

基于 分辨率卫星影像的大区域松材线虫病 警监测*

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摘 要:松材线虫病疫情是一种毁灭性的灾害,具有危害范围广、发病速度快,传播途径多、治理难度大的特点。传统方式排查成本高、工作量巨大,时间周期长,且容易遗漏,难以满足大区域应急监测的需要。从松材线虫病预警、监测,及业务化开展三方面入手,构建松材线虫病防治天空地协同监测技术体系,达到松材线虫病防治的目的。1)首先,在松材线虫分布预警方面,从孕灾环境中考虑自然要求、人类活动和景观要素开展多角度、精细化的预测,构建了最大熵分布预测模型。对其中两个变量进行改进,一是由于人类活动是松材线虫病的主要传播途径,本研究采用监测窗口期间隔 1 年的 2 期吉林一号亚米卫星影像,采用孪生神经网络模型自动识别松林周边 2km 范围内开工建设图斑,作为人类活动要素之一输入模型;二是结合林地一张图提取优势树种为松林的小班,并利用 MODIS 反演松林冠层干燥度输入模型,将监测区域以林业小班为单位划分为松材线虫病发生的高、中、低和不适宜区域四类,作为林地踏查、普查的重要依据。2)其次,基于“天空地”协同模式开展异常变色松树普查监测。其中,“空”指基于疫情小班和已预测的松材线虫病高生存适宜区布设,均匀分布监测区域范围内,采集并构建厘米级无人机影像异常变色木松树的正负样本数据集,并对样本集降尺度采样;抽检总样本数量的 10%进行实地核查,对样本集进行纠偏评价,直到降尺度样本满足精度要求;“天”指检测窗口期内同步获取的 0.5m 分辨率卫星影像和 10 米多光谱影像,利用已有降尺度样本训练小目标识别模型 YOLOv8,当置信度阈值设为 0.3,亚米级卫星影像识别变色木召回率超过 90%,对多光谱影像筛选的敏感光谱特征进行增强,再利用基于深度学习的时间序列分类算法对目标识别中的伪变色点位判别,最终变色木判别准确率达到 85%。3)为解决大区域多家基层林业单位对数量众多的变色点位实际业务应用问题,研发了配套的天空地协同平台和移动核查终端,解决点位图斑任务分发、数据同步、多期数据管理、分区统计、无信号下移动终端林区核查上报、取样除治等业务工作开展,形成完善的协同监测技术体系,为保护林地资源、生态安全构建了通用的技术和业务支撑。

关键词: 高分辨率; 卫星遥感; 松材线虫病; 变色立木

Large Scale Early Warning and Monitoring of Pine Wilt Disease Based On High-Resolution Satellite Imagery*

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Abstract: The pine wilt disease epidemic is a devastating disaster, characterized by a wide range of hazards, fast onset rate, multiple transmission routes, and difficult management. Traditional methods of investigation have high costs, huge workload, long time cycles, and are prone to omissions, making it difficult to meet the needs of emergency monitoring in large areas. Starting from three aspects: early warning, monitoring, and commercialization of pine wilt disease, we will construct a sky ground collaborative monitoring technology system for the prevention and control of pine wilt disease, in order to achieve the goal of pine wilt disease prevention and control. 1) Firstly,

in terms of early warning of pine wilt distribution, a maximum entropy distribution prediction model was constructed by considering natural requirements, human activities, and landscape elements from multiple perspectives in the disaster prone environment. Improvements were made to two of these variables. Firstly, as human activities are the main transmission route of pine wilt disease, this study used two Jilin-1 sub satellite images with a 1-year interval during the monitoring window. A twin neural network model was used to automatically identify construction sites within a 2km radius around the pine forest, which were input as one of the human activity factors into the model; The second method is to extract the dominant tree species as small groups of pine forests based on a forest map, and use MODIS inversion to input the model of pine canopy dryness. The monitoring area is divided into four categories of high, medium, low, and unsuitable areas for pine wilt disease occurrence based on forestry small groups, as an important basis for forest inspection and census. **2)** Secondly, based on the "sky ground" collaborative model, conduct a survey and monitoring of abnormal discolored pine trees. Among them, "empty" refers to the collection and construction of positive and negative sample datasets of centimeter level unmanned aerial vehicle (UAV) images of abnormally discolored *Pinus massoniana* trees, based on the layout of epidemic small classes and predicted areas with high survival suitability for pine wilt disease, uniformly distributed within the monitoring area, and downsampled sampling of the sample set; 10% of the total sample size is sampled for on-site verification, and the sample set is subjected to correction evaluation until the downsampled samples meet the accuracy requirements; "Tian" refers to the 0.5m resolution satellite image and 10 meter multispectral image synchronously obtained during the detection window period. The YOLOv8 small target recognition model is trained using existing downsampled samples. When the confidence threshold is set to 0.3, the sub meter level satellite image recognition color change wood recall rate exceeds 90%. The sensitive spectral features filtered from multispectral images are enhanced, and then the pseudo color change points in target recognition are distinguished using a time series classification algorithm based on deep learning. The final color change wood discrimination accuracy reaches 85%. **3)** In order to solve the practical business application problems of multiple grassroots forestry units in large regions with a large number of color changing points, a supporting sky ground collaborative platform and mobile verification terminals have been developed to solve the business work of point map spot task distribution, data synchronization, multi-phase data management, zoning statistics, forest area verification and reporting under no signal mobile terminals, sampling and removal, forming a complete collaborative monitoring technology system, and building a universal technical and business support for protecting forest resources and ecological security.

Keywords: High resolution; Satellite remote sensing; Pine wilt disease; Color changing standing wood.