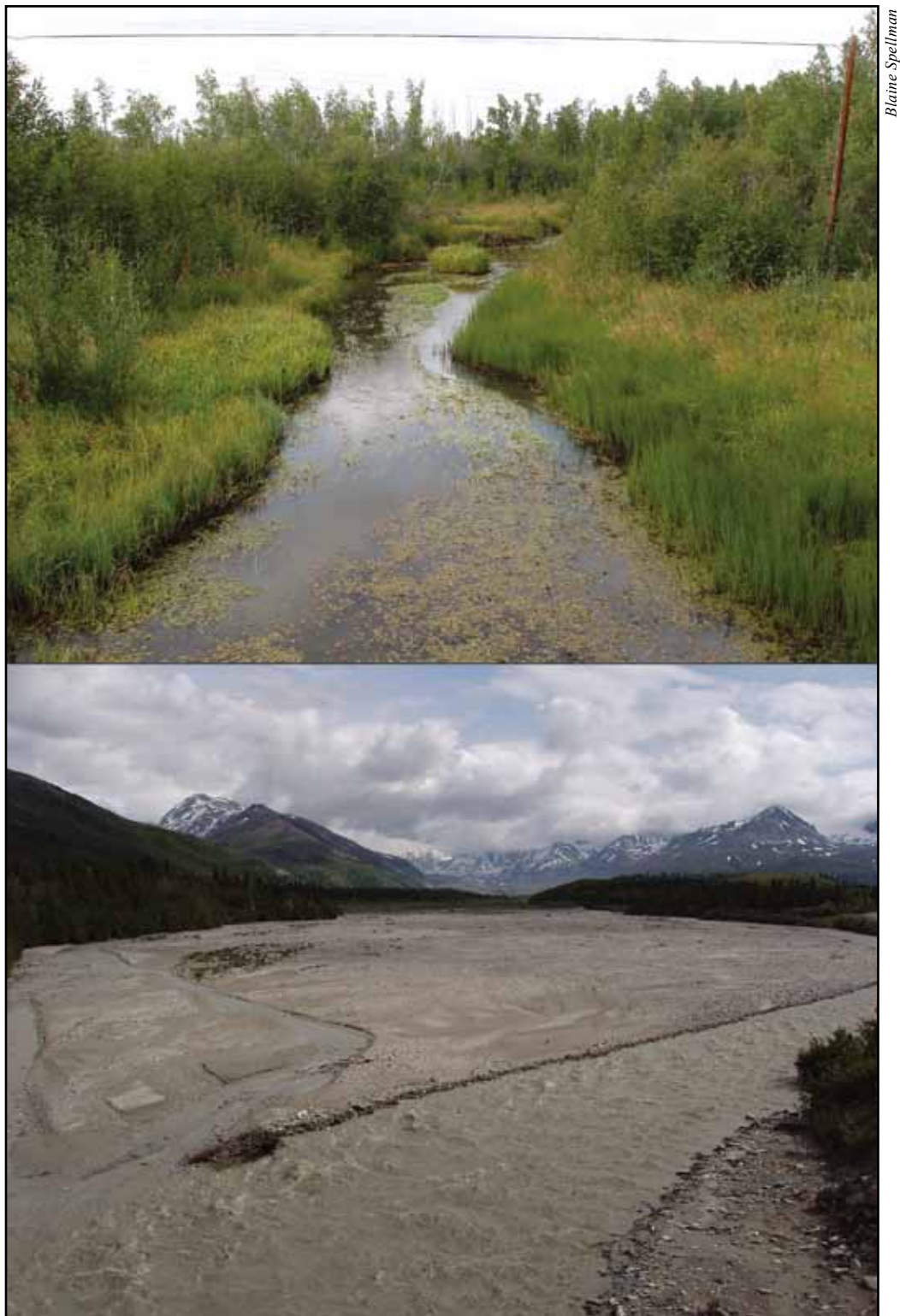
gravel flood plains were considered high in their vulnerability to invasion (Figure 3).

Network Model

The network model examines spatial relationships among roads, river networks, and public land in interior and south-central Alaska. Our analysis is supported by several geographic information system (GIS) data layers. The river network is modeled using the National Hydrography Data set (USGS 1999); the Alaska Department of Transportation global positioning system (GPS) centerline data set provides a detailed road network (Alaska DOT 2006); and the boundaries of federal and state lands were obtained from an Administrative Boundaries data set (Alaska DNR 2001).

National Hydrography Data Set (NHD)

The NHD is managed by the U.S. Geological Survey (USGS) and Environmental Protection Agency (EPA). It



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Figure 3—Flood plain vulnerability to invasion is shown in these examples of flood plains characterized as having low vulnerability to invasion by *Melilotus alba* (top) and as being highly vulnerable to invasion by *Melilotus* (bottom). The top photo shows Fish Creek at the Parks Highway Crossing; the bottom photo shows Lower Miller Creek at the Richardson Highway Crossing.

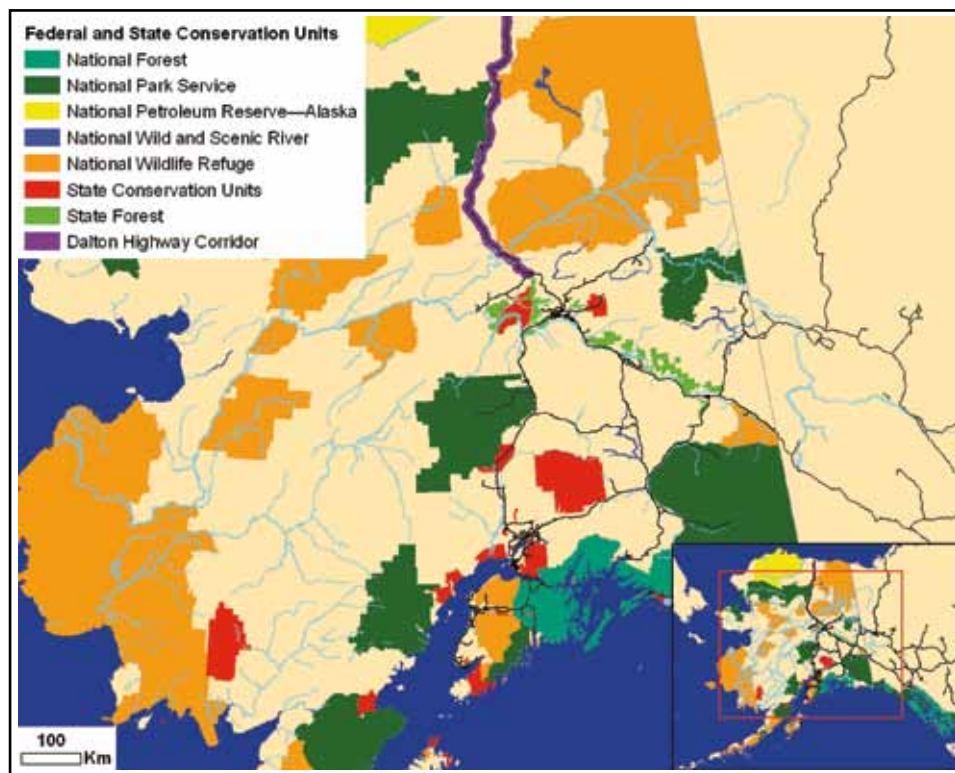


Figure 4—Land classification boundaries identified on the Administrative Large Parcel Boundaries data set from Alaska Department of Natural Resources. We selected parcel types to include in our model by reviewing the agency affiliations of land managers who have been active in Alaska's Committee for Noxious and Invasive Plant Management (CNIPM) over the last few years.

is a comprehensive set of digital spatial data that contains information about surface water features such as lakes, ponds, streams, rivers, springs, and wells. Within the NHD, surface water features are combined to form reaches, which provide the framework for linking water-related data to the NHD surface water drainage network. These linkages make it possible to analyze and display these water-related data in upstream and downstream order (USGS 1999). We started with the assumption that all migration of invasive plants on the river system would be downstream. We then used the NHD as our base layer for river networks because it covers the entire state at a fine scale (1:63360), and also incorporates flow network information allowing us to efficiently identify all river reaches downstream from individual road crossings.

Road Network

There is no comprehensive road network data set available for Alaska, but the Alaska Department of Transportation

(ADOT) provided a draft version of a new GPS road center-line network. It covers the contiguous highway system plus Kodiak and Cordova. Some roads are not included in this data set—for example, the Denali National Park road, State of Alaska-administered logging roads, and private roads—but these road data are the best currently available.

Public Conservation Units

We began with the land classification boundaries identified on the Administrative Large Parcel Boundaries data set from December 20, 2001, produced by the Alaska Department of Natural Resources (Alaska DNR 2001) (Figure 4). We selected parcel types to include in our model by reviewing the agency affiliations of land managers who have been active in Alaska's Committee for Noxious and Invasive Plant Management (CNIPM) over the last few years. Managers who are already aware of and concerned about invasive plants on the public lands they manage may be most likely to benefit from the information provided by

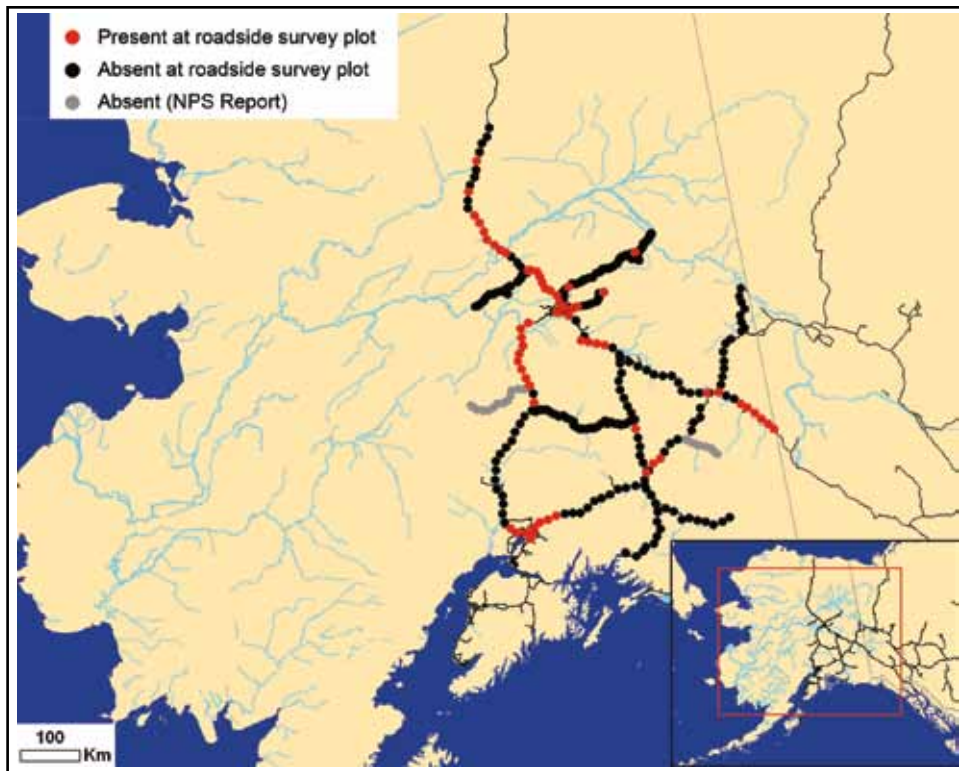


Figure 5—Distribution of *Melilotus* on roadsides, 2004–2006. Most of these data were collected at milepost markers spaced 10 miles apart.

this work. We refer to that list of parcel types in aggregate as conservation units. Land management objectives and agency attitudes and approaches toward invasive species differ widely among these conservation units.

Road-River Interfaces—

The interface between roads and rivers (or streams) can take several forms. Roads can cross, run parallel to, and dead-end at rivers. We defined crossings as intersections between the NHD-derived streams and rivers network and the ADOT road centerline network. At this phase, our analysis does not include the parallel or dead-end road-river interfaces, except for rare occasions where small spatial mismatches cause the river and road linework to intersect. The NHD subregion 1904 (the Alaska portion of the Yukon River drainage) yielded a total of 919 crossings. Where roads cross major rivers or streams, there is typically a bridge; we refer to these points on the landscape as major crossings. Small streams or ephemeral drainages typically pass beneath roads in culverts; we refer to these points as

minor crossings. To associate river reaches downstream from crossings with conservation units, the Administrative Large Parcel Boundary data set was intersected with river reaches downstream from crossings (after the river reaches were buffered by 100 m).

Example

Combining the network model with invasive species distribution data yields information that can help managers determine critical control points for particular conservation units. We provide model output related to the Kanuti National Wildlife Refuge (NWR) as an example of this application. Kanuti NWR is entirely located in NHD subregion 1904, and although it has no direct road access, there are 13 major and 112 minor crossings upstream of the refuge, all on the Dalton Highway. We surveyed only the southernmost 10 of the major crossings, because as we worked north, *Melilotus* had disappeared from the roadsides by the 10th major crossing.

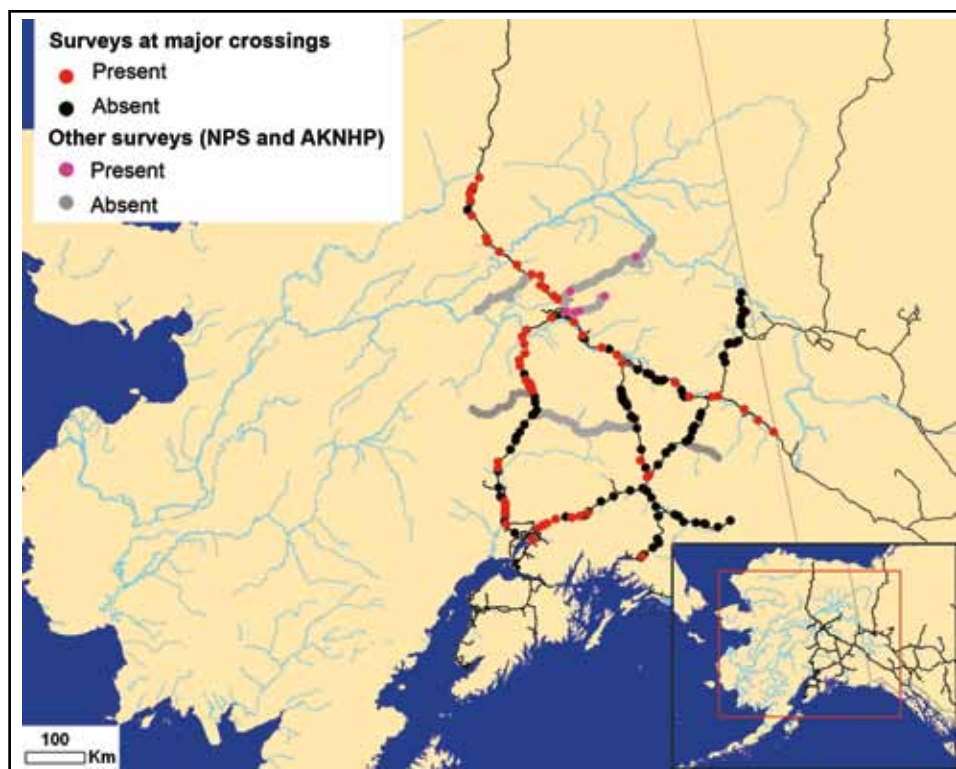


Figure 6—Distribution of *Melilotus* on roadsides immediately adjacent to major crossings, 2004–2006, are displayed. We defined crossings as intersections between the NHD-derived streams and rivers network and the ADOT road centerline network. Crossings with bridges are referred to as major crossings.

Results

Melilotus Distribution

We found *Melilotus* at many points along the highways that we surveyed (Figure 5), with roadsides in the Fairbanks area most consistently colonized. Notably, little or no *Melilotus* was found along several major highways, including the Taylor Highway, the Denali Highway, and the McCarthy Road. In addition, we found *Melilotus* on the roadside immediately adjacent to 64 major crossings (Figure 6).

Of the total of 192 major crossings surveyed, 17 had *Melilotus* growing on a natural flood-plain surface (Figure 7). Most of these were light infestations, but four crossings had moderate to heavy infestations on the flood-plain surface. All 13 of these crossings also had *Melilotus* growing on the roadside immediately adjacent to the bridge.

Though we found *Melilotus* growing on flood-plain surfaces immediately upstream of several crossings, we do not interpret this to mean that this species is spreading

upstream. Instead, all cases where *Melilotus* was found upstream involved heavily colonized individual rivers with multiple road crossings. In these cases, *Melilotus* had spread all along the river from sources upstream of all the surveyed crossings.

Network Model

The network model is a work in progress. At this writing, we have compiled NHD subregion 1904 (the Alaska portion of the Yukon River watershed). Compilation of NHD subregion 1902 (the Matanuska River and Susitna River watersheds) is underway.

Example

Of the 10 major crossings we surveyed leading to Kanuti National Wildlife Refuge, none had *Melilotus* on a natural flood-plain surface either upstream or downstream of the crossing (Figure 8, Table 1). Six had *Melilotus* on the roadside immediately adjacent to the crossing. We characterized

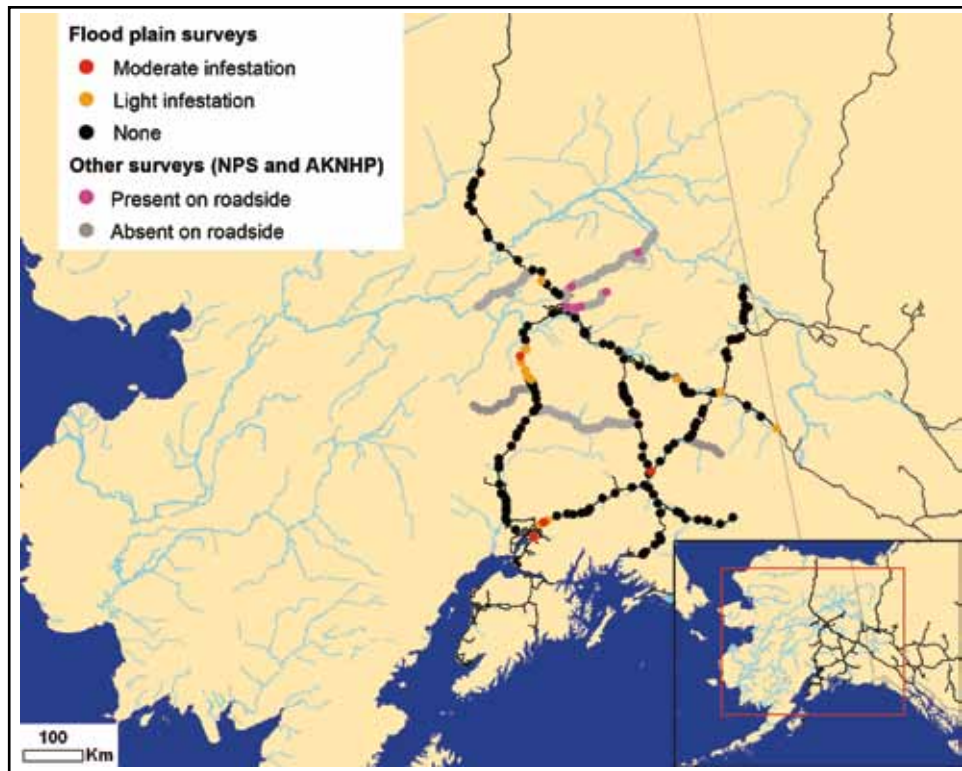


Figure 7—Distribution of *Melilotus* on natural flood-plain surfaces at major crossings, 2004-2006, is shown below. We defined crossings as intersections between the NHD-derived streams and rivers network and the ADOT road centerline network. Crossings with bridges are referred to as major crossings.

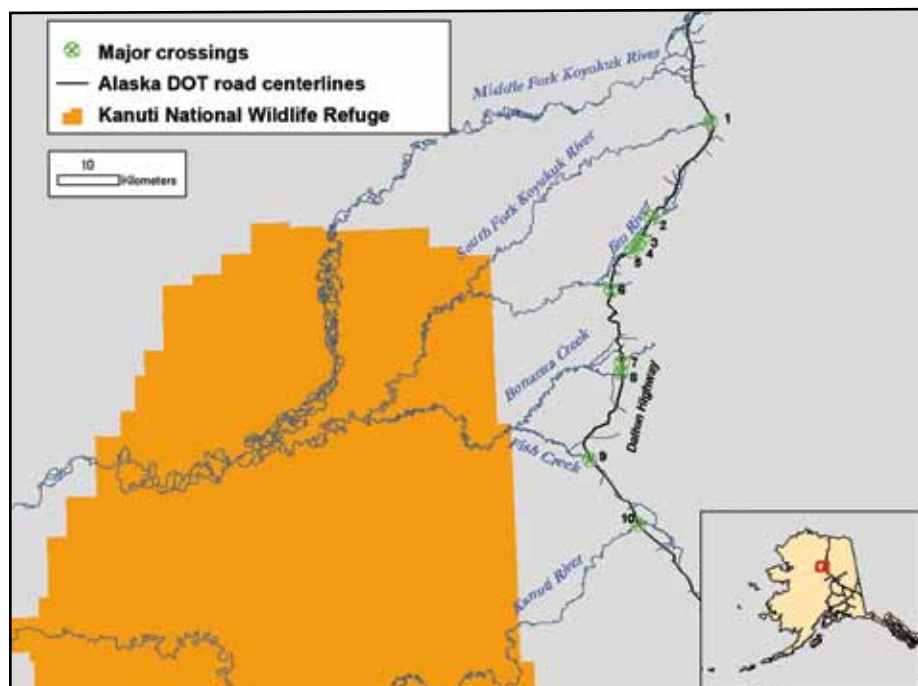


Figure 8—Major crossings upstream of the Kanuti National Wildlife Refuge are outlined below. We defined crossings as intersections between the NHD-derived streams and rivers network and the ADOT road centerline network. Crossings with bridges are referred to as major crossings; identification numbers shown here correspond to numbers in Table 1. There are 13 major and 112 minor crossings upstream of the refuge, all on the Dalton Highway. We surveyed only the southernmost 10 of the major crossings because *Melilotus* had disappeared from the roadsides of the Dalton Highway by the crossing labeled here as 1.

Table 1—*Melilotus* survey results for major crossings upstream of Kanuti National Wildlife Refuge

Number on Figure 8	Highway	Milepost	Crossing name	Distance to Kanuti <i>km</i>	Upstream	Downstream	Roadside	Vulnerability
1	Dalton	156	S_FORK_KOYUKUK_RIVER	80	None	None	Light	High
2	Dalton	144	JIM_RIVER_3	52	None	None	None	High
3	Dalton	142	DOUGLAS_CREEK	46	None	None	None	Low
4	Dalton	142	JIM_RIVER_2	45	None	None	None	Mod
5	Dalton	140	JIM_RIVER_1	42	None	None	None	Low
6	Dalton	135	PROSPECT_CREEK	36	None	None	Light	Low
7	Dalton	125	N_FORK_BONANZA_CREEK	50	None	None	Mod	Low
8	Dalton	124	S_FORK_BONANZA_CREEK	47	None	None	Light	Mod
9	Dalton	113	FISH_CREEK	27	None	None	Light	Mod
10	Dalton	105	KANUTI_RIVER	38	None	None	Light	Low

Milepost refers to state highway milepost marker nearest the crossing. Distance to Kanuti gives the total river distance in kilometers from the Dalton Highway to the eastern boundary of the refuge. The last four columns give data collected in 2005 as part of our *Melilotus* survey.

five of the crossings as moderately or highly vulnerable to invasion by *Melilotus*. Crossings of the Dalton Highway were from 27 river km to 80 km upstream of the eastern boundary of the refuge.

Discussion

The NHD and ADOT road network data sets are both works in progress, and some errors were identified in the NHD data. For example, several small drainages such as the Little Goldstream Creek were isolated from the rest of the hydrography network, and there were several interruptions in the Yukon River flow. These are the best data currently available on a statewide basis, however. We expect that in the future, work in other disciplines will be referenced to the NHD, allowing more detailed data to be incorporated if they become available. For example, additional data may become available regarding water chemistry and flood-plain substrate characteristics.

We are working to link the roads, crossings, reaches, roadsheds, and conservation units so that the data can readily be summarized based on any of these factors and so that an end user can identify a feature (for example, a national park or a national wildlife refuge) and return the crossings, upstream road segments, and river reaches that are associated with it.

In our example with the Kanuti National Wildlife Refuge, our work identified six major crossings where *Melilotus* was found on the roadside immediately adjacent to the bridge. One of these crossings was ranked as highly vulnerable to invasion at the crossing, and two were ranked as moderately vulnerable. Refuge managers could prioritize monitoring and control efforts based on these results. Taken together, the network model and the case study are an effective means of identifying certain river and stream crossings as critical control points for preventing the movement of *Melilotus* toward particular land ownerships downstream.

The general applicability of our network model is demonstrated by examining the structure of data columns in Table 1. The first five columns contain data describing the spatial relationship between roads, crossings, and bridges for the Kanuti National Wildlife Refuge. Other data, such as precise latitude and longitude coordinates and

digital photos, are also available for each crossing. The last four columns contain data from a single survey for a single invasive species. Any future surveys for *Melilotus* or other invasive plant species at these crossings can be directly incorporated using our network model framework and will provide up-to-date information to land managers in Kanuti.

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